Does the location (urban/rural) of a nature reserve have an impact on butterfly biodiversity?

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Abstract

Urbanisation has been attributed to the decline in many UK native species, due to the deleterious effects it has on the environment, for example fragmentation and habitat loss. Urbanisation is the formation of towns and cities where populations move from rural areas to create urban areas. One species that may be affected by urbanisation is the butterfly (*Rhopalocera*), which has drastically reduced in numbers over the years. Butterflies are also seen as indicator species, where they can define environmental characteristics and be used to monitor trends in habitats. This study looked into the effect the proximity of a reserve to an urban area had on the abundance and richness of the butterfly assemblages. This was to see whether there were differences between reserves in rural areas and urban areas. In general, rural reserves showed a higher abundance and also had more species observed than their urban counterparts. A statistical significant difference was found between the two reserve categories (rural/urban) for both their abundance and richness. To improve the diversity of butterfly assemblages on urban reserves re-vegetation of urban spaces is recommended as well as protecting and monitoring such areas.

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Contents

1 Introduction

Over the years the butterfly taxon has been in decline, this is believed to be because of habitat loss and also climate change. The butterfly taxa are commonly thought to be an indicator species, meaning they're a sensitive species that can act as early warning signs for degrading habitats (Brereton et al 2011). Butterflies make good indicators because they have short life cycles meaning they will react quickly to any environmental changes in their habitat. They are sensitive to fine-scale changes because of their limited ability for dispersal, specialisation of larval food plant and a close reliance on climate and weather conditions (Grime 2006.) Butterflies inhabit all main terrestrial habitats making them potential indicators for a range of species and habitats (Thomas 2005.) They are well documented, where there is a wealth of information on their ecology, taxonomy and life-history, they are also easily recognisable making them an easy taxon to assess in relation to bio-diversity (Bosworth et al 2011.) Butterflies can either be generalists, using a wide range of habitats (i.e. meadow brown) or specialists that are more restricted and inhabit a specific habitat, (large heath inhabits wetlands). A high butterfly diversity can be conceived as an indicator for a healthy environment (Wheeler et al 2015.)

The deterioration and loss of habitats from land-use change such as intensification of agriculture and changes in woodland management are considered the key causes of long-term decline amongst habitat specialist butterflies (Dennis et al 2017). Research has shown butterflies have declined more rapidly than other taxa such as birds and plants, this emphasises their ability to be an important bio-diversity indicator species (Brown 1991.) Third of butterfly species have been declining over the last 40 years, with 76% of species decreasing. There has been a long-term decline for the endangered white admiral butterfly, abundance has dropped by 59% in abundance in a long-term decline. There are dramatic declines in species such as the Essex skipper and small heath, once very common farmland species. For the small tortoiseshell, once a ubiquitous species, sightings are becoming rarer and rarer. Overall 70% of species are declining in occurrence and 57% have been declining in abundance (based on the UK Butterfly Monitoring Scheme (UKBMS) since 1976 (Dennis et al 2017). Grassland butterflies have declined by 50% since 1990 (Dennis et al 2017).

Local authority's consistent clearance and frequent flat strimming off grass edges of roadways, motorways and roundabouts has been attributed as an important factor effecting butterfly populations, as well, as loss of sites to development. The destruction of flower-rich grassland and neglect of traditionally coppiced woodland has been linked to the decline of habitat specialist butterflies (Fox 2001.) However, the decline in generalist species is not well understood with no concrete links. As an indicator species, their decline is worrying for the health of eco-systems with implications for other insects and bio-diversity in general. Many conservationists and naturalists are concerned over a bio-diversity crisis were there are calls for urgent attention due to the trends that have been found in recent research. "habitat loss due to human activities has had a devastating impact on the viability of butterfly populations and monitoring can help assess overall conservation effort aimed at reversing these downward trends" (van Swaay and Warren 2012.)

Another reason this taxon is thought to be in decline is urbanisation. Urbanization is a growing cause of many environmental issues (Benfield et al. 1999). Urbanisation is the increase of population in urban areas compared to rural areas. 90% of the English population live in urban areas making it an urban society. Urbanisation can cause environmental degradation, it has been said to cause an increase in precipitation and also air pollution (Foley et al 2005.) However, the impacts of urbanisation on native species hasn't been thoroughly studied. Urban developments have been attributed to some of the greatest local extinction rates and frequently eliminates the large majority of native species (Marzluff 2001). In general urbanisation is often worse than other types of habitat loss, this is due to it having a more lasting effect (Stein et al 2000). Urban-gradient studies have shown that, for

butterflies, the number of non-native species will increase toward centres of urbanization, while the number of native species decreases (Blair and Launer 1997). Urbanisation causes fragmentation effecting species richness, due to a loss of vegetation (McIntyre 2000). Urbanisation involves drastic physical changes; which butterflies are unable to adapt to (Adams 1994). It has been stated that there will be relatively few rarer native species of conservation concern in areas of high human population density (Kendle and Forbes 1997), species richness of many taxa will often decline (McKinney 2002). Reports show a decline of 62% of butterflies in semi-natural habitats however those in the countryside showed an 8% increase in a two-year period (Brereton et al 2014.) This could be indicative of the effect of urbanisation on fauna and flora.

"Trends in numbers on individual sites can be used to assess the impact of land management and make improvements to maximise benefits to biodiversity" (van Swaay and Warren 2012). There are many conservation initiatives and common practises in place to help improve this taxon, such as scrub clearance and cutting rides. Practises for woodland species include promoting diversity of age structure, coppicing, improving connectivity, ride and glade enhancement, canopy thinning, woodland edge buffering, managing deer to reduce browsing and replacement of non-native trees. Since specifically managing meadows and woodlands for Duke of Burgundy the population has risen 67%, the pear-bordered fritillary's abundance has increased by 45% (Schultz et al 2008.)

The high brown fritillary, (UK's most endangered butterfly) are starting to show an increase in numbers, at its remaining sites in Exmoor and South Wales, showing the achievement of targeted conservation efforts. For grassland management grazing and regular cutting occurs as well as scrub clearance to maintain the habitat as a mosaic. Butterflies operate at small spatial scales meaning they will be highly sensitive to site management (Krauss et al 2003). Butterfly conservation reported a find of 30% decline in butterfly numbers even on sites targeted by conservation efforts (Butterfly Conservation 2017). A general approach to conservation has often been criticised for its lack of benefits to overall biodiversity. Even with efforts to improve habitat a decline in certain species is still trending. Policies like the EU Habitats and Species Directive may help to slow declining trends. According to a study by Butterfly Conservation and the Centre for Ecology & Hydrology, rare species are responding to intensive conservation efforts (Brereton et al 2014). Targeted habitat management can contribute in halting butterfly declines, conservation management such as grazing has been essential for species such as the Adonis blue and silver-spotted skipper (Schultz et al 2008.)

The Wildlife Trust is one of many charities trying to combat this issue. The Berks, Bucks and Oxon Wildlife Trust (BBOWT) own and manage approx. 80 reserves in their area. Some of these reserves are located in urban areas and some are located in rural areas. Many of the reserves are SSSI and Sites of Importance for Nature Conservation. The trust manages their sites with particular ecological conservation objectives. For example, managing chalk grassland to promote butterflies such as chalkhill blue, by removing undesired scrub and tree saplings.

Carrying out ecological surveys is important to evaluate management for conservation. Butterflies are monitored through the Butterfly Monitoring Scheme (UKBMS). The Wildlife trust carries out rapid assessments and carry out regular monitoring surveys to evaluate their reserve management techniques. These provide quick but informative descriptions of the reserves ecology and biodiversity. However, this study will hope to discover whether they're other factors (i.e. reserves proximity to an urban area) contributing to the decline of butterflies and provide more insight to improve management for this taxon.

1.1 Aim

The aim of the study is to identify if there are any significant differences in butterfly diversity between rural and urban nature reserves. And to develop any habitat management suggestions that can improve the butterfly diversity based on the location (assuming urbanisation can have an impact). The study will also take into account the size of the reserves, habitat type (i.e. calcareous grassland, lowland meadow), vegetation, habitat management (this will be current and past management techniques).

Specific research questions will include:

- What differences in butterfly species are observed at reserves in urban areas and those in rural areas?
- Are there differences in the butterfly diversity of the urban and rural reserves?
- What habitat type, which is suitable for butterflies, is on each reserve and how is the habitat managed for butterflies?
- What vegetation can be found on the reserves and how is the vegetation managed for butterflies?
- Does the vegetation significantly differ between the urban and rural reserves?
- Are there any butterfly species that are predominant?
- Does the habitat management of the different reserves appear to be having an impact on the reserves butterfly diversity?

2 Methodology

2.1 Study Site

The location of the study will be at various nature reserves managed by BBOWT. Below is the list of reserves:

<u>Urban Reserves</u>

1. Chinnor Hill, 27.5 ha (grassland, scrub, woodland)
2. Hosehill Lake, 23.5 ha (meadows, lake, ponds, reed beds)
3. Thatcham Reed beds, 35 ha (reed beds, heathland, woodland)
4. Bacombe Hill, 25 ha (chalk grassland/ scrub/ woodland)
5. Iffley Meadows, 33 ha (meadows, rivers)

<u>Rural Reserves</u>

1. Foxholes, 23 ha (ancient woodland, ponds, rivers)
2. Sydlings Copse, 21 ha (woodland, grassland, reed beds, fen, streams and heathland)
3. Asham Meads, 22.5 ha (meadows, grassland, scrub, ponds)
4. Calvert Jubilee, 39 ha (lake, scrub, reed beds)

5. Padworth Common, 28 ha (heathland, woodland, ponds)

It was important to have reserves of a similar size (no more than 40 ha and no less than 20 ha), as to make comparable observations.

A reserve was determined to be urban or rural by their proximity to built-up areas. If a reserve is within 2 miles to a built-up area (classified as an area of at least 20 ha with irreversible urban development with at least 1,500 residents) then it was deemed an urban reserve. A rural reserve was more than 2 miles from a built-up area. There will be five reserves from each category surveyed. Rural and urban reserves, where possible, were paired up to be surveyed on the same day as to avoid the weather impacting results. Below is the list of pairings:

(1)-Chinnor Hill (U) - (8) Asham Meads (R)

(2)-Hosehill Lake (U) - (10) Padworth Common (R) - (3) Thatcham Reedbeds (U)

(4)-Bacombe Hill (U) – (9) Calvert Jubilee (R)

(5)-Iffley Meadows (U) – (7) Sydlings Copse (R)

(6)-Foxholes (R)

2.2 Data Collection

Transects were used to carry out the butterfly surveys, each transect was walked by two individuals with one recording and the other helping with identification. If the reserve chosen already had a fixed transect established by the Wildlife Trust, then this was used to carry out the survey. If a chosen reserve did not have an established transect, a transect route was chosen that evenly sampled the vegetation types and habitat (Iffley Meadows was the only reserve that needed a transect route designed). The length of the transects were approximately 2 km, coinciding with typical transect lengths being between 2-4 km (van Swaay et al 2008). Each transect was walked on days where there was no precipitation, with low winds (less than 5 on the Beaufort scale), temperature above 13 degrees where there is 60% sunshine and 17 degrees if overcast (Kadlec et al 2012). Transects were carried out between 11:00 and 15:00. Recordings had a fixed width band of 5m wide on the transects (Bergman et al 2004). Each site was visited twice, with the first survey visits being carried out from the end of May to the beginning of June. The next survey visits were carried out from the end of July to the beginning of August. This was in the hope to catch the flight periods of all possible species. It was also to help control differences in the seasons and temperature.

Determining the differing vegetation and habitat management will be done using survey data from the Wildlife Trust. ANOVA will be used to carry out statistical tests.

3 Results

Coalescing all surveys together a total of 193 individual butterflies were counted. Asham Meads, one of the rural reserves, had the most individuals counted with a total of 49 butterflies counted. Followed by Calvert Jubilee, which is also a rural reserve, however with considerably less counted individuals totalling 27. The reserve with the third most individuals was Sydlings Copse, another rural reserve, with 23 total butterfly counts. The reserve with the least individual counts was Iffley Meadows with only 9 individuals counted from both surveys, this reserve was deemed urban. Thatcham Reedbeds, also an urban reserve, only had 10 individuals counted. Followed by Chinnor Hill, another urban reserve, with a total of 11 counted individuals (Fig.1.)

Figure 1 – Number of individuals counted on each reserve

Reserve	Reserve category	Number of individuals
Sydlings Copse	Rural	23
Iffley Meadows	Urban	9
Hosehill Lake	Urban	16
Padworth Common	Rural	18
Thatcham Reedbeds	Urban	10
Foxholes	Rural	17
Chinnor Hill	Urban	11
Asham Meads	Rural	49
Bacombe Hill	Urban	13
Calvert Jubilee	Rural	27

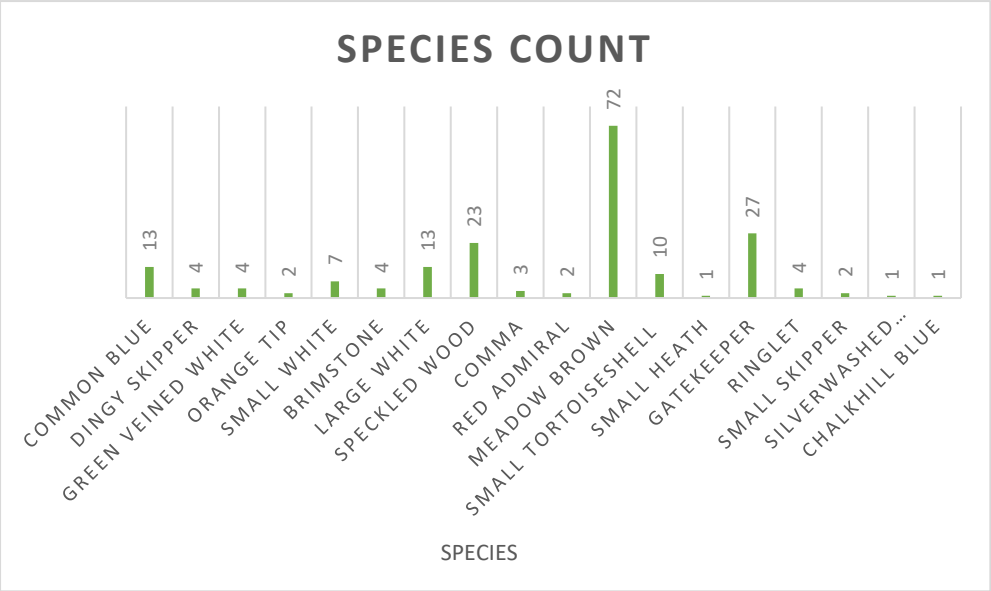
The two reserves with the most species counted were Calvert Jubilee and also Sydlings Copse, both rural reserves with 9 different species found on each reserve. Sydlings Copse was also the only reserve which observed the small skipper and Calvert Jubilee was the only reserve were the small heath was counted. The reserve with the least amount of species was Chinnor Hill, an urban reserve, with only 4 species counted. Followed by Thatcham Reedbeds and Iffley Meadows, both urban reserves with a total of 5 species observed. Though Bacombe Hill was an urban reserve, it was in the middle range of species observed, with a total of 7. It is also worth noting it had the only counting's of both the silver washed fritillary and chalkhill blue (Fig.2.)

Figure 2- Number of species on each reserve

Reserve	Reserve category	Number of species	Notes
Sydlings Copse	Rural	9	Including the small skipper
Iffley Meadows	Urban	5	
Hosehill Lake	Urban	6	
Padworth Common	Rural	8	
Thatcham Reedbeds	Urban	5	Least counts on a reserve
Foxholes	Rural	7	
Chinnor Hill	Urban	4	
Asham Meads	Rural	8	
Bacome Hill	Urban	7	Including the silver washed fritillary and chalkhill blue
Calvert Jubilee	Rural	9	Including the small heath

The species with the most counted individuals was the meadow brown with 72 counted individuals. The gatekeeper had the second most individual counts, with noticeably less individuals counted, with a total of 27. Followed by the speckled wood with 23 counts, and the common blue and the large white both with 13 counts. The small heath, chalkhill blue and silver washed fritillary were the least counted individuals with one being counted for each (Fig.3.)

Figure 3 – Individual counts of species observed



As expected more individuals were counted during the summer surveys (July/August) with a total of 106. Compared to the spring surveys (May/June) with a total of 87 individuals. 13 different species were counted during the spring surveys. Whereas only 10 different species were counted during the summer surveys which was not expected, as there are more butterflies who have their flight periods in the later months. This could be explained by the unexpected good weather that had occurred during May and June and the weather not being as desirable during July. With the weather generally being cloudier, though the temperature was higher in most cases.

The temperature's ranged between 18 and 26 degrees Celsius, with the average being 21.55. For the spring surveys, the average temperature was 20.11 and for the summer surveys the average temperature was 23.2, slightly higher. The humidity ranged from 54 to 75, with the average being 65.35. For the spring surveys, the average was 67.3 and for the summer surveys the average was 63.4. The average wind speed for the spring surveys was 12.4 and for the summer survey it was 5.3, considerably less. The total average was 8.85, with the range being 4 to 15. The average cloud cover was partly cloudy, for the summer surveys it was mostly cloudy and for the spring results it was partly cloudy with more clear days during the spring surveys than the summer surveys. With zero days being overcast. No surveys were carried out with more than 1% chance of precipitation.

The temperature for rural reserves ranged from 18 to 26, the average being 21.2. The humidity ranged from 54 to 75 the average being 64.3. The wind speed ranged from 4 to 15 with the average being 9.2. The cloud cover average was mostly cloudy.

The temperature for urban reserves ranged from 19 to 25, the average being 21.9. The humidity ranged from 56 to 74, with the average being 66.4. The wind speed ranged from 4 to 14 with the average being 8.5. The cloud cover average was partly cloudy.

3.1 Data analysis

The weather can have a significant impact on butterflies. However, the weather conditions for both rural and urban reserves for the most part were alike on surveys undertaking. Where possible urban and rural surveys where paired up to be surveyed on the same day for continuity. For these reasons, the effect of the weather on the survey results were not tested.

Two one-way ANOVA tests on individuals counted and also species on the urban and rural categories were carried out. One-way ANOVA is used when there is one nominal variable and one measurement variable, where the nominal divides the measurements into groups of two or more. It tests whether the means of the measurement variable are the same for the different groups. To conduct an ANOVA test, the data have to be independent, normally distributed and have equal variances (Greene and d'Oliveira 2005). A t-test could have been carried out instead, but there are more chances of making a type I error (Clewer and Scarisbrick 2013.)

The data was transformed using Logarithm to obtain normal distributions and equal variances. Once this had been completed the ANOVA tests could then be done.

The result of the ANOVA test for species was one-way ANOVA F (1,8) = 12.07 p= 0.008. The null hypothesis is the mean number of species seen on urban and rural reserves are the same. The alternative hypothesis is the mean number of species on urban and rural reserves are not the same. As the p value is less than 0.05 the null hypothesis can be rejected.

The result of the ANOVA test for individuals was one-way ANOVA F (1,8) = 6.08 p= 0.039. The null hypothesis is the mean number of individuals seen on urban and rural reserves are the same. The alternative hypothesis is the mean number of individuals on urban and rural reserves are not the same. The null hypothesis can be rejected the p value is less than 0.05.

The butterfly abundance and richness appeared to be effected by reserve location as demonstrated by these one-way ANOVA tests as there were statistically significant differences between the reserve categories.

For data analysis, the following codes were made; Rural- 1 Urban- 2, Clear- 1 Partly Cloudy- 2 Mostly Cloudy- 3 Overcast- 4.

4 Discussion

Any conclusions made have the caveat that this was a very small-scale study where much further surveying is needed to reach any true conclusions. Urbanisation and its effect on wildlife, especially butterflies, is complicated as there are other factors and variables which can also have an effect on results. Very little information on vegetation and habitat management for the sites were provided making it hard to rule these out as determinants for the abundance and richness seen on the different sites. The weather as a variable can be a determinant on the abundance of butterflies. Increased temperature can positively influence the number of butterflies seen whereas cloudiness can negatively influence the number of butterflies (Cormont et al 2011). Butterflies show natural fluctuations in abundance and diversity, this is mainly due to their reliance on weather conditions and climate. However long-term changes in abundance as well as change in distribution have been correlated to factors such as loss of habitat and fragmentation and also land use changes (Parmesan and Yohe 2003.)

The three reserves with the most individuals were all rural reserves. They were also reserves of differing habitats and also different sizes with the smallest being 21ha and the largest being 39ha.

Asham Meads is an ancient flower-filled damp meadow with old hedgerows, scrubs, a pond and an oak plantation on a 22.5 ha site. Vegetation found there is mostly made up of adder's tongue fen, cuckoo flower, great burnet, dropwort, meadow foxtail, ragged robin, tubular water-dropwort, common knapweed, crested dog's tail, sweet vernal grass, pepper saxifrage, yellow rattle, saw-wort, lady's bedstraw and green-winged orchids. The rare black and brown hairstreak are known to inhabit the blackthorn hedges; however, they are hard to spot which is why they might have been missed in

the surveys. Habitat management on this site for butterfly conservation includes trimming/coppicing the blackthorn hedges to maintain differing ages for hairstreak species. Scrub is also cleared to a minimum to maintain a mosaic. Midsummer hay cutting takes place on this site as well as low stock Spring and Autumn grazing.

Calvert Jubilee was an old clay extraction pit, now a lakeside with wild flowers and dense reedbeds on a 39-ha site. Vegetation found there mostly consists of bee orchids, sneezewort, pepper-saxifrage, agrimony, common centaury and cowslips. Grizzled skippers are said to frequent the site in the spring and all 5 species of hairstreaks have been spotted there. Habitat management includes short rotation cutting to slow succession by increasing structural variation, scrub clearance, creation of habitat piles, conservation hedge laying and coppicing.

Sydlings Copse has a variety of habitats including ancient broadleaved woodlands, limestone grassland, reedbed, fen, a stream and heathland all on a 21-ha site. Vegetation being made up of cowslips, hairy violets, knapweed, small scabious, yellow rattle, common rock rose, wild basil, marjoram, bluebells, wild liquorice, bee orchid, woolly thistle, oxeye daisy, sweet-briar, viper's bugloss, nettle-leaved bellflower, blunt-flowered rush, bog pimpernel, primrose, early dog violet, yellow archangel, gorse, and early purple orchid. Habitat management includes short rotation cutting on the reedbeds, scrub clearance, coppicing, annual mowing on the fen, the grassland and heathland is grazed by sheep and new forest ponies.

Sydlings Copse and Calvert Jubilee also had the most species found on each reserve. This makes it unlikely that it could be due to size or habitat for the butterfly diversity and richness to be better on these sites compared to the urban reserves.

The three reserves with the least individuals counted were all urban reserves. These reserves were also of different sizes and habitats but what they had in common were being urban reserves with poor butterfly richness and diversity.

Iffley Meadows is a wet meadow crossed by old river channels with willow lined ditches on a 33ha site. Vegetation found there mostly consists of cuckoo flower, buttercups, great burnet, knapweed, common rue, pepper saxifrage, meadow vetchling, sneezewort, adders-tongue fen, marsh-marigold, ragged-robin, cowslip, snakes-head fritillaries. Habitat management includes Spring/Autumn grazing, willow coppicing, scrub clearance, and midsummer hay cutting.

Thatcham Reedbeds has a range of habitats besides the reedbeds including damp woodland, lakes, rivers and canals on a 35ha site. Vegetation found on the site consists of common dog violet, hemp-agrimony, reeds, brooklime, gypsy-wort, and purple-loosestrife. Habitat management includes coppicing, short rotation cutting of the reedbeds, habitat pile creation and scrub clearance.

Chinnor Hill is chalk-grassland with scrub, oak and ash woodland on a 27.5ha site. Vegetation includes Chiltern gentian, several orchid species, harebell, eyebright, hawthorn, juniper, yew, dog rose, primrose, hairy violet, cowslip, sweet-briar, common rock rose, marjoram, nettle-leaved bellflower, and carline thistle. Habitat management includes coppicing, scrub clearance, and Spring/Autumn grazing.

Butterfly diversity has said be determined by factors including plant richness and habitat diversity (Menéndez et al 2007). Iffley Meadows and Asham Meads have very similar vegetation and habitat however, the butterfly abundance and richness on the sites were very dissimilar, being that Asham Meads had the most individuals counted where as Iffley Meadows had the least. Also, Asham Meads had one of the highest counts of different species where Iffley Meadows had the least. This may

suggest that the location of a reserve can be important to its species richness and diversity as well as plant richness. Previous studies have shown the effects of urbanisation on species richness, McKinney (2008) found that species richness had reduced in areas of urbanisation for both plants and animals. The suggested reason behind this is that urban areas fragment areas available for plants having an inadvertent but adverse effect on other wildlife including invertebrates (McIntyre 2000). Urbanisation also causes greater disturbance to habitats and has increased pollution (Theobald et al 1997.) This reduction in species richness in urbanised areas has also been reported by Marzluff (2001), where the majority of bird studies showed a decline in species richness with urbanisation. A similar study found abundance between 1995–2014 were negative in urban areas compared to rural areas for 25 out of 28 butterfly species (Dennis et al 2017). Dennis et al (2017) stated that national declines in butterfly species is worse amongst and surrounding urban areas. Species diversity in urban areas can be reduced to half of what is found in rural areas (Blair 2001).

Specialist butterflies have appeared to be the worse effected in this study. The chalkhill blue and silver washed fritillary butterfly were only spotted once throughout the entire survey period. The small heath was also only seen once. With many other common species such as the peacock and marbled white not being counted at all. The small skipper was only seen on rural reserves, this can be due to its limited mobility (Dennis et al 2017). Whereas meadow brown, speckled wood and gatekeepers were often observed in both rural and urban reserves. As well as the large white a mobile generalist species. In a survey by Wider Countryside Butterfly Survey (WCBS) the meadow brown was the most widespread species, found in more than 80% of the areas surveyed in 2011 (Randle and Risely 2011.) In this study, the meadow brown was also the most common species found on all sites surveyed. The small white was the second most commonly seen species; in just over 75% of the squares in the WCBS survey. For this survey, the small white was one of the rarer seen species only being seen on the 3 sites with a total number of 7 individuals counted. It is apparent that the small white is lowering in numbers (Butterfly Conservation 2017). The green-veined white appeared in 73% of sampled areas, though for this survey it was less than 50% only being seen on 4 sites. The large white was also found in 73% of survey squares (Randle and Risely 2011), which is similar to this survey with the large white being spotted on 8 of the 10 reserves

Habitat loss and degradation has been closely connected to the decline of specialist butterfly species in the UK (White and Kerr 2006.) Climate change has appeared to have an impact on increasing some species of butterfly populations. This is mainly generalist species such as, speckled wood and orange-tip. Where they are able to expand their distribution further north due to warmer climates. However warmer climates are affecting some species that are used to the cooler climate, this is due to the increase spring plant growth cooling soil temperature effecting the species that overwinter as eggs or larvae (Parmesan 2006).

The habitat management for both rural and urban reserves were in the most part akin with comparable goals, in which to improve diversity for invertebrates alongside other animals. However, the results from the two categories were significantly different concerning their species richness. For this reason, there is no conceivable habitat management technique that could improve this specifically for the urban reserves. However, improving urban areas can have a great impact in improving the butterfly populations of the urban reserves.

Various studies on butterfly ecology has helped conservationists to restore suitable habitat (UKBMS 2017). Improving butterfly assemblages in urban areas can be done by proper maintenance of green corridors on streets, however this would not work in extremely built-up areas. It can also be done by providing open vegetation with nectar rich plants within the built-up area to provide potential habitat areas and reduce fragmentation (Brown and Freitas 2002). The inclusion of ponds may also help.

“Landscape-scale conservation projects targeting threatened species have proved successful and should be rolled out to cover more species in more landscapes” (Butterfly Conservation 2017). Revegetation using native plants of diversity can increase animal biodiversity where intensive land developed has occurred. However non-native plants are often used with unnatural spatial distributions (Wasowski and Wasowski 2000). Revegetated habitat needs to be protected from disturbance to allow ecological succession to improve bio-diversity (Possingham et al 2001.) The effect of urbanisation needs suitable monitoring and reporting for management and policy making, especially for urban greenspaces and gardens (Dennis et al 2017).

5 Conclusion

In conclusion, there appears to be a chance that urbanisation does have a great impact on butterfly abundance and also richness. Rural reserves had both more abundance and more richness than urban reserves despite being of similar sizes, having similar vegetation and habitat management. Through reviewing literature this appears to be because of the many physical changes that occur in urban areas resulting in habitat loss, fragmentation, and an increase in pollution (Foley et al 2005).

However, the impacts of urbanisation on native species hasn’t been thoroughly studied. With there being limited studies done beforehand. Surveys that continuously monitor the butterfly assemblages on the two categories for more than just one season will be necessary to determine the full extent of urbanisation on butterfly bio-diversity.

Butterfly Conservation has blamed the decline in butterflies on “ongoing deterioration of suitable butterfly habitat across the countryside" and has stated “The conservation of the UK’s butterflies remains an enormous challenge” (Butterfly Conservation 2017.)

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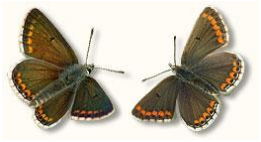
Appendix 1 Data Sheets- Butterfly Survey Data Sheet (May/June)

Date:	Site:	Cloud cover:
Start time:	Precipitation:	Temperature:
Finish time:	Wind speed:	

Species:

Adonis blue

Brimstone



Argus

Clouded yellow

Comma

Common blue

Dingy skipper

Duke of Burgundy

Green hairstreak

Green veined white

Grizzled skipper

Holly blue

Large skipper

Large white

Orange tip

Painted lady

Peacock

Red Admiral

Small blue

Small copper

Small heath

Small pearl-bordered fritillary

Small tortoiseshell

Small white

Speckled wood

Wall brown

Additional species/notes:

Butterfly Survey Data Sheet (July/August)

Date:	Site:	Cloud cover:
Start time:	Precipitation:	Temperature:
Finish time:	Wind speed:	

Species:

Gatekeeper

Black hairstreak

Brimstone

Brown Argus

Brown hairstreak

Chalkhill blue

Clouded yellow

Comma

Common blue

Dingy skipper

Essex/small skipper

Green hairstreak

Green-veined white

Holly blue

Large skipper

Large white

Marbled white

Meadow brown

Orange tip

Painted lady

Peacock

Purple hairstreak

Red admiral

Ringlet

Silver spotted skipper

Small tortoiseshell

Small blue

Small copper

Small heath

Small white

Speckled wood

White letter hairstreak

Adonis blue

Additional species/notes:

Appendix 2 Primary Data

Site	Urban/Ru	Cloud Cov	Wind Spe	Temp	Humidity	Common	Dingy skip	Green vei	Orange tip	Small whi	Brimstone	Large whi	Speckled	Comma	Red admi	Meadow b	Small tort	Small hea	Gatekeep	Ringlet	Small skip	Silver F	Chalkhill	Totals of F
Sydlings C	1	2	10	18	60	1	3	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	**9**
Iffley Mea	2	2	9	19	72	0	0	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	**4**
Hosehill la	2	2	14	21	70	0	0	0	0	2	1	0	3	1	0	0	0	0	0	0	0	0	0	**7**
Padworth	1	2	13	21	70	1	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	**5**
Thatcham	2	1	14	20	61	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Foxholes	1	3	15	17	61	1	0	1	0	0	0	2	5	0	1	0	0	0	0	0	0	0	0	**10**
Chinnor H	2	1	8	22	65	0	0	0	0	0	0	1	2	0	0	2	0	0	0	0	0	0	0	**5**
Asham me	1	2	15	20	65	4	0	1	0	0	0	1	0	0	0	16	4	0	0	0	0	0	0	**26**
Bacombe	2	1	13	20	74	0	0	0	0	0	0	1	2	0	0	2	0	0	0	0	0	0	0	**5**
Calvert jul	1	3	13	21	75	0	0	1	0	0	0	1	9	0	1	1	0	1	0	0	0	0	0	**14**
		1.9	**12.4**	**19.9**	**67.3**	**8**	**4**	**4**	**2**	**7**	**4**	**7**	**22**	**1**	**2**	**21**	**4**	**1**	**0**	**0**	**0**	**0**	**0**	
Padworth	1	3	5	22	61	0	0	0	0	0	0	3	1	1	0	5	0	0	2	1	0	0	0	**13**
Thatcham	2	3	6	22	64	0	0	0	0	0	0	1	0	0	0	4	0	0	3	0	0	0	0	**8**
Hosehill la	2	3	5	23	65	0	0	0	0	0	0	0	0	0	0	3	0	0	6	0	0	0	0	**9**
Sydlings c	1	2	4	21	54	1	0	0	0	0	0	0	0	0	0	7	0	0	3	2	1	0	0	**14**
Iffley Mea	2	2	4	23	56	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	**5**
Bacombe	2	2	6	24	68	0	0	0	0	0	0	0	0	0	0	4	2	0	0	0	0	1	1	**8**
Calvert jul	1	3	7	24	65	1	0	0	0	0	0	1	0	1	0	6	0	0	4	0	0	0	0	**13**
Foxholes	1	2	4	22	63	0	0	0	0	0	0	0	0	0	0	4	0	0	3	0	0	0	0	**7**
Chinnor H	2	3	6	25	69	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0	0	0	0	**6**
Asham me	1	3	6	26	69	3	0	0	0	0	0	1	0	0	0	10	3	0	4	1	1	0	0	**23**
		2.6	**5.3**	**23.2**	**63.4**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**1**	**2**	**0**	**51**	**6**	**0**	**27**	**4**	**2**	**1**	**1**	