DUST IN HISTORIC LIBRARIES

HELEN LLOYD, CAROLINE BENDIX, PETER BRIMBLECOMBE AND DAVID THICKETT

ABSTRACT

Dust poses a particular challenge for historic libraries, where the quantity of fragile books makes the task of cleaning them labour-intensive, time-consuming and potentially damaging. This project investigates the frequency of cleaning appropriate in historic libraries, by monitoring the distribution of dust across shelves, the risks of high humidity causing cementation, and the usefulness of traditional dust falls (cloth or leather flap covering the gap between book and shelf above). The results enable book-cleaning teams and their managers to understand the relationship between visitors, dust and cementation, and to refine their cleaning regimes.

INTRODUCTION

Dust is recognised as a widespread problem for historic interiors, its presence reducing artistic value and imposing considerable cost in cleaning. Within properties belonging to the National Trust, English Heritage and Historic Royal Palaces, control and removal of dust represents one of the largest calls on budgets for housekeeping and preventive conservation [1]. Having said this, dust can also add a sense of mystery or historicity to interiors and in itself can provide evidence of the past or perhaps even be considered to add patina. Some historic properties are deliberately presented today with an air of dustiness to reflect the lack of housekeeping prevalent when the rooms were formerly occupied [2].

Libraries are a particular challenge because of the very large numbers of books that can be housed within a single room (Fig. 1). Cleaning books is labour intensive and time consuming, requiring the use of brushes and, on occasion, vacuum cleaners with variable suction [3]. In modern libraries this has prompted the development of commercial devices to clean books, such as the De Pulvera and Bassaire machines [4]. While there have been some worries that dust on books represents a health threat to librarians and readers, and more widely to staff and visitors in historic properties, dust is more likely to be a really serious issue during cleaning. Dust often contains mould spores, especially if the books have not been cleaned for some time and are in an uncontrolled environment. Evidence suggests that mould spores have the potential to damage the human immune system, so when cleaning and handling mouldy material, it is always sensible to wear appropriate protective clothing. [5, 6]

Books are made from organic materials, and many books in historic libraries are now fragile, their materials degrading and fragmenting, and creating dust. At the same time, books are potentially damaged by dust, by handling and by the abrasive process of repetitive cleaning. As books in historic houses are rarely read, cleaning activities are usually the major source of mechanical damage.

The design of some books makes then more vulnerable to damage during cleaning. Publisher's bindings generally have uncut text-block edges which become stained and brittle after prolonged exposure to dust. To clean them is time-consuming and difficult, as every page must be treated individually. In albums stored vertically on shelves, where the pages cannot close firmly together, there is greater potential for dust and humidity cycles to penetrate down into the gaps between the pages resulting in 'foxing' or staining of the paper, which remains after any dust has been removed.

In historic houses, teams of volunteers have been trained by a libraries conservator to clean books. The work has been carried out annually by rote, with little understanding of the variations in dust deposition in different parts of a room. This resulted in unnecessary handling and abrasion to books, and a lack of attention

Figure 1. View of the Library at Felbrigg Hall in Norfolk (UK), taken from the visitor route in the south-east corner. The Gothic interior was commissioned by William Windham II in 1752-5 and houses the books collected on his Grand Tour of Europe. ©National Trust Photographic Library/Nadia Mackenzie

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Figure 2. Close-up showing five of twelve sticky samplers attached to slide mounts and inserted in a bearer strip on a library bookshelf. Every three months one dusty sampler was removed and stored in a rigid case until the end of the three-year monitoring project.

to the needs of individual volumes, whether more fragile or less dirty. However, once trained, and in the absence of hard evidence to support the need for a different approach, book teams have proved reluctant to refine their practices or swap their coarse hogs-bristle shaving brushes for softer pony-hair brushes.

In this project we have investigated the frequency of cleaning appropriate in historic libraries by monitoring the distribution of dust across shelves and presses, the risks of high humidity and the usefulness of traditional dust falls. This work enables book-cleaning teams to understand the relationship between visitors, dust and cementation.

Monitoring dust in libraries

We have now gathered a considerable amount of data concerning the deposition of dust in historic interiors generally [7], and further information about libraries in particular [8]. In parallel, automated monitors were used to aid assessment of the source and rate of dust accumulation in historic interiors [9].

Our measurements have used either glass slides with image analysis [10] or sticky samplers and, for libraries, we developed simple monitoring kits of bearer strips, each carrying twelve sticky samplers, which were laid on top of books (Fig. 2). Every three months, one sampler was removed from the strip and stored until the end of the project for comparison with samplers removed at different quarterly intervals. This method allowed the continuation of sampling over periods up to three years and also created the opportunity to compare several locations in different parts of the country. Within individual libraries, the samplers were located according to a variety of criteria, such as proximity to the visitor route, height from the ground, and headroom between book and shelf. We have also used sticky samplers for spot sampling and detailed analysis in libraries [11].

Library interiors prove to be a heterogeneous environment, with areas of high and low dust deposition. Overall the measurements within libraries are much in line with our expectations from other historic interiors accessible to visitors [7]. They emphasise the role of the visitor in delivering coarse dust to the surfaces of materials that are on open display, yet libraries are protected from the usual sources of outdoor particulate material because they are in relatively well sealed rooms.

In archives, the source of dust is much reduced because there are few visitors and spaces are often air conditioned. Here the dust is predominantly degradation products from books (especially from leather red rot) and from documents or their storage boxes. There are other dust sources, of course, and, in some less well sealed old libraries in London, the books are still black and smell of smoke from coal fires, deposited in earlier centuries, and other more recent airborne pollutants [12]. Pollutants from historic and modern industries and the combustion engine can affect books within urban libraries. However, potentially dangerous indoor emissions from traditional wood and coal fires affect not only urban interiors but also the libraries of historic houses in the countryside.

When examining books in historic libraries, it is not surprising to find that most of the dust is deposited on the top of text blocks. The elevation of the shelf above the floor is also significant; notice the large amount of dust at ground level and at 1.5 metres, and how this is affected by the distance between visitors and bookshelves (Fig. 4). The larger deposits between

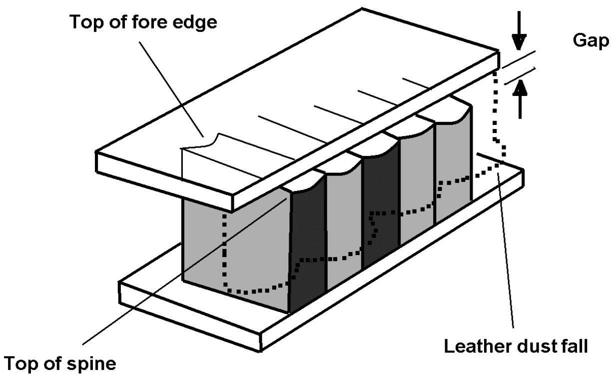

Figure 3. Terms used when describing the distribution of dust across books on shelves, and the effect of traditional dust falls (cloth or leather flaps covering the gap between the top of the book spines and the underside of the upper shelf).

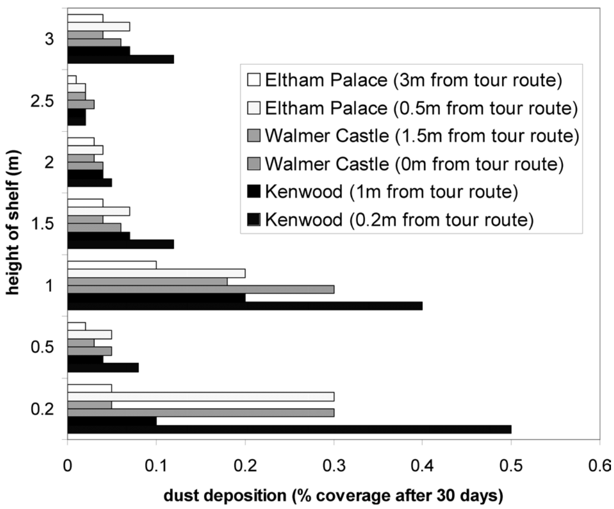

Figure 4. Rates of dust coverage close to floor level, and at shoulder height, are greater than on intermediate and higher book shelves in historic libraries managed by English Heritage. Books closest to the visitor route receive more dust than those at a distance. Visitor proximity and activity generated similar patterns of dust distribution on state beds in the care of the National Trust and Historic Royal Palaces.

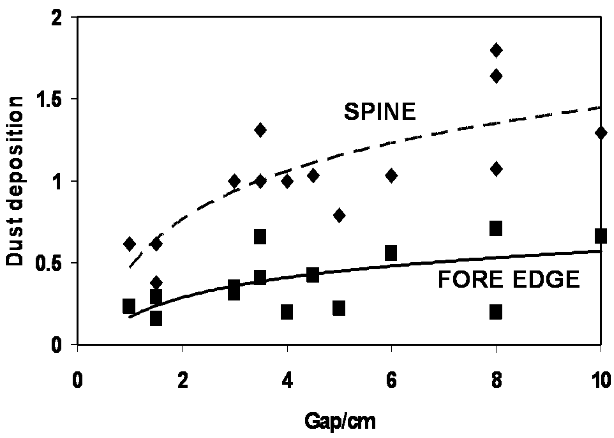

Figure 5. The rate of dust deposition at the fore-edge and spine of books is plotted against the size of the gap between the top of each book and the shelf above. Deposition rate is measured in Gs^{-1} [7] and generally rises as the gap size increases. The large scatter of data results from shelves at different heights above the floor and different distances from the visitor route. (Credit Y H Yoon)

1.0 - 1.5 m arise from dust and fibres shed from upper garments of visitors. The deposit close to the floor is somewhat coarser and arises from dust stirred up from the floor through walking. The gap between a book and the shelf above is another important factor; the bigger the gap, the greater the deposit – with more dust, quite naturally, being deposited at the spine compared with the fore-edge (Fig. 5).

Flaps to cover this gap, called dust falls, were sometimes installed in Victorian libraries and these substantially lower the rate of dust accumulation (Fig. 6, 7). However, their design means that in order to reduce dust deposition, the tops of the

Figure 6. Where traditional dust falls are installed in historic libraries, there may be a large reduction in dust deposition. However, where book shelves are located against cold outer walls, there are also risks of increased humidity behind the books, with attendant propensity for mould growth.

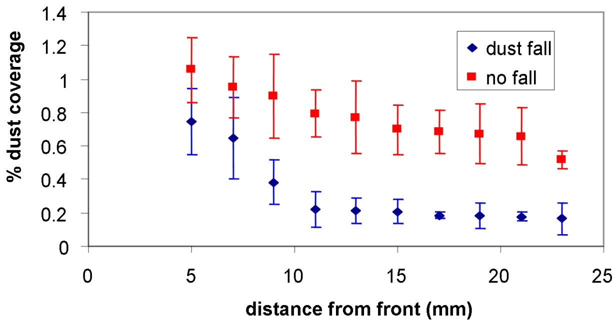

Figure 7. Fig Traditional dust falls reduce the penetration of dust, and rates of dust deposition, in book shelves in the Great Library at Audley End House (English Heritage). The deposition rate is measured as % coverage over a thirty day period.

Figure 8. Damaged dust falls at Penrhyn Castle (National Trust), demonstrate the extent of cumulative abrasion that occurs between book spine and dust fall when books are removed from and returned to the shelves.

spines must be behind the falls. This can result in damage to the tops of spines, caused by abrasion against the falls whenever books are removed and replaced (Fig. 8).

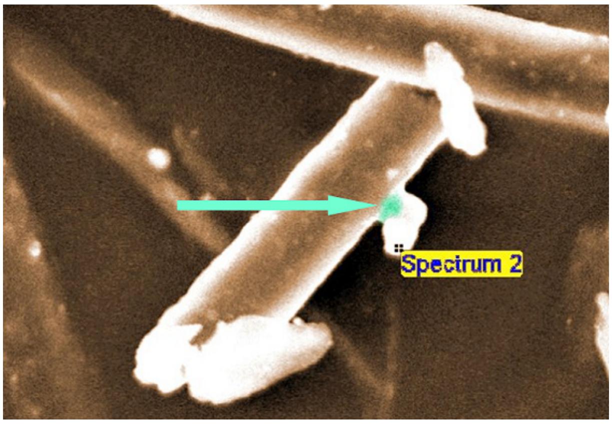

Figure 9. A Scanning Electron Microscopy image showing dust particulates cemented to textile fibres. The highlighted region binding the particle to the fibre is rich in calcium and, using Raman microspectrometry, has been identified as a fine grained calcite.

CEMENTATION

Where the dust just settles and can later be brushed off, it creates less concern than when deposits become ingrained or cemented to the underlying surfaces. In a recently completed three-year project funded by the Leverhulme Trust, we have been examining this process of cementation [13].

Cementation tends to occur at high humidity and can be driven by biological, physical and chemical processes. Under warm damp conditions (which are anyway harmful to paper) biological activity increases; bacterial cells can exude exo-polymers that can act like an adhesive and bind dust particles to the underlying substrate [14]. Humidity cycles cause physical movement of fibrous material that allow dust to embed deeper into porous surfaces [15, 16]. At high humidity calcium ions can leach from dust particles, and re-deposit as microcrystalline calcite, which cements the dust particle to the substrate (Fig 9) in much the same way as lime mortars recrystallise. This chemical process can be quite rapid at high relative humidity (80%) such that the cements may form in less than a day [15, 16].

The importance of humidity in the process of cementation has led us to examine the microclimate of bookshelves. Behind books, especially those on shelves against a cold outer wall, there is a potential for the formation of humid microclimates when warmer air moves in behind the books and cools, thus raising its relative humidity. At high humidity, dust adheres very effectively to organic materials such as cotton and silk [16] (Figs 10, 11). Books are largely made from organic materials, and their hygroscopic nature enables enhanced cementation.

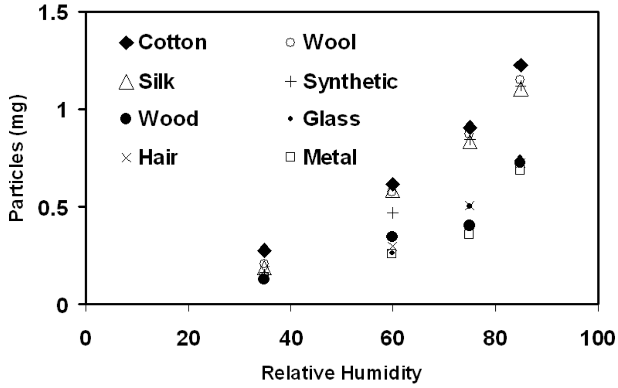

Figure 10. A variety of fibres (1 cm long) were exposed to fine soil dust in small dishes in the laboratory, at differing levels of relative humidity. After 4 weeks, greater quantities of dust had adhered to the fibres at 85% RH, than to those at 35% RH. The dust adhered more readily to textile fibres than to other materials.

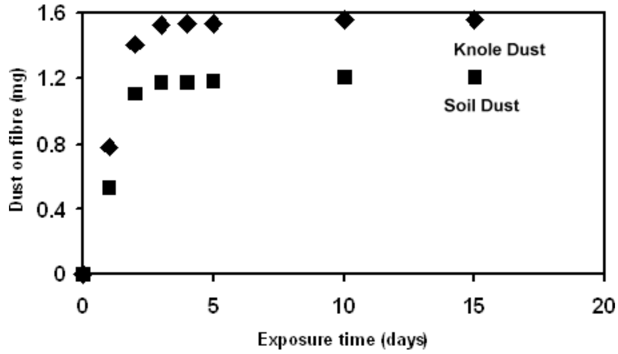

Figure 11. Two batches of cotton fibres were exposed, in a laboratory, to fine soil dust and to house dust extracted from vacuum cleaners at Knole in Kent (National Trust). In a matter of days, cementation of both types of dust had occurred but a greater weight of house dust adhered to the fibres because it is more hygroscopic than soil dust.

The cementation process increases dramatically at high RH values. Mould spore germination is also a strong function of relative humidity above 65%. Reducing ventilation across the gap between the tops of book spines and the shelf causes concern because of a number of mechanisms by which higher RH may be generated. Wet walls are common in historic buildings and ventilation is a major mechanism that reduces RH. As temperatures increase, the RH in equilibrium with the water content of the books will increase within a closed or low air exchange rate system. Rapid cooling of exterior walls can cause condensation leading to wet walls. At RH and temperatures supporting mould spore germination, air flow can significantly retard this process.

Two sets of library shelves were monitored at Audley End House, one on a damp external wall and the other on an internal wall. Similar runs of books were selected with two runs separated by a wooden divider and pieces of card fitted to one of each to act as falls. The test shelves were selected

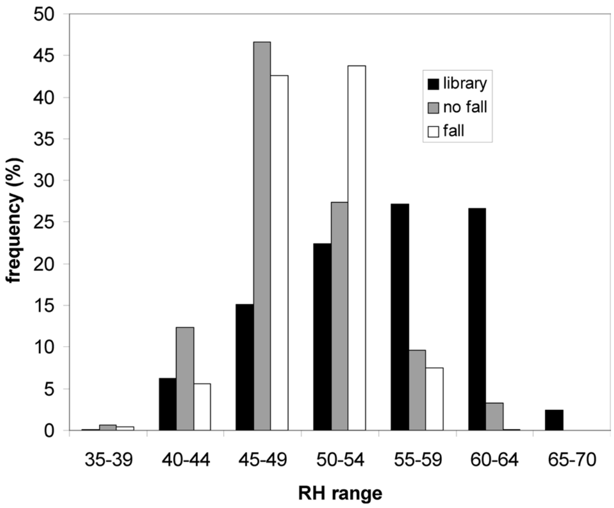

Figure 12. The environment in the Library at Audley End House, and behind books on shelves with and without dust falls. (A second set of measurements taken in front of the books gave identical results to those marked 'library' and has not been included.) The histograms show the time spent within specified RH intervals. Note the considerable stabilisation provided by the falls.

to provide as near to identical situations as possible. They had similar size books to give equal gap sizes and widths, similar dates and adjacent shelves. The conditions behind the books were monitored with electronic RH+T data-loggers for twelve months with the falls in position, and for a further six months after the falls were removed. The data-loggers were calibrated at three RH values with saturated salt solutions traceable to UK National Physics Laboratory standards.

Initial examination of the recorded data indicated little difference in relative humidity behind books, compared to the room environment. Figure 12 shows the results of monitoring and the frequency of various RH values (in intervals of 5% RH). One set of shelves with falls showed a greater degree of buffering (Fig. 13); the second set appeared to show less buffering than the adjacent set without falls. The extended six months monitoring without the falls in place revealed that these shelves had less stable RH behind them, probably caused by higher air exchange through the slatted wooden construction and hence the two sets of data were not comparable. The RH behind the false falls does not rise as high as that behind similar books when the temperature rises (Fig 13). This indicates that the buffering effect of the books is not the major driving factor in the RH rise. It would be expected to be greater behind the false falls as humidity escape would be expected to be limited.

In order to assess mass transfer the hourly vapour pressure change was calculated from the Clausius-Clapeyron equation. The data for the shelf with no falls is plotted against that with false falls in Fig 14. Since the slope of the regression line is less than one, more water vapour is moving into or out of the air behind the books with no falls, than when falls are present.

It would appear that in this instance ventilation is dominating the RH experienced behind the books. It is reassuring that addition of falls has not raised the RH in

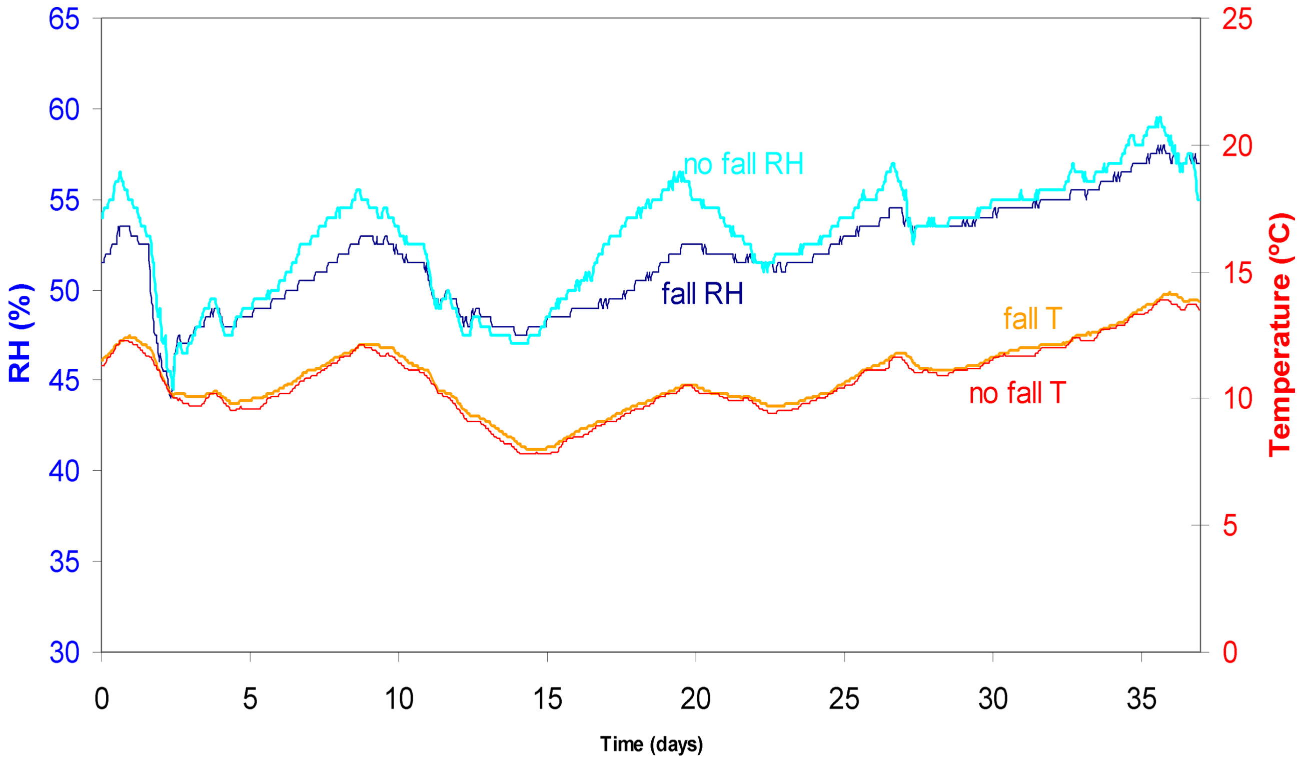

Figure 13. The environment behind books with dust falls compared to those without. Analysis detailed in the text indicated that the buffering effect of the books behind the falls was being overridden by ventilation.

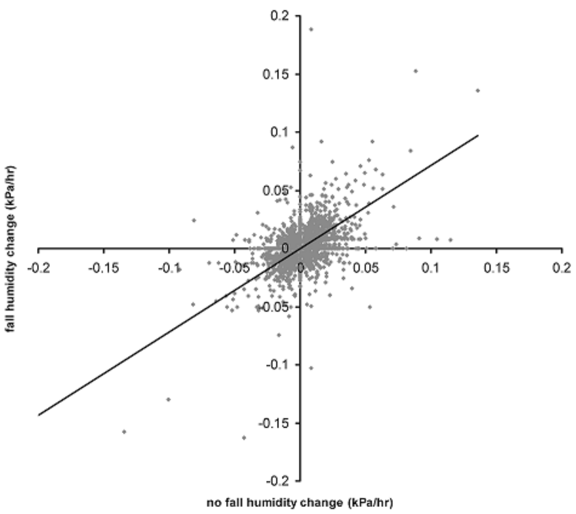

Figure 14. Rate of humidity change in KPa/hour with and without falls. The slope of the plot indicates whether water vapour transport is faster with or without the falls in place.

this case. These initial measurements have suggested that the air exchange is sufficient on most shelves to prevent enhanced cementation and mould growth from being a problem. However, monitoring would be required in each instance to ensure the risk is acceptable.

Visitor and staff perceptions

Over recent years our research has examined visitor and staff responses to dust in historic interiors and libraries [17, 18]. In general, visitors have found the interiors clean and, although they appreciate that dust creates a sense of age, they are not especially forgiving if they sense care or cleaning standards have dropped [19]. A narrow group of staff meet visitors and sense their disquiet, so often feel obliged to press for more frequent cleaning [20].

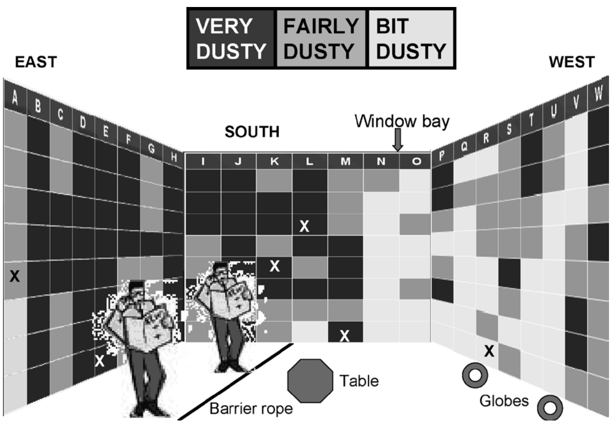

Figure 15. Mapping book shelves in the Library at Felbrigg Hall (Figure 1): the book team's perceptions of dustiness are recorded on a schematic plan of the presses, together with the location of sticky samplers. On this occasion, the book team observed that no shelves were clean. The highest levels of dust were found beside the visitor route along the east and south walls.

Alison Walker, Head of the National Preservation Office has said that "libraries with historic collections are often perceived as dusty and old books are often described as dusty". We studied the perceptions of volunteer book-cleaning teams who were asked to rate the shelves in book presses as "clean" "bit dirty" "fairly dirty" and "very dirty".

The assessments by the book teams at Felbrigg Hall broadly matched more quantitative measurements using sticky samplers. The four shelves with the highest coverage of dust were also areas of shelving ranked dustiest by the book team. The shelf with the lowest measured coverage came from the area of shelving ranked as only 'a bit dusty' by the book team (Fig. 15). No shelves were termed 'clean'. When shelves were labelled "fairly dirty", this seemed to indicate that a historic library would soon need cleaning as staff began to worry about the appearance of the presses. Measurements from sticky samplers suggested that this occurred when more than 6-7% of the surface was covered by dust (Fig. 16).

In some of the libraries we examined, it could often take more than three years before this amount of dust would accumulate. The rate of deposition in libraries is less than half that encountered on other furnishings on open display in historic interiors, where housekeepers are prompted to clean when only 2-3 % of surfaces are covered by dust. It is perhaps not surprising that books can be left longer before needing cleaning, as books on shelves are less exposed to dust, and partially hidden from view.

Judging dustiness by eye is a subjective process and one person's definition may well differ from another; this means that staff working in historic libraries need help in making objective assessments of when the level of

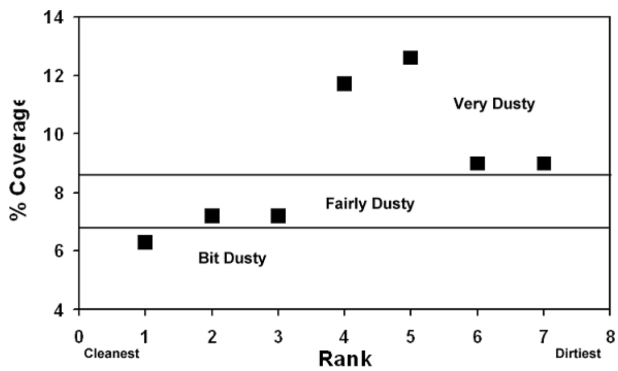

Figure 16. Perceptions of dustiness at Felbrigg Hall broadly match more quantitative measurements using sticky samplers. The four shelves with the highest coverage of dust were in areas ranked dustiest by the book team. The lowest measurement coincided with the book team's ranking of 'a bit dusty'. Where more than 6-7% of the surface was covered by dust, shelves were labelled "fairly dirty", and deemed to be in need of cleaning.

dust is sufficient to demand cleaning. Semi-objective measurements can be made by wiping a defined area of the top edge of the boards and text-block, or the shelf, and retaining the sample pads for comparison with that taken from other books. While books with gilt-edge decoration lend themselves to this approach, those with deckled edges give less clear results. A semi-quantitative tool currently under development is a simple monitoring kit using sticky samplers, a hand lens and a calibration scale to indicate percentage coverage. Prototype dust monitors that allow computer analysis of images of dust deposition recorded in real time have been used for a number of studies [9].

MANAGEMENT OF DUST

Practical outcomes from this study can be incorporated into preventive conservation regimes for the care of historic libraries. Control of relative humidity is key because, where it is impossible to predict excursions outside the normal target band (50-65% RH in National Trust properties [21]), books will need to be cleaned more frequently than once in three years to prevent cementation of any substantial deposits of dust. Fortunately in most libraries, the shelves are close enough together for this not to be a significant issue, but where books are exposed to deposits of dust, the optimum time for cleaning might be the end of dry spells. This extra cleaning conflicts with the desire to reduce the frequency of handling, which accelerates degradation of materials and generates dusts.

Rates of dust deposition can be reduced in libraries, as elsewhere in historic houses, by keeping visitors away from shelves and presses, using rope barriers to achieve 1.5-2 m distance between visitors and books. Such separation is likely to reduce the deposition of dust two- to four-fold. Where space is tight, transparent barriers to shoulder-height can also reduce deposition two-fold [7, 22]. Fewer visitors will reduce soiling, but if the flow of visitors increases dramatically, jostling may enhance the production of fibres from visitor clothing. Furthermore, overcrowding could force visitors to depart from the designated route and soil objects by greater proximity.

Limiting the hours of public access will release time for routine cleaning of robust surfaces, and occasional but timely treatment of fragile materials. Where possible, it is advantageous to remove accumulated dust before periods of high humidity and to protect surfaces with temporary covers during closed periods. Keeping windows and external doors closed helps to exclude dust. During activities such as events and building works, assess the risks and need for additional prevention and protective measures.

As cleaning can cause damage through abrasion (and is resource intensive), it can be delayed until dust has reached the identified critical levels at which aesthetic impact and public concern becomes significant. This may mean that, where there is little risk of high humidity occurring, library books are cleaned only every three years or more. However, any reduction in cleaning frequency must be accompanied by an annual check of books for mould and insect activity, to ensure the swift identification and treatment of any problems.

The design of the shelving should be considered, in particular the implications of dust falls. In our survey, we could find no effect of dust falls on humidity although, before taking decisions to use or reinstate dust falls, there may still be a need to monitor the internal climate of bookshelves where there are cold walls. The traditional design of dust falls attached to a fixed batten could be substantially improved if the batten were to be hinged. However, these interventive conservation measures may not be appropriate in historic libraries where dust falls were not originally installed.

Methods of preventing dust falling on books can be obtrusive and may not blend in with an historic interior. Polyester covers are being tested in a few National Trust libraries. Cut to the depth of the shelf and moulded to fit the profile of the tops of the books, they should provide protection without being visible to visitors (Fig. 17). If successful, this method has the potential to reduce quite dramatically the frequency of cleaning and its attendant risk of abrasion. Enclosures, such a 3-flap phase-wrappers or 4-flap phase-boxes can also be used to protect individual volumes, such as publisher's bindings,

Figure 17. Protecting books from dust deposition, using static grade polyester film on shelves above eye-level: (top shelf) unmoulded, i.e. laid over books; (bottom shelf) moulded, i.e. creased to follow contours.

but not as a method of mass protection. Shrink-wrapping books, used in some storage facilities, is not an option in historic libraries. In storage areas, pieces of archival card can be laid on top of books.

This study is now influencing housekeeping practice in historic libraries in the care of English Heritage and the National Trust. Book cleaning teams, whether staff or volunteers, are encouraged to look more closely at dust, assess dirt levels on individual shelves and map their assessments on a plan of the library presses. Mapping bookshelves gives a shelf-by-shelf analysis of cleaning needs and provides a basic guide to cleaning frequency for individual shelves. It also identifies the unexpected, e.g. dirty shelves far from visitor access, and prompts staff and conservators to investigate sources of dust unrelated to visitor activity (Fig. 15). As deposition rates vary up/down presses and across shelves, the frequency of cleaning can then be tailored to individual shelves. The cleaning regime should be regularly reviewed and changed whenever unusual events occur, e.g. building works or filming which may affect the distribution of dust.

Our studies of visitor perceptions of dustiness highlight the importance of communicating to visitors the ways in which libraries can be effectively preserved, together with an understanding of the effects of visitor activity on cleaning regimes and the conservation of individual books. Where there is no risk of mould, conservation activities can be shown to visitors as part of the visitor experience of a historic house, for example demonstrating simple book dusting techniques, together with the mapping of dust deposition.

Conclusions

When assessing the desirable frequency of cleaning in libraries, the fragility of book bindings should be taken into account. Where dust accumulates over long periods, there is a potential for it to become strongly cemented to surfaces through bacterial growth, formation of microcrystalline calcite, as well as humidity fluctuations causing fibre movement. As relative humidity is an important factor in this process, control of relative humidity is fundamental to the prevention of cumulative damage to books from dust and cleaning processes. Especially important are monitoring programmes, and cleaning schedules prior to seasonal cycles of high humidity.

It is essential that staff and volunteer book teams understand both the process of cementation and visitor perceptions of dustiness, so that decisions on how often to clean are based on objective assessments of dust distribution and accumulation, and resources are directed where most needed. Scientific data also add force to debates with management over the need to spend scarce funds on new ways of preventing damage to collections.

To minimise deposition and hence frequency of cleaning in historic libraries, it is necessary to control visitor proximity to book presses, and visitor capacity and flow. It is also important to interpret to visitors the preventive conservation issues concerning dustiness, as their concerns over the appearance of rooms can impose more frequent cleaning than is good for the long term care of collections.

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Equipment and Suppliers

Hanwell RH-T Data Logger

For specification, see
http://www.hanwell.com/pdf-industry/rh-t.pdf
Hanwell Instruments Limited
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Hertford SG13 7BJ,
United Kingdom

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United Kingdom
info@conservation-by-design.co.uk
http://www.conservation-by-design.co.uk/equipment/hanwell_data_logger.html

Polyester film

Sold as Melinex® in the UK, and supplied by:
Preservation Equipment
Vinces Road, Diss, Norfolk IP22 4HQ
info@preservationequipment.com
www.preservationequipment.com

Glossary of terms

Press or stack

One vertical division within book-shelves

Dust fall

A flap, usually made from leather or cloth, between 3-10cms deep and the same width as a book-shelf. It is usually attached to the underside of the leading edge of the shelf and hangs down from it in front of the tops of the spines of volumes on the shelf beneath.

3-flap phase wrapper

An enclosure made from archival board, which encloses all but the spine of the book.

4-flap phase wrapper

An enclosure made from archival board which completely encloses the book (also known as a phase-box).

Publisher's binding

A book produced already bound by the publisher but often without the text block (pages) having been trimmed.

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National Trust Views - PDFs of articles on dust research can be found at:
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