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National Trust

Climate Change Adaptation Guidance – Collections and Interiors

Paper and Books

Climate change vulnerability: high

Paper and books – introduction

Paper items are a core part of the National Trust's collections. Many of our historic houses contain books that shed light on the residents' interests and tastes and on the history of private book collecting. Often, they may also contain historic records that detail family history and the workings of the estate, as well as artistic works on paper.

Works on paper may include ink-based prints such as engravings and lithographs, drawings and sketches in pencil, ink, or charcoal, watercolours and pastels, as well as photographic material. Our paper collections include works by Old Masters as well as manuscripts by some of the United Kingdom's best-loved writers. Handwritten annotations on books and other documents may add to their value and significance.

There are many other paper-based objects in our collections, such as globes and fans. Many houses also contain significant examples of period wallpaper as well as print rooms where works are pasted to the walls.

Paper is a fragile and environmentally sensitive material. Books and other paper-based objects need special care, even when environmental conditions are stable. As the impacts of climate change on our properties increase, we may need to take special adaptive measures to ensure that our important collections are safeguarded for the future.

Books are complex to care for because they are composite objects made up of more than one type of material: the paper will be made of wood or fabric-based pulp; the binding of animal skin or fabric, with a wooden supporting board; there may be different adhesives used. Some books may include metal clasps or inlays. These materials all degrade under different environmental conditions.

Similarly, wallpaper can be tricky to care for: on walls, it becomes part of the fabric of the building; its media may include thick distemper pigments, gilding or flocking made of wool or silk.

This chapter looks principally at paper collection items as well as wallpaper. Photographic materials are covered in a separate chapter of this guidance.

Image credit: Close shot of facsimiles of some of John Wordsworth's documents and accounts written by his clerk, on display in the Back Office at Wordsworth House, Cumbria, the home of the Wordsworth family in the 1770s (© National Trust Images/Nadia Mackenzie).

Paper and books – why do they matter?

Paper and paper-based objects are perhaps the most widespread and numerous types of material in the National Trust's collections. Paper is also very vulnerable to changes in environmental conditions, which means that we need to take special care to safeguard it from the impacts of climate change.

Our historic properties are home to libraries of national and international importance. Caring for these important collections ensures continued access for visitors, including researchers. Libraries are often central to 'spirit of place', telling us about the interests and lifestyle of those who lived in a house as well as being an aesthetic or decorative element in their own right. It is crucial that these collections are properly looked after – but climate change is already increasing our conservation challenges, with higher temperatures, water damage, fluctuating relative humidity (RH), higher light levels and pests all likely.

Paper is particularly vulnerable to incorrect RH. In high RH, paper will absorb water and expand, and in low RH it will lose water and shrink. This can lead to 'cockling', distortion and splitting. Above 65 per cent RH, size will begin to soften and bonds between the cellulose fibres weaken. The paper becomes limp, and if not supported it can sag and tear. High RH also encourages mould. Paper does not itself provide a good diet for insects, but both silverfish and booklice will feed on mould.

We own many works on paper that are framed and glazed. To some extent, the frame and glazing may provide a buffer from the exterior environment, protecting the contents from high RH. However, a framed work of art placed against a cold wall could effectively create a microclimate, with condensation leading to mould, which may go unnoticed until the damage is already significant. Microclimates of incorrect RH can also be overlooked when items are stored away. Climate change is likely to bring wider seasonal fluctuations in RH in many properties, making it more challenging to control this to within the ideal range of 40–65 per cent. More regular monitoring will be needed, followed by adaptive interventions to ensure that precious paper items are safeguarded.

Where paper comes into direct contact with water – which may happen more often as properties experience flooding or water ingress due to extreme rainfall – it will lose structural strength as cellulose fibres weaken. Water damage may result in disfiguring staining and a contaminated 'tideline' at the edge of the wetted area. Media such as ink or gouache may run or become dislodged. Preventing this kind of damage via increased maintenance and monitoring of the building envelope is the essential first step.

The following page gives further detail on the key agents of deterioration and how paper-based objects are likely to be affected by these as the impacts of climate change are increasingly felt at our places.

Image credit: Conservation assistant carefully cleaning a book at Llanerchaeron, Wales (©National Trust Images/Arnhel de Serra).

Agents of deterioration, impacts and options

Agent of deterioration	Climate change impacts	Options
Water Contamination from direct contact with water can cause staining, tidelines, loss of inks and pigments, and planar distortion.	Increased rainfall may result in water ingress and damp problems in many properties. With more frequent and extreme wet weather, RH may be more difficult to control.	This issue concerns failure of the building envelope (poor pointing, leaky roofs, inadequate rainwater goods); proper building maintenance is key along with adaptation of building fabric and rainwater goods where necessary (see guidance chapters on *Buildings: Historic Building Fabric and Rainwater Goods)*.
Relative humidity (RH) See previous page for a brief outline of how incorrect RH affects paper. RH is likely to see greater seasonal fluctuations, depending on location and local conditions.	As well as damage directly related to higher levels of RH, we may see increased mould and pests (see below). Low RH may also be an increasing seasonal problem.	Increased monitoring of display and storage conditions. Investigate sources of moisture/ building defects. Increasing ventilation may help tackle higher RH; use dehumidification (although air conditioning is unlikely to be effective or desirable in historic houses); move items to a more controlled environment. Local use of portable dehumidifiers may be a short-term measure in some instances until a longer-term solution is possible.
Temperature Higher temperatures accelerate chemical degradation.	Higher average temperatures are likely, although this will vary greatly across sites.	Increased monitoring of display and storage conditions; change location of collections stores, to move items to a more controlled environment. Remember that temperature and RH are always connected, as warm air can hold more moisture.
Light UV weakens and embrittles paper fibres and causes them to yellow; inks and pigments will often fade. It also accelerates chemical degradation.	According to the Met Office's 2021 State of the UK Climate report, winters in the decade 2012–21 were 13 per cent sunnier than between 1961 and 1990, and springs 15 per cent sunnier. It is reasonable to assume future conditions will include greater average levels of direct sun in most UK locations.	Paper objects vulnerable to light should always be kept in controlled conditions, with monitoring of cumulative light levels; move to a more controlled environment where necessary. Light levels indoors can be tightly controlled using UV filters, awnings, shutters, blinds, curtains or sun curtains.
Chemical agents Acidity is the main factor: gaseous pollutants such as sulphur dioxide, nitrogen oxide and ozone are absorbed into the paper and cause it to become brittle and brown.	If windows are opened in higher temperatures, this could expose paper items to increased pollution and RH. Metal particles in the atmosphere (particularly in urban or industrial areas) can act as a catalyst and accelerate chemical deterioration.	Keep windows closed, especially in urban or industrial areas where pollution is high (although this would need to be balanced with the need to regulate temperature and RH); store and display significant or sensitive items in controlled environments, such as conservation grade showcases, frames and storage enclosures.
Biological agents These consist of mould and pests: woodworm, death-watch beetle larvae, silverfish, booklice.	Increased RH leads to increase in mould growth and creates ideal conditions for pests (wood-boring beetles, silverfish and booklice all thrive in damper conditions).	Increased monitoring of display and storage conditions. Always tackle the source of the problem: if RH is an issue, look for problems with the building envelope and deal with these first. Increase ventilation; use dehumidification (see above); move items to a more controlled environment; upgrades to building fabric to address sources of damp. Increase integrated pest management programme.

Paper and books – options and thresholds

Adaptation options for collections are likely to relate to building fabric and the conditions in which objects are displayed and stored. The objects themselves cannot usually be adapted. You may find it useful to refer across to other chapters of this guidance which deal with building fabric, including rainwater goods.

Adaptation options for paper collection items include:

Increased monitoring – where there is a concern about climate change impacts on paper items, monitor storage and display conditions more intensively, and check more regularly for signs of damage. Record, photograph and date your findings.

Increased environmental control – the most significant and/or sensitive items in a collection might be moved to a display case where environmental conditions can be more tightly controlled, but the item remains on public view. Some particularly precious items may need to be removed from regular display.

Alternative storage – stored items may be moved to a different location in the building, or to a different building with better RH, temperature and light control. However, care must be taken when moving paper-based material from damp to dry conditions: for example, the different materials in a book may react at different speeds to a swift change in RH, causing distortions. Acclimatisation may be necessary.

Improved ventilation – it may be possible to lower RH by taking some relatively simple steps. For example, if books are stored in cupboards, open doors to increase air flow. Move books forward on shelves to allow air to flow behind. Where possible, cut a 3cm strip in the back of bookshelves to encourage airflow. Cork stoppers may be placed behind wall-mounted framed works to allow air to circulate.

Thresholds & tipping points

At what point might you diverge from your current management strategy? What are the events/factors that may trigger this change of approach (action/philosophy)?

- Condition monitoring logs a change in RH or other agents of deterioration.
- Signs of damage are noted during regular inspections. These may include pest damage, 'foxing' from mould, discolouration, fading of pigments and inks or changes to the shape of the paper – cockling or planar distortion.

The contribution of house and collection teams cannot be underestimated. Any concerns should be flagged early by teams and a conservator should be alerted so that the problem can be addressed before there is significant damage.

Image credits, left to right:

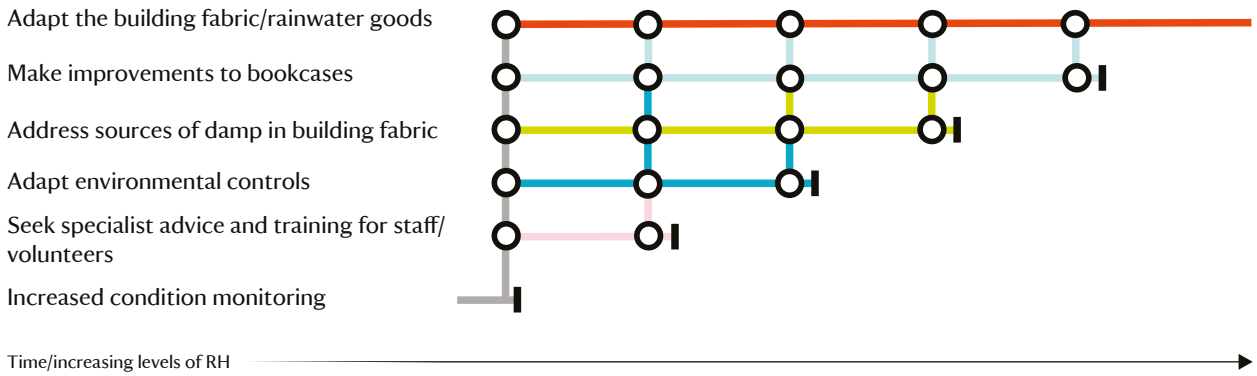
Water damage with tideline to a map at Seaton Delaval Hall, Northumberland; woodworm damage to an Old Master Drawing at Bradley, Devon; mould on the flocked areas of a wallpaper at Castle Coole, Northern Ireland (all photographs by Nicola Walker)

Paper and books – worked pathway example

This section explores how you might move between different adaptation options to safeguard paper-based objects from the impacts of climate change.

Working as a team is key to understanding and mitigating against the impacts of climate change on collections in your care. It is also crucial to understand the significance of the collection items you are caring for to help guide your decision-making, so you should consult with a curator before undertaking any adaptive measures.

The following adaptive pathway[1] sketches out adaptation options for the library in the Long Gallery at Blickling, Norfolk – the largest and most important library in the National Trust. The library has a history of high RH, which has previously resulted in insect damage and mould. As weather patterns change, higher temperatures and fluctuations of RH will likely cause mould to become more problematic. Taking a holistic approach by ensuring that stable conditions are maintained across the whole library will prevent the deterioration of individual books and ensure scarce resources are used efficiently.



This pathway includes a number of measures (condition monitoring and environmental control via conservation heating) that are routine practice, but are likely to be intensified or adapted when climate change impacts are observed. Specialist, targeted advice and training for staff and volunteers will give them the tools to identify issues such as mould outbreaks and deliver interventions such as integrated pest management. Physical adaptations, such as increased ventilation around book shelving, may be desirable, especially in localised hotspots of high RH. The fabric of the building and exterior environment is an important factor in RH levels, so maintenance and potential upgrading of the building envelope is key (see *Historic Building Fabric*). Adaptations to the external environment might include measures such as planting trees to protect against wind-driven rain, or garden adaptations to absorb water into the surrounding landscape.

[1] Dynamic Adaptive Pathways Approach (Haasnoot, Kwakkel, Walker & Ter Maat, 2013).

Significance, access and preservation

In using our resources, we need to balance the provision of access to our visitors and specialist researchers with the preservation of collection items for the future.

Of course, we have a duty to preserve all collection items that we own or that are on loan to us. Understanding the significance of paper-based items will help to guide decisions about their care. For instance, different pathways may be appropriate for a unique watercolour or manuscript, compared with a print or book of which there may be multiple copies.

One of the unique characteristics of many historic properties is that they contain collections which have been there for many generations. They are part of what makes the house significant, and the collections are themselves most significant in the context of the house. It may therefore be more appropriate to retain them in situ than to move them to a more controlled storage environment. A curator can help you to make informed decisions about this.

Prevention is often better than cure. Using preventative measures such as conservation grade storage materials, and carefully constructed display supports, is preferable to expensive remedial treatments. Always discuss care and conservation with a conservator.

Case studies, signposting and references

These examples show where collections teams have identified impacts that may be related to climate change, and what measures can be put in place to safeguard paper-based materials.

In July 2023, **Sudbury Hall in Derbyshire** experienced a significant leak from the pitched roof during torrential rain. Water came down into the Talbot Room, which contains part of the library collection. Some books were protected by Perspex screens (originally installed to protect items from visitors' hands), but others on the upper level were exposed to water damage. One adaptive measure to prevent further damage would be to add screens on the upper level, but it is most crucial to address the source of the water ingress. On this occasion, a makeshift leaf guard, put in place to prevent blockages to a drainpipe, was allowing water to collect in the gutter and track back into the building. This was removed and no further leaks have been noted. The facilities team is also investigating whether adaptation of the historic drainage system may be necessary to cope with more frequent heavy rainfall associated with climate change.

For many years, there has been silverfish damage to a Chinese wallpaper at **Saltram, Devon,** causing loss of both paper and pigments. A portable de-humidifier reduced the RH and slowed down the damage. Consistent monitoring with photographs, charting the increase in damage over time, led to further intervention to the building. This included the installation of small radiators (for low-level heating) and improved ventilation around the window shutters – both of which were more sustainable options than air conditioning. As RH levels increase seasonally at many of our properties due to climate change, similar adaptations are likely to be needed.

At **Tredegar House, Newport,** extended and cumulative exposure to light caused fading of the red inks and some black inks on the top sheet of a stack of architectural drawings. No remedial treatments can 'restore' these lost inks, so preventing light and UV damage to paper and sensitive media is vital for long-term preservation. Light plans should be undertaken for all rooms containing sensitive materials. Light can be controlled with UV filters, awnings, shutters, blinds, curtains and sun curtains and monitored with dosimeters. Increased levels and hours of sunshine due to climate change will necessitate more intensive monitoring and increased levels of protection.

Signposting & additional guidance

National Trust staff should consult relevant sections of the Manual of Housekeeping and Acorn guidance on Care of paper, books, portrait miniatures and photographic materials.These resources can be shared with other organisations on request.

The Institute of Conservation offers guidance on collections care which includes books and works on paper.

The Canadian Conservation Institute has published an online resource on Caring for Paper Objects.

The Climate for Culture project produced a range of research outputs outlining the impact of climate change on indoor climates and collections.

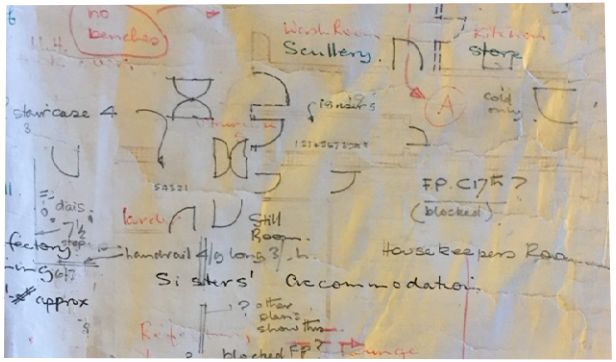


Image credit: far left, the makeshift leaf guard at Sudbury (photograph by Laura Wheeldon); middle, silverfish damage at Saltram (photograph by Nicola Walker); above, faded inks in the architectural drawings at Tredegar House (photograph by Nicola Walker).