An investigation into plant species composition on the Roman wall in Silchester, Hampshire, UK

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Abstract
This study investigated the plant species composition growing on a two thousand year old Roman wall in the village of Silchester, Hampshire, UK. The factors controlling differences in species composition were investigated. The wall, which is 1.5 miles in perimeter, was systematically sampled using quadrats inside, outside and on top of the wall itself. The data was statistically analysed using the Shannon Index of Diversity to determine the diversity of various sections of the wall. The results indicated that the main controlling factors governing the differences in the species diversity and composition on the wall were aspect, the type of restoration material and also the time since restoration, concurring with the literature researched. The analysis indicated that the sections of the wall facing in a north-east direction had the highest species diversity. These sections were also restored using lime mortar, a soft, porous bonding material. The sections of the wall facing in an eastward direction had the lowest species diversity. These sections have been left unrestored in recent times (i.e. during the last two centuries). However, the effects of aspect, restoration material and time could not be differentiated from each other because management of the wall and therefore the materials used in its restoration, were directly related to aspect. It was concluded that lime mortar is preferable for management as it lacks harmful effects on the wall construction, and also on the plants themselves.

Silchester, Roman Wall, Species Composition, Aspect, Restoration, Diversity

1.0 Introduction

The Iron Age and Roman settlement of Calleva Atrebatum is situated within the small parish Silchester, in the north of Hampshire (Figure 1.1).

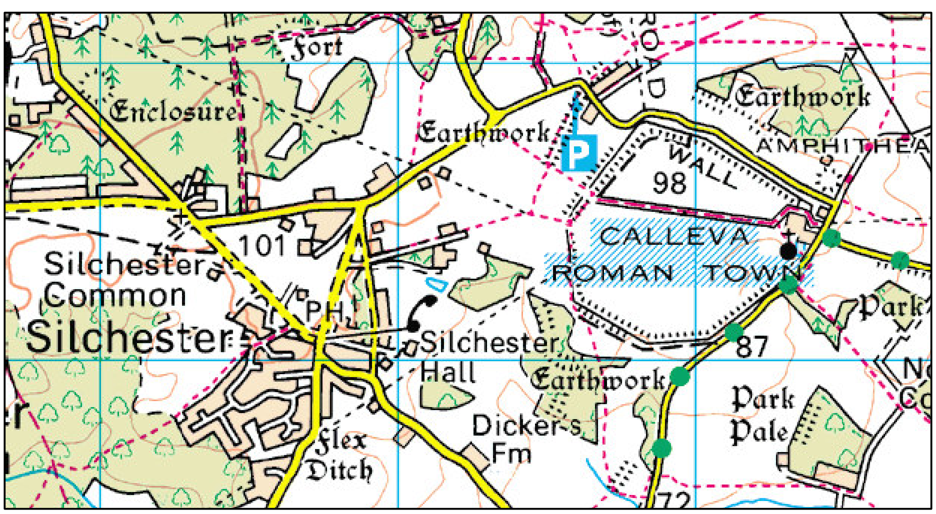

Figure 1.1: Location of the wall within Silchester (Streetmap, 2008).

Calleva Atrebatum was a fortified town and its original defensive walls are 1.5 miles in perimeter, and are still standing over 4m high in some places (Figure 1.2).

Figure 1.2: Photograph of the south section of the Roman Wall, (source: author).

The stone walls were constructed around the same course as the original inner earthworks in the third century between AD 260-80, and were thought to have been over 6m high, with a parapet of 1.8m and 3m thick at the base (Boon, 1974, Fulford, 1987). The outer face of the wall no longer remains, so what is existing is the internal rubble core constructed from roughly-coursed flint set in a strong concrete of gravel, sand and lime (Boon, 1974, Fulford, 1984). Lime mortar was used for bonding. It is thought that 105,000 wagon loads of flint and 45,000 loads of bonding stone were used (Boon, 1974). The Roman wall at Silchester in more recent years has been restored and renovated using different types of substrates and materials. This study investigated the effect of these different materials on the vegetation composition on the wall, and also investigated the other factors of aspect and temporal differences that influenced the spatial variation. Management implications have been highlighted from the findings of the study, which is important for retaining plant diversity on the walls. This information is also important for determining effective restoration methods, such as the correct material for restoration.

1.1 Background to wall vegetation

Wall vegetation is of special interest as wall habitats offer an extreme environment creating varied and sometimes unusual vegetation compositions (Darlington, 1981). The environment is extreme in terms of the effects of temperature and precipitation, wind, humidity, wall inclination and the hardness and alkalinity of the substratum (Segal, 1969). Colonisation can only develop when conditions for settlement are favourable, such as a long exposure time to allow weathering of the material and for the accumulation of soil particles. Other conditions favourable for growth include low temperature extremes, high winter temperatures and no prolonged periods of drought (Segal, 1969). Lichens are the pioneer species followed by mosses, such as *Tortula muralis* in 4 to 5 years (Darlington, 1981). According to Darlington (1981) higher plants such as *Cymbalaria muralis* (ivy-leaved toadflax), then colonise once the mortar courses are 50-100 years old. Thus it may be expected that older walls, i.e. of

Roman origin, should have more developed vegetation. However, Segal (1969) who wrote a pioneering book comparing the vegetation of walls in 1,200 sites in western, southern and central Europe states that the best examples of wall vegetation are present on walls between 100 to 500 years old. Segal (1969) also states that walls over 2000 years old may be badly decomposed and have trapped large amounts of soil so that vegetation cover may have developed into a higher-level community, with shrubby species such as *Rubus fruticosus* (blackberry) out competing the original, more typical vegetation. Other factors influencing the deterioration of ancient walls include over slanting and leaning of the walls, as well as drastic renovation by humans leading to the ancient characteristics of the wall being destroyed (Segal, 1969). This study consequently investigated whether the factors as stated by Segal (1969) affected the vegetation on the wall, i.e. is there evidence of dominating shrubby species and has decomposition or drastic restoration influenced the species presence.

1.2 Factors influencing wall vegetation

It has been recognised by many authors (e.g. Rishbeth, 1948; Segal, 1969; Darlington, 1981) that the main factors controlling the composition of wall flora are aspect and the wall substrate. The materials with which walls are made are particularly important to wall vegetation as they influence how fast weathering occurs, which then determines when and what plants can colonise the wall. Wall materials also influences mineral availability and the pH of the trapped soil. Segal (1969) noted that the materials of construction, especially the type of bonding material used are the main controlling factors influencing the rate and type of colonization. Segal (1969) states that older mortars that have been used for centuries decompose relatively quickly allowing rapid colonisation of pioneer species in the joints in the wall. Lime mortar is a key example, which has been widely used in building for about 5000 years (Gibbons, 2000). However, in 1870 the properties of Portland cement were discovered (a mixture of calcium oxide, cement and sand), which caused the use of lime mortar to become less fashionable, and by the 1950s its use in construction had ceased (Schofield, 2000). Unlike lime mortars Portland cement is extremely hard and weather resistant, cracking less easily along the surfaces and is very water resistant. Segal (1969) notes that its high pH value of 11 to 12 is too high for many forms of life. He also notes that many walls originally jointed with lime mortar were later restored by being plastered over by Portland cement. This can be detrimental to both the wall and the plants growing on them, and it was later determined that the best methods of restoration are to use as close to the same materials originally used in construction (Gibbons, 1995). Lime mortars have advantages over harder denser mortars, as they are more able to expand and contract with temperature and moisture changes (Schofield, 2000). Lime mortars are also more permeable allowing moisture evaporation, whereas harder mortars are less porous (Gibbons, 1995). If lime based walls are pointed with a cement mortar which is less permeable than the surrounding construction materials then moisture will be forced out through the wall stones or bricks causing erosion (Gibbons, 1995). Cement pointing can also deteriorate the wall face, via stress created by the more resistant movement of harder mortars to temperature and moisture changes (Schofield, 2000).

Aspect is another factor controlling wall vegetation as it influences a walls microclimate. For example Segal (1969) notes that the best specimens of wall vegetation are restricted to north, west and east-facing walls, whereas south-facing walls have poor development of vegetation. This is due to south-facing walls having greater climatological extremes, receiving the highest amount of solar radiation in the day with large heat losses during the night. South-facing walls also suffer from large fluctuations in temperature and evaporation extremes, whereas north-facing walls receive the strongest radiation early morning and late evening, so intensity and evaporation are low (Darlington, 1981).

The main aim of this research was to investigate how the factors of aspect, restoration materials and time since restoration have affected the plant species composition and distributions on the wall. Although vegetation studies have been carried out on walls, there has been an evident lack of research in recent literature, especially concerning ancient walls. Thus, this study presents a unique piece of research important for maintaining and preserving archaeological monuments and increasing our understanding of the interactions between biotic life and our abiotic heritage.

2.0 Methods

A preliminary study and a review of the literature highlighted aspect, restoration materials and time since restoration as the main determining factors influencing vegetation compositions and distributions on ancient walls. Thus, the methods used in this study endeavored to measure what effects these factors had on species diversity and composition. The vegetation on the wall was sampled using a $1m^2$ quadrat at regular intervals of 50 metres inside, outside and on top of the wall. Approximately 121 quadrats were taken. A systematic sampling method was chosen as it gave a fair representation of all the different vegetation types along the wall and did not miss out any vegetation patterns needed for analysis (Magurran, 2004). Detailed digital photographs were taken of each quadrat to aid identification of the species. Only angiosperms were recorded on a presence/absence basis. At each sampling location the following variables were recorded: aspect, height, conditions of wall material (if the material crumbled easily or was loose) and the surrounding environment (i.e. whether the wall was overlooked by fields or wooded areas, or was shaded by trees). A map outlining the perimeter of the wall was used to locate the factors being analysed (Figure 2.1).

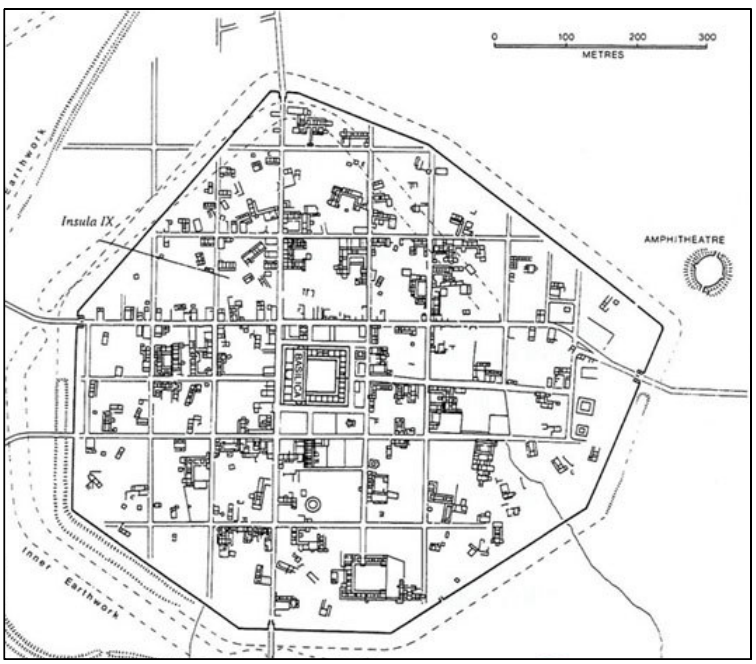

Figure 2.1: The Roman wall perimeter with the probable Roman town layout (Fulford, 1970).

For the statistical analysis the data were organised on the basis of the factors of aspect, restoration practice and time since restoration. For this, the wall was divided into relevant sections and analysis focused on the quadrats that were sampled within each of the factors being analysed, see Figures 2.2 and 2.3. The source of the past management methods and timescales for maintenance of the Roman wall were unavailable from documentary sources, so the information was obtained from email correspondence with an English Heritage representative. English Heritage now manages the wall and retains details of past management practices.

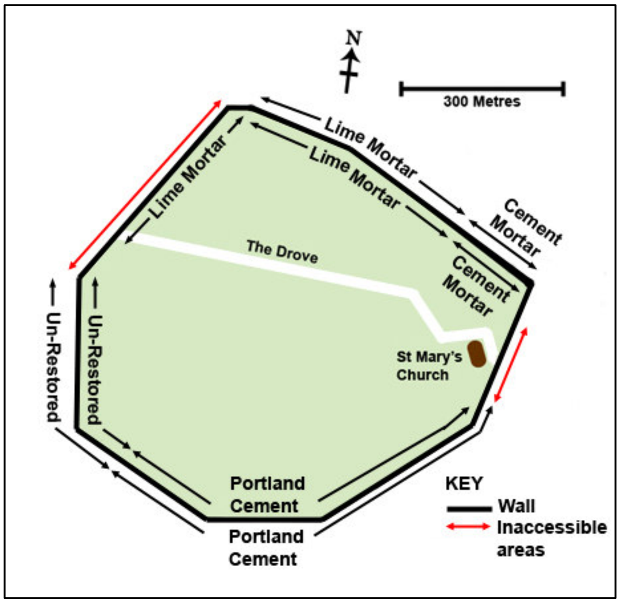

Figure 2.2: Map of the restoration work carried out on the wall between the years 1938-1990 (source: author, English Heritage, 2008).

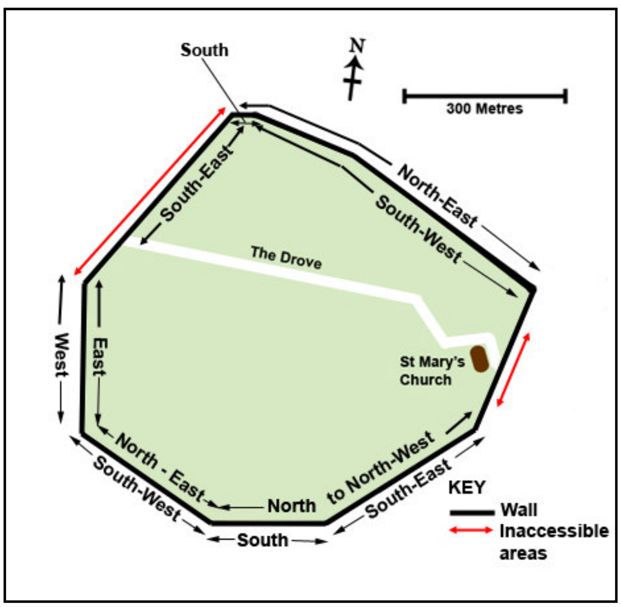

Figure 2.3: Map showing aspect location on the wall (source: author).

The Shannon index statistical test was used on the results to determine the diversity of the different sections of the wall. The Shannon Index is a measurement that compares diversity between habitat samples and is one of the most widely used diversity indices as it incorporates both diversity and abundance measures (Kent and Coker, 1992, Magurran, 2004). It was the most practical method of analysis as it was simple to use, gave clear results and was the most applicable method to the data used. One limitation is that it assumes individuals are randomly sampled from an infinitely large community, and that all the species are represented in the sample (Magurran, 2004). This assumption is impossible to meet. Despite this disadvantage the Shannon Index was the most suitable test to use in comparison to other tests, due to is simplicity and clarity. Another limitation was that some of the sample sites were located in inaccessible areas, such as those on private land. Some of the sites were non-existent such as a break in the wall e.g. due to a relic gate. In these locations samples had to be taken at alternative sites as near to the measured location as possible.

3.0 Results

The results of this investigation were organised according to the three variables that were studied.

3.1 Details of restoration work

The past restoration work details carried out on the wall were obtained from English Heritage who now manages the site, see Table 3.1.

Materials used	**Approximate year of work**	**Conservation Body**
Portland cement	1968- c.1972	Department of Environment
Cement mortar	1938-1939	Ministry of Works
Lime mortar	1990-?	Department of Environment

Table 3.1. Details of the restoration work carried out on the wall from 1938-1990 (English Heritage, 2008)

Unfortunately details of earlier work are vague or absent as the work was previously carried out by bodies other than English Heritage. For example, the Ministry of Works and the Department of the Environment carried out work in 1938-39 and 1968, respectively. No other information before this time could be located. Some end dates of work are also unknown. Two areas of the wall have been left completely unrestored for the last two centuries (see Figure 2.2).

3.2 Species lists and summary tables

The numbers of plant species recorded per quadrat and a full species lists are displayed in Tables 3.2 and 3.3. Table 3.2 compares the results for restoration materials and time since restoration (this is the same data as each of the restoration work was carried out at different times) and Table 3.3 compares the results for aspect. Both of the tables show the same data but are organised differently according to the factors being analysed. The tables are organised by family then by species.

Table 3.2 is displayed at the end of this article.

In total, 64 plant species were recorded belonging to 27 families (Table 3.2). The most species abundant families were the grass family with 11 species and the daisy family with 10 species. The results from Table 4.2 show that sectors of the wall restored with lime mortar had the highest number of recorded species of 42. Sectors of the wall restored with cement mortar had the lowest number of species recorded, with a difference between the two of 25 species.

Table 3.3 is displayed at the end of this article.

The aspect with the highest number of recorded species was north-east with 32 species. The aspect with the least number of recorded species was north to north-west with 13 species. Overall the plant species to be recorded with the highest number of individuals in one area was *Geranium robertianum* with 17 individuals on the west aspects.

3.3 Shannon Index results

The Shannon Index was calculated on the sectors of the wall according to aspect and building material. The Shannon index is calculated from the following equation:

$$H' = \Sigma p_i \ln p_i$$

Where, H = measure of diversity
pi = proportion of individuals in the ith species
ln = log basen

The value of the Shannon index usually falls between 1.5 and 3.5. A high number indicates high diversity, and a low number indicates lower diversity (Magurran, 2004).

Variable		***H'***
Material	**Year**	
Lime mortar	1990	3.29
Portland cement	1968- c.1972	2.89
Cement mortar	1938-1939	2.71
Un-restored		2.53

Table 3.4 Shannon index comparisons for restoration materials and time since restoration. Arranged in numerical order.

It is clear from Table 3.4 that the sectors restored with lime mortar are the most diverse with a Shannon index value of 3.29. The least diverse sectors are the sectors that were not restored with a Shannon index value of 2.53. There is a large difference (0.76) between the lowest index result and the highest. The sectors restored with lime mortar were also most recently restored and the sectors with the lowest diversity had the longest time since restoration or were unrestored completely. Therefore the differences in diversity could be attributed to both material and time since restoration.

Variable	***H'***
North-East	3.11
South-East	2.90
South-West	2.80
South	2.77
North to North-West	2.39
West	2.39
East	2.37

Table 3.5 Shannon Index comparisons for aspect. Arranged in numerical order.

Table 3.5 shows that the sectors with a north-east aspect had the highest diversity index of 3.11. The sectors with aspect facing east had the lowest diversity index of 3.27. The difference of 0.74 between these numbers is quite prominent.

4.0 Discussion

The overall aim of this study was to investigate the differences in species composition around the wall, and to investigate if parts of the wall were more diverse than others and to determine the causes of the differences. Differences in species composition patterns were found over the site as shown by the Shannon index results and by the total number of species per site. It was shown that the species composition varied according to the location on the wall, and the type of physical influences it came under.

4.1 Comparisons with other wall floras

Silchester was compared to other studies undertaken on wall flora in three other parts of England to highlight any unique features and to compare any similarities or dissimilarities (Table 4.1).

Place and author	Number of species (total number of walls sampled)	Number of species common to Silchester	Number of species only found in Silchester
Cambridge (Rishbeth, 1948)	177 (-)*	33	31
Durham (Woodell, Rossiter, 1959)	158 (66)	37	25
Middlesex (Kent, 1961)	204 (500)	30	34
Essex (Payne, 1978)†	47	18	-

Table 4.1: Comparison of wall flora between Silchester and other sites (* Number unknown †Payne only lists the most common 47 species).

Table 4.1 shows that Silchester has a notable difference in species composition than the other sites. In contrast Kent (1961) found 117 species in common between Middlesex and Durham and 106 between Middlesex and Cambridge. Payne lists 28 common species between Essex and Cambridge and 24 species between Essex and Durham. It should be noted that the sample size of Silchester was much smaller, and all of the above studies took place over a period of 3-4 years allowing all seasons to be sampled. Altogether 90 species recorded at Silchester were absent from the other studies. This highlights the potential botanical importance of Silchester, as these species may be uncommon in general to walls. For example *Cerastium fontanum* (common mouse-ear) usual habitat is grassland and bare ground and *Myosotis sylvatica* (wood forget-me-not), *Carduus crispus* (welted thistle) and *Chaerophyllum temulentum* (rough chervil) usual habitats are hedges and grasslands (Fitter *et al.,* 1996). An interesting observation is that while *Geranium robertianum* (herb robert) is common at Silchester and generally on walls, *Gerranium molle* (dovesfoot cranesbill) and *Geranium pyrenaicum* (hedgerow cranesbill) that are found at Silchester are both absent from all the other sites lists. These species' usual habitats are open grassy places (Fitter *et al.,* 1996). In general this site has a build up of non-typical wall plants; therefore it potentially offers an unusual habitat for plants. This could be due to the antiquity of the wall, as it has acquired large amounts of soil, humus and nutrients allowing plants usually unsuitable for walls to establish. For example of the species Rishbeth (1948) states are the most common wall species throughout Britian i.e. *Cheiranthus cheiri* (wallflower)*, Cymbalaria murlais* (ivy-leaved toadflax), *Parietaria judaica* (pellitory of the wall)*, Poa compressa* (meadow grass) and *Asplenium ruta-muraria* (wallrue) only *Parietaria* was found at Silchester. The west section had the presence of unusual plants which are only found in ancient woodland e.g. *Lamiastrum galeobdolon* (yellow archangel) and *Mercurialis perennis* (dog's mercury) (Rackham, 1980). Therefore Silchester could be considered as a significant botanical site for the analysis of wall flora due to its unusual species patterns. It is also likely to be the only wall of similar antiquity displaying this unique flora in the local area.

4.2 Restoration materials

The spatial variation displayed by the restoration materials shows the highest species diversity within the lime cement areas, followed by areas of the wall restored by Portland cement, followed by cement mortar and with the unrestored areas being the least diverse (see Figures 4.1 to 4.4 for pictures of all the restoration types). It has been recognised within the literature (e.g.; Rishbeth, 1948; Woodell and Rossiter 1959; Kent, 1961; Segal, 1969) that the materials of construction especially the type of bonding material, influences plant species composition by affecting the rate of colonisation and establishment of individuals.

Figure 4.1: Section of the south wall, restored with Portland cement. Note Portland cement's characteristic white colour, and see that large areas are covered with the cement (Source: author).

Figure 4.2: Section of the north-east facing wall, restored with lime mortar. Note its decomposition and 'crumbly' appearance, the whole area looked like this (Source: author).

Figure 4.3: Section of the north-east facing wall, restored with cement mortar. This material was also hard, and did not crumble as the lime mortar (Source: author).

Figure 4.4: Un-restored section. *Hedera helix* (ivy) and trees can be seen covering the wall (Source: author).

The main factors resulting in a low species composition include the following: a hard rough mortar, low mortar porosity, low moisture retention, resistance to weathering and an extreme pH (e.g. Rishbeth, 1948; Segal, 1969; Darlington, 1981). These factors are characteristic of Portland cement. Although the results indicated that parts of the wall restored with Portland cement were more species diverse than unrestored and cement mortared areas, they were mainly dominated by one species, *P. judaica* (pellitory of the wall) and although the Shannon index is intended to take dominant species into account, this factor should not be overlooked. For example if *P. judaica* is temporarily taken out of the Shannon index equation, the result changes to 2.57, which is a smaller number than the result for cement mortar. Some caution also needs to be exerted over the interpretation of these results as for practical reasons the different variables had different sample sizes. For example, areas restored with Portland cement extended over 750m and 68 quadrats could be taken (including sampling vertically up the wall), while only 260m of wall was restored with cement mortar, and only 9 quadrats could be taken. These factors influence the interpretation as fewer quadrats will sample fewer species and *vice versa.*

Segal (1969) and Darlington (1981) have observed that Portland cement creates a harsh environment for plant growth, due to its hardness and water resistance, thus it would be expected to have a lower species composition. Whereas, lime mortar is more favourable for plants due to its water permeability, un-non-extreme pH and rapid decomposition rates (Segal, 1969).

As predicted, lime mortared areas had the highest species composition, and it had the presence of species that were not found on other parts of the wall, such as *Papaver rhoeas* (poppy), *Veronica chamaedrys* (germander speedwell), *Fragaria vesca* (wood strawberry) and *Vicia sativa* (common vetch).

The unrestored sections of wall had the lowest diversity index, although it had a higher species number than that recorded in cement mortar areas. It also had a larger sample size than the cement mortared areas and even had a larger sample size than that of the most diverse lime mortared areas. This emphasises its low species composition. English Heritage had no record of these areas ever being managed and without any restoration work these sections of wall have allowed succession to lead to the establishment of higher plant species that are not found elsewhere on the wall. For example large shrubby and woody species such as *Rubus fruticosus* (blackberry) and *Hedera helix* (ivy) have become dominant, and species such as *Utica dioica* (nettle) and *Heracleum sphondylium* (hogweed) have smothered smaller weaker species. Smaller species common elsewhere on the wall such as *Sonchus oleraceus* (sowthistle) and *Taraxacum officinale agg* (dandelion) are absent. This section of wall is surrounded by a wooded copse area, and is a remnant of a once extensive woodland that existed when the wall was built (Fulford, 1987). The species found on these sections are characteristic of woodland and some, such as *Campanula trachelium* (nettle-leaved bellflower), *Lamiastrum galeobdolon* (yellow archangel) and *Mercurialis perennis* (dog's mercury), are generally restricted to ancient woodland (Rackham, 1980). The low species diversity has probably been caused by the dominance of the larger species leading to fewer small plants, owing to greater shading and interception of water. If vegetation clearance had been carried out in the past, succession may not have led to this dominance, as the larger dominant species may have been largely eradicated (Segal, 1969).

4.3 Time

Segal (1969) noted that it takes many years for plants to become established on new material, as some weathering is needed before plants can get a foothold. Thus the oldest restoration work should have higher species diversity than the others. This would be the cement mortar areas, which were restored between 1938-1939. Unfortunately due to the small sample size of this area, this theory cannot be accurately tested. Although it should be noted that in just 9 quadrats 17 species were recorded, and this areas diversity index result was higher than that of the unrestored areas, implicating a potentially high diversity if the sampling area was more extensive. The results of this study contradicted Segal (1969) who stated that the bonding material should be at least 50 to 100 years old to allow for the establishment of higher plant species such as *Asplenium ruta-muraria* (wallrue) and *C. muralis* (ivy-leaved toadflax). Although these particular species were not recorded at this site, equivalent higher species were recorded on all the restoration sites, which are all (apart from the cement mortar areas) less than 50 years old. Even the Portland cement areas facing in a southward direction have allowed the establishment of higher species such as *P. judaica.*

Segal (1969) also stated that walls older than two millennia are usually badly decomposed, having allowed the entrapment of large amounts of soil, leading to the establishment of higher-level community vegetation which out-competes the original, more typical vegetation. He also stated that drastic renovation by humans has usually led to the ancient characteristics of the wall being destroyed, such as visible wall construction and the original materials. At this site the study mostly found no evidence of over decomposition, as much of the wall was not dominated by late succession typical vegetation. The only sections that may have led to the ancient characteristics of the wall being destroyed were the unrestored areas, as the vegetation had overgrown the wall to such an extent that the wall was hidden and perhaps is in bad repair (see Figure 4.5). Therefore the results of the unrestored sections concurs with Segal's (1969) statement, but not the other parts of wall which have been actively managed. Therefore adequate restoration not only helps the maintenance of the walls construction, but also helps to maintain its characteristic biotic life.

Figure 4.5: Overwhelming vegetation in the un-restored sections. The wall is to the right in the photograph (Source: author).

4.4 Aspect

Aspect affects a walls microclimate by influencing its temperature, moisture, light intensity, evaporation rates and humidity, all of which can influence diversity patterns. The spatial variation shown by aspect at this site produced the highest species diversity on wall sections facing north-east and the lowest species diversity facing east. Although it should be noted that the north-east aspect spanned 700m and had a larger sample size than other aspects, for example the east and west spanned 350m and 450m, respectively. The west aspect actually had the second largest sample size, but it still had one of the lowest diversity indexes. The sectors facing south-east, south-west and south were the next species diverse sites. Although all of these sites had the presence of the dominant *P. judaica.* The patterns that have been highlighted by the literature indicate that south-facing walls have the least developed vegetation and north-facing walls have well developed vegetation (e.g. Woodell and Rossiter, 1959; Raistrick and Gilbert, 1963; Segal, 1969). This is because south-facing walls are more susceptible to climatological extremes, and are more prone to desiccation as daily fluctuations are emphasised because of high incidence of solar radiation (Segal, 1969). North-facing walls have the highest amount of solar radiation reaching them in the evening and morning. Therefore their maximal extremes are low and environmental conditions are more stable creating a more intricate vegetation structure (Segal, 1969).

Overall the site was mainly sampled with aspects facing in a general southward direction. The results indicated that these walls were more diverse than west and east facing. This is contradictory to the above authors. A fact that should be considered is that that many of the plants sampled on southward facing sites showed xerophytic characteristics. These are plants that are adapted to withstanding water deficiency, for example species present such as, *Verbascum thapsus* (common mullein) that has thick glandular hairs and *S. oleraceus* (sowthistle) with thick waxy cuticles (Segal, 1969). Also, *P. judaica* which was the dominant species along the southward facing walls, is known to be tolerant of high temperatures and periods of drought (Segal, 1969 and Darlington, 1981).

4.5 The factors

Some caution should be exerted over the interpretation of the extent that each factor determines the diversity of the wall, as all three factors are interrelated. The factors are not isolated from each other, as each section of the wall is under the influence of aspect, materials and time combined. It was not possible within the scope of this study to determine the actual influence of each, as a longer study would be needed to isolate each factor from another. For example other walls could be studied and compared so as to better understand the actual effects of each factor in general, i.e. using a wall with a uniform material of construction so just aspect influences could be determined. However, even though there was difficulty in determining the actual influence of each factor it still can be concluded that differences in diversity were found, and these were caused by the physical influences each section came under. For example the highest diversity was caused because the section faced north-east and was restored most recently (1990's) with lime mortar.

4.6 Management implications for retaining plant species diversity on historic features

In general plants are considered detrimental to walls, and because many walls are built for a purpose of use, clearance of vegetation is a common practice (Woodell, 1979). This Roman wall no longer serves a structural purpose but remains as a piece of heritage. Although some plants can be deleterious to walls such as woody species e.g. trees and ivy, many are not (Woodell, 1979). Many of the species found at this site were small herbaceous plants with soft stems that did not penetrate deeply into the substrate, for example species of Compositae and Geraniaceae (Woodell, 1979). Vegetation can also have preservation influences on walls by soothing wide temperature and moisture fluctuations, and can protect the wall from high light intensities (Darlington, 1981). For educational and aesthetical reasons vegetation can be a welcome presence on walls, and walls can also offer a habitat for refugia species that cannot survive elsewhere, especially in urban areas.

Although not directly supported by the results of this study, Portland cement is known to create a harsh environment for vegetation, and also for the wall itself. Overall once subjectively compared to other parts of the wall these sections appeared more species deficient. As supported by the research and results of this study it is indicated that the management of old, historic buildings and walls should avoid using this material due to its destructive influence. It is known that the best methods of restoration is to use the same materials as used in the original construction (Gibbons, 1995 and Schofield, 2000). Thus the use of lime mortar is recommended and supported by this study it displayed the best examples of wall vegetation. The results also revealed that the unrestored sections of wall did not only display the loss of characteristic un-harmful small wall species, but also the loss of the walls ancient characteristics. For example smothering of the wall by species such *H. helix* that could have lead to decomposition by strong roots. This highlights the need for effective management practices, so vegetation does not become detrimental by overwhelming the wall. Figure 4.5 illustrates the vegetation in the unrestored section completely covering the wall.

5.0 Conclusion

This study provides evidence that the nature of the species composition was varied around the wall, according to the factors that were analysed. It has been concluded that no one of the factors of aspect, restoration materials or time, were the sole dominating cause of the differences seen in the species composition. The variables were not independent to each other as they worked inter-dependently to influence the establishment of the plant species. A longer study would need to be implemented to isolate the direct influences of each factor. In summary, the results and analysis demonstrated that, as predicted by the literature (e.g. Rishbeth, 1948; Segal, 1969; Darlington, 1981) the parts of the wall with the highest species composition were sections facing northwards and sections that were restored with the softer, more porous lime mortar. In contrary to the literature that stated southward facing walls, and walls restored with Portland cement should be the most species poor, the sections that were more species deficient at Silchester were sections of the wall that were not restored, and those facing eastward. However, due to the unavoidable limitations of small quadrat sample sizes, these conclusions should be treated with caution as some of the sample sites may be underrepresented. In comparison to the studies that were previously undertaken on wall vegetation it was shown that Silchester harbours plants that are generally unusual to walls. This highlights that the Roman wall provides a unique habitat and is a significant site in terms if its age.

5.1 Wider implications

Segal (1969) originally stated that the best examples of wall vegetation are found on walls aged between 100 to 500 years, and walls older than two millennia are too badly decomposed to allow for the development of diverse wall flora. The results and analysis of this study has challenged this statement, and concluded that the results of the unrestored areas did concur with Segal (1969). In comparison to the studies that were previously undertaken on wall vegetation it was shown that Silchester harbours plants that are perhaps unusual to walls. The research concludes that the nature of the plant species is diverse with the presence of non-typical wall plants as compared to other species lists. This indicates that the Roman wall at Silchester is not only of interest for heritage reasons, but also as an interesting botanical site for the study of wall flora. In comparison to newer walls, Silchester would be more significant in terms of species composition and diversity. It is therefore important that the restoration maintenance of the wall should be as un-detrimental as possible to plants. The analysis of the results has indicated that management efforts should focus on the use of lime mortar, over other harsher materials such as cement based bonding. One limitation to this study was the assumption that the sample size over the whole site was large enough to adequately represent all of the community. Although all efforts were made to do this, due to time limitations sampling occurred every 50m. A recommendation for future work would be to sample smaller distance intervals with more quadrats being taken increasing sample sites. Another limitation was that sampling was carried out during just one season, a recommendation for a future study would be to sample over a longer timescale to allow succession on the wall to be analysed in all seasons, which has important implications for wall conservation. Understanding this process would give an indication of the time-frame after any clearance or restoration plants re-colonise the wall. This could aid conservation practices by helping to set management objectives.

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Data tables:

Table 3.2: Full species list and the number of species per quadrat for comparisons between restoration materials and time since restoration.

		Number of quadrats each species was recorded in			
Family name	**Species Name**	**Un-restored**	**Lime mortar**	**Cement mortar**	**Portland cement**
Number of sampled quadrats		**24**	**20**	**9**	**68**
Araliaceae- Ivy family	*Hedera helix*	17	6	2	
Aspleniaceae- Spleenwort family	*Phyllitis scolopendrium*			1	
Betulaceae- Birch family	*Betula pendula*	2			
Boraginaceae- Borage family	*Myosotis arvensis*	1	2	1	2
	Myosotis sylvatica	1			
Brassicaceae- Mustard family	*Alliaria petiolata*		1	1	
Campanulaceae- Bellflower family	*Campanula trachelium*	1			
Caryophyllaceae- Pink family	*Arenaria serpyllifolia*		1		5
	Cerastium fontanum				2
	Silene latifolia		2		
Clusiaceae- St. Johns's wort family	*Hypericum perforatum*		1		
Compositae- Daisy family	*Achillea millefolium*		1		
	Bellis perennis				2
	Carduus crispus	2			
	Cirsium arvense	1			
	Crepis vesicaria		1		
	Hypochaeris radicata		2		1
	Leontodon hispidus		1		
	Senecio jacobaea		3		2
	Sonchus oleraceus		3	1	6
	Taraxacum officinale agg.		17	5	17
Convolvulaceae- Bindweed family	*Convolvulus arvensis*		1		2
Crassulaceae- Stonecrop	*Umbilicus rupestris*	2			

Table 3.2 continued:

Family name	Species Name	Number of quadrats each species was recorded in: Un-restored	Lime mortar	Cement mortar	Portland cement
Euphorbiaceae- Spurge family	*Mercurialis perennis*	3			
Geraniaceae- Geranium family	*Geranium molle*		2		2
	Geranium pyrenaicum			1	
	Geranium robertianum	20	8	4	3
Gramineae- grass family	*Agrostis gigantea*		3		5
	Arrhenatherum elatius		4	1	2
	Bromus ramosus				1
	Bromus mollis	1	1	1	6
	Bromus sterilis		1		6
	Dactylis glomerata		8	1	14
	Elymus caninus	1			
	Holcus lanatus	1	4	3	2
	Hordeum murinum		2	1	3
	Lolium perenne		4		10
	Poa pratensis		2		2
Juncaceae- Rush family	*Luzula sylvatica*				1
Lamiaceae- Mint family	*Glechoma hederacea*	10	9	5	3
	Lamium album	1	3	1	
	Lamiastrum galeobdolon	1			
	Lamium purpureum	1	1		
	Stachys sylvatica	1			
Leguminosae- Pea family	*Trifolium dubium*		1		
	Trifolium pratense		1	1	1
	Vicia hirsute		1		
	Vicia sativa		2		
Malvaceae- Mallow family	*Malva sylvestris*		4		8
Oleaceae- Olive family	*Fraxinus excelsior*	1	1		2
Onagraceae- Willowherb family	*Epilobium ciliatum*				3
Papaveraceae- Poppy family	*Papaver rhoeas*		1		
Plantaginaceae- Plantain family	*Plantago major*		1		
Rosaceae- Rose family	*Fragaria vesca*		1		
	Rubus fruticosus	7	4		
Rubiaceae- Bedstraw family	*Galium aparine*	1			
Scrophulariaceae- Figwort family	*Verbascum thapsus*				3
	Veronica arvensis		3		
	Veronica chamaedrys		2		3
Umbelliferae- Carrot family	*Chaerophyllum temulentum*	2	3		
	Heracleum sphondylium	9	2		
	Torilis japonica	3			
Urticeae- Nettle family	*Parietaria Judaica*		3		27
	Utica dioica	14		1	1
Total number of species recorded		**25**	**42**	**17**	**31**

Table 3.3: Full species list and the number of species per quadrat for comparisons between aspect.

		Number of quadrats each species was recorded in						
Family name	**Species Name**	**North -East**	**East**	**South - East**	**South**	**South-West**	**West**	**North to North-West**
Number of sampled quadrats		**28**	**7**	**11**	**7**	**12**	**17**	**6**
Araliaceae- Ivy family	*Hedera helix*		4	2		2		
Aspleniaceae- Spleenwort family	*Phyllitis scolopendrium*	1						
Betulaceae- Birch family	*Betula pendula*							
Boraginaceae- Borage family	*Myosotis arvensis*	2		1		1		1
	Myosotis sylvatica						1	
Brassicaceae- Mustard family	*Alliaria petiolata*	2						
Campanulaceae- Bellflower family	*Campanula trachelium*						1	
Caryophyllaceae- Pink family	*Arenaria serpyllifolia*	1		1	2			2
	Cerastium fontanum			1		1		
	Silene latifolia			2				
Clusiaceae- St. Johns's wort family	*Hypericum perforatum*	1						
Compositae- Daisy family	*Achillea millefolium*					1		
	Bellis perennis				2			
	Carduus crispus						1	
	Cirsium arvense		1					
	Crepis vesicaria	1						
	Hypochaeris radicata			2				
	Leontodon hispidus			1				
	Senecio jacobaea			2	1	1		
	Sonchus oleraceus	3		4	7			
	Taraxacum officinale agg.	11			7	8	3	3
Convolvulaceae- Bindweed family	*Convolvulus arvensis*					3		
Crassulaceae- Stonecrop	*Umbilicus rupestris*						2	
Euphorbiaceae- Spurge family	*Mercurialis perennis*						1	
Geraniaceae- Geranium family	*Geranium molle*	1			1	1		
	Geranium pyrenaicum	1						
	Geranium robertianum	11	1	2	1		17	3
Gramineae- grass family	*Agrostis gigantea*	3			3			
	Arrhenatherum elatius	6			1			2
	Bromus ramosus			1				
	Bromus mollis	4	1	2	2	3		
	Bromus sterilis			2	1	4		
	Dactylis glomerata	9		3	1	2		7
	Elymus caninus		1					
	Holcus lanatus	7	1	1		2		2
	Hordeum murinum	6						1
	Lolium perenne	7		3	1			6
	Poa pratensis	3				1		1

Table 3.3 continued:

		Number of quadrats each species was recorded in						
Family name	**Species Name**	**North -East**	**East**	**South - East**	**South**	**South-West**	**West**	**North to North-West**
Juncaceae- Rush family	*Luzula sylvatica*				1			
Lamiaceae- Mint family	*Glechoma hederacea*	8	3	1	1	8	5	
	Lamium album		1	1		2		
	Lamiastrum galeobdolon						1	
	Lamium purpureum	1	1					
	Stachys sylvatica		1					
Leguminosae- Pea family	*Trifolium dubium*				1			
	Trifolium pratense					1		1
	Vicia hirsuta	1						
	Vicia sativa	1						
Malvaceae- Mallow family	*Malva sylvestris*	1		1	3	1		
Oleaceae- Olive family	*Fraxinus excelsior*	1			2		1	
Onagraceae- Willowherb family	*Epilobium ciliatum*				3			
Papaveraceae- Poppy family	*Papaver rhoeas*	1						
Plantaginaceae- Plantain family	*Plantago major*							
Rosaceae- Rose family	*Fragaria vesca*	2						
	Rubus fruticosus		2	2			5	
Rubiaceae- Bedstraw family	*Galium aparine*						1	
Scrophulariaceae- Figwort family	*Verbascum thapsus*			1		3		
	Veronica arvensis	1						
	Veronica chamaedrys	1		1	1	3		
Umbelliferae- Carrot family	*Chaerophyllum temulentum*		2	1				
	Heracleum sphondylium	1	1	1			8	
	Torilis japonica		1				2	
Urticeae- Nettle family	*Parietaria judaica*	3		13	4			2
	Utica dioica	4	4		1		10	1
Total number of species recorded		**32**	**15**	**25**	**22**	**19**	**15**	**13**