University of Manchester Pollinator Project, 2019.

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Lancashire, Manchester & N Merseyside

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Contents:

EXECUTIVE SUMMARY

The Wildlife Trust for Lancashire, Manchester & North Merseyside (Lancashire Wildlife Trust) were commissioned by the University of Manchester (Jennifer Strong, Environmental Sustainability team) to carry out a pollinator survey on the Oxford Road Campus (see map - page 11).

A background and project brief was provided:
"The University of Manchester has 'Living Campus'1 as a priority area of work within the sustainability agenda. This includes developing/retaining flourishing key spaces (gardens, green walls, green roofs etc.) to encourage key species and improve biodiversity and develop the look and feel of the campus for staff, students and visitors. In 2016 (June-August) an initial pollinator survey was completed by a master's student. Building on this, we would like to conduct a follow up survey to establish a more robust baseline in order to more confidently map the impact of our work in improving the living campus, and establish a replicable methodology for future studies which may be supported by students".

Project objectives were outlined:
"To conduct a pollinator survey of key green spaces on the University of Manchester South Campus in and around Oxford Road, comparing results to 2016 (a previous, relevant MSC study) where possible and creating a replicable methodology for future studies".

The expected deliverables / outputs of the commissioned work included:

- Development of a survey area
- Development of survey methodology - informed by previous methodology but with (A) more detailed (expertise) input to provide a detailed baseline and (B) a methodology that was broadly comparable to the previous, related, MSc study (2016, data protected) but also less intensive / complex.
- A report based on the findings of the survey, principally - *"Types and frequency of pollinator species recorded"* – to show how pollinators are interacting with the campus environment presently and with reference to the 2016 study and equivalent urban environments was requested.

SUMMARY OF RESULTS

In summary:

* It has been shown that areas of the U.O.M. campus support varying abundance and diversity of pollinators

* Some plant species are more attractive to pollinators than others

* Abundance of pollinators is positively correlated with an increase in abundance of flowering plant species *but is strongly correlated with certain plant species i.e. Nepeta, Salvia.*

* Diversity of pollinators increases with abundance of flowering plants *but increased abundance of all pollinators is not equivocally correlated with diversity of pollinator groups / species*

Background to Lancashire Wildlife Trust and the Author

The Wildlife Trust for Lancashire, Manchester and North Merseyside (LWT) is a wildlife charity, working to protect wildlife and nature for the future. We are a key voice for nature, both locally and nationally - directly and strategically. We manage Nature Reserves, deliver specialist projects and have a people and wildlife team engaging people in sustainable living and conservation from the very young to the retired. Although core funding supports some key senior roles, we don't receive any direct government funding so all project work is entirely, externally funded.

Ben Hargreaves (the author of this report) has worked for Lancashire Wildlife Trust since 2002 and has been employed in the Conservation / Environmental sector since 1997. An experienced Project Officer, he has been involved in the development and delivery of various - predominantly ecologically focused - projects throughout this time and has specific interest and experience in Botany (higher plants) and Entomology (insects). Ben co-ordinated the Plan Bee project (2012 – 2016), which focused on bees, related insects, habitats and their conservation (through direct survey, research, capital works and outreach / environmental education). Ben is a specialist in the study of *Hymenoptera* (a large family including bees, wasps, ants and sawflies), is a member of BWARS (Bees, Wasps and Ants Recording Society) and is the aculeate Hymenoptera - *Apoidea* (all bees)*, Crabronidae, Sphecidae, Pompilidae, Vespidae etc* – all wasps excluding *Ichneumonidae* and *Braconidae – Formicidae* (ants) - recorder for Lancashire Vice Counties (V.C.) 59 and 60, working closely with the Local Record Centre's (Lancashire Environment Record Network, Greater Manchester Ecology Unit, Merseyside Environmental Advisory Service) in the verification of records, production of regional checklists and species accounts.

Acknowledgements

The author would like to especially thank Dr. Dmitri V. Logunov, Curator of Manchester Museum, for recommendation for this commissioned work and also to the University of Manchester for the award of the commission. Jennifer Strong is thanked for support on all aspects of planning and logistics (especially relating to field work carried out). Karen McCartney is thanked for records of bees and wasps in Longsight and Stuart Fraser is thanked for assistance with maps.

SECTION I: CONTEXT

Introduction to "pollinators"

A "pollinator" could, in theory, be any vector which removes pollen from one plant to another. Many plants (including grasses, non-vascular plants, some larger plants and trees) are predominantly wind-pollinated or even self-fertile and do not require a vector to transfer pollen from one plant to another. Many plants – in order to be pollinated and/or to increase fecundity and promote genetic diversity - are partly or wholly reliant on animal vectors to carry out pollination.
Although there are many non-insect "pollinators" (including birds, reptiles and mammals), the most regular, important and effective pollinators in many parts of the world are insects. Of insects, there are many potential pollinators which (for example) include thrips, beetles, flies, bees, wasps, sawflies and ants. The most important wild pollinators for plants are those that are naturally abundant and visit flowers regularly. Furthermore, bees (all bees in the temperate world) are adapted for pollination – they require pollen as a larval food source. Most UK bee species carry the pollen from the plant to nest - amongst their body hairs or on a specifically modified leg (the "pollen basket" of Honey-bees and bumblebees – forming balls of pollen), with one exception amongst *Hylaeus* – a primitive genus of bees that eats and regurgitates pollen back at the nest. Sawflies (Symphyta) are also important pollinators, nectaring on flowers and becoming coated in pollen, as do hoverflies (*Syrphidae*) and other flies (*Diptera*). Wasps can – like sawflies, hoverflies and beetles – be inadvertent pollinators generally but are also important specific pollinators for certain plants including UK species of figworts (*Scrophularia* sps).

Noted decline in "pollinators"

The decline in insects both nationally (in the UK) and on a global level has been well documented. There have been many hypotheses suggested as being the principal driving force behind the decline in insects, though it is likely that there are multiple factors involved on a global level which vary (in level of importance) according to region. Habitat loss – quite simply a huge reduction of flowering period and floral resource - pollution and climate change have all had serious impacts on insects leading to changes in distribution, decline and even extinction of certain species.

Compared to some insects (for example butterflies, moths), bees and related insects have not been as studied – rigorously and taxonomically – historically. Despite this, the decline in some of the bees and wasps amongst the order *Hymenoptera* was already apparent by the time of E. Saunders, "The *Hymenoptera Aculeata* of the British Islands". London.: L Reeve & Co. Ltd, 1896. the first major and comprehensive taxonomic treatment of aculeates (bees, wasps and ants). From the period of the early to late 1800's some species had become rare or likely extinct and by 1978 there had been 22 likely extinctions of bees and wasps in the UK, with many others becoming far less common or indeed rare. However, there has been an increase in the UK checklist of 25 species between 1978 and 2016 with species new to the country in this period. There have been overall declines in flies and hoverflies as well (particularly noted - by *Syrphidae* specialists - in declined general abundance of all species), though no national extinctions recently (none since the mid-20th Century, at least – "A review of the scarce and threatened flies of Great Britain Part 6: Hoverflies family Syrphidae"; S.G. Ball and R.K.A. Morris, 2014, JNCC, Species Status Number 9).

Importance of "pollinators" and changes

There has been much recent discussion on the importance of pollinators, both in the commercial sense (crop pollination, honey production and "ecosystem services") and in the more basic natural function and value of insects pollinating and cross-pollinating plants. The decline in abundance of many species of bees, wasps and flies does highlight a more fundamental environmental crisis and the status of bees – in particular – has been used as a barometer of environmental and ecosystem "health", "coherence" and "robustness". Bumblebees – subject to some of the most severe declines amongst UK bee genera – place "great demands on the landscape" (Steven Falk, pers. comm.) as they have a longer and more complex life cycle than other aculeate bees and wasps and have an intrinsic relationship with plants. Some of the most severely declined (*Bombus humilis, Bombus muscorum, Bombus sylvarum, Bombus distinguendus, Bombus subterraneus, Bombus ruderatus*) species are now known to be particularly associated with flower-rich habitats such as un-intensive farmland, dune systems, salt marshes and extensive, post-industrial brownfield sites (Thames Gateway) and – with the huge loss of un-intensive farmland and loss of species rich grassland on farms – are now restricted to these fragmented, fragile and threatened spaces. The overall UK – and European – picture is not positive, but there have been examples of rapidly expanding species more recently. The most well-known "explosions" in UK populations of bee species have occurred with Tree Bumblebee (*Bombus hypnorum*) and the "Ivy-bee" (*Colletes hederae*) – both recent (post 2001) "colonists". This has also occurred with several wasp species, both with "colonisation" – first UK records – and with rapidly expanding ranges of resident, previously rare and/or very southern species (eg. *Gorytes laticinctus*, *Vespa crabro*).

Urban habitats and pollinators

The importance of urban habitats for insects has not – historically – been much studied. For one reason this is due to the rapid onset of industrialisation and urbanisation – before this stage in history recording of insects by entomologists concentrated on the (still) extensive, high quality and very productive (entomologically) rural and rural fringe habitats. Even with the vast increase in gardens and championing of urban greenspace, our understanding of "pollinator" abundance and distribution in urban areas is still limited.

In a review, Hernandez et al. (2009) found only 59 research publications – worldwide - on urban bee ecology and concluded that study and documentation of urban bee communities and their dynamics is at an early stage. However, interest in urban bee ecology has vastly increased in recent years (Everaars et al. 2011; Winfree et al. 2011; Hennig and Ghazoul 2012; BanaszakCibicka and Zmihorski 2012; Hinners et al. 2012; Matteson et al. 2013; Verboven et al. 2014; Lowenstein et al. 2014; Baldock et al. 2015).

Urbanisation can affect bee species in different ways depending on the species - and its biology / ecology (Liow et al. 2001; Fetridge et al. 2008) - and may increase or decrease bee species richness depending on (variable) taxon, spatial scale of analysis, and intensity of urbanisation. However, (in their reviews) Hernandez et al. (2009) and Winfree et al. (2011) suggested that overall urbanisation has a negative impact on bee species richness.

Urbanisation can partly or completely eliminate resources (Czech et al. 2000) and replace previous native habitats with a mosaic of buildings, parks, pavements, gardens and small spontaneous vegetation patches (French et al. 2005; Johnson and Klemens 2005).

Gardens and small weedy patches are also considered to have biodiversity value in urban habitat studies (Matteson et al. 2008; Sarah and Jeremy 2012; Larson et al. 2014; Maclvor et al. 2014) - providing refuge, food and apposite habitats to various species (Gilbert 1989) – and these may share some affinities with areas (planted areas, quads) covered by the present study.

Urban habitats may be diverse in nectar / pollen producing flowers (pollen being crucial for bees) and hence support a wide variety of pollinating insects (Harrison and Davies 2002; Maclvor et al. 2014; Larson et al. 2014). They may also provide nesting resources for bees (Cane et al. 2006), although research has shown that urbanisation may have overall negative effects on the abundance and diversity of bees (Fetridge et al. 2008; Hernandez et al. 2009; Winfree et al. 2011). Contrasting results have also been demonstrated which show less negative effects (Baldock et al. 2015) and overwhelmingly higher abundance in urban areas compared to proximal urban fringe rural habitats and Nature Reserves (Sirohi et al. 2015).

Studies on (UK) urban habitats are also widely conflicting in their results, from urban and suburban areas of cities having fewer individual bees and hoverflies and lower diversity than similar rural habitats (A.J. Bates et al. 2011) to significantly higher numbers of solitary bees found in an urban centre to closely adjacent farmland and Wildlife Trust managed Nature Reserves (Sirohi et al. 2015).

More importantly – and with respect to the current report – the previous (referenced, field) studies relied to a greater extent on “passive sampling” techniques (pan and malaise traps) rather than more traditional survey methods (visual observation, hand netting and sampling), the latter being the sole methods used by the previous MSc study and the current study. Passive sampling gives more comprehensive results with a higher number and abundance of species being recorded – as it includes many species that are overlooked in the field (and usually covers a greater number of taxa identified to genera and/or species) – but will not serve to illustrate which urban areas are “hotspots” in attracting more pollinating insects (which exhibit foraging behaviour / affinity), which is central to the current study.

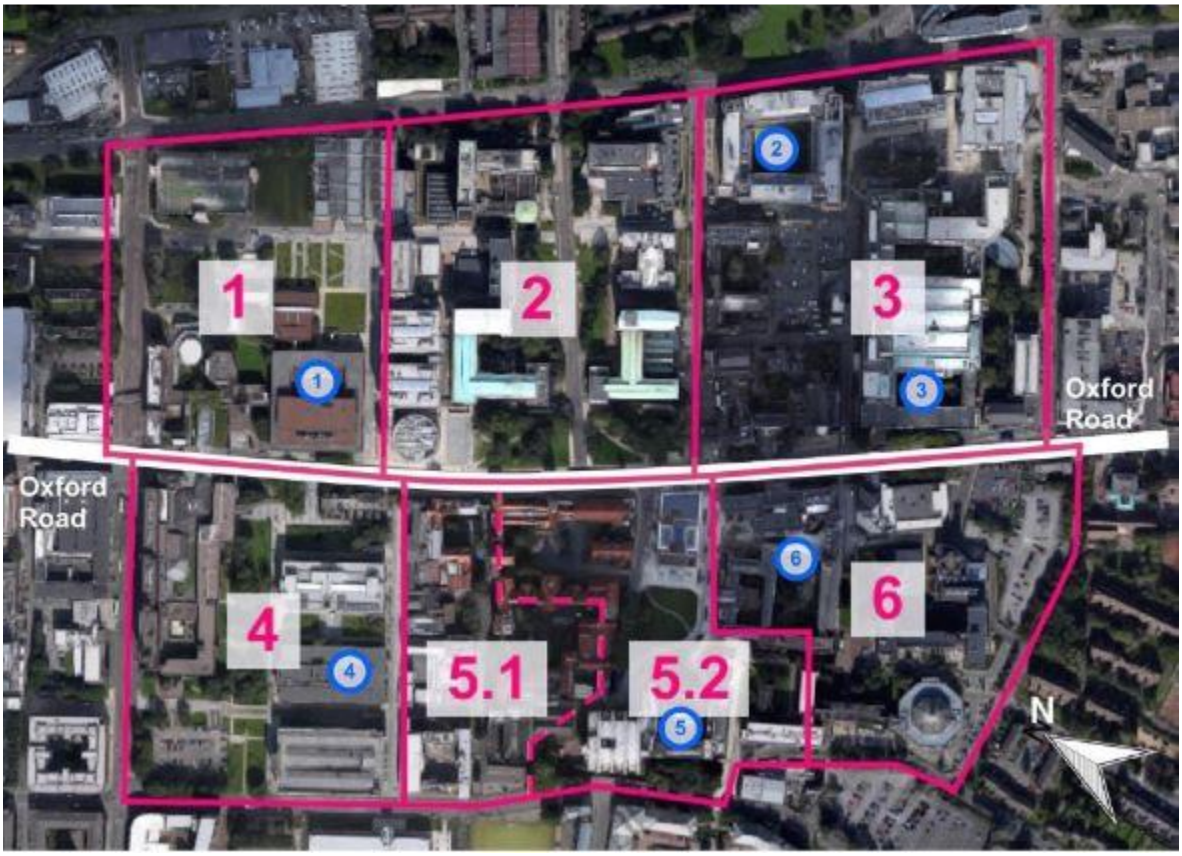
Previous MSc study

The previous “pollinator” study carried out on the campus area (2016) focused on the interaction of bees and hoverflies with plants in different areas and was detailed in its examination of flower visits (to different plant species / different flower colours). The findings of the study have relevance to the present study – which has also made reference to plant species visited – though identification of taxa present was not undertaken to the same extent (being restricted at the species-specific level to bumblebees). However, some of the most numerous observed “groups” (species of bumblebee and *Syrphidae* – hoverflies identified to the family level at least) are common to both studies and therefore the studies have considerable overlap for comparison.

SECTION II: METHODOLOGY

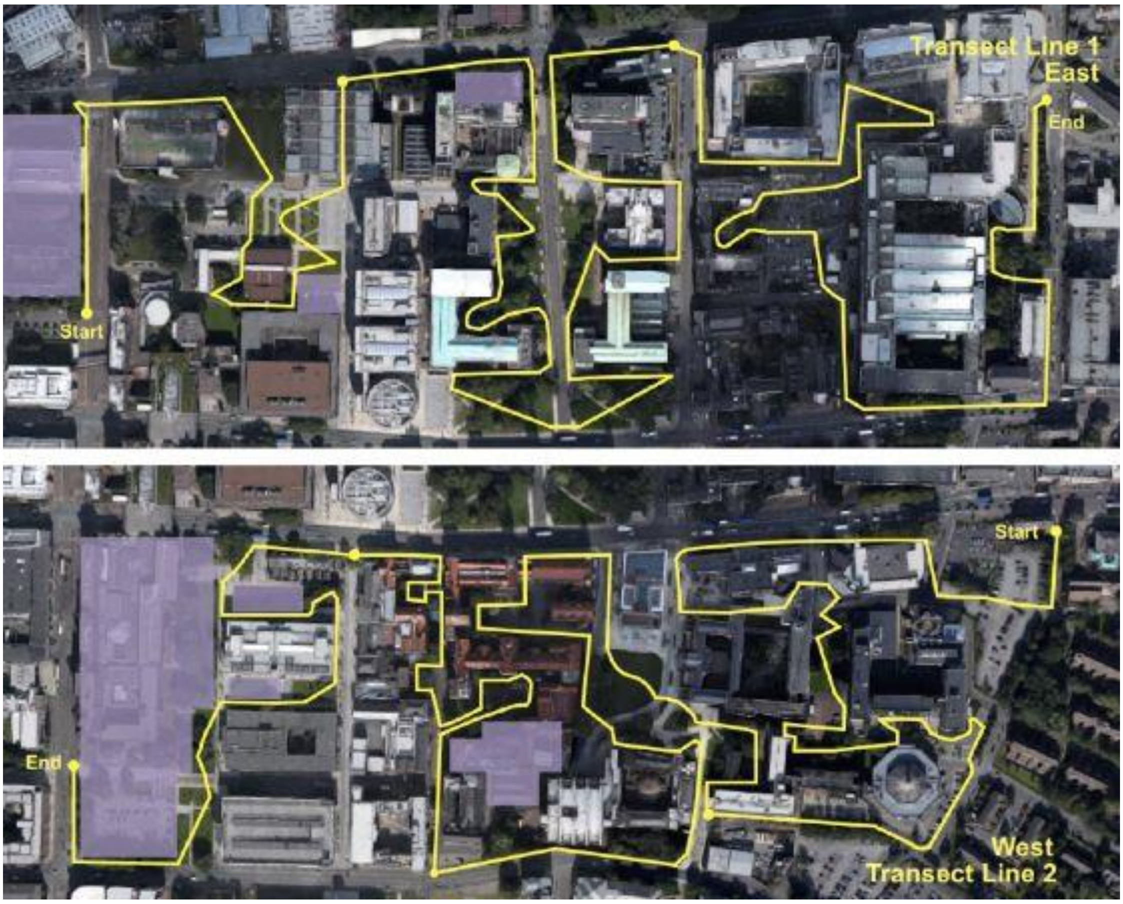
Methodology of previous study

The MSc study of 2016 studied the south Main Campus area and split this into 6 sections (1 of these sub-divided into 2) with 6 key spaces – the key spaces were studied for variable amounts of time (ranging from 7 minutes to 1 hour). The key spaces included 4 "quads" (green spaces within and enclosed by the buildings they are in) and two green roofs (the green roofs located on buildings):



A transect route (over leaf) was set out which adhered to (A) the distribution of flowering plants on campus and (B) to the hard line of buildings where they occurred. Visual observation was made at a range of 2 metres to the side and 4 metres in front, at an intended speed of 50 metres per minute (shown overleaf):

MSc Study Transect



Methodology of present study

The present study covered the same Main Campus area generally and also adopted the transect route method for survey of the general area, bordered by Booth Street West / East (to the north) Dilworth Street / Grafton Street (to the south and east), Upper Brook Street (east) and Lloyd Street North (to the west).
However, the route was much simplified as (A) many sections of the MSc transect route were along the edges / sides of buildings containing no plants or amenity, non-flowering plants (usually ornamental shrubs) and (B) many sections of the MSc route were no longer accessible to travel between / over / through.
It was also thought that the complexity of the previous route would make repeat monitoring / comparable projects and comparison of data more challenging.
It also includes several areas not covered at all – or at least in as much in detail – during the MSC study.

Current study transect

The area was not split up into (6) zones and the number of “key spaces” – set up along the transect route and of which one of these was given priority on each transect - was increased from 6 – 10. All points had their grid reference recorded by GPS (checked by GIS mapping) – these are included in the data appendix (corresponding to records).

1 = Brunswick Park 1 (north / west)
2 = Brunswick Park 2
3 = Brunswick Park 3
4 = Brunswick Park 4 (2 x 5 minute “stops”)
5 = Ackers Street / Portsmouth Street
6 = Samuel Alexander Building / Lime Grove
7 = Learning Commons Green Space
8 = University Green (pedestrianised area north of Humanities, Bridgeford Street)
9 = University Green (pedestrianised area north of Humanities, Bridgeford Street)
10 = Car park area between Prospects House and Royce Institute (cornfield annual area)

All the points above (bar 5) were chosen following an initial survey / assessment of the campus area and focused on relatively informal planted (formal) areas, areas seeded with wildflowers (generally “cornfield annuals”) and more formally planted areas – shown on the next page, location below picture.

Brunswick Park (north / west area)

Brunswick Park (Oxford Road end)

Ackers Street (leading to Portsmouth Street)

Learning Commons Green Space

University Green

Car Park area between Prospects House and Royce Institute (the cornfield annuals – poppies, Corn Marigold etc. have died down and have been replaced / overgrown by perennial vegetation).

The distinction between informal and formal planting - for the purposes of this report – is for formal areas to be longer established and having some presence or dominance of non-flowering "ornamental" or "structural" shrubs, whilst informal planted areas are more recently established and dominated by more flower rich species (mostly perennial herbs and smaller shrubs) rather than larger shrubs.
Point 5 differed in being a relatively short section of wall, some of older brick work with some gaps in the mortar, which were observed to support nesting aculeate bees and wasps (records in the data appendix and results).

On each transect a different point was chosen and a ten-minute survey of that data point was undertaken.

In addition, 5 quads were visited. Though these did not constitute part of the transect route (in contrast to the ten minute stops) they were treated in the same way as one of the ten minute stops (as described under survey technique).

Survey technique

Standard field survey techniques were employed for the transects, with the aim to carry out surveys in predominantly dry, sunny weather, with light winds.
In line with standardised survey techniques for pollinating insects (including bees, butterflies and hoverflies) surveys were only carried out when temperature exceeded a minimum of 15 degrees Celsius for the majority of the survey period.
A slow walking speed (= to 50 meters per minute) was utilised, in line with the previous MSc survey. The length of time the transect took varied between 1.5 – 2.5 hours, with the route being longer at the start (due to unfamiliarity with the route) but also longer on the days with the better (warmer, drier, less windy) days when insects were more evident and more time was required to observe and count them.

Where possible, insects were observed in terms of behaviour - flying generally or visiting general / specific flowers – and identified (where possible) visually. As emphasis (on species identification) was given to the important pollinating family of *Hymenoptera* (bees, wasps, ants, sawflies) these were occasionally caught by hand net and examined in the field (some species can be identified with experience, in the field) and where field identification was doubtful or not possible, specimens were collected in ethanol for later identification. Specimens will be passed on to Dmitri Loganov, Entomology Dept., Manchester Museum, for storage in the *Hymenoptera* / *Diptera* collection.
Most *Syrphidae* hoverflies were identified to family level, though a number of species were familiar to the author at genera or species level and were therefore recorded more specifically.
1 species of (notable) hoverfly was collected for confirmation. All other flies (family *Diptera* – all subfamilies excluding *Syrphidae*) were recorded to family level only.

During the ten minute stops, visual observation took place at fixed grid reference points – planted areas were observed from stationary and slow moving positions. Again most observation was visual, although hand netting / field examination and specimen collection did feature (time was allowed for this as general visual observation is not possible during field examination / sampling).

Limitations to survey / data collection

Only active field survey – visual observation with targeted netting and more limited general sweeping with a fine net - was utilised to capture insects and generate the data. Other “passive collecting” techniques such as malaise (a modified tent with a collecting bottle) or pan trapping (small yellow / white / blue dishes or pans filled with water and detergent) can help to capture a range of species (especially *Diptera* / *Syrphidae* but also some *Hymenoptera*) not otherwise encountered during more active field searching (the traps are left to run for several days to weeks at a time and can generate v. large amounts of biological material - specimens). Unfortunately, the transect area was very public and very well used, so setting up of a large and very conspicuous malaise trap was simply not an option. It was also not possible to locate any sufficiently discrete areas to set up pan traps. Additionally, the pan traps need to be emptied / specimens preserved following a few days of collecting (as dead insects will be “poached” by birds and/or start to decompose), which given the widely variable weather (to the effect that survey days were seldom consecutive) was not conducive to this study.

Malaise traps and/or pan traps could be used in future studies to capture more biological data which would give a far more comprehensive and accurate representation of pollinator abundance and diversity throughout the campus area. It may be that one of the quad’s (such as that within the Michael Smith Building) could be used to run a malaise trap and/or pan traps – if pure ethanol is used in collecting and preservation, specimens can yield DNA for analysis (should this be a study objective).

SECTION III - RESULTS

Transects were carried out on 11 days between 17/06/19 and 12/08/19 – 10 days were costed and scheduled for the project quote, but 1 day was particularly poor weather (predominantly rain and cool for the time of year – resulting in only 2 biological records), so another “replacement” transect was carried out.

Visits to 5 quads – Main library, Michael Smith, Humanities Bridgeford St. and Stopford (2) were made. The quad visits were undertaken on standard transect days – as a standalone survey of these spaces (i.e. not incorporated into the transect route – completed after the transect).

A total of 1037 biological records were made in total over the survey period:

Family	**Count**
Bees (including Bumblebees, Honey-bee, solitary bees)	699
Hoverflies (excluding all other Diptera)	113
Diptera (excluding hoverflies)	161
Wasps (including social wasps, parasitic wasps, solitary wasps)	44
Lepidoptera (butterflies and moths)	19
Sawflies	1

From the above records 12 records are for the quad spaces visited (all from the Michael Smith Building or Stopford quad 2).

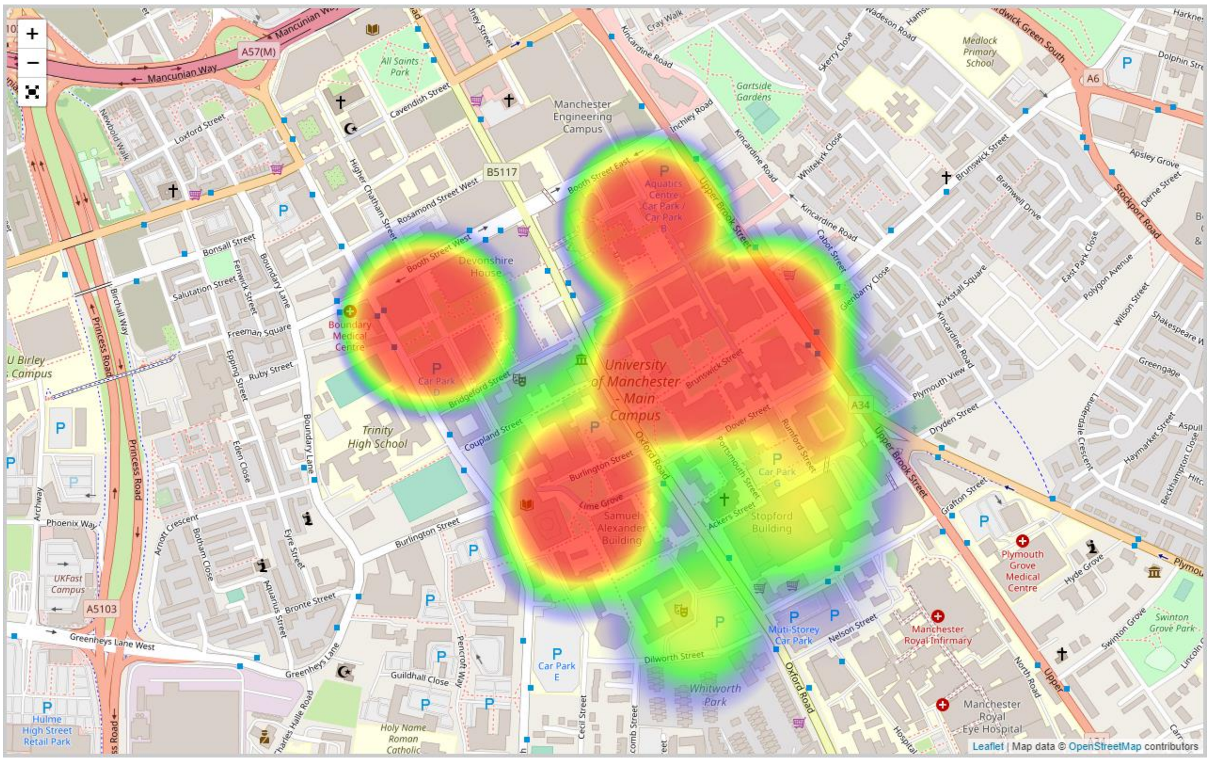
For the most numerous family – bees – a further breakdown is useful to provide more direct comparison with the previous MSc study (in which bumblebees were identified to species:

Species	Count
Honey-bee (*Apis mellifera*)	310
Buff-tailed Bumblebee (*Bombus terrestris*)	175
“Colletid bees” (*Colletidae* sps) - solitary species	60
Common Carder-bee (*Bombus pascuorum*)	36
Tree Bumblebee (*Bombus hypnorum*)	31
Red-tailed Bumblebee (*Bombus lapidarius*)	29
White-tailed Bumblebee (*Bombus lucorum* agg / sensu lato)	16
Early Bumblebee (*Bombus pratorum*)	15
Small Garden Bumblebee (*Bombus hortorum*)	11
“Leafcutter-bees and mason-bees” (*Megachilidae* sps) – solitary species	7
“Sweat bee” (*Lasioglossum, Halictidae*)	5

Vestal Cuckoo-bee (*Bombus vestalis*)	3
Unidentified bee (*Bombus* sp.)	1

All details of the records on the tables (previous page) – identification (for bees, wasps and butterflies to species – for others to family, sub-family or genus), caste of insect (worker, male or female – relevant to bumblebees and Honey-bee's), date, area and grid reference – are provided in the "Records" appendix excel sheet.

The spread of records across campus is illustrated on the following "heat-maps", with the lowest density of records shown in purple. Subsequent change in colour is - with increasing number of records - from green-yellow-orange-red, with red showing the highest number of records. Maps are presented in greater focus, by sequence.

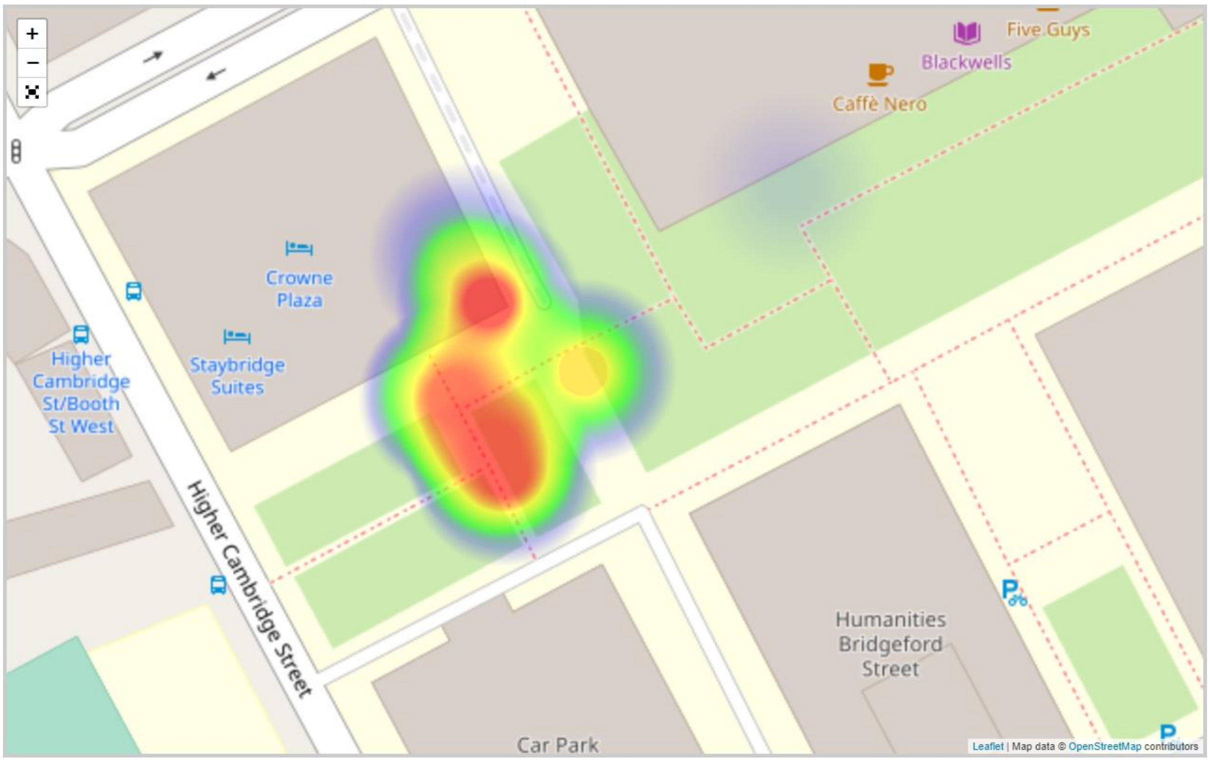


General area

Focus on high intensity areas

Brunswick Park (showing greatest concentration in the planted areas and, in particular, the centrally planted area).

High density of records again associated with informal planted areas at Learning Commons Green Space



High density of records again associated with informal planted areas at University Green

The strong, correlated relationship between informal planted areas and pollinator density – and of *particular* planted areas and pollinator density - is shown clearly.

SECTION IV – CONCLUSION & DISCUSSION

Comparison with MSC study

In the MSC study the most abundant pollinators (in decreasing order, based on counts) were:

- Buff-tailed Bumblebee (1165)
- Tree Bumblebee (1060)
- Syrphidae (970)
- Honey-bee (873)
- Common Carder-bee (521)
- Red-tailed Bumblebee (300)
- Early Bumblebee (155)
- Lepidoptera (Butterflies and Moths) (41)
- Small Garden Bumblebee (2)

Although the MSc study period (in 2016) was carried out during the same period (late June to early August) direct comparison with the current study is difficult, namely as this study undertook more than twice the number of days (22 – 2 were classed as invalid due to unexpected rain). Additionally, the 5 key spaces investigated in the MSc study were all quads – visited 5 times over the period. The quads were visited for various lengths of time on each visit ranging from 7 minutes to 1 hour depending on the size of the quad (longer for the larger areas).

Thus, the number of recorded sightings for each species would be quite different due to the transect and – more importantly - the difference in timed visits to the quads (all quads being visited during the current survey for 10 minutes).

The length of time given to recording in the enclosed quad environments could – speculatively – give rise to repeat counting of the same individual insects, as it is not thought that it would be possible to judge as to the import and export (or rate of movement) of individual insects to such a resource. However, this is not likely to be significant as the number of records for the quads was 178 – in contrast to the total number of transect records at 5087.

There is – therefore – a large discrepancy between observations of insects between the transects of both studies. Although better – drier, warmer, less windy - weather in 2016 could affect pollinator abundance significantly, it is very surprising that this should result in the MSc study generating over 5 x the number of records. Granted, there will have been changes to the campus over that period – with losses and gains in terms of planted floral resources – but this is still highlights a puzzling discrepancy. In terms of relative comparison, only *Lepidoptera* (moths and butterflies) – with 41 records for the previous study and 19 for the current study – seem to have similar / equivalent abundance for both studies given the factors discussed.

In terms of the actual species recorded the results also differ substantially, with Honey-bee's the most abundant insect in the current study (it is thought that if anything the count of 310 is a significant under-estimate given their local abundance in some areas – making counts difficult).

It is not known how many hives were located on the buildings at the time of the previous study – nor as to the management of the hives at that time – mention of those known currently is in the discussion.

Also notable is the vast decrease in number of Tree Bumblebee's from the previous to current study. The reason for this is unknown. Tree Bumblebee's are a relative newcomer to the UK *Bombus* fauna, first recorded in 2001 (Southampton) – following which they have rapidly colonised all of England and Wales (and much of Scotland). This species has also become one of the most abundant species in many places - producing large colonies of up to 400 workers. It is – predominantly – an aerial nesting species, which often utilises garden bird boxes (but will utilise a range of aerial cavities in addition) and in the UK exhibits a strong synanthrophic bias.

A noted increase is in Small Garden Bumblebee – 2 in the previous study and 11 in the current study. Small Garden Bumblebee's are not particularly uncommon in urban areas (especially lowland) and – as the name suggests – often visit gardens to forage (nectar and pollen) from flowers with long / deep corolla's (i.e. *Lamiaceae* – mint, oregano etc. – foxgloves and others). They have the longest tongue of the more common UK bumblebees (other bumblebees can and do visit the long flowered plants but are required to crawl into the flower or "rob" the nectar by biting at the base). There has been substantial planting of *Nepeta* sp. and *Salvia* sp. in the planted areas on Campus and it was always *Nepeta* (attractive to all the insects in the current study – but especially bees) that this species was recorded on.

Discussion of species recorded by the current study

A brief account of the species – where these have been confidently identified in the field or from specimens - recorded during the current study is given below:

Social Bees ("social bees" – having a caste system of workers and reproductive queens / males, includes many bumblebees and Honey-bees – and cuckoo bees, parasites of the same genus)


Honey-bee © C. Highfield

Apis mellifera (Honey-bee): Usually a domesticated (kept in a managed hive) species, it occasionally escapes and produces "wild" (feral would be a more accurate description) colonies in aerial structures. Honey-bees are "corbicular bees" – workers collect pollen in a modified corbicula "pollen basket", which also occurs in all the true (non-cuckoo) bumblebees (note the pollen ball on the back leg, in the photo above and on some subsequent bumblebee pictures). Considerable debate exists as to whether *A. mellifera* was ever a wild species in the UK, however this is a moot point - considerable import / export and breeding of colonies has been undertaken by Apiarist's resulting in a large variety of "forms" or "types" which (nonetheless) are inter-fertile (and as a result no attempt has been made to ascertain variously assigned forms or sub species to any recorded in the current study). As Honey-bees have been closely associated with / highly managed by man for such a long period of time, it is impossible to ascertain any true habitat / ecological associations. The taxa show no particular preference for any group or species of plants although as a short-tongued bee, it is unable to forage easily from some deeper flowers (although will climb in to flowers or bite through the base to access nectar, as do some bumblebees).


Buff-tailed Bumblebee

Bombus terrestris (Buff-tailed Bumblebee): This is one of the most familiar, common and widespread of the UK bumblebee species. It is one of the larger “banded” species and is well recorded over the whole of the UK (and in Europe, where it is represented throughout the continent by a range of sub species according to region). Historically (pre-1960) this was an uncommon species in the north of the UK, much outnumbered by the similar *Bombus lucorum* aggregate of 3 species.
In the north west of England, it is ubiquitous - occurring from the coast to the uplands in a range of habitats, showing no particular affinity for any type of flowers – and excepting the highest ground is often the most locally abundant species in any given area.


Common Carder-bee

Bombus pascuorum (Common Carder-bee): The most common of the “carder-bees” – bumblebees which nest just above ground level in grass or moss – Common Carder-bees are, again, one of the more common UK species and ubiquitous in much of the UK. It can be difficult to separate this species from the related *Bombus humilis* and *B. muscorum* in the field, but both of these species are v. rare (if present at all) in Lancashire and not typical of most urban habitats. In the north west it is found in most places and is often – with *B. terrestris* – one of the most locally abundant of the bumblebee species. It has no real preference for habitat and forages on a very wide range of plants.

 **Tree Bumblebee**

Bombus hypnorum (Tree Bumblebee): Only a UK resident species since 2001, this aerial nesting species (a relative of Early Bumblebee, Heath Bumblebee and Bilberry Bumblebee, though marked more like a carder-bee with a white tail) has rapidly spread throughout the UK, becoming one of the most locally abundant species in many places (including urban areas, where it often utilises an abundance of aerial nesting niches – bird boxes, roof cavities etc).

 **Red-tailed Bumblebee**

Bombus lapidarius (Red-tailed Bumblebee): One of two UK species of social bumblebee with a basic black and red colouration in both queens and workers (the other – *Bombus ruderarius* – is rare and not recorded in Lancashire), this is a species without clear habitat preferences but in the north west was – historically - more typical of coastal lowland areas. It is found in urban areas as well as rural areas, but is not generally the most common urban species (evidenced by both studies).
It is – reputedly – more attracted to yellow flowers (such as *Lotus corniculatus*, shown on the picture on the previous page), which are not generally prevalent amongst the floral resources amongst the campus.

 **“White-tailed Bumblebee”**

Bombus lucorum s.l. (“White-tailed Bumblebee” – an aggregate / sensu lato, of three, genetically distinct, phenotypically cryptic, white-tailed species): Although three distinct species of white-tailed bumblebee have long been recognised in other parts of Europe the UK – until recently – has regarded this as one variable species. Recent genetic evidence has proved that the UK does in fact have all three species (*B. lucorum* s.s., *B. cryptarum* and *B. magnus*), with some evidence that *B. cryptarum* and *B. magnus* are more prevalent in upland areas. Although queens and workers of these three species are not reliably separated in the field (or under microscopic scrutiny), there is evidence to suggest that males may differ in their general appearance (essentially – the degree of yellow patterning of hairs about the body). The degree of yellow patterning does help to separate some males of the lucorum complex from the v. similar *B. terrestris* – useful as the workers are often difficult to distinguish in the field. Although the lucorum “complex” is widespread throughout the UK – and not considered to be habitat specific generally – it is not one of the most common urban species in N.W. England and, again, this is borne out by the results of the current study.

 **Early Bumblebee**

Bombus pratorum (Early Bumblebee): This is a smaller species which is red-tailed in all castes (queen, worker and male) but not to the same extent / brightness as Red-tailed Bumblebee. It is widespread and locally abundant throughout the UK and the north west and although said to be primarily a species of woodland / wooded habitats (including gardens) it is locally abundant in upland areas of Lancashire. This is the species that is the first to produce its shorter-lived colony (hence “Early” denoting this and not emergence of queens) and is regularly bivoltine (double-brooded) in the south of England (though this phenomenon has not been observed as yet in northern England).


Small Garden Bumblebee

Bombus hortorum (Small Garden Bumblebee): This is one of two particularly long-tongued species of bumblebee in the UK, though the other species – *B. ruderatus* – is nationally scarce and not recorded in Lancashire (nor a typical urban species). It is another "banded" bumblebee, distinct from *B. terrestris* and *B. lucorum* in having 3 – rather than 2 – yellow bands (2 on the thorax and one on the abdomen). Although not an "urban specialist" it is not uncommon in urban areas / gardens as it favours (and is able to more easily exploit – with the exceptionally long tongue) deep flowers such as foxglove's and labiates (mints, sages etc) which are often found / planted in gardens and urban areas.


Vestal Cuckoo-bee

Bombus vestalis (Vestal Cuckoo-bee): As a social parasite of the most commonly recorded bumblebee in the current study (*B. terrestris*), this was the most likely cuckoo-bee to be recorded on Campus. Although rare historically this species is certainly – currently – the most common Lancashire cuckoo species and can be found wherever the host is found. As with the host, it has no clear habitat or flower preferences. All cuckoo-bees are related to the "true bumblebees" but have evolved to become parasitic – they do not produce workers and rely on the queen cuckoo-bee killing or usurping a host queen and taking over the nest (utilising the workers of the host queen to help rear its own offspring).

<u>Solitary / primitively social bees (these species – although varied in ecology and biology – nest singly and do not produce the “social caste” of males, workers and queens common to the social bees)</u>


Colletes daviesanus © Jeremy Early

Colletes daviesanus (Davies Colletes): One of the two “colletid” bees (primitive bees) recorded in the current study, *C. daviesanus* is the only species of the *Colletes* genus (9 UK species) to be locally abundant in many urban areas (regionally and nationally). Indeed, it was more frequent in the current study than all bees except *B. terrestris* and *A. mellifera*. It has a preference for plants in the *Asteraceae* family – Corn Marigold and Ox-eye Daisy were the principal floral resources for it on Campus – and nests in the ground.


Hylaeus hyalinatus

Hylaeus hyalinatus (solitary bee): This is not a commonly recorded bee in the north west, but that is almost certainly down to it being overlooked as the small, black, relatively hairless - and superficially solitary wasp-like - bee that it is. This genus is amongst the most primitive of bees and are the only UK genera that do not collect pollen on their body (trapped on long hairs – which *Hylaeus* lack), they regurgitate pollen that they collect when back at the nest. As an aerial nester – in “bee-hotels”, masonry, rocks and sandbanks as well as hollow(ed) vegetation – with no particular floral preference it is not uncommon (nationally) in urban and city areas.

 **Blue Mason-bee** © Michael Foley

Osmia caerulescens (Blue Mason-bee): Found in only one area on campus (as with other solitary bees in the current study), this is a “megachilid bee” (the family includes the “mason-bees” and the “leafcutter-bees”). Whilst not exclusively a bee of urban habitats it is often recorded from gardens and urban habitats, readily utilising “bee hotels” and other aerial nesting niches.
It is not the most common mason-bee in the region although there are existing records for Longsight, Manchester, to the south of the campus (Karen McCartney – Pers.comm). Of the other, most likely mason-bees to be found in urban environments *Osmia bicornis* “Red Mason-bee” (the most common species in many areas – regionally and nationally) is active much earlier and would not be expected to be encountered from late June onwards.

 **Patchwork Leafcutter-bee** © Louise Hislop

Megachile centuncularis (Patchwork Leafcutter-bee): As (usually) an aerial nesting species that cuts pieces of leaf from a wide variety of tree and shrub species, this is not an uncommon species in rural and urban gardens and was recorded twice (in different areas) in the current survey. Females are readily distinguished from other, similar leafcutter species as they have an entirely orange-red scopa (pollen collecting hairs on the base of the abdomen – but beware trapped pollen which can be confusing) with no black hairs at the tip.

 **Willoughby's Leafcutter-bee** © Jeremy Early

Megachile willughbiella (Willoughby's Leafcutter-bee): Alongside the previous species, this is one of the more common leafcutter-bees of urban areas. It can nest aerially or in soil, although as with all the leafcutter species, it cuts sections of leaf to use in nest construction.
It shows no clear habitat preferences and has been recorded from a wide variety of flowers, though is particularly attracted to *Campanula* bellflowers. The females are very similar to a number of other leafcutter-bee species, though the distinctive males are one of a pair of species with modified, enlarged "mittens" (expanded, white-haired tarsi on the front legs – the other species, Coastal Leafcutter-bee, is restricted to dune areas in Lancashire would not be expected to occur in urban Manchester).

 **Lasioglossum smeathmanellum** © Louise Hislop

Lasioglossum smeathmanellum (one of the "sweat-bees"): This genus of bees derives their occasional common name of "sweat-bee" from behaviour exhibited more usually in tropical areas, where they may land on people to lick sweat / obtain salt. It is a member of the Halictidae family, many species of which are primitively social (a nest will often produce a larger "foundress" female as well as "worker types"). This species is one of four v. similar – not easily field identifiable – metallic species which have blue / green metallic reflections from the cuticle. Although it has a patchy distribution in the UK – and has declined in some areas – the recorded distribution is no doubt partly due to the small size of the bee, making it easy to overlook. As an aerial nesting insect, *L. smeathmanellum* is known to readily utilise soft mortar in walls for nesting, is recorded from a garden in Longsight (K. McCartney, pers.comm) and is, therefore, not an unexpected species on Campus.

Social Wasps (the most readily recognisable wasps – often attracted to picnic areas and rubbish bins. As with social bees – all species have a worker / male / queen cast system and build large, populous nests):


Common Wasp

Vespula vulgaris (Common Wasp): The most common social wasp (image – previous page), widespread in a wide range of situations and habitats throughout the UK and north west. Although primarily predators and scavengers (young are fed on macerated insects) the social wasps are important pollinators. In many urban areas – particularly so in northern England - *V. vulgaris* will be one of the more commonly encountered species.


Red Wasp © Jeremy Early

Vespula rufa (Red Wasp): This was a surprising (recorded twice) species on campus. Of the social wasps, this is one of the less common species in urban areas of the UK (mirrored in N.W. England – with only 5 truly urban records, including one from Lancaster University's campus). It nests underground in the more usual upland / moorland haunts but aerial nesting is less uncommon in urban areas. It has been recorded at 23 species (of a wide variety) of plants.

Solitary Wasps (frequently overlooked wasps – in many instances as they are smaller and less vividly marked than the social wasps. A wide variety of ecology and biology with no species known to be typically or preferentially urban. Not especially associated with flowers, they nonetheless visit many for nectar and are important predators of a range of insects including flies, bugs and spiders, some of which are taken from flowers).


Rhopalum coarctatum © Jeremy Early

Rhopalum coarctatum (a solitary, fly-hunting wasp): This is one of 3 similar species found in the UK – all construct aerial nests and stock the nests, predominantly, with small flies as larval food for their brood. This particular species usually nests in plant stems – or occasionally wood – and the two records from virtually the same grid reference point (in the current study) suggest that it had nested successfully in that area. Although often recorded near to water, this species was found around the border-planted "hedge" of a car park, with no sources of water obviously within the vicinity. There are other urban records for Liverpool and Blackburn, so it may be overlooked / under-recorded in urban areas.


Crossocerus annulipes © Robin Williams

Crossocerus annulipes (a solitary, bug-hunting wasp): One of a number of v. similar, small and predominantly black wasps. Although not regarded as the most common of the genus (Richards, 1980), it has been recorded frequently in the north west region more recently which may indicate that it has been previously overlooked or has become more abundant. Another aerial nesting species, it prefers soft / rotted wood in which to create nesting "cells". There is another, recent urban Manchester record from a garden in Longsight (K. McCartney – pers. comm).

 **Diodontus tristis** © Jeremy Early

Diodontus tristis (a solitary aphid-hunting wasp): Perhaps the most interesting / curious record from the current study, this species is well known from the Sefton coast where it is a ground nesting species of the dune areas. It is not regarded as being particularly common and this is borne out by the current, sparse distribution shown on the UK distribution map (BWARS). Although there are no Lancashire urban records for the species, there is a reference to nesting in mortar as well as loose sand (Richards) and the 1 species record from this study was from an old section of wall that had loose mortar.

<u>*Lepidoptera* (Butterflies and moths):</u>

 **Painted Lady**

Vanessa cardui (Painted Lady): This is an attractively patterned, long-distance migrant species (from N. Africa and S. Europe) which is commonly encountered in flowery areas (including gardens and urban areas).
It will visit a range of plants for nectar and the caterpillars can use a wide range of plant species as food, so it can occur anywhere. This year (2019) saw particularly high numbers of the species "recruited" to the UK, following a spell of warm weather and winds directed from S. Europe to the UK.


Large White

Pieris brassicae (Large White): One of three similar UK species of "white", this is a common species and a serious pest of cultivated cruciferous plants (cabbages etc. – hence one common name of "Cabbage White"). It is found throughout the UK, being absent only from some areas of Scotland and Ireland. The one record from this survey was on Oil-seed Rape as listed on the Excel records data-sheet.


Six-spot Burnet moth

Zygaena filipendula (Six-spot Burnet Moth): This distinctive black and red species often frequents flowery grasslands (including downland, cliff-edges, woodland rides, roadside verges and sand-dunes) and the larvae are chiefly associated with Common and Greater Bird's-foot Trefoil, of which the latter was recorded from the quad where the moth was recorded during this survey.

Syrphidae (Hoverflies):


Pellucid Hoverfly © Steve Priestley

Volucella pellucens (Pellucid hoverfly): This is one of the larger and more distinctive (black and white) hoverflies in the UK fauna. Its larvae live within the nests of social bees (bumblebees) and social wasps, eating waste products and also larvae. It is common throughout the UK and not uncommon in urban areas.


Volucella inanis © Pete Kinsella

Volucella inanis (a hornet-mimic hoverfly): Slightly smaller than the other, large hornet-mimic species - *V. zonaria* – this is nonetheless a large and distinctive hoverfly. This species is a parasite of wasp larvae and historically was unknown outside the London area. There have been increasing numbers of (N.W. England) sightings in recent years, which seems a likely result of climate change.


Narcissus Bulb-fly (a hoverfly)

Merodon equestris (a bumblebee-mimic hoverfly “Narcissus bulb-fly”): This is a variable species, with different colour forms resembling different bumblebee species. It is found throughout the UK and is most frequent in sheltered, warm and sunny spots including gardens (the larvae live on daffodil and bluebell bulbs).

Key discussion points and recommendations:

The current study had the following objectives:

- To assess the current "status" of pollinators on campus; record the species present and their abundance (relative to regional and national status and records) which can serve as a baseline for future study.
- To compare the results of the current study with the previous (MSc) study.
- To provide some feedback to U.O.M based on the results of the current study.

The areas which were – by far – most attractive to pollinators were located on Brunswick Park (central grid reference point - SJ 84716 96636) and University Green (central grid reference point – SJ 84319 96703).
Brunswick Park – previously a road – has now been pedestrianised and there are several areas with plants (that were not there at the time of the 2016 study). Within this restricted area the plant species most visited, by most species, was *Nepeta* sp., although *Leucanthemum vulgare* (Ox-eye Daisy) was attractive to *Syrphidae* and – particularly amongst bees – *Colletes daviesanus*.
Similarly, University Green is – mostly - pedestrianised currently (cars can access the far western end of the area for the multi-story car park). In this area the planted bed areas are similar (to Brunswick Park) but in addition to *Nepeta* sp., have a large (larger) proportion of *Salvia* sp., *Lavendula* sp. and *Verbena* sp. – by far the most visited plant (by pollinators) after *Nepeta* was *Salvia* sp.

The open space / planted area between Burlington Street and Lime Grove – "Learning Commons Green Space" (central grid reference point - SJ 84555 96456) generated the greatest diversity of unrelated species (and the highest concentration of solitary bees) and the planted (mostly "cornfield annuals") area near the car park off Booth Street East (central grid reference point - SJ 84651 96851) consistently attracted more modest numbers of pollinators.
Other records of pollinators – in other areas – were more scattered and included insects less reliant / associated with plants (i.e. solitary wasps), although some areas with a lack of floral resource did support nesting insects by affording suitable nesting niches (i.e. soft mortar in older brick walls).

Conclusion:

<u>The following points were raised by U.O.M – to be addressed in the context of the results of the present study and to form the basis of a conclusion which can inform future planting and habitat management / creation at U.O.M. campus:</u>

· *Has the more naturalistic planting affected the abundance and diversity of species found on campus, are there examples/types of planting found on campus which has been more effective in attracting pollinators?*

There have been changes to the abundance and diversity of species found on the campus, but despite changes to the environment, there are some obvious similarities / parallels between the studies, despite the substantial changes to landscape / potential habitat / planted areas.

The previous study recorded most species in the following areas – (1) Aquatics car park near Booth Street East (SJ 84651 96851), (2) Areas of Brunswick (- street, as it was at the time) and (3) areas between Lime Grove – Burlington Street, within the Learning Commons Green Space. There was also a concentration of records in other areas but these were the most “prolific” areas (in terms of plants visited / species recorded). The current study has noted that that the most “prolific” areas are – still – the aforementioned areas, although the composition of plant species has been substantially altered (most significantly, in terms of replacement of shrubs with smaller, herbaceous plants with an emphasis on *Lamiaceae* in certain areas). Certain areas, i.e. the area of cornfield annuals at SJ 84651 96851, have not been altered in terms of the plant species present but are reduced in size – as expected this has resulted in less records of pollinators in this area, although it is still a valuable area for insects given records from the current study.

The biggest difference between the studies relates to the types of plants that are currently on campus and visited by insects. During the MSc study *Trifolium repens, Lotus corniculatus, Heuchera villosa, Hypericum androsaemum, Lavandula angustifolia, Hebe speciosa, Lythrum salicaria, Verbena bonariensis, Cotoneaster simonsii, Spiraea japonica, Pyracantha coccinea* and *Nepeta racemose* were the plants most visited. The current study saw most activity at *Nepeta* sp. (presumably the same species – or certainly the same genus – as *Nepeta racemosa*). Of the other plants *Trifolium repens, Lotus corniculatus, Heuchera villosa, Hypericum androsaemum, Hebe speciose* and *Heuchera villosa* are no longer present in any abundance (some *Lotus pendunculatus*, *Hypericum* species and *Heuchera* species are found in the quad areas).

Of the other plant species little activity was seen to be associated with recorded insects, with the minor exception of *Lavandula angustifolia* which attracted a small (<10) number of insects (mostly Honey-bees) throughout the study. It is thought likely that of the other plant species listed, most have been removed and/or are located in areas that are no longer accessible.

· *Is there a difference in the abundance and diversity of species found between the quads (managed by local staff members) and other formal planting (managed by environmental services)- any opportunities for improvement between these two types of green spaces?*

With regard to the quads, yes – very much so. The only quads that generated records of any pollinators were the Michael Smith Building (quad) and Quad 2 within the Stopford building. The Michael Smith Building had by far the greatest diversity of insects of all the quads and has been planted with a wide range of native / regionally appropriate plant species amongst created, naturalistic habitats. The other quads – Library, Humanities Bridgeford Street and Stopford (Quad 1) - lacked flowering plants at the time of the visit, so it was not surprising to make 0 records of any pollinators.

However, it should be borne in mind that the Library Quad had a large amount of Cotoneaster sp. which was in fruit at the time of the current study – had it been in flower at the time of the study there is a good chance it would have attracted a large number of pollinators. Also, two library staff members were keen to develop this quad area with a wide range of native plants – any provision of a wider range of species and a prolonged period of floral resource would be encouraged.

Any potential to increase the amount and diversity of flowering plants within the quads generally would be encouraged.
If possible most (or a significant proportion) of the plants should be native species, although non-native plants can usefully extend the period when flowers are available to pollinators. Common and much maligned "weeds" such as dandelion sp., (*Taraxacum* sp.) willow (*Salix* sp.) and Colt's-foot (*Tussilago farfara*) and flowering fruit (rosaceous – Apple, Plum, Pear) species are particularly valuable in early spring when there is a dearth of floral resource. In fact, willows are a vital source of pollen for the spring emerging (most species of) bumblebees.
Bird's-foot Trefoil (*Lotus corniculatus*) is a very important pollinator plant in mid-summer and planting quantities of this – throughout campus - would be encouraged. Also more *Nepeta* sp. – already planted in many of the Brunswick Park planted areas – could be added to other areas as this was by some distance the most visited species of plant on campus, highly attractive to pollinators. Later season-flowering plant species such as heathers (*Erica* sp., *Calluna*), knapweed's (*Centaurea* sp.) and other *Asteraceae* (i.e. *Scorzoneroides autumnalis*) and Ivy (*Hedera* sp.) can help to sustain later (in year) flying or longer (life) cycle species of pollinators.

· *Any lessons from Brunswick Park planting/maintenance in relation to pollinators- this wasn't in place during the last survey, how much has this contributed to overall sightings within this year's survey?*

The greater abundance and diversity of pollinators found at Brunswick Park (between the 2016 study and the present study) is most likely due to the increased planting / planted areas. *Nepeta* sp. is obviously a particularly attractive plant here (as it is elsewhere). However – it is not possible to determine the importance of *Nepeta* as a pollinator plant without pollen analysis. Nectar is important for all pollinators (regardless of family or species) – for energy - but all bees require pollen to serve as the larval food. It is possible to observe pollen collecting in some bees – as they forage – but it can be difficult to ascertain with certainty as to whether flower visits are for nectar or pollen (they are normally for one or the other).

It would be necessary to carry out pollen analysis of a large number of bees to ascertain which plants were being utilised by bees for pollen. Although beyond the scope of the current study this would be an interesting project that could be undertaken as further research by the University / in collaboration with entomologists.

There were records for pollinators from the Brunswick (street at the time) area in the 2016 survey, though at that time Brunswick did not have the density of records compared to the car park near Booth Street East (area with many "cornfield annuals") or the southern part of the planted Learning Commons Green Space area between Lime Grove and Burlington Street. This is a key difference in the two studies and shows that Brunswick Park is an improved area of the campus for pollinators.

Brunswick Park is – currently - the most important area on campus for bumblebees - in terms of the abundance and diversity of bumblebee species recorded there. In terms of the diversity of bumblebees, Brunswick Park and University Green hold joint honours in this regard – in both areas nearly all of the bumblebees were foraging exclusively from *Nepeta* sp. and *Salvia* sp.

However, the greatest overall diversity of species (counting bees, wasps and flies of all kinds recorded generally and specifically) is highest in the Learning Commons Green Space, the planted area between Lime Grove and Burlington Street (with several species - including Blue Mason-bee and Willoughby's Leafcutter-bee - only recorded here and nowhere else on Campus).

Honey-bees

Honey-bees are kept on campus at St. Peters House and – just outside the campus grounds – at the Whitworth Gallery (Jennifer Strong, pers.comm). Hives were previously positioned on the roof of the Manchester Museum building but these are no longer active (Dmitri Logunov, pers.comm).

Honey-bees are pollinators – and require pollen (as mentioned in the previous discussion point) – but are not the most efficient pollinators amongst bees. Solitary and primitively social bees (including the *Lasioglossum* "sweat-bees" and *Megachile* "leafcutter-bees recorded during the current survey) are the most efficient pollinators amongst all bees, principally as they are less efficient at carrying pollen. They lack the modified hind leg (corbicula or "pollen basket") that allows Honey-bees and bumblebee species to carry pollen neatly and efficiently and carry the pollen dry and diffused around the body (or in certain areas). As a result, they lose much more pollen when visiting flowers, which increases the likelihood of pollen transfer between plants. Solitary bees tend to spend more time at flowers collecting pollen – they forage more slowly and thoroughly in contrast to the fast, scrabbling action of Honey-bees.

Also, Honey-bees are not – generally – a truly wild species. Of course Honey-bees can swarm, disperse and produce feral colonies in the wider environment (including in trees and buildings) but the majority of them are effectively domesticated and managed – to a greater or lesser extent – by human intervention.

There is considerable disagreement as to whether Honey-bees were ever a native, truly wild species in the UK but this is a moot point today as so much importation and cross-breeding of different "strains" - from different areas of Europe - have resulted in a very imprecise gene pool (and therefore, the lack of a precise phenotype). Although some selective, controlled breeding of "native" Honey-bees (sometimes referred to as the "Western Honey-bee" or "Black-bee") does take place (and they possibly exist in some remote UK locations), the majority of those in the UK are "mongrels". Furthermore, are the important issues of disease transfer – between Honey-bees and truly wild bees – and effects from competition for a finite resource (pollen and nectar, from flowers). Studies (Thomson, 2004) have shown that hives negatively affect bumblebee colonies when both forage in the same area whilst Goulson, 2009 showed that presence of hives can (negatively) affect the size of bumblebee workers produced. Other studies such as those of Genersch, 2005, have shown that virus pathogens associated primarily with Honey-bees kept in hives cause disease and deformity in bumblebees. Urban areas are by nature / logistics more restricted in terms of available floral resources, so competition between Honey-bees and wild pollinators is inevitable when the former are introduced to an area.

This leads to the question – “why keep Honey-bees”? In the author’s opinion the motive and justifiable reason for keeping Honey-bees should be (only) to produce honey. The conflation of Honey-bees with truly wild species has resulted in much misunderstanding as to the issues affecting truly wild species and regular calls for “the protection of the threatened and endangered Honey-bee”. Issues of disease notwithstanding the Honey-bee is not threatened nor endangered – in contrast to a wide range of wild UK bees. As an educational resource, there are many commercial and publicly promoted apiaries where Honey-bees can be observed and studied. As a result, it would be recommended that unless the motive to keep hives is to produce honey, Honey-bees should be removed from campus for the benefit of wild pollinators.

Increasing other required, life-cycle resources

Obviously, provision of many flowers is vital to pollinators but this is only one aspect of their biology - they also require areas to nest / lay eggs / predate main food sources. For bees and wasps nesting resources are subterranean (i.e. small mammal holes in grass), or aerial (natural and artificial cavities, mortar, dead wood, purpose built “bee hotels”), whilst hoverflies and other flies require dead wood, water, vegetation, the nests of other insects or decaying matter to lay their eggs on / in. Lack of nesting resources may be as - or more - limiting to the abundance and diversity of pollinators on Campus.

Any objectives to increase abundance and diversity of natural habitat features / artificial “habitat-mimic” features in addition to increased levels / diversity of flowering plants throughout the Campus area would be of benefit to most pollinators. Any spaces (“green roofs, “living walls” and informal grassland / “set-aside areas” can help to support a wider range of floral and nesting resources for pollinators.

SECTION V – REFERENCES

Baldock KCR, Goddard MA, Hicks DM, Kunin WE, Mitschunas N, Osgathorpe LM, Potts SG, Robertson KM, Scott AV, Stone GN, Vaughan IP, Memmott J (2015) Where is the UK's pollinator biodiversity? The importance of urban areas for flower-visiting insects. Proc R Soc B. doi: 10.1098/rspb.2014.2849

Banaszak J, Banaszak-Cibicka W, Szefer P (2014) Guidelines on sampling intensity of bees (Hymenoptera: Apoidea: Apiformes). J Insect Conserv 18:651–656

BWARS (2013a) List of British and Irish aculeate Hymenoptera (January 2012), bees, wasp and ants recording society.

BWARS (species accounts) https://www.bwars.com/species_gallery

Czech B, Krausman PR, Devers PK (2000) Economic associations among causes of species endangerment in the United States. Bioscience 50:593–601

Everaars J, Strohbach MW, Gruber B, Dormann CF (2011) Microsite conditions dominate habitat selection of the red mason bee (Osmia bicornis, Hymenoptera: Megachilidae) in an urban environment: a case study from Leipzig, Germany. Landsc Urban Plan 103:15–23

Falk S (1991) A review of the scarce and threatened bees, wasps and ants of Great Britain. Research and Survey in Nature Conservation No. 35. Nature Conservancy Council for England, Peterborough

Falk S (2015) Field Guide to the Bees of Great Britain and Ireland. Bloomsbury.

Fetridge ED, Ascher JS, Langellotto GA (2008) The bee fauna of residential gardens in a suburb of New York City (Hymenoptera: Apoidea). Ann Entomol Soc Am 101:1067–1077

French K, Major R, Hely K (2005) Use of native and exotic garden plants by suburban nectarivorous birds. Biol Cons 121:545–559

Fürst M. A., McMahon, D. P., Osborne, J. L., Paxton, R. J. & Brown, M. J. F. (2014) Disease associations between honeybees and bumblebees as a threat to wild pollinators. Nature 506:364–366 (20 February 2014)

Genersch E, Yue C, Fries I, de Miranda JR.(2006) Detection of Deformed wing virus, a honey bee viral pathogen, in bumble bees (Bombus terrestris and Bombus pascuorum) with wing deformities. Jour Invert Path 91:61-63

Goulson D, Lye GC, Darvill B (2008) Decline and conservation of bumble bees. Ann Rev Entomol 53:191–208

Goulson, D., & Sparrow, K. R. (2009). Evidence for competition between honeybees and bumblebees; effects on bumblebee worker size. Journal of Insect Conservation, 13(2), 177-181.

Harrison C, Davies G (2002) Conserving biodiversity that matters: practitioners' perspectives on brownfield development and urban nature conservation in London. J Environ Manag 65:95–108

Hennig EI, Ghazoul J (2012) Pollinating animals in the urban environment. Urban Ecosyst 15:149–166

Hernandez JL, Frankie GW, Thorp RW (2009) Ecology of urban bees: a review of current knowledge and directions for future study. Cities Environ 2: article 3. http://escholarship.bc.edu/cate/vol2/iss1/3

Hinners SJ, Kearns CA, Wessman CA (2012) Role of scale, matrix and native habitat in supporting a diverse suburban pollinator assemblage. Ecol Appl 22:923–1935

Johnson EA, Klemens MW (2005) Nature in fragments: the legacy of sprawl. Columbia University Press, New York

Larson JL, Kesheimer AJ, Potter DA (2014) Pollinator assemblage on dandelion and white clover in urban and suburban lawns. J Insect Conserv 18:863–873

Liow LH, Sodhi NS, Elmquist T (2001) Bee diversity along a disturbance gradient in tropical lowland forests of south-east Asia. J Appl Ecol 38:180–192

Lomholdt O (1984) The *Sphecidae* (*Hymenoptera*) of Fennoscandia and Denmark. 1984.

Lowenstein DM, Matteson KC, Xiao I, Silva AM, Minor ES (2014) Humans, bees, and pollination services in the city: the case of Chicago, IL (USA). Biodivers Conserv 23:2857–2874

Maclvor JS, Ruttan A, Salehi B (2014) Exotic on exotics: pollen analysis of urban bees visiting Sedum on a green roof. Urban Ecosyst. doi: 10.1007/s11252-014-0408-6

Matteson KC, Ascher JS, Langellotto GA (2008) Bee richness and abundance in New York City urban gardens. Ann Entomol Soc Am 101:140–150

Matteson KC, Grace JB, Minor ES (2013) Direct and indirect effect of land use on floral resources and flower-visiting insects across an urban landscape. Oikos 122:682–694

Richards, OW (1980) *Scoliodea, Vespoidea* and *Sphecoidea*. Hymenoptera, Aculeata. Royal Entomological Society Handbooks.

Sarah L, Jeremy T (2012) Ecosystem services provided by urban spontaneous vegetation. Urban Ecosyst 15:545–557

Sirohi, Jackson, Ollerton and Edwards (2015) Diversity and abundance of solitary and primitively eusocial bees in an urban centre: a case study from Northampton (England). Journal of Insect Conservation 19: 487-500.

Smith RM, Gaston KJ, Warren PH, Thompson K (2006) Urban domestic gardens (VIII): environmental correlates of invertebrate abundance. Biodivers Conserv 15:2515–2545

Thomson D, Competitive interactions between the invasive European Honey-bee and native bumble bees. Ecology 85(2):458-470

Verboven HAF, Uyttenbroeck R, Brys R, Hermy M (2014) Different responses of bees and hoverflies to land use in an urban–rural gradient show the importance of the nature of the rural land use. Landsc Urban Plan 126:31–41

Winfree R, Bartomeus I, Cariveau DP (2011) Native pollinators in anthropogenic habitats. Ann Rev Ecol Evol Syst 42:1–22

Yeo PF and Corbet SA, Solitary Wasps. Slough: Richmond Publishing, 1995.