Historic England

IVY ON WALLS

Interim Seminar Report

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Edited by Troy Sternberg

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SUMMARY

The role of ivy (*Hedera helix*) on historic monuments is a significant issue for heritage conservation in England. As a common plant, ivy is found throughout the British Isles and is found at many heritage sites. Opinions are divided as to whether it should be removed or could play a role in conservation. To better understand ivy impact on stone surfaces English Heritage commissioned a 3-year project that investigated whether ivy covering historic walls and buildings plays a largely deteriorative or protective role. The research investigated several aspects of ivy impact on historic walls and buildings. This report summarises these interim research findings and other investigations by the National Trust and Natural England which were presented at a research seminar held at the Geological Society in London in May 2010. The findings contributed to debate on the topic and should influence future practice, management, and policy surrounding ivy growth on walls. Further research was programmed.

Ivy on Walls

Seminar Report

May 19, 2010

ENGLISH HERITAGE

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Foreword

The role of ivy (*Hedera helix*) on historic monuments is a significant issue for heritage conservation in England. As a common plant ivy is found throughout the British Isles and is found at many heritage sites. Opinions are divided as to whether it should be removed of could play a role in conservation. To better understand ivy impact on stone surfaces English Heritage commissioned a 3-year project that investigated whether ivy covering historical walls and buildings plays a largely deteriorative or protective role. The research investigated several aspects of ivy impact on historic walls and buildings and was carried out by Heather Viles and colleagues in the School of Geography and the Environment, University of Oxford in association with Alan Cathersides of the Gardens & Landscape team, English Heritage.. The project was based in Oxford and included sites across England. This report is a write-up of presentations given at the end-of-project seminar held at the Geological Society of London on May 19, 2010. The chapters present the main findings of the 'Ivy on Walls' research project and related work on ivy undertaken by English Heritage, the National Trust and Natural England. Findings are expected to contribute to a lengthy debate on the topic and should influence future practice, management, and policy surrounding ivy growth on walls. The report has been edited by Dr Troy Sternberg, University of Oxford.

1. Introduction - Ivy on Walls

Alan Cathersides, English Heritage

"I also think that all the ivy on the walls should be cut. I believe the Queen favours such a policy. Ivy is a rank and odious plant"

These comments on a project at Windsor Castle were made by Sir Lionel Earle, Secretary of the Office of Works in 1923 and they largely sum up the suspicion surrounding ivy, with regard to buildings, which existed for much of the 20th century and, to a lesser extent, before this. Indeed there are still many misconceptions about the impact of ivy on buildings and a scoping project carried out by the University of Oxford in 2006 found a range of perceptions of the benefits and detrimental effects of ivy amongst gardeners and building managers – many of them directly contradictory as shown in Table 1.1. But there was no clear evidence to support most of these views – only inbuilt prejudice, both for and against – but mostly against – ivy.

Table 1.1 Perceived benefits and problems of ivy on buildings.

Perceived benefits	**Perceived problems**
Keeps old walls sound	Roots damage stone, mortars, pointing
Provides a security barrier	Triggers security lights
Can help with weather-proofing (shields walls from driving rain)	Can cause damp
Can give colour and texture to a building	Rootlets leave marks on the stonework
Easy to grow	Can grow onto other people's properties
Can cover an unsightly building	Lifts copings and slates
Can enhance the appearance of buildings	Grows into glass windows
Good habitat for birds and insects	Can encourage insect infestations
	Can grow up gutters and hoppers and get into drainpipes
	Maintains moisture on wall surface
	Rootlets remove moisture and 'suck cement out of mortar'

Abridged summary of the benefits and detrimental effects associated with ivy, as perceived by clerks of works/maintenance managers and gardeners interviewed in the scoping project by Carter and Viles (2006, Table 1, p. 11)

The experience of English Heritage during the conservation of Wigmore Castle in Herefordshire crystallized these dichotomous viewpoints – some of the ivy covered walls were clearly being damaged by the plant which had rooted in at every opportunity whereas on others entire sheets of ivy were easily removed to reveal pristine stonework beneath (Figure 1.1). Following these observations it was decided that to produce better maintenance and conservation advice for the future, the impact of ivy on walls required a much more systematic examination by:

- testing the protective potential of ivy
- investigating what damage it can cause.

Figure 1.1 Wigmore Castle – decades old ivy being removed from unharmed walls.

Research Aim

The aim of this project was to investigate the effects of Common or English Ivy (*Hedera helix*) canopies on walls in England in order to test whether ivy serves as a beneficial (bioprotective) or detrimental (biodestructive) agent on historical walls and buildings.

It is important to highlight that we have confined the research to *Hedera helix*, the Common or English Ivy, which is the most prevalent self-clinging climber found on walls in England. The plain green species is dominant but on garden sites ivy may be one of several dozen ornamental varieties available. The research findings should be applicable to all forms as their method and pattern of growth is identical. They should also be applicable to the 10 or so other species of ivy which also have very similar growth. With the exception of the Irish or Atlantic Ivy (*Hedera hibernica*) these are rarely found outside garden sites in England.

There are a handful of other self-clinging climbers which will grow outside in the UK, most notably Virginia Creeper or Boston Ivy, but these are only rarely encountered outside garden sites. Some of these are not evergreen and thus may not offer the same potential for bio-protection as *Hedera spp*.

Hedera helix is a native evergreen creeper/climber common in woodlands throughout the British Isles, Europe and into Asia Minor. It will creep along the woodland floor until it encounters something to climb up – usually a tree – although as we all know buildings will do equally well in providing a location for climbing. The driver for climbing is to reach high light levels to enable flowering. This usually starts when the ivy reaches the top of whatever it is climbing, but can then occur from the ground. It is unusual for flowering to occur before the top has been reached. The flowering growth, usually referred to as 'arboreal growth' is distinctly different from the climbing growth (Figure 1.2). It grows horizontally out from the vertical stems, is much more woody than the soft flexible 'juvenile' climbing stems and has leaves of a very different shape (Figure 1.3). In undisturbed situations this growth can reach several metres in length. Cuttings taken from this growth will grow as small shrubs and do not revert back to 'juvenile' growth.

Figure 1.2 (right). Flowering or arboreal growth of *Hedera helix* showing altered leaf shape and flowering heads

Figure 1.3 (below). Typical juvenile leaf of *Hedera helix*

Research Approach

The approach we have used is to look at the protective potential of ivy as well as what potential it has for damage in order to produce an informed and balanced assessment of its role (Figure 1.4). For this purpose we have focussed our attention on:

1. The temperature and humidity conditions at the wallface
2. The mechanism of attachment
3. What causes ivy to send 'proper' roots into walls
4. Particulate filtering

In more detail we have investigated:

1. The temperature and humidity conditions at the wallface – conditions behind a layer of ivy in comparison to those on uncovered walls. It is well known that two major causes of damage to exposed historic fabric are the freeze/thaw cycle where water expanding as it turns to ice causes damage and the wet/dry cycle where salts within the fabric cause damage by expanding as they come out of solution. Anything which moderates either of these cycles is potentially protective
2. The mechanism of attachment – how the aerial rootlets stick to walls and whether this causes permanent damage.Because ivy is a "self-clinging" climber it uses small, aerial rootlets to attach itself to the surface on which it climbs. Understanding how these rootlets adhere helps to determine the severity of an damage caused.
3. What causes ivy to send 'proper' roots into walls – the aerial rootlets which ivy uses to climb are not roots in the normal sense. They do not continually grow bigger and they appear to have no water/nutrient uptake function. 'Proper' roots are not generally produced by climbing stems, but when they are will inevitably be damaging. Such roots grow and displace the masonry around them causing cracking and possible destabilisation.

4. Particulate filtering – whether ivy leaves prevent dust and pollution particles from reaching the wall surface. Several species of tree have been found to preferentially remove particulate pollution from the air. If ivy plays such a role it could potentially reduce the deposition of damaging pollutants on to vulnerable wall surfaces.

Erosion of exposed historic fabric back beyond previous pointing repair

Typical aerial rootlets used to cling on to the climbing surface

'Proper' roots produced by ivy, which can continue to increase in size

Ivy showing the ability to pick up airborne particulates

Figure 1.4 Potential impacts of ivy.

What we have not looked at (Figure 1.5) are:

- Anything other than ivy rooted in the ground and using the wall as a climbing frame.
- Condition assessment for ivy covered structures – this is not to say this is not important, but unless the initial phase of research showed that ivy could be protective and, therefore, might best be left in place, it would be premature to look at how condition might be assessed with ivy in place.
- Presentational issues of ivy covered structures - the research project has been concerned with the physical or 'actual' protection ivy might offer or damage it might do. The aesthetics of ivy covered structures are in many ways more complex and certainly more subjective the potential to physically protect or harm. Consideration also needs to be given to the desirability or otherwise of allowing interpretative features on structures to be obscured.

Chapter 2 provides a contextual background to the research through examing the role of ivy on the presentation of historic buildings. Chapters 3, 4 and 5 review the research methods, results and implications of the Ivy on Walls project. Chapters 6, 7 and 8 highlight the issues of ivy removal, its impact on stone and an ecological perspective drawn from research carried out and observations made both as part of the Ivy on Walls project and by National Trust and National Heritage. Chapter 8 considers future research directions whilst Chapter 9 gives concluding remarks about the seminar presentations.

Clearly, despite our research goals, there are some circumstances where ivy is an undeniable nuisance and must be removed (Figure 1.6). There is no question that ivy or other plants properly rooted into walls will cause damage and should be removed in a similar way to any other tree or shrub – at the earliest possible stage.

Condition surveys – are they possible with ivy cover?

Presentation – does a building look better with ivy or without?

Figure 1.5 Ivy issues not investigated by the project.

Figure 1.6 Ivy rooted in the wall, not the ground, is always damaging.

Reference

Carter, N.E.A., Viles, H.A. 2006. Ivy on walls: scoping report (unpublished report to English Heritage).

2. Ivy and the Presentation of Ancient Monuments and Buildings.

Jeremy Ashbee, English Heritage

When looking for evidence of historic attitudes to ivy in the conservation and presentation of historic buildings and monuments, the default position, at least in the written word, is generally unremitting hostility. What is curious is that pictorial and photographic sources sometimes give a rather more positive message, suggesting that at least from an aesthetic point of view, ivy might sometimes have arguable benefits in the presentation of a structure. This is why some of this paper will fall into a pattern, in which I shall quote from eminent authors deprecating the presence of ivy on walls, while showing at the same time a photograph of a building or monument wearing a beard of ivy (Figure 2.1).

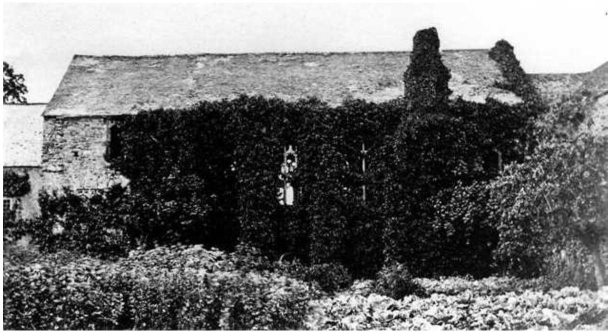


Figure 2.1 Cleeve Abbey refectory with ivy cover (left) and after ivy removal.

Attitudes to ivy are a side-issue of attitudes to vegetation in general, and for this reason I have to revisit some of the remarks I made in 2007 as part of the day conference on soft capping of ruined monuments. On that occasion I quoted from historic correspondence about one of the sites from the soft capping experiment, Hailes Abbey in Gloucestershire, to highlight a divergence of opinion. This was between the essentially technical arguments of the Office of Works, concerned with the practical matter of ensuring the survival of historic masonry in good repair, and a counter-view, particularly espoused by certain commentators like James Lees-Milne of the National Trust. Lees-Milne had taken vocal objection to a piece of masonry conservation that the Trust's own labourers had carried out in 1938 under the direction of the Office of Works's local foreman, works that had involved the dismantling and re-erection of a section of wall around the cloister (in fact, not quite the bit in these photos), and he complained that the works had been so brutal that no vegetation would ever grow on the wall again. Lees-Milne was unimpressed by the argument that without conservation the wall would have collapsed. As he wrote '*it will henceforward always look artificial and self-conscious. It is the worst example I have yet seen of wanton sacrifice of aesthetic considerations to mere archaeological pedantry*…' One undercurrent of the Hailes Abbey correspondence is worth noting in the light of what will follow: Lees-Milne and his superiors at the Trust set themselves up as advocates for the view of the wider populace, ranged against the uncaring and unsympathetic 'experts' of the Office of Works, and this appeal to popular opinion is actually quite common in other cases, for example in the letters pages of *Country Life*. Plant life is good, soft and widely-appreciated: bare stonework is bad, hard, and the exclusive province of the specialist. (Ivy, admittedly, has a notably bad popular press as uncontrollable and almost parasitical, but this sets it apart from the mainstream: an appreciation for other kinds of greenery on monuments has always been widespread).

Ivy as Concealer: Rochester Castle

The publications by Inspectors of Ancient Monuments, and also a number of antiquarians of the 18th and 19th centuries, make it clear that in their view, monuments were to be preserved for a well-defined social purpose: the instruction of those who visited them. As the Norfolk antiquary Henry Harrod wrote in 1872, historic buildings provided '*valuable studies for the architect, the antiquary and the historian*' or in other words, people with a high level of expertise, already minded and equipped to interrogate the monuments to ascertain their earlier form. At almost exactly the same time as Harrod was writing, a Royal Engineer took the black and white photograph of the castle gardens at Rochester in Kent, in which the section at the bottom left shows the drastic effect of ivy on site-presentation and the education of the visiting public. As the photo shows (Figure 2.2), the elevation of the curtain wall facing into the interior of the castle was entirely hidden by ivy until the early 20th century when the architect George Payne removed the covering in order to inspect and repair the stonework. This revealed several features of great interest in this stretch of the wall: the remains of two window embrasures of two lights (it has been suggested that there was formerly a third, in the place where the putlog holes mysteriously stop), the wall arches on the ground floor, the offset for the level of the first floor, and the line of joist sockets, which, incidentally, had to be restored by Payne: the medieval stonework in this area was fast deteriorating. But the obvious point to make is that only after the ivy came off was it possible to argue about the form of the building, or even to recognise that this was part of a building rather than just another stretch of the curtain wall. In fact it is generally accepted that this is one wall of the king's chamber in the castle, built in the 1220s on the orders of King Henry III, so there is evidence that the building is historically significant as well as architecturally reconstructable.


Figure 2.2 Rochester Castle wall covered in ivy (left) and without ivy (right).

Ivy as Concealer: Beaumaris

The point is a fundamental one and underlies not just the past approaches of the Office and Ministry of Works but also much of what we do now. The writings of Michael Thompson are perhaps the most elegant recent exposition of the objective, and in these publications, he draws particular attention to the paramount importance of making the buildings and monuments legible. A few quotations give an idea of the governing principle. *'The pleasure of a ruin is to stimulate our imagination and reconstruct in our mind's eye the structure in its original state.' 'The dominant factor in the minds of those concerned with preserving ruins today is an awareness of the value of the remains as evidenc '* (Thompson 1981, page 17). The role of the Inspector is *'to secure what remains, and to render what he secures intelligible both to himself and to the onlooker…' 'Intelligibility is the foundation of the whole operation of preservation and display'* (Thompson 1981, page 22). Like the curtain wall at Rochester, the back of the south gatehouse at Beaumaris Castle on Anglesey is a complex but fragmentary structure that benefits from analysis according to the techniques of Buildings Archaeology (Figure 2.3). Only the de-vegetation of wall surfaces after the site came into guardianship in 1925 revealed the stubs of cross-walls, details of the wall-head and so on. (I should note in passing that the concealing ivy has adverse consequences for the modern work of interpretation and conservation in the 21st century: since there are very few good records from the early years of guardianship, historic photographs of this kind become crucially important in assessing how much of the fabric is original and how much dates from early consolidation works in the 1920s). When ivy or other vegetation compromises the legibility of a monument, this is obviously an impediment to the site's presentation, at least to an archaeologically informed audience: it's a good thing that the ivy has stayed off.

Figure 2.3 Beaumaris Castle with ivy (left) and without (right).

Ivy as Concealer: Byland Abbey

While our predecessors have kept sight of the social and educational benefits that arose from their conservation work, it is true that much of their writing explicitly about ivy and vegetation focused on the technical problems that plants might pose for conservation and maintenance. In fact the Office of Works files for a site like Byland Abbey (Figure 2.4) say less than we might expect about ivy: they give the impression that lots of the debate is taken as read. Vegetation is generally malign and ivy is to be regarded as particularly dangerous, for practical reasons of which two stand out. Heasman, the Office of Works architect directing the conservation works at Byland in 1921, was particularly concerned about the potential for ivy roots to loosen stones at high level, especially on the wall-heads, and bring them down. Thus the first tasks he identified were the '*cutting out of all growths on the walls and wall-tops*' and '*securing loose and dangerous stones on the wall-heads and elsewhere*': this task was assumed to be necessary in all parts of the site. His second complaint about ivy concerned the weight it imposed on masonry and particular wind-loading in stormy weather. Thus there was fairly acrimonious correspondence between the Office and a local resident about the old gatehouse at Byland, where an ivy bush that had taken root in the masonry was deemed to pose a risk of pulling the monument over.

One further technical problem is implicit in the examples I have already used: as well as hiding the architectural and archaeological details from view, a thick growth of ivy will necessarily conceal the condition of the wall face, as was found to be the case in the decaying stonework of the curtain wall at Rochester: only when it comes off can a proper assessment be made.

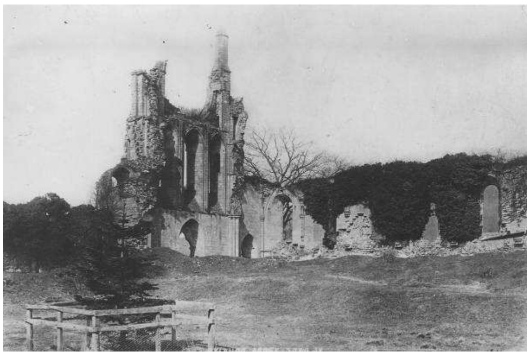


Figure 2.4 Byland Abbey.

Ivy and aesthetics - a subjective matter: Netley Abbey eastern end and St John's College, Cambridge.

The other field in which ivy and vegetation have entered the wider debate about the presentation of historic buildings has been in *aesthetics*. This is of course a very subjective matter, and before launching into it, it's important to bear in mind that the debate is concerned with the visual aspect of two sometimes different things: the merits of the building or monument itself, as it would be without the addition of any covering, and the 'finished product' of building fabric-plus-ivy. The sites that perhaps illustrate the issue most obviously are the remains of monastic houses, of which a good example is the east end of the church at Netley Abbey in Hampshire (a site for which there exists a particularly excellent set of photographs pre-dating the clearance of the early 20th century) (Figure 2.5). Almost by definition, the medieval abbey churches were buildings of some architectural merit, with complex features such as traceried windows, rib vaults, moulded columns and so on: this is why the traditional approach is to focus on the mental reconstruction of the buildings as they once were, and clearly many of them were truly a sight to see. But in some ways, they have proved no less inspiring as ruins. The appearance of a new set of fragmentary monuments in the English landscape in the middle of the 16th century stimulated a variety of creative endeavours, ranging from a revived interest in history in Tudor onlookers, to better known responses in poetry and art. A key moment must be the later 18th century and early 19th century, when writers such as William Gilpin were alerting travellers around Britain to the potentially picturesque qualities of the monuments they might visit. Netley got the same kind of reaction, as in this description of 1818: *"Where legendary saints and martyrs on the ornamented panes once testified the zeal of the founder and the skill of the artist, the ivy flaunts and the daw builds her nest while to a fanciful eye Nature and Time seem proud of their triumph over the labour and ingenuity of man"* (Bullar 1818, page 17). The fact that ivy will colonise a masonry wall on its own without the assistance of wires, beams or other support, gives particular emphasis to this quality of nature untamed and without human intervention.

Figure 2.5 Netley Abbey; abbey with little girl.

The picturesque quality of Netley Abbey in its late 19th century state with ivy is undeniable, as shown in numerous carefully composed photographs like this one (Figure 2.5). To read descriptions of what it felt like to visit such an abbey, or a castle during the nineteenth century is to be left in no doubt that many visitors responded very positively to the ruined nature of the sites, and that the shrouding of walls in ivy was regarded as a genuine enhancement. The spirit of 'melancholy contemplation' is a recurrent motif in appreciations of this kind of monument. Rather like Edward Gibbon taking inspiration from the ruins of the Forum in Rome, a visible sense of the monument in decay, over-run by greenery, only served to heighten the contrast between the present scene and the supposed former prosperity of the days when monks still processed chanting around the cloister. (This contrast may be attractive at abbeys suppressed by Henry VIII or castles ruined in the Civil War, but it is likely to be unwelcome in more recent buildings or monuments: for example the ivy that covers Western Heights at Dover, a Napoleonic and Victorian fort, appears obviously as a matter out of place and highlights the poor condition of a monument that should not be allowed to fall into disrepair (*author's view*).

It is true that people at all ages have been influenced by more widespread cultural trends, but ultimately the question of whether something is appealing or unsightly is often going to be a subjective matter. When reviewing historic buildings the potential for controversy is likely to rise considerably compared with modern structures. That said I'm happy to stick my neck out and give this example of a building that ivy has helped, through softening and even concealment: it's the rear face of New Court at St John's College Cambridge, commonly known as the 'wedding cake', built between 1826 and 1831 (Figure 2.6). The nickname refers to the other side of the building, mostly faced in stone with much more complex architectural detailing: this side has plain brick walls articulated only by tiers of identical windows and looks for all the world like a factory or a workhouse.

Figure 2.6 St John's College. Cambridge, rear face with ivy

As I mentioned, it has sometimes been possible to detect a separation between the views of the 'professionals' and those of the 'laity': what we are now talking about is the latter position, and among its principal characteristics has been an appreciation of the monument in its current state, not solely as an archaeological or architectural understanding shows it once to have been. As we've seen, this point of view has a long ancestry, longer than that of the analytical approach. But it is a fair question of whether as professionals we have completely divorced ourselves from the emotional baggage in favour of their potential to inform directly from their existing fabric.

In 1977 the answer from within the Inspectorate would have been 'yes.' The late Andrew Saunders, formerly Chief Inspector could insist that '*we have moved a long way from the 'cult of ruins', attractive though this can be, to something a good deal more scientific*.' He nevertheless felt the need to sound a note of caution. '*There are still those who see virtue in the 'progressive ruin'; who value monuments more for their 'atmosphere' and the aesthetic appeal of decay and creeper. It is however a selfish view which tolerates the rapid destruction of the object which is admired. A balance has to be struck between the romantic approach which can at least be catered for at monuments of little archaeological importance and the identification of those monuments to be kept for their evidential quality'* (Saunders 1977, page xv-xix). The contrast he drew between the evidential value of sites and their atmospheric quality was apparently in some cases too fundamental to reconcile, and he also clearly took the view that in most cases, making the evidential value of the sites visible to the public was the over-riding priority.

Ivy and Conservation Principles

Nowadays it is unlikely that we would be so prescriptive. When analysing a problem, we are now required to use the terminology of *Conservation Principles* in whose schema three of the four types of value are likely to embody appeals to the emotion as well as the intellect: *aesthetic value*, but also *historical value* (which I choose to interpret as associations with persons, groups or events other than those that can be read directly from the fabric), and *communal value* (how modern people use the site, what it means to them). I should note by the way that *Conservation Principles* really only deals with cultural values: any modern project will additionally involve cognisance of ecological values, both the importance of the vegetation itself and its capacity to serve as habitat for other species.

So to start to look for a way forward, as with soft capping, it seems to me that there are certain basic priorities that should not be forgotten, of which the most pressing must be to ensure the ongoing survival of the monument, and at the very least to remove agents that accelerate the process of deterioration. For this reason this seminar is invaluable, for a dispassionate assessment of the conditions under which ivy is dangerous and those under which it has a protective effect. Recent experience has provided a salutary reminder of how these two effects can appear together in close juxtaposition. The conservation works at the Chapter House at Westminster Abbey involved the removal of ivy from two large buttresses, in order to allow assessment and where necessary conservation of the masonry. For the overwhelming majority of the elevations, the stonework was found to be in astonishingly good condition: masonry joints completely sound and good survival of the facing, sometimes with tooling still preserved. But at the highest level of the buttress, this coping stone had become displaced through ivy action, and obviously needed to be re-set: such measures are central to the work of an organisation such as English Heritage.

Such works will require ivy to be taken off: whether we keep it off is another question. To determine this will depend on the part of the building and monument in question, and *Conservation Principles* sets out a rationale for the discussion. It isn't now taken for granted that the evidential value of a site will always take precedence over other factors, and it is now permissible to acknowledge that the values may sometimes be in direct conflict: for example some parts with the greatest interest for reconstructing the development of the fabric may also be visually jarring, with a mixture of building materials, ragged stubs of walling, exposed wall core and so on. In those moments the task becomes one of assessing the degree to which the fabric expresses or embodies each of the values and still more subjectively, how central each is to the identity of the site.

Conclusion

While we have moved some distance away from the cultural values of the Picturesque, it is undeniable that positive associations of vegetation run deeply, in discussions among professionals as well as the laity: this is sometimes signified by emotive terms such as the contrast of 'hard and soft' surfaces, the use of the word 'organic' and the most generic term of all, 'green.' But among plants, ivy brings certain specific associations. We may have moved away from the ubiquitous mown lawns, straight paths and bare masonry of the traditional site presentation regime, but an organisation like English Heritage is still likely to struggle with the connotations of lack of control that free-growing ivy can sometimes embody. Where to draw the line is the difficult part, and I leave you with this image of Fountains Abbey (Figure 2.7). For me this just on the uncomfortable side of the line, partly because I'd admit that Fountains is an especially famous site among the suppressed monasteries of the north, partly because this west elevation is one of the show-pieces of the monument, recorded in millions of photographs, and partly because ivy conceals some evidence for the form of the western galilee porch. I leave it to others to consider whether the softening effect of the ivy here strikes them as pleasing, as inessential but harmless, or as intrusive, as matter out of place. And then after hearing in greater detail over the course of the day about the physical effects of ivy on the fabric, we should ask ourselves again at the end whether we still view this kind of image in the same way.

Figure 2.7 Fountains Abbey

<u>References</u>

Thompson, M. 1981. Ruins - Their Preservation and Display. Colonnade Books, London.

Bullar, J. 1818. A Companion in a visit to Netley Abbey, to which is annexed Mr Keate's Elegy, 5th edition. T. Baker, Southampton, p 37.

Saunders, A. 1977. Introduction. in: Apted, M., Gilyard-Beer, R., Saunders, A. (eds) Ancient Monuments and their Interpretation (London and Chichester, 1977), pp xv-xix.

3. Research Methods and Sites

Heather Viles, University of Oxford

The Ivy on Walls research project had five main objectives and specific methods and sites have been used to address each of these, as documented in Table 3.1. Our basic methodology was to combine field monitoring, field experimentation and laboratory analyses with questionnaires and interviews in order to provide an interdisciplinary assessment of the role of ivy.

Table 3.1 Project objectives and the sites and methods used to address them

Objective	Sites	Methods
1. Testing the role of ivy in regulating wall temperature and relative humidity regimes	a) 5 field sites in different climatic areas b) 5 sites within Oxford	Each site monitored for 1-3 years with temperature and RH probes and dataloggers.
2. Evaluating how aerial rootlets attach to walls	Small-scale test walls in Oxford	Medium term growth experiment
3. Finding out when, why and how ivy roots into walls	Large-scale test wall at Wytham Woods, near Oxford	Long term growth experiment
4. Testing whether ivy prevents or reduces particulates (e.g. dust and pollution) reaching walls	Various Oxford walls	Collection of samples followed by laboratory analysis
5. Understanding perceptions and management strategies for ivy on walls	Oxford and monitored field sites	Interviews and questionnaires

Objective 1: Testing the role of ivy in regulating wall temperature and relative humidity regimes.

a) Sites used

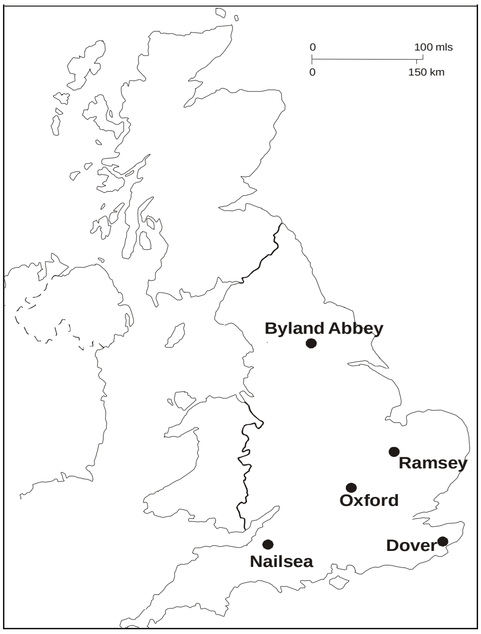


Figure 3.1 Ivy test sites in England.

To provide a broad, England-wide test of the role of ivy in moderating microclimatic conditions at the wall face, we monitored conditions at five sites. Ideally, we wanted to compare sites which were similar in every characteristic except their location. We hypothesized that ivy might provide a different influence on wall microclimates in harsher climatic zones (e.g. northern and coastal locations) than in more benign environments. The spatial distribution of sites is shown in Figure 3.1. However, a range of practical constraints meant that our sites varied not only in location, but also in terms of thickness of ivy cover and aspect. Within the Northern part of England we monitored the front (east-facing) wall of the Abbey Inn in Byland, which is built of the local sandy-limestone. Parts of the wall are covered with an ivy canopy around 20 cm thick (Figure 3.2a). In western England we monitored conditions on the west-facing side of Elms Colliery in Nailsea. The wall is around 10 m high and composed of limestone (Figure 3.2b). Sections of it are covered by a relatively thin (< 10cm) ivy canopy. The third monitored site (Figure 3.2c) is in the south east of England and forms part of the Drop Redoubt, within Western Heights, Dover. It is an east-facing brick wall, around 7 m high largely covered by a thick ivy canopy (around 90 cm thick). In the east of England we monitored a south-facing limestone wall forming part of the boundary of the St Thomas a Becket churchyard in Ramsey, Cambridgeshire. The wall, probably built of limestone, is around 2.5 m high and patchily covered with a c. 25 cm thick cover of ivy (as shown in Figure 3.2d). Within the central part of England we monitored a south facing limestone garden wall at Worcester College in Oxford, about 2.5 m high and patchily covered with a 35 cm thick growth of ivy (see Figure 3.2e). A further site was monitored for several months before vandals stole the monitoring equipment in Autumn 2007. This site at Leicester Abbey was on a west-facing sandstone and granite garden wall around 3.5 m high with a 50cm thick ivy canopy (see Figure 3.2f).

a. Abbey Inn, Byland *b*. Elms Colliery, Nailsea (2 views) *c*. Drop Redoubt, Dover

d. Ramsey churchyard *e*. Worcester College, Oxford *f*. Leicester

Figure 3.2. Ivy monitoring sites in England

In order to test the influence of ivy on wall microclimate on walls of different aspect, without the confounding influence of different climatic conditions, we used a similar network of sites within Oxford as summarised in Table 3.2. We hypothesized that ivy might have a more obvious impact on the microclimate of walls whose aspect favours intense heating and cooling throughout a diurnal cycle, i.e. walls facing south. As Table 3.2 indicates, some problems were experienced in Oxford with trimming and cutting down the ivy at some sites. Replacement sites were established where possible. Clearly, it is not possible to hold all other variables apart from aspect constant in this type of field experiment and sites also varied in respect of the thickness and nature of ivy cover. Furthermore, the geometry of roads and buildings means that the aspect is not the only control of conditions on the wall – as some walls may be shaded by other nearby buildings.

Table 3.2 Sites used to investigate the influence of ivy on the microclimates of walls of different aspects in Oxford.

Rewley Abbey	Rhodes House	Trinity College	Old City Wall (Social Studies Library)	Pembroke College
East facing Limestone 2.5 m high 25-55 cm thick ivy	East facing Limestone 3m high 25 cm thick ivy	West facing Limestone 3 m high 40-100 cm thick ivy	North facing Limestone 3.5 m high 110 cm thick ivy	South facing Limestone 5m high 50 cm thick ivy
Ivy cut down in Dec 2008	Set up Jan 2009 to replace Rewley Abbey	No problems	Ivy removed in Feb 2009	Ivy trimmed April 2009

b) Methods used

In order to test the role of ivy in regulating temperature and relative humidity at the surface of the walls we used two sets of monitoring equipment. At the beginning of the project we used Tinytag data loggers (Tinytag Plus 2: TGP-4500) with self-contained temperature and RH sensors (Figure 3.3a). These small (c 8 x 6 x 3 cm), weatherproof and robust dataloggers are capable of storing 32,000 data points and can be programmed to collect data at any specified time interval from 1 sec to 10 days. We attached them to the walls with Blu-tack adhesive and programmed them to collect data every hour. Initial tests indicated that these dataloggers were reliable under our field conditions, but two problems emerged later. Firstly, the RH sensors were prone to clogging with dust, and secondly they were prone to theft. A second type of datalogger was then deployed at all sites, i.e. iButton hygrochrons which also record temperature and RH at intervals (Figure 3.3b). Hygrochrons are also robust, weatherproof devices, but much smaller than the Tinytag (c 1.5 cm diameter and 0.25 cm thick). They can be programmed to collect data at intervals from 1 sec to 273 hours, and can store over 8,000 data points. We attached them to the walls with Blu-tack. At each site we set up pairs of dataloggers, one set on the wall behind the ivy canopy and one set on an adjacent section of wall without ivy. We collected data every hour for at least 1 year and then statistically analysed (t-test, analysis of variance) the data to compare ivy-covered with bare walls. We also assessed the impact of ivy on surface moisture using a GE Protimeter on test walls at Wytham Woods, Oxfordshire. This involved monthly surveys on walls beneath ivy canopy vs exposed surfaces. Protimeters give a rough estimate of surface moisture, based on the resistivity method. Because porosity and salt contents influence protimeter readings it is not possible to compare data between sites composed of different materials.

a) 

b) 

Figure 3.3 *a*) Tinytag and *b*)Hygrochron devices in place on an ivy-covered wall.

Objective 2: Investigating the effects of ivy's aerial roots

In order to study how ivy's aerial roots interact with walls, it was necessary to create our own micro-scale test walls so that we could grow ivy on fresh and clean stone and mineral samples over a known period of time and then observe what occurred. There is very little published information on how ivy rootlets adhere to materials; recent work suggests that the ivy can secrete nanoparticles which rely on hydrogen bonding to attach to surfaces (Zhang et al., 2008; Meltzer et al. 2010). We hypothesized that ivy rootlets would have a greater effect on carbonate stones and minerals (calcite, limestone and marble). Two micro test walls (35 x 45 cm) were constructed in the oxford Rock Breakdown Lab from plywood. Individual test blocks of limestone, sandstone, calcite, marble and glass were then glued to the wall to create an array of different substrates for the ivy to grow on. The walls were placed in two Oxford centre gardens (one facing north and one facing east). Ivy was planted in front of them and encouraged to grow over them. After 1 year in situ from May 2009 to May 2010, the test walls were taken down and studied in detail. Where ivy stems had grown over the different substrates and rootlets attached to them, these were observed and photographed under the dissecting microscope.

Objective 3: Finding out when, why and how ivy roots into walls

In order to address this objective, we built a test wall at our field site at Wytham Woods, near Oxford, and allowed ivy to grow up it. Based on field observations, we hypothesized that ivy roots would penetrate into walls only when there are holes reaching right through the wall. The wall was built in August 2007 from Elm Park limestone with lime mortar. It consists of four faces (facing N, S, E and W) around a central core. Each face is 1.2m wide and 2m high. The wall was built with a range of defects which we hoped would encourage ivy to take root within the wall. The defects were different forms of hole within the mortar joints, from small tubes to large crevices. Ivy was planted at the base of the left hand side of each face and encouraged to grow up the walls, so that on each face we would end up with one ivy covered half and one bare half. A wire mesh fence was placed around the wall to prevent deer (common in Wytham Woods) and other animals from nibbling the ivy. The test wall is shown in Figure 3.4 before and after ivy growth.

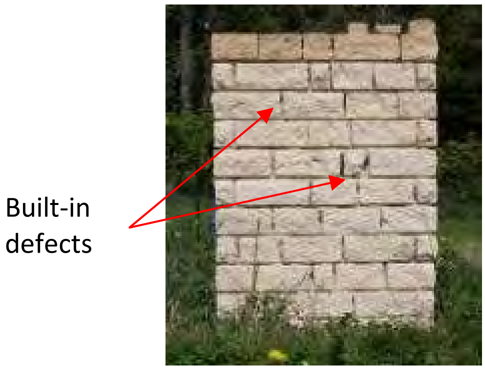


Figure 3.4 Wytham test wall before and after ivy growth.

Objective 4: Testing whether ivy prevents or reduces particulates reaching walls

Ivy may play a role in protecting walls from the deposition of dust, pollutants and other harmful particles. In order to test whether ivy does play a significant role, we chose three sites in and around Oxford where ivy grows on roadside walls. The sites were chosen to reflect different levels of traffic, which we assume results in different concentrations of particulates in the air, based on much evidence which suggests that traffic is a major control of particulate pollution levels within urban areas. The three sites chosen were (a) London Road, Headington which experiences around 19,000 vehicles a day (b) Walton Street which has around 3,100 vehicles a day and (c) two sites in Wytham Woods – one of which has 50 vehicles a day passing (and where the ivy grows on a tree) and the other of which has no traffic (where the ivy grows on our test wall).

We investigated a range of methods to compare the particulate pollution loading on ivy-covered and bare sections of walls, and found problems with most of them. The use of test substrates (plastic, glass or foam) on which to collect particulates deposited on ivy-covered and bare walls suffered from high loss rates of the substrates. Comparing particulate deposits on actual bare and covered wall surfaces was difficult because of the ancient nature of many walls and the difficulty of taking samples. Finally, we devised a method whereby at each site two leaves were sampled from the front and back of the ivy canopy. This sampling reflects the amount of material deposited on identical substrates (in this case ivy leaves) at the front of the canopy (which would be analogous to the amount deposited on a bare wall surface) and at the back of the canopy (analogous to that deposited on an ivy-covered wall surface). It has the advantage that it compares like with like – as both sets of samples are taken from ivy leaves themselves. Furthermore, it has the advantage of illustrating exactly how particulates get absorbed onto ivy leaves. Disadvantages of this method include the fact that we do not know how long each leaf has been exposed to particulate deposition.

Having taken the samples, two 1cm^2 sections of leaf were attached to aluminium stubs and viewed at high magnifications (x 100, x 250 and x 500) using scanning electron microscopy (SEM) in the Department of Earth Sciences, University of Oxford. The number and areal coverage of particulates on each section of leaf was then quantified using Image J software and statistical comparisons made between front and back of canopy samples at the three different sample sites.

Objective 5: Understanding perceptions of ivy

Whilst the major focus of our research was on the actual impacts of ivy on the environment surrounding walls and the deterioration of building materials, we were also interested to find out more about people's perception of ivy and its role in building conservation and deterioration. We carried out interviews with the people in charge of managing the ivy at all our study sites to find out whether they regarded ivy as a nuisance or something which might bring practical benefits. We also carried out a questionnaire survey of 113 people within central Oxford to gain a wider sample of views on ivy and whether it is a good or bad thing on walls. The questionnaire involved both closed questions (using a 5-point ranked scale for answers from strongly disagree to strongly agree as shown in Table 3.3) and open questions in order to try and get a balanced impression of people's views.

Table 3.3 Section of the questionnaire showing the closed questions asked

	1=strongly disagree	2=mildly disagree	3= neither agree nor disagree	4=mildly agree	5=strongly agree
Ivy looks attractive on walls					
Ivy damages walls					
Ivy cover makes walls look neglected					
Ivy protects walls					
Ivy has an effect on old buildings					
Ivy gets out of control					
Ivy may have health benefits					
Ivy is harmful to stone walls and buildings					
Ivy is part of England's history					
Ivy should be removed from walls					

References

Zhang, M., Liu, M., Prest, H, Fischer, S. 2008 Nanoparticles secreted from ivy rootlets for surface climbing. Nano Letters 8, 1277-1280.

Melzer, B., Steinbrecher, T., Seidel, R., Kraft, O., Schwaiger, R., Speck, T. 2010. The attachment strategy of English ivy: a complex mechanism acting on several hierarchical levels. Journal of the Royal Society - Interface. 7: 1383-1389.

4. Field and laboratory results

Troy Sternberg, University of Oxford

Part 1 Ivy – biodeterioration or bioprotection

To meet the project objectives in Chapter 3 we conducted exploratory tests including several lab-based and *in situ* trials to assess the effect of ivy (*Hedera helix* L.) on stone walls. Two objectives were selected for in-depth examination - investigating ivy's impact on wall surface microclimates and whether ivy stops particulate pollution from reaching walls. Ongoing research of two additional aims assesses ivy rootlet attachment on different stone types through a micro-wall study and uses the purpose-built ivy wall to examine ivy rootlet attachment and impact on stone and mortar, moisture patterns on ivy-covered and exposed surfaces and the importance of aspect on ivy-related processes. Additional work identified the public's perception of ivy in the built environment.

Public impressions of ivy

The project began with interviews of gardeners, landscape managers and architects. These 'experts' had a predominately negative view of ivy's impact on stone. It was expressed that ivy had a deteriorative effect wall surfaces and should be 'managed'. We followed this up with a survey of the general public in Oxford in Spring, 2010. A representative sample (n=113) covering three age groups (18-29 years; 30-59 years; 60+) was undertaken in central Oxford. Strongest responses were that ivy gets out of control, that it looks attractive and that ivy is part of English history. Next came opinions that ivy affects old buildings, harms stone and damages walls. There was less consensus over whether ivy makes walls look neglected or may have health benefits whilst there was no agreement whether ivy should be removed or that it protected walls. Women and people with ivy on their walls had stronger opinions, while there was no difference between town and country dwellers. A large majority of respondents (80%) formed their opinion from personal experience. Older (>60 years) residents disliked ivy whilst young (18-29 years) people had a favourable impression. Some respondents believed, perhaps a little idealistically, that 'ivy should be managed by ivy managers'.

Ivy Microclimates

Research investigated whether ivy affects wall microclimates and thus might contribute to protection or deterioration of stone wall surfaces. The study selected five sites in England in different areas with varying aspect and thickness of ivy canopy (Figure 4.1). Locations included Byland (near the North York Moors in Yorkshire), at Dover Drop Redoubt near the coast, Elms Colliery in Nailsea, Somerset, at St Thomas a Becket Church in Ramsey, Cambridgeshire and at Worcester College in Oxford.

iButton Hygrochron recording devices (about the size of a coin) were used to monitor temperature and relative humidity fluctuations at the wall surfaces (Figure 4.2) as explained in more detail in chapter 3. Hourly temperature and relative humidity data were recorded for and data has been analysed for one year from May 2008 to April 2009 (Table 4.1).

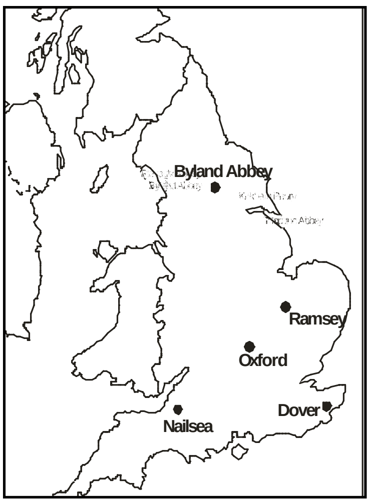


Figure 4.1 Ivy monitoring sites in England.

From the iButton measurements daily maximum, minimum, and mean temperature and relative humidity statistics were calculated for each site. This process provided a huge data base (>3 million points) on the ivy microclimate for analysis. A data checking process enabled an evaluation of the quality of temperature records and identified problems with relative humidity results when humidity reached 100% and then cycled back to 0, necessitating some ‘cleaning’ of the data.

Table 4.1 Summary site information

Site/Location	Aspect	Ivy canopy thickness (cm)	Exposure to light*
Byland	East	c.20	high
Dover	East	c. 95	high
Nailsea	West	c. <10	low
Oxford	South	c. 45	high
Ramsey	South	c. 24	medium

* Exposure to sunlight without obstruction (building, trees) evaluated through repeated visual inspection.

Figure 4.2 Byland site showing ivy-covered surface (left) and exposed surface (right).

Results

Hourly data showed a general mediating effect of ivy canopies on both temperature and relative humidity regimes. The ivy reduced extremes of temperature and relative humidity, with the most clear-cut differences found for temperature. Across all five sites the average daily maximum temperature was 36% higher and the average daily minimum temperature 15% lower on exposed vs ivy-covered surfaces. Differences in the exposure level of studied walls (i.e. whether they are shaded or not by trees or other walls) influenced the degree of microclimatic alteration provided by the ivy canopy. Other important factors influencing the strength of the ivy impact on microclimate were found to be thickness of the canopy and aspect of the wall.

Figure 4.3 illustrates the difference between ivy covered and exposed walls at each site. The bar chart shows the differences between the average daily maximum and minimum temperature on ivy-covered vs exposed surfaces throughout the year. The last pair of bars uses data from all sites to create an average across all sites. This shows on average exposed walls experienced 4.5 °C warmer maximum temperatures and 1.5 °C cooler minimum temperatures.

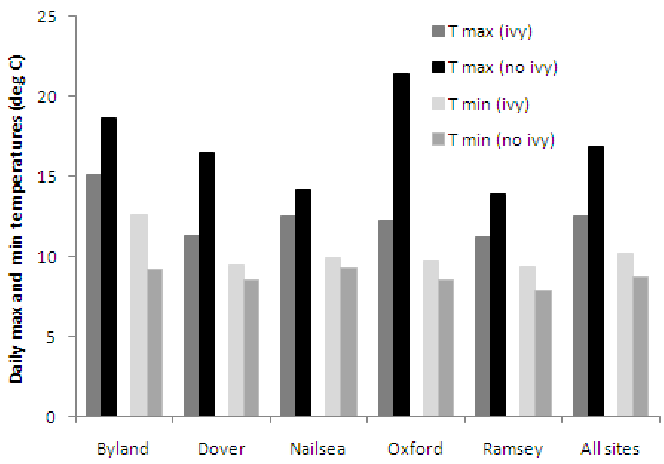


Figure 4.3 MaxImum and minimum daily temperatures with and without an ivy cover at the five sites and mean values for all sites

The ivy also affected the diurnal range of temperature and humidity throughout the year. On average, exposed surfaces had a mean daily temperature range which was 3.6 times greater and a humidity range 2.7 times greater than those found on the ivy-covered walls (Table 4.2).

Table 4.2 Average temperature/humidity and range of temperature/humidity between ivy-covered and exposed surfaces.

Mean Daily Temperature °C		Mean Daily Temperature °C Range		Mean Daily Relative Humidity %		Mean Daily Humidity Range %	
Covered	Exposed	Covered	Exposed	Covered	Exposed	Covered	Exposed
11.20	11.75	2.30	8.27	89.6	86.04	9.33	24.95

Byland – detailed analysis

Looking at one site in detail helps understand the microclimate processes at work over the year. For example, the Byland site illustrates the multiple effects ivy cover can have on a stone wall. The difference in mean daily temperature between ivy-covered and bare sections of the wall at Byland was only around 1 °C, but the exposed surface experienced higher maximum daily temperatures (average 3 °C higher) and lower daily minimum temperatures (average 3 °C lower) than the ivy-covered surface. Such differences were highly statistically significant. Similar differences are also found in the relative humidity data (Table 4.3).

Table 4.3 Differences in maximum and minimum daily temperature and relative humidity data from Byland, Yorkshire (summarised after Sternberg et al., 2011, table 5)

	Temperature (°C)				Relative humidity (%)			
	Max	Min	Mean	Range	Max	Min	Mean	Range
Covered	15.14	12.58	13.77	2.56	76.90	62.76	69.53	14.14
Exposed	18.61	9.20	12.68	9.41	91.22	60.65	78.68	30.57

Difference	3.47	-3.38	-1.09	6.85	14.31	-2.11	9.16	16.42

Investigating daily temperature data for January and July at Byland illustrates greater variability on the exposed surface, particularly in July (Figure 4.4). The ivy cover creates a microclimate with less variation and a more limited daily range than the exposed surface. In July the major effect of the ivy cover is to significantly reduce the diurnal temperature maxima, especially on warmer days, keeping surfaces cooler. In January, conversely, the major impact is to prevent the surfaces from cooling down excessively at night – and reducing any threat of the temperature falling below 0 °C. There was a marked difference (exposed minus covered) in maximum and minimum temperatures for the highlighted months.

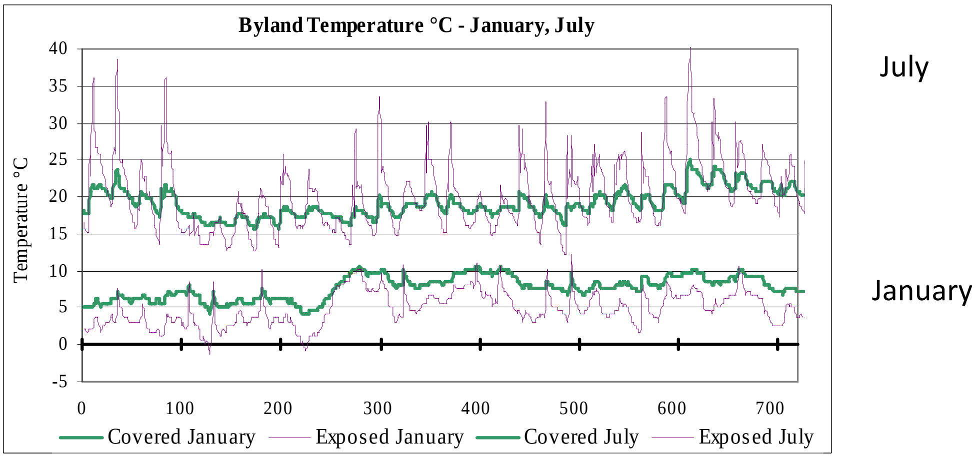


Figure 4.4 Byland hourly covered and exposed temperature, July 2008 (top 2 lines) and January, 2009 (bottom 2 lines). From Sternberg et al., (2011).

More details on the data collected from the England sites are reported in Sternberg et al., (2011).

Ivy, Stone and Particulates

A range of recent research papers have addressed how urban greenery interacts with airborne dust and pollutants. As a common form of vegetation across much of the world the role of ivy (*Hedera helix* L) can have broad environmental and management implications in diverse urban settings. Using Scanning Electron Microscopy we investigated particulate deposition on ivy along roadways to determine if ivy can protect or reduce exposure to dust and pollutants that can instigate decay processes on stone walls and impact upon human health in urban environments.

We examined three sites in Oxford (London Road – high traffic; Walton Street – moderate traffic; Wytham Woods – minimal traffic) to assess (a) dust adherence on ivy leaves; (b) particle number, size, density and composition; (c) potential role of ivy in reducing impact of pollutants. As presented in Sternberg et al. (2010), our findings showed that ivy trapped particulate matter to act as a ‘particle sink’, especially in areas with lots of traffic. Figure 4.5 illustrates the difference in particle loadings on exposed leaf surfaces from the different locations. As figure 4.6 shows, the outer parts of the ivy canopy on the busy road site (London Road) had significantly more particles per mm^2 than the inner parts of the canopy, and a higher proportion of fine and ultra fine particles (< 2.5 micron in diameter) which often come from vehicle exhausts.

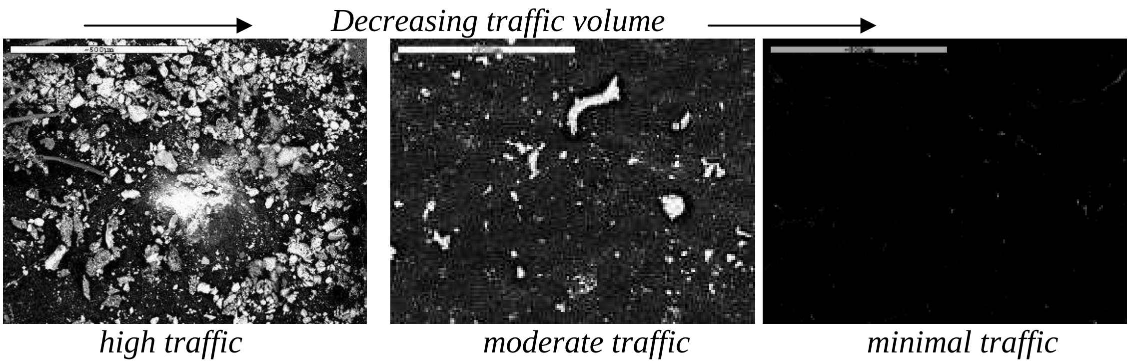


Figure 4.5 Microscope images at 100x magnification on exposed surface (*left* – London Road, *centre* – Walton Street, *right* – Wytham Wall). Scale bar = 500 microns in each image. Reproduced from Sternberg et al., (2010).

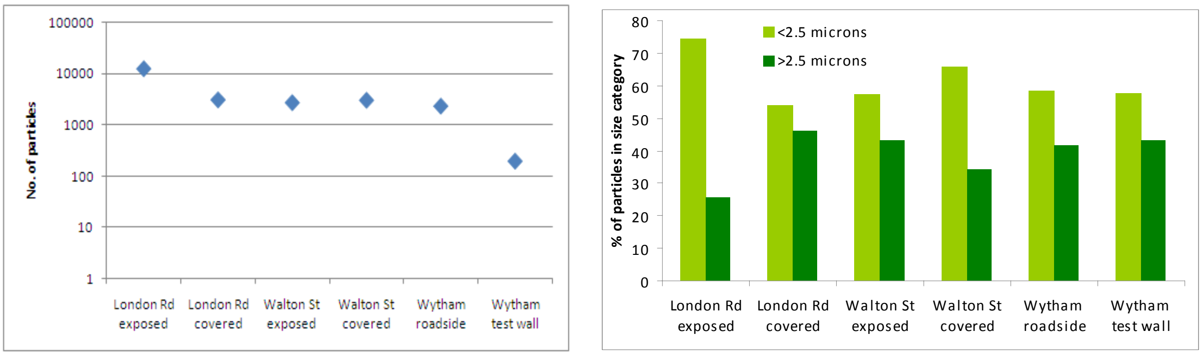


Figure 4.6 Number of particles per mm^2 of leaf surface at x250 magnification (note logarithmic scale) – *left,* and % of fine and ultra fine vs coarser particles at x 250 magnification – *right.*

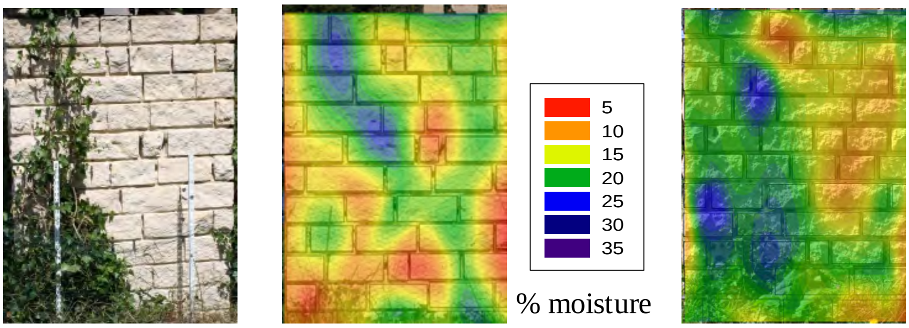
Figure 4.6 also illustrates that the other, less well trafficked, sites had less clear differences between the outer and inner parts of the ivy canopy. The difference between the particulate loadings on leaves on the outer and inner parts of the canopy at the most trafficked site suggests that ivy can protect or reduce exposure to pollutants that can instigate decay processes on stone walls. However, the low particulate counts on sites along quiet roads limit its bio-protective role in rural settings. Further details on the methods used and the data collected to elucidate the role of ivy in removing harmful pollutants are given in Sternberg et al., (2010).

Part 2 - Ongoing research

Two ongoing research experiments not covered in the seminar presentation include monitoring on a specially-built ivy test wall and examination of ivy rootlet attachment to different stone types. The ivy test wall was constructed in 2007 (see Chapter 3) to investigate the role of ivy on stone surfaces, including ivy effect on the wetness of wall surfaces, exploitation of structural weaknesses, methods of attachment and the potential role of aspect. As Figure 4.7 Illustrates ivy has successfully started to climb the walls. As yet there is no evidence of ivy roots growing into any of the hollows and crevices built in to the design of the wall. Preliminary data collected with a protimeter suggests there can be a difference in moisture levels between ivy-covered wall surfaces and exposed surfaces. As can be seen in Figure 4.8 the south-facing wall appears drier under ivy; whereas the reverse applies for the east-facing wall. Figure 4.8 *b* & *c* show the difference in stone moisture levels depending on wall aspect. Findings also suggest that aspect plays a role as temperatures differ between the wall faces and ivy growth is thicker and more substantial on west and east walls. Thus, the impact of ivy on wall surface moisture levels will vary with aspect.

Ivy Test Wall 2008 2009 2010

Figure 4.7 Ivy test wall, east face reflecting ivy colonization over time.



a *b* *c*

Figure 4.8 *a*. South facing wall with ivy, *b.* moisture on the south wall, and comparison with *c.* east wall, May 2010.

We have grown ivy on a special micro-wall built of small blocks (~2cm^2) of different stone types to test ivy adhesion (Figure 4.9). After one year rootlets and stone blocks have been examined using microscopy to assess any deteriorative effects (Figure 4.9*b* & *c*). We found no noticeable impact or degradation of the stone surface from rootlet attachment.

a *b* *c*

Figure 4.9 *a*. Micro-wall testing ivy rootlet impact on different stone types, *b* & *c* magnified photo of ivy rootlets on stone.

<u>References</u>

Searle D. 2001. The comparative effects of diesel and coal particulate matter on the deterioration of Hollington sandstone and Portland limestone. PhD. Thesis, university of Wolverhampton.

Sternberg, T., Viles, H., Cathersides, A. 2010. Evaluating the role of ivy (*Hedera helix*) in moderating wall surface microclimates and contributing to the bioprotection of historic buildings. *Building and Environment.* DOI:10.1016/j.buildenv.07.017

Sternberg, T.,Viles, H., Cathersides, A., Edwards, M. 2010. Assessing how ivy (*Hedera helix*) on walls interacts with airborne particulates in an urban setting. Science of the Total Environment. DOI:10. 1016/jscitotenv.2010.09.022

5. Interpretations and implications of our results

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1. Weighing up the risks and benefits of ivy

In order to evaluate clearly the influence of ivy on the deterioration and preservation of historic walls, it is important to think more broadly about the factors which cause deterioration. Table 5.1 summarises the key processes of deterioration which are known or suspected to affect walls within England.

Table 5.1 Major processes of deterioration affecting masonry walls

Physical	Chemical	Biological
Freeze-thaw	Runoff- or rising damp-induced chemical weathering	Roots
Wetting and drying	Pollution-induced chemical weathering	Lichen weathering
Heating and cooling		Microbial weathering
Salt weathering		

Looking first at physical deterioration the processes of freeze-thaw, wetting and drying, and heating and cooling encapsulate different ways in which temperature and moisture cycling (over diurnal or shorter timescales) can cause building materials to break down. Linked to this, salt weathering processes occur when salts repeatedly cycle through crystallised and dissolved phases as a result of cycles of temperature and moisture. In order to reduce the impact of such processes it is necessary to reduce the amplitude and/or frequency of such damaging cycling events. Turning to chemical deterioration, runoff-induced and pollution-induced chemical weathering occur when elements and compounds dissolved in water passing over or through the building materials react with the minerals in them. For example, rainwater is naturally acidified with carbon dioxide and this weak acid can react with carbonate minerals. Air pollution brings other threats – such as sulphur-rich particles and gases which, in the presence of water, can react with minerals to produce deterioration. Soiling of building materials is also a concern when air and rainwater contains particle loadings (pollutants and natural dust). In order to reduce the threat of these chemical deteriorative processes it is necessary to reduce the amount of rain and pollutants, dust etc. reaching the walls. Finally, looking at biological processes of deterioration it is clear that microbes, lichens and higher plants can all cause deterioration as a result of physical and chemical processes. They can cause physical breakdown through exerting pressure as they grow into building materials, and chemical decomposition as they can secrete acids and other compounds. However, looking at the other side of the coin it has been shown that some lichens and microbial communities (often called biofilms) are capable of protecting the surface from other processes of deterioration by producing a protective film on the surface.

Focusing now on the potential impacts of ivy, Table 5.2 lists the good and bad roles – with passive effects largely having a protective role and active effects causing deterioration.

Table 5.2 Active and passive roles of ivy in relation to deterioration of walls

Passive roles	Active roles
Ivy canopy may prevent excessive heating and cooling – moderating freeze-thaw, salt weathering and other processes	Roots may penetrate vulnerable walls and cause physical breakdown
Ivy canopy may regulate humidity and stop rainfall hitting wall – reducing chemical weathering	Aerial rootlets may chemically deteriorate vulnerable minerals
Ivy may absorb pollutants and salts - reducing weathering	
Ivy may keep walls damp through reducing evaporation – potentially enhancing chemical weathering	

Looking at the passive effects of ivy, it is clear that the presence of a canopy of ivy should reduce damaging cycling of temperature and relative humidity, and stop rainwater and pollutants and other particulates from reaching walls. However, ivy and other biological covering on walls might also keep walls affected by rising damp etc. wet by reducing evaporation from the surface if relative humidity is kept high under the canopy. Turning to the active impacts of ivy it is clear that, like many other higher plants, ivy roots pose a threat to historic walls. They can grow under walls and into cavities within walls and cause physical breakdown as they grow. Aerial rootlets may cause damage to sensitive minerals as a result of the way they cling on to walls (which seems to be a result of some 'glue' that they produce – the details of which are debated – see Zhang et al., 2008; Melzer et al., 2010). However, their impact is much more superficial than that of ordinary roots – they do not penetrate into walls in any significant or serious way.

Three important points come out of this review of the deteriorative processes affecting walls. Firstly, the role of ivy in deteriorating or protecting historic stonework needs to be seen as multi-facetted – ivy plays many roles. Secondly, the impacts of ivy need to be weighed up against the other agents of deterioration affecting walls – of which there are usually many. Finally, the dominant role of ivy will vary from wall to wall depending on the local situation and the balance of other processes operating. Thus, ivy may be clearly good for some walls but less good or even damaging for others. The key to good conservation decisions involving ivy is in weighing up for any one situation its multiple impacts against those of other agents of deterioration.

2. Evaluating our results in terms of the project objectives

Our research project had five major objectives and our results need to be evaluated in the light of each of these. In some cases we have already collected clear evidence, in other cases more needs to be done because of the difficulties in providing short term answers to long term questions.

2.1 Does ivy regulate microclimatic conditions on the face of walls

Using the one year of data collected with ibuttons at the five main sites around England we can see that there is clear evidence that ivy does indeed regulate microclimates at the wall face. The evidence is most strong for temperature as summarised in Table 5.3 These findings illustrate that ivy is generally successful in moderating temperature fluctuations across all the studied climatic areas of England.

Table 5.3 Observed impacts of ivy on wall surface temperatures from research at 5 sites in England

Parameter	Impact of ivy
Mean temperature	No significant impact
Daily maximum temperature	Lowers the maximum temperature experienced at all sites, most notably at Worcester College, Oxford
Daily minimum temperature	Raises the minimum temperature experienced at all sites, most notably at Abbey Inn, Byland
Daily temperature range	Leads to an average of 3.5 x lower daily range in temperatures across the five sites, with greatest reductions felt at Abbey Inn, Byland, Worcester College Oxford and Western Heights, Dover.

Looking in more detail at the differences in the aspect, degree of exposure and thickness of ivy cover at each site helps to explain some of the variation in strength of the 'thermal blanketing' effect of ivy. The wall studied at Worcester College, Oxford is south facing with high exposure to light throughout most of the day (no nearby shading) and has a relatively thick cover of ivy (c. 45 cm). The thick ivy here has been proved to provide an excellent way of reducing excessive heating under these conditions. In contrast, the wall studied at the Abbey Inn, Byland has a relatively thin cover of ivy (c. 20cm), is east facing and exposed to high levels of light (no local shading) and in an area prone to very cold winter conditions. Even this thin cover of ivy has been proven to prevent extremes of cooling in this cold climate – and prevented freezing within the winter months (see Chapter 4, Figure 4). Smaller, but significant, impacts on diurnal temperature cycling were recorded at the south-facing Ramsey site, which has some shading from nearby walls and trees and a thin (c 24 cm) cover of ivy. Even the very thin and patchy cover of ivy at the Nailsea site (< 10cm thick) has been demonstrated to have a significant effect on daily temperature cycling at a west-facing site which is quite heavily shaded all round by other trees. The other sites studied within Oxford showed similar trends.

The relative humidity data shows further, but less convincing, evidence that ivy controls the wall surface microclimate, as summarised in Table 5.4. One of the key issues to bear in mind when interpreting this data is the limitations of the monitoring equipment used, especially in measuring relative humidity variations in situations where rain can directly hit the ibutton. Dust, spiders and mites can also compromise readings by clogging up the sensor.

Table 5.4 Observed impacts of ivy on wall surface relative humidities at 5 study sites in England

Parameter	Impact of ivy
Mean relative humidity	Slightly, but not significantly higher on average under ivy
Daily maximum relative humidity	Generally very slightly higher under ivy cover, except at Byland where it was clearly lower under ivy
Daily minimum relative humidity	Higher under ivy, notably at Worcester College, Oxford, Ramsey and Western Heights, Dover.
Diurnal range in relative humidity	Significantly reduced under ivy, on average by 2.7 times

The key point to note here is that there is a significant reduction in the daily cycling of relative humidity, which should lower the likelihood of weathering from wetting and drying, or some types of salt crystallisation. At Ramsey, Western Heights Dover and Worcester College Oxford ivy's most notable impact was to keep relative humidity from plunging during the heat of the day, whereas at Abbey Inn, Byland the key effect was in reducing the relative humidity peaks. These effects are to be expected, given the accompanying impacts on temperature noted at these sites (as temperature and relative humidity are intimately related). Observations when downloading the dataloggers indicated that the ivy canopy considerably reduced the amount of rainfall hitting the wall – but we have no concrete measurement proof of this.

Our iButton data does not indicate whether ivy keeps the wall damp (as it only measures temperatures and relative humidities) and in order to provide some direct evidence of this we have started to carry out surveys using a moisture meter. The Protimeter is a resistivity-based surface moisture meter, commonly used in building survey work. It is easily influenced by salts which may be dissolved in the water, and also temperature, and thus has relatively low accuracy. Figure 5.1 shows two comparative surveys. As can be seen, no clear pattern emerges because of the differences in materials and conditions on these old walls, as well as differences in weather conditions before and during the survey. Along Walton Street the ivy-covered wall seems wetter than the exposed, whereas the reverse is true at Pembroke Street.

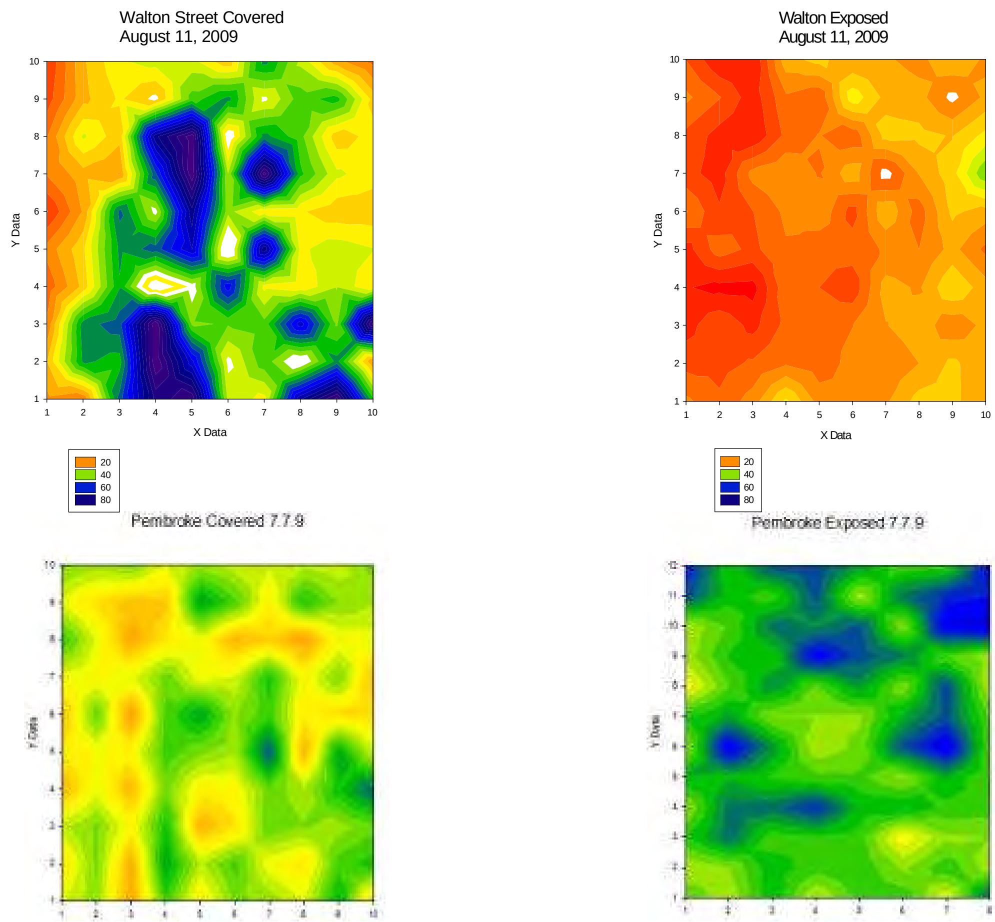


Figure 5.1 Protimeter surveys on ivy covered vs exposed sections of old walls along Walton Street and Pembroke Street, Oxford

However, the Protimeter can provide meaningful data when used on walls of known composition – making it ideal for regular monitoring of the test wall at Wytham Woods. We have now started monthly surveys here. Figure 5.2 shows the moisture patterns recorded on the north face of the wall in October 2009. Generally wet conditions are found at the base of the wall, whether or not ivy is present and there is no clear imprint of the ivy on moisture levels. Comparing this data set with those presented in chapter 4 (Figure 4.8, page 29) shows that, as yet, no consistent pattern is emerging. We cannot yet confidently state whether or not ivy significantly influences surface moisture regimes.

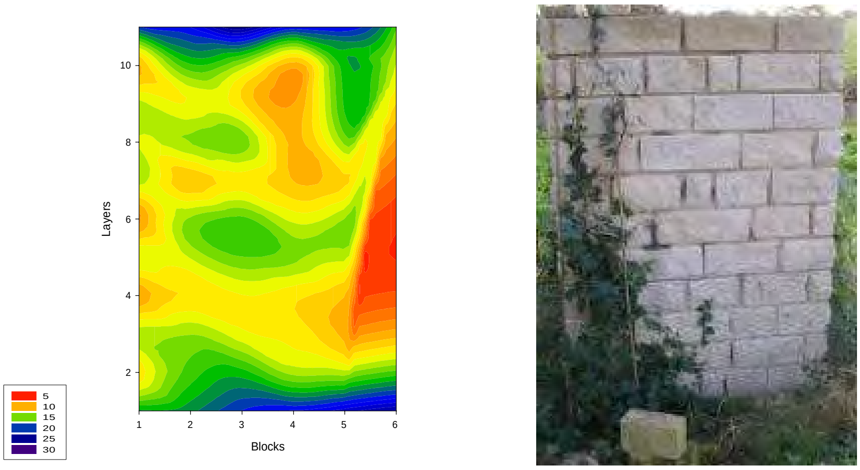


Figure 5.2 Protimeter survey data in October 2009 on the north face of the test wall at Wytham Woods. Ivy is growing on the lower part of the left side of the wall.

2.2 Do ivy's aerial rootlets cause damage?

We have only recently taken the mini test walls down and have not yet completed the microscopic analysis. One of the mini test walls was badly affected by the cold winter (in a north facing position, central Oxford) and the ivy failed to colonise on any of the test blocks. However, the other test wall has several aerial rootlets adhering to different stone and mineral types which have not revealed any significant damage (Figure 4.9, page 29). Some observations from the gravestones in Ramsey churchyard (see chapter 7 for more details of this site) provide further direct evidence of the role of aerial rootlets (Figure 5.3). Here, careful removal of the ivy revealed fresh and clean surfaces of limestone underneath. There was no visible evidence of any deterioration – the lettering was crisp and clear, and there was no soiling or roughening of the stone surface. Indeed, Figure 5.3b shows evidence that the ivy rootlets act in a positive way to clean off any existing soiling. Furthermore, the aerial rootlets themselves showed little or no trace of any attached particles of limestone (the white patches seen on the rootlets in Figure 5.3d were bits of dead lichen which would formerly have been growing on the stone before the ivy colonised).

a

b

c

d

Figure 5.3 Minimal impact of aerial rootlets on limestone grave stones, Ramsey Churchyard, Cambridgeshire.

Our data so far show no cause for concern – there is no evidence that ivy's aerial rootlets are causing damage both on newly colonised test blocks and on gravestones convered with a well-established ivy canopy. Indeed, any damage is likely to be entirely superficial and spatially restricted to the small contact zone between rootlet and the wall. However, it is important not to extrapolate from one type of material as a cut or polished gravestone face may respond very differently to ivy rootlets than porous mortar or brick. Further investigations are needed to provide a more robust test of the potential deteriorating role of ivy rootlets on a wide range of historic building materials.

2.3 When, why and how does ivy root into walls?

We designed the Wytham Woods test wall with a number of defects in it so that we could carefully monitor the growth of ivy and evaluate when and where, if at all, it started to root into the wall. The slow growth of the ivy and its reticence to cling onto the wall has meant that we have as yet no examples of ivy rooting into any of the defects. Some aerial rootlet attachment has been noted, but other than that there has been no real contact with the wall. Previous observations of ivy on walls have showed that ivy only roots into the wall when there are holes in the wall, and that rooting into the wall is especially encouraged when the ivy is cut off at the base of the stems in an often misguided attempt to kill it off. We will continue to monitor the ivy growth in order to understand the rooting problem.

2.3 Does ivy prevent or reduce particulates reaching walls?

Using the data collected from the two roadside locations in Oxford, which varied in the density of traffic, we find significant evidence that ivy reduces the amount of fine-grained particles reaching the wall surface on the busier road. A summary of the key findings is presented in Table 5.5.

Table 5.5 Summary of results from the survey of particulates on exposed and ivy-covered surfaces on roadside walls in Oxford.

Site type	Impact of ivy
Busy road (19,000 vehicles per day)	Number of particles per mm^2 reduced by 60-85% depending on the magnification at which observations made. The ivy is particularly effective at trapping the smallest particles (> 2.5 microns) Particles here found to be dominantly from diesel and other pollutant sources
Medium road (3,100 vehicles per day)	No significant reduction in overall particle numbers under the ivy canopy Similar size distribution of particles deposited on exposed and ivy-covered walls Site affected by recent building works

Our sample size is too small to make overly confident statements, but we have illustrated that this method is effective at quantifying particle deposition. Under the conditions along a busy, highly polluted road ivy does indeed act as a ‘particle sink’ providing some protection especially from damaging and soiling fine-grained pollutants.

2.4 People’s perceptions of ivy

Our interviews and questionnaire survey results indicate that many experts have a very negative view of ivy, whilst the general public expresses a diversity of views. The publicity generated by the research project itself has also revealed a wide range of ideas about ivy and its role on buildings. Whilst many people have expressed their worries about ivy, we have received several positive examples of the protective role of ivy based on people’s direct personal experience. Clearly, any change in conservation practice to leave ivy in place will have to acknowledge this diversity of views, and will need to provide detailed evidence to refute some of people’s fears and worries.

3 Implications of our findings for managing ivy on walls

Looking at Tables 5.1 and 5.2 it is apparent that our research has produced evidence about many facets of the direct and indirect roles of ivy on the deterioration and conservation of historic walls. We now have strong evidence that ivy reduces the threats of freeze-thaw, heating and cooling and wetting and drying (and associated salt weathering) through its regulation of the wall surface microclimate. Ivy canopy does not need to be very thick to have such an effect, and the benefits seem to affect walls in many different climatic regions and in exposed as well as shaded positions. Furthermore, we have strong evidence from our research that ivy will reduce deterioration and soiling induced by particulate air pollution under busy roadside conditions because of its ‘pollution sink’ role. However, it is less clear whether this role extends to other, less directly polluted environments. We also have strong evidence that ivy will reduce the impact of rain-based chemical weathering, as it appears to drastically reduce the amount of rain reaching the wall surface. We have some evidence that ivy’s aerial rootlets produce minimal or no deterioration to limestone, and we await further evidence to confirm or refute this statement for other building material types. We cannot yet make any statements about the role of ivy roots, as the test wall ivy has not yet shown any desire to root into the wall.   We have no clear evidence yet that ivy makes wall surfaces wetter or drier and/or reduces other types of biological decay – although the lack of light under ivy canopies reduces the chance of lichen and algal colonisation on these surfaces as observed on the Ramsey gravestones.

Our findings have several implications for practical conservation and management of historic walls. Firstly, ivy’s moderating influence on the wall microclimate is widely found, on all wall types and in many different environmental settings. Thus, if the major agents of deterioration affecting the walls are related to harsh climatic conditions ivy will ameliorate those and prevent or reduce damage. Ivy growing on roadside walls with high traffic flows should additionally reduce the amount of pollutant particles reaching the wall, leading to lower rates of soiling and deterioration. Aerial roots do, at most, only very superficial damage (<< 1mm depth) on limestone and thus should not pose any serious risk. Overall, our research suggests that as long as ivy is not rooting into the wall its benefits outweigh its risks in terms of deterioration on the masonry materials tested and that it can play an effective role in a balanced conservation strategy.

References

Melzer, B., Steinbrecher, T., Seidel, R., Kraft, O., Schwaiger, R and Speck, T. 2010 The attachment strategy of English ivy: a complex mechanism acting on several hierarchical levels. Journal of the Royal Society Interface 7, 1383-1389

Zhang, M., Liu, M., Prest, H, Fischer, S. 2008 Nanoparticles secreted from ivy rootlets for surface climbing. Nano Letters 8, 1277-1280

6. Ivy Removal at Godolphin Estate

Chris Turner, National Trust

Ivy removal is a contested issue as there are several opinions on how this is best done. The three most common methods are cutting the stem, poisoning the plant and peeling ivy off the wall. Effective ivy removal depends on several factors such as ivy species, weather conditions, soil types and bricks and mortars used. An opportunity arose to research ivy removal on buildings belonging to the Godolphin Estate in West Cornwall, recently acquired by The National Trust (Figure 6.1). This enabled a controlled study to be carried out in 2009 on the effects of ivy on a group of buildings on the estate which reduced potential variables such as climate, rainfall, and stone/mortar types. By employing a variety of ivy removal techniques the project objectives were to:

1. Investigate the nature of ivy removal
2. Test a number of removal techniques
3. Identify the least destructive method of ivy removal

Figure 6.1 Godolphin Estate (left), section of wall undergoing ivy removal (right).

Ivy is a very resourceful plant with the ability to live under severe conditions. If cut it has the ability to multiply and grow as it find new sources of nutrients and water. In this manner ivy can invade tiny cracks very aggressively in order to grow and survive. If left alone ivy matures and grows up building walls, using them as structural support. However, if buildings are in poor condition it will take advantage of small crevices that provide support. Ivy can grow year-round in southern areas of the UK because of the mild temperatures, with growth continuing throughout winter without needing food stored in the adventitious roots. In cooler areas the plant will stop growing in cold weather and survive using stored nutrients. The mild year-round temperatures at Godolphin in West Cornwall mean that there may not necessarily be a best time of year to remove the plant from walls. The research project timescale was less than one full year and further research over a longer period is needed to get the full range of results over all the seasons.

Removal Methods

The first method of removal tested was cutting the plant at the stem and letting the plant die naturally before taking it off the wall. This method of ivy removal has often been recommended, exemplified by:

> *'A length of the main stem of the ivy should be cut out at a convenient height above ground level. The plant may be left in this state to die of its own accord.'*
>
> Ashurst and Ashurst 1998

This statement, however, conflicted with the author's findings in this case study and other viewpoints of those researching in this field. For example, Viles (personal communication, 2009) stated that:

> *'When ivy is cut off at the roots it tends to try and use adventitious roots within holes in the walls to provide alternative moisture sources – thus causing more damage.'*

Results throughout the case studies tested confirmed this statement. The current study found ivy that was cut at the root and left to die had grown larger adventitious roots than the section that was still alive. This treatment also caused more damage to the wall than the ivy section that was undisturbed. The large adventitious roots are shown below (Figure 6.2).

Figure 6.2 Adventitious roots on the cut ivy (left, upper stem) are much larger than on the live section (left, lower stem). This difference occurred over approximately 3 months. The photo on the right shows how large the adventitious roots can grow.

These results from the current research are supported by previous findings. Adams & Early (2004) wrote about the vegetative propagation of ivy and how the normal growth of the plant will be interrupted if the main source of nutrients and moisture is cut, resulting in the adventitious roots growing aggressively to survive. The roots on the section of ivy that had been cut were approximately double the size of the area that had not been cut at the stem. The author makes the presumption that the roots have grown bigger to seek moisture - a detailed quantitative study would be necessary to prove this further. If time allowed it would have been interesting to see what effect the cut ivy would have had on the wall a full twelve months after being cut at the stem. There were other areas of ivy that had been cut at the stem for longer than twelve months but the poor condition of the wall prevented a controlled test being carried out. However, the ivy had grown deep into the wall with parts of the ivy still alive, indicating that the plant was getting moisture and nutrients from a source other than the ground. In one area where ivy had been removed some years ago there was new ivy growth on top of a wall. This ivy was growing directly from the wall with no connection to the ground which provides further evidence that cutting the plant at the stem and leaving it to die will not necessarily work and could encourage further, more aggressive growth into a structure.

The second method of removal to be tested was poisoning the ivy as recommended in the UK Code of Practice for cleaning and surface repair of buildings (BS 8221-1:2000):

> *'Chemical treatments should be used for an initial kill prior to removal of organic growth, and to control re-growth.'*

This method of ivy removal was tested during the case studies. The ivy was poisoned using a glyphosate based poison which did kill the plant. However, in the six month period after it had been poisoned there were signs of re-growth. The author found in this study that the poisoned ivy was more difficult to remove than untouched ivy. After the bulk of the ivy was removed there was much debris left on the wall which took additional time and effort to remove using scraper-type tools which could potentially damage the wall further. The use of these tools for ivy removal was recommended in the Code of Practice which stated:

> *'Heavy growth, small plants, and moss cushions should be removed with stiff fibre brushes, wooden spatulas, scrapers, or a low pressure water lance.'*

The same document also recommended poisoning the ivy prior to removal so this method requires the use of tools whereas the other two methods of ivy removal leave less debris on the wall so that tools are not always necessary. This method of ivy removal on stone walls with soft lime based mortars is not a good technique for removing ivy from buildings as it may itself cause damage through scraping.

The poison used to kill the ivy is another factor which should be considered when trying to remove ivy. Unfortunately, the author could not poison as much ivy as he would have liked because of the risk to other plant and animal species; the National Trust policy is to not use poisons on plants unless absolutely necessary. The author would have liked to carry out another test area but this was not possible because of the sensitivity of nearby plants.

The third method of removal that was tested was simply pulling the plant off the wall. The first case study carried out revealed that the ivy growing over the building came off the wall very easily and caused little damage to the surface beneath. The ivy was not treated in any way but was slowly cut and pulled off the wall. The root system on the plant was growing up from a mill leat which is moist year round. The wall behind the ivy was in good condition. Christopher Brickell (2006) stated:

> *'If wall-grown, ivies will not damage sound brickwork but they may dislodge loose mortar and damage paintwork.'*

The ivy growth removed by hand had the least destructive impact on the wall surface and was the easiest to remove of the three methods tested. The ivy came off the wall causing very little if any damage and no debris was left that had to be removed using scrapers. The ivy came away from the wall in one large section except for the areas around the eaves and gutters of the building where cutting had to be done so not to damage these sensitive areas (Figure 6.3).


Figure 6.3 Ivy removal by hand (left). Care should be taken when removing ivy around eaves (left).

It was interesting to note that the author could not find any published data on removal of ivy using this method although there was a section on a website (ivy removal, www.whatprice.co.uk) which recommended removing the ivy immediately after cutting the plant at the stem:

> *'…it is best to leave the cut ivy to die for 1 – 2 years before attempting to remove from the brickwork. However it is not so beneficial to wait as the ivy tends to come away from walls easier, and there is less chance of it pulling the material that it is clinging to away with it. So either immediately or after a period of time simply prune, cut and generally pull the ivy off the brickwork.'*

This text does somewhat hedge its bets because it gives options for the removal of the ivy by stating that it can either be left to die or can be removed immediately. The findings in the primary research that has been carried out in this study indicate that it is best to remove the ivy directly without letting the plant die off.

The overall conclusions and recommendations of the research project are that the best method of removal of ivy at Godolphin on stone walls with soft lime based mortars is to simply remove the ivy gently with no other treatments (Figure 6.4). Cutting the plant at the stem and leaving it to die is detrimental to the wall because the plant will grow sporadically, potentially causing damage to the walls especially if they are already in poor condition. Though poisoning ivy is recommended in some books and publications, the findings in these case studies showed that it can pull off mortar and need additional work to remove the plant completely which could also damage the wall further. There can also be problems poisoning areas especially if they are close to other delicate species.

Figure 6.4 Methods of ivy removal. Cut stem (left), poison (centre) remove by hand (right).

A full version of the report is available. If you would like a copy please contact Chris Turner by email – christopher.turner@nationaltrust.org.uk

References

Adams C., Early M. 2004. Principles of Horticulture. Elsevier Publishing Ltd.

Ashurst, J., Ashurst, N. 1988. Practical Building Conservation, English Heritage Technical Handbook, Volume 1 Stone Masonry Gower Technical Press.

Brickell, C. 2006. The Royal Horticultural Society, A – Z Encyclopedia of Garden Plants. Dorling Kindersley Publishers Ltd.

British Standard 8221-1. 2000. Code of practice for cleaning and surface repair of buildings – Part 1: Cleaning of natural stones, brick, terracotta and concrete BSI publications.

7. Ramsey Churchyard

Amanda White, English Heritage

Introduction

St Thomas a Becket Churchyard, Ramsey, Cambridgeshire was brought to the attention of English Heritage (EH) in January 2008 because of extensive and unusual ivy growth on the majority of gravestones in the churchyard (Figure 7.1). In March 2008 a team from EH and Oxford University were brought in to assess the impact of ivy on gravestones as part of the Ivy on Walls research project. The team removed all ivy from 3 gravestones and partially removed ivy from a 4th that served as a demonstration. The work followed initial discussions between EH, the District Council responsible for this scheduled area and local representatives of the Town and Ramsey Rotary Club who were keen to have all ivy removed. Ramsey Churchyard contained a remarkable, probably unique, number of gravestones completely encased in ivy growth. Individual stones, and in some cases whole rows of stones, were encased, often with neighbouring stones fully exposed.

Figure 7.1 Ramsey Churchyard.

Ramsey Churchyard

Although gravestones may seem somewhat removed from the building walls which were the main focus of the 'Ivy on Walls' research project, there were parallels to be drawn from ivy's impact on gravestones and stone wall surfaces. The team was interested in preservation and the need to avoid damage to the stone surface and carved features during removal. Research findings can establish procedures and can help to inform other projects where ivy removal is necessary.

The team divided the ivy covered stones into 4 classes;

- **Juvenile** - stones with young growth/s of ivy growing up one or both sides, but where the individual ivy stems are very clear and a large proportion of the gravestone is visible (Figure 7.2*a*).
- **Shroud** – stones which are completely covered with ivy, with very little, if any, stone showing on either side and ivy growths cascading down from the top increasing the thickness of the cover, but no flowering/arboreal growth present (Figure 7.2*b*).
- **Shrub** – stones as above, but where the woody flowering stems of ivy have been produced over the whole structure, from ground level up to and above the top of the stone (Figure 7.2*c*).

- **Shrub & Shroud** – similar to 'shroud' but where the woody flowering stems have been produced at the top of the stone only, not all the way down to the ground (Figure 7.2*d*).

Ivy was removed completely from one example each of 'Shrub', 'Shroud' and 'Shrub & Shroud' types.

a *b* *c* *d*

Figure 7.2 Four types of ivy cover – *a.* Juvenile *b*. Shroud *c.* Shrub *d*. Shroud & Shrub.

Methods

The work was carried out using hand tools only – secateurs, loppers and hand saws (Figure 7.3*a*). These tools were effective for ivy removal and greatly reduced the risk of damage to the gravestones beneath. In each case work began at the outer extremities of the ivy growth with shoots cut and removed in easily handled lengths. Care was taken to remove only freely cascading growth first (Figure 7.3*b*) and where they were entangled with other stems to cut them free before removal to avoid pulling to sharply on stems and risk damage to any gravestone features. In this manner the growth was gradually removed until the framework of main stems affixed to the gravestone were fully exposed (Figure 7.3*c*).

a *b* *c*

Figure 7.3 Ivy removal - *a.* sample of tools used for ivy removal, *b.* removal of cascading ivy first, *c.* framework of main stems.

Removal of material from the tops of stones needed careful attention for two reasons; firstly, the tops were heavily covered with numerous overlapping stems and care was taken to ensure that tools did not damage the gravestone (Figure 7.4*a*). Secondly, the tops of stones were of different forms, with stepped details, carved swirls and ornate finials so attention was necessary to prevent damage to these when pulling stems off. The simplest way to tackle these was to remove stem sections individually rather than trying to peel off large chunks. Once the top had been cleared the stems running down the sides were cut. The rest of the framework proved surprisingly easily to simply peel away from the face of the gravestone (Figure 7.4*b*). When this was done the main stump and roots could be removed to prevent re-growth (Figure 7.4*c*).

a *b* *c*

Figure 7.4 Ivy removal – *a*. removal of material from top of stones, *b*. peeling ivy away from gravestone surface, *c*. removal of main stump and root.

Points to note

In each case we uncovered the ivy stump was close to, or wedged between, the main gravestone and the smaller 'footstones' which at some point had been placed next to the main stone. This inadvertently provided ivy seedlings with a spot protected from strimmers and enabled plant growth (Figure 7.5*a*). Juvenile stems of ivy were found to be harder to remove than older stems. This indicates that ivy depends on the initial adhesion of these rootlets from a young stem to stay in place and that the adhesion mechanism is not continually refreshed on older stems (Figure 7.5*b*). All stems which touched the ground layered – producing proper roots from leaf nodes. In this location it had led to some rows of stones effectively becoming ivy 'hedges' as the low stems between gravestones layered (Figure 5*c*). This may offer some clues as to what causes ivy stems to produce 'proper' roots as opposed to the aerial 'climbing' roots.

a *b* *c*

Figure 7.5 Ivy – *a*. growth between gravestones and 'footstones', *b*. juvenile stems, *c*. example of ivy 'hedge' behind row of uncovered stones.

Ivy removal by hand is advisable when dealing with unknown factors such as fragile or intricate features covered by ivy. Whilst our work was done slowly to prevent damage and document the process, two people working methodically could remove the ivy from a heavily covered, large gravestone in 45 to 60 minutes.

It was quite clear that nesting birds used the thick ivy cover on stones, a fact likely to be the case with any dense covering of ivy. Because of this removal should be undertaken outside the nesting period (Mar – July) where possible. If this is not feasible the ivy to be removed would need to be checked to ensure there were no nesting birds and work stopped if there were. Under the Wildlife and Countryside Act 1981 it is an offence to 'take, damage or destroy the nest of any wild bird while that nest is in use'.

It might be advisable to consider whether ivy removal during the cold winter months is advisable, as the sudden exposure of stonework to the elements might be more damaging than being uncovered during summer and allowed to acclimatize more gradually. Uncovering already damaged stones might result in increased damage through their exposure to the elements (Figure 7.6).

Figure 7.6 Uncovered damage on gravestones.

Sections were taken from the main stems of the ivy plants covering the stones to have the rings counted at the University of Oxford Dendrochronology Lab. One stem was 7 years old, the remainder 9 years old. This shows that it takes as little as 7 years for unchecked ivy to completely cover a gravestone.

Damage assessment

There was little evidence that the ivy covering had done any physical damage on the four gravestones uncovered. The aerial roots had not penetrated into the stones and do not appear to have any marked impact on stone surfaces. However, in some cases these aerial roots do seem to have left clear marks. The marks are not visibly etched into the stone and seem to be either where aerial roots have covered part of the stone whilst the surrounding area was exposed to climate and weathering processes (Figure 7.7*a*) or where the ivy rootlets have cleaned the surface.

On two of the uncovered stones there is clear evidence of brown staining directly associated with the branch network (Figure 7.7*b*). This appeared not to be associated with the ivy stems/branches directly producing materials which stain the stone, but with the accumulation of organic matter above branches which begins to decay and release humic acid. This staining may disappear over time as the stone is exposed to the elements.

a *b*

Figure 7.7 Aerial root marks (*a*) and brown staining (*b*) on gravestones.

There is no clear evidence about whether such massive growths of ivy on individual gravestones had any de-stabilising effect. In the case of the ‘shroud’ types it probably does not and may even have a stabilising effect – making a tall narrow object only slightly taller but much wider. This may also apply to the ‘shrub’ type, although the arboreal, flowering growths on these do make the gravestones notably taller. However the ‘Shrub and Shroud’ type, with a massive growth of the arboreal, flowering stems above the top of the gravestone are more likely to make them ‘top heavy’.

The weight of ivy removed from each of the gravestones fully cleared (3 in total) was weighed during the work and the results are shown in Table 7.1.

Table 7.1 Weight of ivy removed from gravestones.

Gravestone No.	Type of covering	Weight of ivy – normal (kg/lb)	Weight of ivy – flowering (kg/lb)	Total weight of ivy (kg/lb)
1	Shroud	43/ 95	-	43/95
2	Shroud	19/42	11/24	30/66
3	Shrub and shroud	21/46	4/9	25/55

These figures provide an interesting record of the weight of vegetation growing on these three stones but are not directly comparable because the stones were not identical in size. Although the weight of flowering growth high up on stone 3 was substantial and must to a degree affect stability by making the stone more ‘top heavy’, it must be remembered that there is the additional ‘windsail’ effect of this vegetation. There was only one example of toppled gravestone which was covered in ivy. This appeared to be more of a ‘shrub’ type and it is impossible to say if the stone itself had a pre-existing flaw or whether vandalism was involved.

One year after the pilot study of the 4 gravestones ivy re-growth was evident on two stones where the ivy had been removed (Figure 7.8 *a* & *b*). New ivy was evident on the shroud and between footstones and headstones where the plant was cut back but not removed. As a final note two years after the team removed ivy from the gravestones the community removed ivy from all remaining gravestones (Figure 7.9). All stones appeared in good condition, thus confirming our observations.

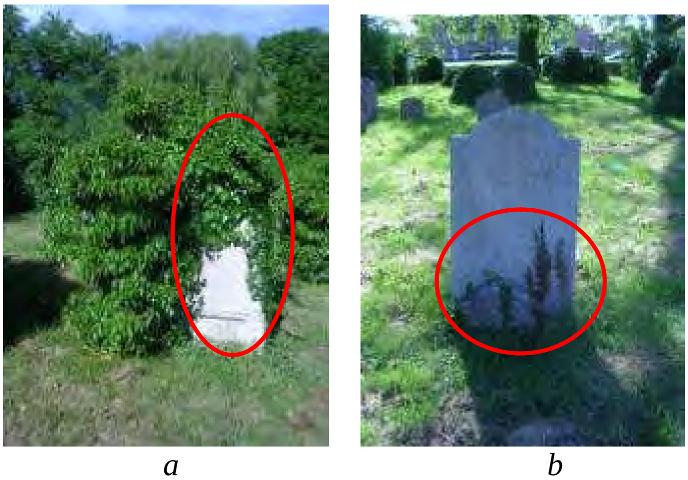


Figure 7.8 Ivy regrowth on gravestones after one year – *a*. shroud, *b*. between gravestone and footstone.

Figure 7.9 Ramsey Churchyard after complete ivy removal, March 2010.

8. Ivy – an ecological perspective in relation to walls

Rachel Thomas

Introduction

Ivy (*Hedera helix* L.) is a common plant across the British Isles with the exception of the most exposed parts of the Scottish Highlands and Islands (Figure 8.1). Native from Spain to Ukraine and north to Norway, Ivy has been introduced to the New World and the Pacific where it can become invasive. It is a component of most UK woodland types, except the most upland and north-westerly communities but, when abundant and blanketing the woodland floor, is often diagnostic of secondary and disturbed sites. Ivy grows and fruits in areas with cool to warm summers and mild winters and has several life forms – a perennial vine, a climber, a woody (sub) shrub and occasionally as a tree. It grows vertically or horizontally and has the ability to extend over soil-less ground.

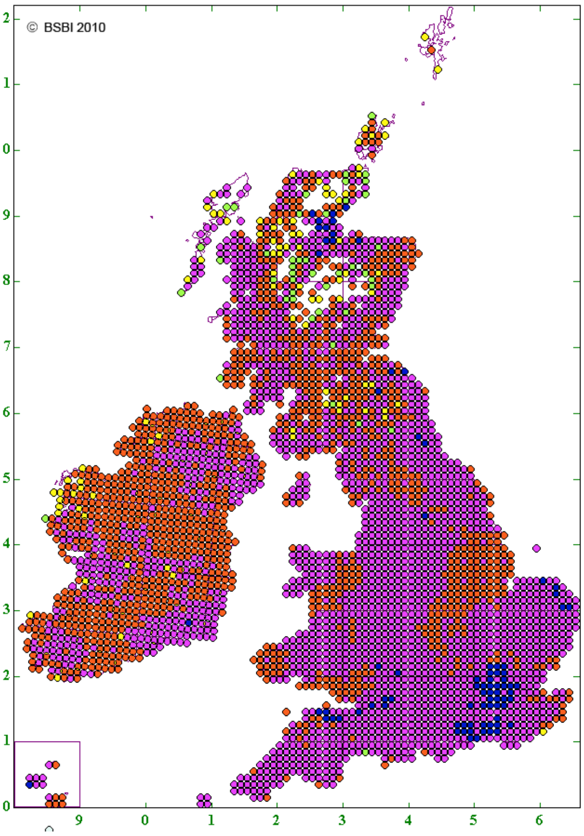


Figure 8.1 Distribution of ivy in Britain.

However, despite being widespread and common; its evergreen nature, its structure and its late flowering and fruiting season make it of considerable nature conservation value. Ivy provides shelter, habitat structure and a food source, directly and indirectly, at times of year when other sources are in short supply. A wide variety of animals, both vertebrate and invertebrate, benefit either because they feed on Ivy directly or on the flying invertebrates attracted to it. The latter provide an often abundant, localised, food source for bats and insect-feeding birds.

Structure

Ivy is important because, as an evergreen plant, it provides warm, dry places for birds to nest in the spring especially Blackbirds, Robins and Sparrows (Figure 8.2), for Owls and Woodpigeons to roost in overnight and for hibernating animals during the winter. Stems on tree trunks form nesting niches for song birds and roosting sites for Owls. Small mammals, including bats, and invertebrates will shelter under its cover and in the dry conditions under thick Ivy. These features are particularly important where cover is otherwise scarce.

Figure 8.2 Blackbird nesting in ivy.

Food source

As a food source, the considerable value of ivy is that its nectar and berries (Figure 8.3) are available late in the season, when other sources are over or have been depleted. Ivy comes into flower from September onwards into the late autumn and the berries mature over the winter months. Consequently it provides a particularly valuable food supply for insects and birds late in the year. It does not support many particularly rare species, but its abundance contributes to its importance at that time of year. Flowering Ivy in full sun in September or October can be heard several meters away!

Figure 8.3 Ivy berries (left), Rear Admiral butterfly feeding on ivy leaf (right).

A particularly interesting and attractive species closely associated with Ivy is the Holly Blue butterfly *Celastrina argiolus* (Figure 8.4). This butterfly has two generations of adults each year. The first generation emerge from pupae in Ivy in late April or May, mate and lay eggs on the buds of Holly, Dogwood, Spindle, Alder Buckthorn or *Pyracantha*. The caterpillars feed on these buds and pupate in July. The second generation adults emerge in late July or August and lay their eggs on Ivy buds. These feed through September and October and overwinter as pupae amongst the Ivy stems. The butterflies do best if there are good stands of flowering ivy and holly within *c.* 100 meters of each other. Of the many other insect species associated with ivy, several interesting species of beetle bore holes into mature Ivy stems and the rare hoverfly *Callicera spinolae* feeds on Ivy blossom. The berries are a significant source of food for birds in winter particularly for Blackbird and Woodpigeon. Some of the common, larger vertebrates eat Ivy including Red and Fallow Deer and Sheep.

Figure 8.4 Holly Blue butterfly on ivy leaf.

The ecological down-side

However, the role of ivy is not all positive. It can also shade out other species on walls such as small ferns, lichens and mosses which have nature conservation and aesthetic values of their own. Some plants associated with walls are uncommon, and a small number are rare. Ivy may also overwhelm existing woodland features, including trees.

The management solution

When evaluating the role of Ivy it is important to first get the big picture of the habitat or site. This can be done through existing documentation and records, commissioning any additional site surveys needed at the right time of year and mapping the location of important features. Through careful assessment, the strengths of the site can be identified, priorities recognised and management decisions made.

In general, lichens, small ferns and small annuals do little damage to the wall and can be retained without risk. Bramble, Red Valerian, Buddleia and tree seedlings, especially Sycamore and Ash, have the potential to significantly damage the wall. When small they are of minimal nature conservation interest and can be removed. Large stands of Bramble, large Buddleia and mature trees have potentially great value to nature conservation but may also pose significant threats to the wall and their future should be carefully considered.

Overall, making the right management decision regarding Ivy on monuments and historic sites requires our best professional judgement, weighing up the following points. What sort of building is it? How intact is it? What wildlife interest is there - birds, bats, invertebrates or other plant species. What does the wildlife present contribute to the understanding, landscape, aesthetics and interpretation of the property? Bats in and around the property, receive statutory protection and the necessary permissions and consents should be obtained before any work on Ivy is undertaken. Similarly, if any other species which also benefit from statutory protection are present, the legal requirements should be factored into decision making. The evidence, the thinking and the recommendations can then be pulled together into an overall, agreed management plan that delivers the best for the site.

Acknowledgements

I should like to thank Alan Cathersides and former colleagues with English Heritage for the opportunity to think through the relative merits of Ivy; Paul Waring for taking photos of the Ivy and associated wildlife in our garden and Natural England, my current employer, for the time to compile this presentation. The views expressed are however mine rather than Natural England's.

References

Lockton, A.J. 2010. Species account: Hedera helix. Botanical Society of the British Isles, www.bsbi.org.uk. Accesed 12/10/2010.

Richards, D. 2010. English ivy is an invasive weed in Pacific Northwest http://extension.oregonstate.edu/news/

Lockton, A.J. 2010. Species account: Hedera helix. Botanical Society of the British Isles, www.bsbi.org.uk.

Kirby, P. 1992. Habitat management for invertebrates: a practical handbook. RSPB

Gilbert, O. 1996. Rooted in stone: the natural flora of urban walls. English Nature, Peterborough.

9. Future research directions

Heather Viles, University of Oxford

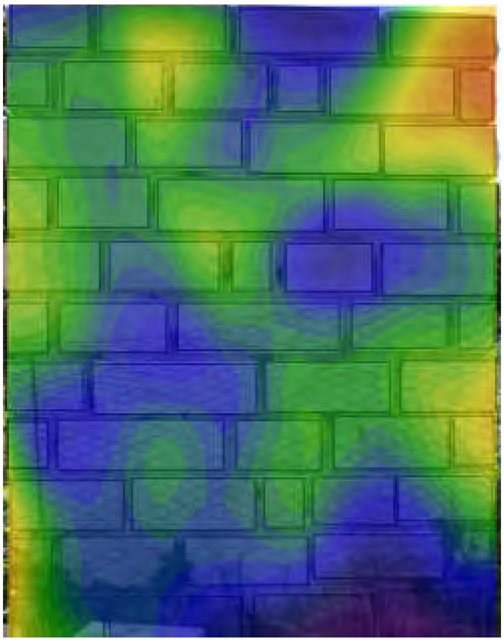
Our research project has yielded many useful results, but as always with pioneering research there have been some unexpected problems and some aspects of ivy's role on walls have proved very hard to disentangle. Sometimes it has proved necessary to spend a lot of time perfecting techniques for collecting and analysing data, meaning that we have only had time to collect small amounts of real data. The research results collected so far and our discussions with interested parties have also led us to come up with new aspects of ivy's role on walls which need testing. We propose five areas of research which should be carried out in future in order to strengthen our knowledge of the role of ivy on walls.

1. The influence of aspect and thickness of ivy

Whilst our research so far has demonstrated that ivy plays a general role in moderating wall microclimates, the fact that each site studied had many slightly different characteristics (e.g. not only varying in aspect but also in ivy thickness, shading and climatic zone) means it was impossible to decouple the influence of different factors. Now that the Wytham Woods test wall has a decent growth of ivy providing a reasonably continuous ivy canopy over half of each of the N, S, E and W facing sides, more intensive surveys can be carried out under more controlled conditions. Furthermore, the fact that we know exactly the age and the history of the ivy, as well as the detailed composition of the wall and the climatic conditions faced by it, make this a uniquely valuable field experiment. We propose that comparative monitoring of the microclimatic impact of ivy on different aspects (N, S, E and W) should be carried out over a one year period. We also propose that more iButtons are used under each canopy of ivy – so that we can study both thick and thin parts of the same canopy to isolate the impact of ivy thickness. Finally, we have already started using a larger number of iButtons over a short monitoring campaign of a few months to look at the wider microclimatic impacts of ivy. Up until now the research has focused on the microclimate behind the ivy – but ivy may also affect the microclimate in front of and behind the wall. This can identify more broadly how ivy impacts on a wall's thermal environment.

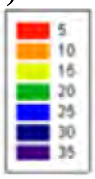
2. How does ivy influence moisture levels in walls?

Whilst it is clear that ivy should reduce the amount of rainfall reaching walls, our research so far has given inconclusive results about the overall influence on ivy on moisture regimes in walls – in terms of quantifying the amount of rainfall hitting the wall how ivy might control the rate of evaporation and drying of damp surfaces. One of the key problems we experienced was finding situations where we had uniform materials of known chemical characteristics to enable us to use and interpret the results of moisture meter surveys. The Wytham Woods test walls provide a unique opportunity to carry out meaningful surveys – as the material characteristics are simple and well-known. We have already started monthly surveys of each aspect of the test wall using a protimeter (see Figure 9.1) and propose that these should be expanded in the future. As well as this, we suggest that full 2D resistivity surveys should be carried out every 6 months or so to look in more detail at the subsurface moisture conditions. We have pioneered the use of this technology in other projects (e.g. Sass and Viles, 2006 and 2010) and it has been demonstrated to provide good evidence of moisture regimes in walls (see Figure 9.2).



a)

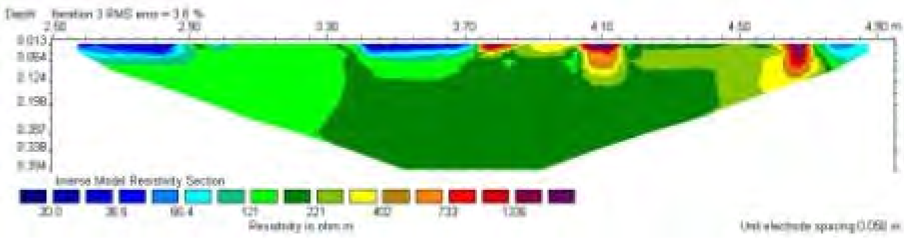
b)



% wood moisture equivalent

Figure 9.1 Surface moisture patterns on the north facing side of the Wytham Woods test site in a) May 2010 and b) June 2010

a)



b)

Figure 9.2 a) Measuring a 2D resistivity profile on the chapel wall covered with patchy lichen and algal growth, Byland Abbey using medical electrodes and Geotom resistivity kit, b) The measured profile showing the moisture patterns stretching from the surface (top of the image) to c 40cm deep in the stone (bottom of the image). Blue = low resistivity or wetter, whilst red = high resistivity or drier.

3. How do ivy aerial rootlets affect porous and vulnerable materials?

The micro test walls developed for the current research have proved to be a reasonably successful way of getting samples of the interactions between rootlets and different material types. So far, the observations from these test walls, and limestone gravestones at Ramsey, Cambridgeshire have shown minimal if any damage caused by these rootlets. However, the possibility still remains that ivy rootlets could be of more threat to materials such as mortar and brick (and even the more porous limestones used in the Wytham Wood test walls. We thus propose that future research should a) use the micro test wall method followed by microscope observations (light microscopy and scanning electron microscopy) to look at their impact on more porous substrates and b) take samples from the Wytham Woods test wall when aerial roots come in contact with the porous limestone and mortar and use microscope techniques to look at their impacts.

4. When, where and how does ivy root into walls?

During the current research we have made many observations of ivy which has been cut off at the base of the stems now rooting into walls at a range of historic sites, but have not been able to make any detailed observations about exactly when and why such rooting occurs. We propose to make careful records of the progress of ivy growing on the Wytham Woods test wall, in relation to the voids and defects built into the wall, in order to track when (if at all) rooting occurs. Over the longer timescale we might also be able to cut off parts of the ivy growths when well-established and see if this triggers off rooting into the wall. Once we have roots growing into cavities within the walls we propose using strain gauges to monitor the forces exerted.

5. Does ivy act generally as a 'pollutant sink'?

Our research so far has demonstrated clearly that ivy along very busy roadways is capable of filtering out much fine particulate and thus preventing further soiling and pollution-caused deterioration. However, we need more study sites in order to have greater confidence in the general applicability of our findings. We propose that more sites should be observed along roads with a range of different traffic volumes in order to see if the effect is noticeable more generally. We have established a viable methodology for conducting this sort of study.

References

Sass, O and Viles, HA 2006 How wet are these walls? Testing a novel technique for measuring moisture in ruined walls. Journal of Cultural Heritage 7, 257-263.

Sass, O and Viles, HA 2010 Wetting and drying of masonry walls: 2D-resistivity monitoring of driving rain experiments on historic stonework in Oxford, UK. Journal of Applied Geophysics 70, 72-83.

10. Implications for future conservation practice

Alan Cathersides, English Heritage

The work presented highlights the potential benefits of ivy on walls (Figure 10.1):

1. Results clearly show that a covering of ivy can moderate the damaging freeze/thaw and wet/dry cycles which affect exposed fabric
2. Findings identify that ivy leaves can intercept all manner of air borne pollutants which walls might otherwise be exposed to. This has a double advantage in both trapping pollutants which can act with water to instigate stone decay and in providing a wider health benefit gained from leaves trapping pollutants and ultrafine particles which can lodge in the lungs/respiratory systems – similar to one of the advantages of trees in cities
3. It has ecological advantages
4. It can enhance presentation of some sites

A blanket of ivy can moderate the erosion suffered by exposed fabric

Airborne pollutants can be trapped

Late flowering gives a valuable nectar source and evergreen leaves offer winter shelter

Site presentation might be enhanced

Figure 10.1 Examples of potential benefit of ivy on stone surfaces.

Ivy presents potential problems as well (Figure 10.2):

1. It is difficult to carry out a condition survey on a structure covered in ivy
2. Ivy is able under certain conditions to root into – rather than cling onto – some structures and when this happens damage will occur
3. It has ecological disadvantages
4. It may not assist the presentation of all sites

Assessing the condition of structures is difficult

Where it occurs, rooting into the structure is damaging

Removal of encroaching ivy from this walltop shows that covering of ivy allows no other vegetation to survive

Presentation may not necessarily be enhanced

Figure 10.2 Potential negative impacts of ivy on walls.

We are still working on the issue of how much, if any, damage the attachment mechanism does and what causes it to sometimes root properly into walls (Figure 10.3).

Figure 10.3 Example of root attachment on stone surface. The mechanism by which aerial roots cling on to the surface and whether this damages the surface is still being investigated

There are some clear management recommendations that we can make following this first phase of research and close observation of ivy in a number of varied locations – Ivy can perform a bio-protective role so;

- Don't just remove ivy 'because it's there' - take a close look at any ivy covered structure to see if the ivy is actually doing any damage - Clear a trial section if necessary.
- Be sure that any removal for structural or presentational reasons is justified.
- Ensure removal is not going to make things worse – by exposing fragile fabric to the elements
- If the ivy is actually rooted into the wall, rather than the ground at the bottom, removal is always the best option. Ivy is not a tree, but be under no illusion, its stems can reach the proportions of a small tree. The largest Ivy I have encountered had a stem diameter of 1 metre at ground level.

Below are photo illustrations of these points.

Above and right: a close look at an old ivy stem reveals that it is barely touching the wall and certainly not rooted in. Removal may not be necessary

Note: the curious shield like flattening of the stems was probably caused by grazing animals

a

b

a) A clear case where ivy growth will cause increasing problems and should be removed
b) Here the case is not so clear cut, the ivy may be preventing damage getting worse

In both cases removal of the ivy would have to be followed by structural repair

Above: Always consider the ecological advantages and disadvantages of ivy removal

Left: On complete structures keep ivy out of roofs and gutters

If it is decided that removal is necessary:

- Remove a trial section to find the best method and to see if any damage to the wall is likely
- Bear in mind that the youngest stems (usually near the top) are usually the most difficult to remove, older stems are often only very lightly attached.
- If money is not available for the whole job, start at the top and work down – cutting back in this way will cause the ivy to re-grow at the cut level, but does not encourage rooting into the wall
- If stability of sections of wall are of concern, cutting back the arboreal growth to near the main stem will greatly reduce the 'windsail' effect. It will regrow, but this does not seem to encourage rooting into the wall
- Never, ever, cut at the bottom and leave to die – if you are lucky it might, but this is the one action which without doubt cause ivy to try and root into a wall
- Do not doubt that ivy rooted into a wall will cause damage. Ivy may not be a tree, but it is capable of reaching tree like proportions.

If removal is necessary, remove a trial section to assess likely difficulty. If 'proper' roots (above left) rather than just aerial rootlets (above right) are found then greater care should be taken to avoid further damage to the fabric.

Above left: Consider the 'windsail' effect of large amounts of arboreal growth – especially on unsupported sections of masonry

Left and above right: Cutting ivy at the base and leaving to die may be successful (end wall, photo left) but seems to be a major driver behind rooting into walls – photo above shows ivy on the same site, cut at he same time and clearly still alive.

Left: Ivy rooted into or growing through a wall should always be removed – ideally before damage occurs.


Ivy stem in Cumbria – 1 metre in diameter at ground level. Fortunately, in this case, it was rooted into the ground and not the wall.

The seminar began with the quotation;

“I also think that all the ivy on the walls should be cut. I believe the Queen favours such a policy. Ivy is a rank and odious plant”

Hopefully we have shown you that Ivy is not quite as ‘rank and odious’ as Sir Lionel Earle believed in the 1920’s and perhaps we can consider something different for the 21st Century, perhaps even;

“I think that all the ivy on the walls should be carefully considered. I believe English Heritage should favour such a policy. Ivy is a noble and agreeable plant”

Appendix

1. Acknowledgements

Alan Cathersides and Heather Viles would like to thank all those who have helped with the Ivy on Walls research project. In particular, Dr Nick Carter was instrumental in writing the scoping report, whilst Dr Mary Thornbush provided invaluable help in planning the research and managing the early data collection. Dr Troy Sternberg has been an indefatigable researcher for the latter stages of the project, as well as carrying out the major editorial work on this seminar report. The staff and students in the Oxford Rock Breakdown Laboratory, School of Geography and the Environment, University of Oxford provided technical and logistical assistance throughout the project. We particularly thank Dr Mona Edwards and Hong Zhang for their many contributions to laboratory and field work. English Heritage staff and the site managers at Abbey Inn, Byland, Dover Drop Redoubt, Elms Colliery, Nailsea, Leicester Abbey and St Thomas a Becket Church, Ramsey were all extremely cooperative and facilitated our data collection. Pembroke, Trinity and Worcester Colleges in Oxford as well as Rhodes House and the Oxford City Council provided similar support and assistance for our data collection within Oxford. We thank Nigel Fisher and the management committee of Wytham Woods for permission to build our test wall, and facilitating our work at the site. We also thank Norman Charnley and the department of Earth Sciences, University of Oxford, for help with scanning electron microscopy. Finally, we also want to thank all the other authors who were not part of the research project but who generously contributed chapters to this report.

2. Report Contributors

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Jeremy Ashbee has worked for English Heritage since 2003, as an Inspector of Ancient Monuments and Senior Properties Historian. He previously worked as a field archaeologist at Lincoln and Lancaster, and for seven years was Assistant Curator of Historic Building at Historic Royal Palaces, based at the Tower of London. In 2006 he was awarded a doctorate from the Courtauld Institute of Art on the planning of medieval royal palaces. In 2007 he became Head Properties Curator at English Heritage, heading a team of properties curators, responsible for giving advice on the conservation and presentation of properties in state guardianship.

Alan Cathersides M.Sc., B.Sc., Dip.Hort.(Kew), M.I.Hort.

Alan Cathersides is the Senior Landscape Manager in the Gardens & Landscape Team at English Heritage. The team specialises in the management of historic landscapes and the landscape and ecology around historic structures. He is particularly interested in methods of management which benefit both historic and natural heritage. He has supported and been involved with both the research projects on soft wall capping and ivy on walls since their inception.

Dr Troy Sternberg B.A., M.S., D.Phil. (Oxon)

Troy Sternberg is a Post-Doctoral Research Assistant in Geography working on the Ivy on Walls project. As a geographer his research is focused in England and East Asia where he recently worked with the United Nations on reducing environmental and social vulnerability to changing climates across the steppe grasslands. Extensive fieldwork throughout England has developed his perspective on ivy in the nation's cultural heritage. His findings on ivy's role on microclimates and interaction with airborne particulates on stone surfaces have been presented at the Stone Weathering and Atmospheric Pollution Network meeting this September in Greece and a paper will be given at the 2011 ICBBE Environmental Health conference in China.

Dr Rachel Thomas B.Sc., M.Sc. (Oxon), Ph.D., MIEEM.

Rachel Thomas was nature conservation advisor to English Heritage between 1994 and 1997. She is an ecologist by training and although her professional work now takes her into other fields, has maintained her long term interest in the historic environment and historical ecology. She contributed a chapter on her work with English Heritage to *Managing the Historic Rural Landscape*, (Routledge, London, 1999) and recently promoted the approach at a conference organised by the New Dutch Waterline conservation project. http://www.hollandsewaterlinie.nl/pages/english-information.aspx

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Chris Turner is currently employed by The National Trust in the role of Regional Building Technician covering Devon & Cornwall. He joined The National Trust in 2003 after working as a Quantity Surveyor for a local authority. During his time with Trust Chris has completed a degree in Building Surveying at the University of Reading. During the final year of the degree course he wrote his dissertation on ivy removal concentrating on the Godolphin Estate in West Cornwall. Chris works on conservation building projects on many of the Trust's historic buildings in Devon & Cornwall.

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Heather Viles is Professor of Biogeomorphology and Heritage Conservation at the University of Oxford. She carries out much research on the deterioration and conservation of building stones, and has a special interest in the role of biological processes in stone decay and conservation. Her research has resulted in over 115 scientific papers and 14 books and edited volumes. She sat on the steering committee of the UK National Heritage Science Strategy.

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Amanda is a chartered building surveyor accredited in conservation by the Royal Institute of Chartered Surveyors. She is an SPAB Lethaby Scholar and has a Postgraduate Diploma in building conservation from the Architectural Association. Amanda joined English Heritage's

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