Conservation Heating to Slow Conservation: A Tale of the Appropriate Rather Than the Ideal

By Sarah Staniforth

Introduction

"There is something inelegant in the mass of energy-consuming machinery needed at present to maintain constant RH and illuminance, something inappropriate in an expense which is beyond most of the world's museums. Thus the trend must be towards simplicity, reliability and cheapness. We cannot, of course, prophesy what will be developed, but I should guess that it will include means for stabilising the RH in showcases without machinery, use of solar energy for RH control in the tropics, improved building construction to reduce energy losses and extensive electronic monitoring" (Thomson 1978, 249).

So wrote Garry Thomson, Scientific Adviser, National Gallery London, in 1978. Garry's thoughts were directed toward different approaches to environmental control in museums in the developed and developing worlds—but how relevant his words seem when we consider the challenge of climate change now faced by the whole world, regardless of the extent to which countries' carbon footprints have contributed to global warming.

Another scientist—one whose work in atmospheric physics pioneered our understanding of the relationship between the use of energy and the climate—was also involved at the National Gallery London in the 1970s and 1980s, as a member of the Honorary Scientific Advisory Committee. James (Jim) Lovelock is best known as the author of *Gaia* (Lovelock 1979) and, more recently, *The Revenge of Gaia* (Lovelock 2006).

In 1979 Jim was relatively sanguine about the ability of the planet to regulate the climate. The Gaia theory is a view of the Earth that sees it as a self-regulating system made up from the totality of organisms, the surface rocks, the ocean, and the atmosphere tightly coupled as an evolving system, with a goal of regulating surface conditions so as always to be as favorable as possible for contemporary life: "If, due to fossil fuel combustion, the level of carbon dioxide rose too rapidly for inorganic equilibrium forces to cope, the threat of overheating might become serious. Fortunately, this greenhouse gas interacts strongly with the biosphere" (Lovelock 1979, 82).

In the 1980s the only energy-related issue that most governments were concerned about was how they could access more energy sources, whether they were fossil fuels or nuclear power. Renewable energy was a glint on the horizon, an aspiration but not the necessity that it has now become. In his latest book, Jim Lovelock is altogether less optimistic. He warns, "if we continue to burn fossil fuels and let carbon dioxide rise in abundance, ocean life, essential to the health of Gaia, will be further damaged" (Lovelock 2006).

We are all becoming aware of the impacts of climate change on the planet, and its effects are already felt by the museum and heritage sectors, with events such as Hurricane Katrina and flooding in European cities on the Danube. An increasing number of torrential downpours are overwhelming the capacity of gutters and downpipes to disperse rainwater from the roofs of the historic buildings managed by the National Trust.

But what have these changes in the global environment got to do with the environment inside buildings, where collections are housed? A great deal, I would suggest, because by looking again at the needs of collections and by looking at the buildings that house them, particularly if they are of architectural or historic significance, a virtuous circle is created: by designing an appropriate, rather than ideal, environment within a building, we can minimize the impacts on the structure of the building and on the wider environment.

The Historic House Environment

By the middle of the 1980s, when I moved from the air-conditioned haven of the National Gallery London to the altogether more bracing climates of the country houses in the care of the National Trust, there were the stirrings of a nascent movement of awareness of the need to regulate the use of energy in the United Kingdom. The UK government's Department of Energy operated an Energy Efficiency Scheme for nondomestic (largely industrial) premises. Surveys that reviewed environmental control in historic houses open to the public and that recommended energy-efficient improvements to plant, controls, instrumentation, and so on could qualify for grant assistance under this scheme. By 1987, when we first reported on the emergent strategy for environmental control in National Trust houses (Staniforth and Hayes 1987), thirty initial short surveys and six extended surveys, in which the need for more detailed investigations or monitored trials was identified, had been carried out by the engineer, Bob Hayes, who was technical environmental control adviser to the National Trust.

In this article we looked at three case studies that used dehumidifiers to control RH in spaces that did not require heating for human comfort. Monitoring carried out as part of the Energy Efficiency Scheme surveys showed that dehumidification used as little as one-fifth of the energy input of heating for the same measure of RH reduction using heating. The case studies demonstrated the need for well-sealed spaces when using dehumidification, provided by display cases or polyethylene tents in storage areas. Dehumidification is much less effective in rooms in historic houses, which are designed to have high levels of ventilation. Sealing these rooms is difficult, requiring major intervention to the fabric of the building for preventing leakage up chimneys and around door and window frames.

In show rooms, we began to experiment with the control of RH through temperature, by using thermostats to raise the internal temperature approximately 5°C above external average conditions, in order to bring the RH to within the emerging target band of 50%–65%. It was in this article, in 1987, that we introduced the use of the term *conservation heating* to describe the use of temperature to create an environment conducive to the preservation of museum collections.

Ideal Versus Appropriate Museum Environment

RH specifications for artifacts became very stringent in the 1980s, perhaps following the publication of Garry Thomson's *The Museum Environment,* which made museum professionals across the world aware of the risks of an adverse museum environment (Thomson 1978). Specifications selected a set point, typically 50% in Europe and North America, with limits of +/– 5% RH. These specifications were usually based on the performance capabilities of the methods of control rather than on the requirements of the artifacts. This tightness of control is extremely expensive to achieve, in terms of both capital expenditure on equipment and running costs. Many museums re-examined these specifications and asked if such tight conditions were required. Appropriate environmental conditions are selected, depending on facts such as the condition of the collection, the climate, the type of building, and finance. What is known about incorrect levels of RH was admirably summarized in a review carried out at the Canadian Conservation Institute (Michalski l993), and a methodology for selecting appropriate RH levels is given in a paper prepared by scientists at the Smithsonian Institution (Erhardt and Mecklenberg l994).

In many ways, these articles provided post hoc justification for a practice that was becoming established in National Trust historic houses to keep RH as stable as possible and to avoid extremes within the constraints of architecturally important structures.

The Importance of the Building

For many museums housed in historic buildings, the building is the most significant artifact in the collection, and the needs of the collection should not be considered in isolation from the conservation of the building. There are many aspects to the relationship between a building and its contents. These include the relationship between the internal and external environment and the fabric of the building, the impact of heating and environmental control equipment on the structure of the building, and the appearance of environmental control equipment in display spaces.

Studies into the pathology of buildings have demonstrated the complicated physics involved in the interactions of the internal and external environment and moisture movement through the fabric. Water in the wrong place in a building's fabric can result in biological activity such as dry rot outbreaks, corrosion of metal structural elements, and physical damage through freeze-thaw cycles if condensation occurs near external surfaces in cold climates. Moisture moving through walls can carry soluble salts, which disrupt surfaces when they crystallize. Condensation on surfaces can cause more severe damage in a short time than long periods of the "wrong" RH.

Heating in buildings is generally less damaging than environmental control systems that alter the internal air moisture content, since it is changes in vapor pressure that set up the gradients within walls resulting in the movement of water molecules, leading to condensation and soluble salt transport. Air-conditioning (HVAC) systems that humidify or dehumidify, as well as room-based humidifiers or dehumidifiers, should be avoided unless the units can be contained within sealed structures, such as exhibition cases or polyethylene tents in storage areas.

HVAC systems require a significant amount of space for the plant, and large ducts to transport the conditioned air around buildings. Inevitably installation means cutting holes through the original building fabric. There have been some ingenious solutions, particularly in North American historic houses—where the plant has been concealed in basements or attics, and the conditioned air is introduced through vents in floors and ceilings with ducts in basements, attics, and chimneys—but in the majority of cases, it has proved difficult to install a system without considerable impact on the building fabric.

The impact of the appearance of environmental control equipment in a room in a historic building is also important. The thoughtless selection of radiators, heaters, and monitoring devices, and their positions in a room, can have a significant impact on the aesthetics of a historic place. Decisions about whether to select equipment that blends into the background, is concealed, or is unashamedly modern should be consciously made.

Environmental control methods that are most benign for historic buildings work with the building rather than against it, and they take account of the local climate. Thus, temperature and RH set points may change during the year, with lower values in the winter than in the summer in continental climates, and broader ranges are allowed. The aim should be to minimize differences between average internal and external values.

The "Do Nothing" Option

The first option is to do nothing to change the RH, but this is done as a conscious decision, not as the result of inaction! The temperature and RH should be monitored for a minimum of one year. Monitoring can be carried out using individual dataloggers, from which data is regularly downloaded onto a laptop. The data collection task can be streamlined if all the temperature and RH sensors are connected to a central computer or a building management system. The wiring of these systems can be detrimental to the structure of a building, since sensors have to be attached to walls, wires chased into plasterwork, and holes drilled through the structure for the wires. Radio systems, which remove the need for wires, are now available; they are therefore particularly suitable for use in historic buildings (Staniforth et al. 1997).

The state of the building is surveyed, usually by quinquennial survey. Very often the most serious damage to collections is caused by water penetration because of poor maintenance. RH-related damage is secondary to this. The condition of artifacts is recorded at frequent intervals, and it is established if their condition is changing. If it is getting worse, then the cause of the deterioration should be determined. Most museums cannot afford to do everything, and therefore it is important to establish priorities. They should not be afraid of doing nothing about RH control if the biggest threat to a collection comes from poor building maintenance or the risk of fire. Schemes for assessing priorities for preventive conservation were described in two papers presented at the l994 International Institute for Conservation of Historic and Artistic Works (IIC) Congress on Preventive Conservation (Michalski l994; Waller l994).

If it is found that deterioration to the collection is RH related, then attention should be paid to the conditions to which the collection has become acclimatized. Any changes should be made slowly, and the RH set point should be chosen with regard to the original conditions rather than to the so-called ideal environment.

In the cool, damp, temperate climate of the United Kingdom, buildings with no form of heating or other methods of environmental control are damp, with the RH greater than 65%, for much of the year. Only during the summer months, when the house is warmed by solar gain, does the RH drop below 65%. We observe condensation several times a year, mold growth during the spring, extensive insect attack, and many other forms of deterioration to the contents of such buildings which are directly or indirectly linked to incorrect RH. Conservation heating is introduced to bring the average RH below 65%.

I have visited museums in India where the temperature is high throughout the year, and the RH is above 75% for months at a time during the summer and monsoon season. There is no sign of mold growth on the artifacts, nor is there other RH-related deterioration, probably because of the excellent design of the buildings, which encourages ventilation. In spite of the RH being nowhere near the levels recommended in the museum literature, it may be wise to leave things as they are in such a museum, rather than interfering with a building that seems to be working for its contents.

Conservation Heating

The majority of conservation scientists agree that for the conservation of artifacts, it is less important to control temperature than RH, with the rider that, in general, lower temperatures are preferred, since they reduce the rate of chemical and biological change.

People, including visitors to museums, are very conscious of temperature, and many assume that it is the most important environmental condition to control. In a domestic situation this is certainly the case, since the comfort of people is the prime consideration.

Temperature is related to RH and air moisture content, and this relationship is shown on the psychrometric chart. In a space in which the air moisture content remains constant, RH rises as temperature falls, and vice versa. The moisture content of an object is in equilibrium with the temperature and RH of the air surrounding it. A change in RH will result in a change in moisture content, which in its turn may result in a dimensional change. If an object is constrained, a dimensional change may cause damage. A change in temperature will cause a smaller dimensional change. The change in moisture content caused by a 10% change in RH is equivalent to that caused by a 30°C change in T (Thomson l978, 213). Low temperatures (below 5°C) should be avoided for paintings, since the paint becomes brittle when it falls below the glass transition temperature and may crack if the painting is moved (Mecklenberg and Tumosa l991). Low temperatures should also be avoided in buildings with water services, to avoid the risk of frozen pipes, which then burst as they defrost.

Condensation should be avoided by not allowing any object to fall in temperature below the dew point of the air surrounding it. If storage areas are kept at lower temperatures than exhibition areas, care should be taken not to allow warm, damp air to leak in. Care should also be taken to avoid condensation forming on cold objects brought into a warmer area. This can be a particular risk when objects have been transported during the winter in unheated trucks or in cold aircraft holds.

The temperatures recommended in museums (18°C–25°C) are governed by the comfort of people. When people do not have to be considered, as, for example, in historic houses that close during the winter or in a storage area, the temperature can be controlled to give the required RH. This humidistatic method of heating control was first suggested in Canada (Lafontaine l982); as mentioned above, we have coined the term *conservation heating* to describe this method of RH control (Staniforth and Hayes 1987).

Conservation heating is the main form of RH control used in National Trust houses. In domestic conditions, when comfort heating is required, heating systems are controlled by thermostat, but constant temperature does not give rise to constant RH. In temperate climates where external RH is higher than the recommended maximum for museum collections most of the time, then heating can be used to reduce RH. In the climate of the United Kingdom, raising the temperature by 5°C will reduce the average RH to approximately 60%. The amount of heating required in any part of the world can be determined by studying meteorological data and using the psychrometric chart.

Yet the low winter temperatures that result from the application of conservation heating only are not high enough for the comfort of the staff and families who live and work in the houses, so comfort heating is provided in private areas where there are no RH-sensitive artifacts. The RH control criterion gives way to a minimum room temperature for frost protection (5°C), and to conserve energy, the criterion is discontinued for the small amount of time when it would result in room temperatures of more than 18°C during winter (November to March). In summer, the heating is left on, but to save energy, the National Trust usually sets a maximum operating temperature for the heating of 22°C. For most of the time, solar gain provides the necessary increment of 5°C. Only on cool, dull days will the heating come on. A maximum temperature of 60°C for heating surfaces is specified to avoid local dry conditions caused by radiant heat.

Heating can be directly controlled with humidistats. On a small scale, this can be cheaply and easily achieved by connecting a humidistat to an oil- or water-filled electrically powered radiator. Cheap hair humidistats require frequent recalibration and have quite large switching differentials, resulting in a sawtooth shape on the RH trace. Electronic humidistats are now available with small switching differentials that can be incorporated into controllers with built-in temperature limits.

Before introducing conservation heating into whole houses, we run trials in individual rooms. The aim of a trial is to test the ability of the heaters to control RH and to adjust the power input to give control, as well as to relate the system's operation to energy consumption. Humidistatically controlled heating is suitable for controlling RH in storage when the mass of buffering material is not too large (Padfield and Jensen l990).

On the scale of a whole building, Building Management Systems have been installed to control the heating system on RH priority. A central computer is linked to outstations, which in turn are linked to temperature and humidity sensors in rooms, valves on water-circulating heating systems, switches on electric heaters, and so on. The computer is programmed to give the required temperature and RH parameters, and the outstations process readings from sensors and operate controls. The computer also provides an alert on alarm conditions and stores the data at regular intervals for subsequent analysis.

The Quest for Comfort

There is a general movement in the United Kingdom to have "visitor attractions," including historic houses and theme parks, open throughout the year, although, until quite recently, they closed at the end of October and reopened at Easter. Because of this interest, the National Trust is looking again at the opening arrangements for properties. By 2010 we plan that all properties will open by March 1, and we will keep some rooms open until Christmas. The November and December openings will focus on special events, such as Conservation in Action programs, in which visitors will be invited to see the conservation work that used to go on behind closed doors; where possible, they will participate in this work. Houses will also be open for Christmas events, such as displays of Victorian Christmas decorations and carol concerts. There are also an increasing number of requests for weddings, dinners, and other uses for properties during the winter. Even with global warming—which reduced the number of days on which the temperature in England, Wales, and Northern Ireland fell below freezing to less than a handful for the winter of 2006–07—low inside temperatures make National Trust houses chilly, particularly during March.

Guidance for the use of comfort heating during the winter has been available for properties for many years, and it has been formalized in the latest edition of the National Trust *Manual of Housekeeping* (National Trust 2006a, 110). The first edition of the manual recommended that comfort heating should be applied as gradually as possible, and that temperature should be raised and lowered over a period of hours or even days (Sandwith and Stainton 1984, 24). Thinking has moved on, following research into the moisture behavior of materials, which has shown that the majority of objects found in historic houses are made from materials that do not respond to rapid changes in RH. It is now recommended that for comfort heating during the winter, the heating should be turned on for as short a time as possible.

The National Trust uses two strategies for comfort heating: to apply heat for a fixed length of time, and to apply heat until the RH falls to a specified level. For the first strategy, conservation heating is switched to comfort heating with a temperature set point of 18°C for as short a time as possible. Typically this will be for one hour before opening until one hour before closing time, or six hours—whichever is shorter. For the second strategy, more sophisticated control systems are needed. Building Management Systems can be programmed to raise the temperature to higher levels, above 18°C to a maximum of 20°C, for longer times, provided the heating is turned off if a preset lower RH limit is reached. Depending on the sensitivity of the contents of the house, the lower limit is set at 45% or, exceptionally, at 40%.

There are issues about the capacity of conservation heating systems to deliver comfort heating when outside temperatures are exceptionally low. A design temperature uplift of 12°C is used when sizing conservation heating systems. Thus, on days when external temperatures are 0°C, the heating system will only achieve 12°C. Supplementary heating may be needed, which will usually be provided by freestanding electric heaters, assuming that there is sufficient power supply to the house.

There is no doubt that winter opening will provide a challenge to the National Trust in properties where heating systems and their controls have been designed for conservation heating. Yet the challenge is being met, and new systems are being designed with the dual function in mind. One advantage of global warming is that it is making this task easier to achieve.

Conservation Cooling and Conservation Ventilation

Although a hot and humid climatic condition is not common in the United Kingdom, there are a few days during the summer months that are both hot and humid, and with global warming, such days are becoming more frequent. On these occasions it would be possible to reduce both temperature and RH by using freestanding air-conditioning units. These pass the hot, humid air over their cooling coils, condensing water out of the air as its temperature falls below the dew point, and then they exhaust the hot air to the outside. The condensate must be collected and safely drained away. These units can be operated on RH priority. Their successful use depends on rooms being sufficiently well sealed to make their operation economical. This approach has been practiced by Richard Kerschner at the Shelburne Museum, along with conservation ventilation, in which external air is introduced into a building under humidistatic control (Kerschner 1992). The new National Trust central office uses air from the outside to cool the building during the night in the summer to provide comfort cooling.

Energy Matters

Running through this paper is the theme of reducing energy used for environmental control in museums with a number of measures:

- Aim for an appropriate rather than an ideal environment.
- Adjust set points seasonally.
- Broaden target bands.
- Improve insulation in buildings.
- Select environmental control methods to increase energy efficiency.

There has been less attention paid to the type of energy that is used in museums. The main sources that are available are oil, gas, and electricity. Oil and gas are fossil fuels and emit carbon dioxide when burned. Museums can calculate their carbon emissions quite easily from fuel bills, but how many do? The source of electricity is more variable. It may be generated in a power station that burns fossil fuel, in which case it has an equivalent carbon emission, or it may be generated in a nuclear power station, which does not generate carbon dioxide but, depending on where you stand on the nuclear debate, has other disadvantages. In some countries, there are ample sources of renewable energy, generated from wind and water turbines. All countries are turning to renewables such as wind energy, tidal power, and solar energy. These energy sources can be used at the microlevel, with small wind and water turbines and with photovoltaics that are used for individual buildings (National Trust 2006b).

Biofuels, including wood chip and straw, can be sourced locally, and several National Trust properties are now using them for conventional boilers as well as combined heat and power plants.

As part of a new strategy, from 2007–10, the National Trust has an ambitious target to reduce its energy consumption by 10% per year. This reduction will be achieved by a combination of energy-reducing measures, such as the introduction of thermal insulation (sheep's fleece rather than rock wool) and the use of renewable energy and biofuels. These measures require the support of the agencies charged with the protection of historic buildings, such as English Heritage, whom we are working with to seek agreement to the use of solar panels, photovoltaic cells, wind turbines, and water turbines on or near historic buildings.

Slow Conservation

I would like to end this paper by introducing the concept of "slow conservation," a holistic approach to conservation that looks not only at the collection in a museum or historic house but also at the building and the environment that surrounds the building. In the context of the museum environment, slow conservation is to that "mass of energy-consuming machinery needed at present to maintain constant RH and illuminance" (in the words of Garry Thomson, as quoted at the beginning of this paper) as "slow food" is to "fast food" (Thomson 1978, 249).

The Slow Food movement began in 1986, when Italian journalist Carlo Petrini saw a new branch of McDonald's at the foot of the Spanish Steps in Rome (Slow Food 2007). To him, it seemed that a global takeover by industrialized, standardized fast food was well on the way, which could be the beginning of the end for the huge variety of good, traditional, regional Italian food. He decided that it was necessary to set up a "slow food" movement to counteract the potential for "fast food" world domination. Since the 1980s, Slow Food has become an international organization of members who not only are interested in retaining our diverse heritage of regional food and drink, and protecting it from unthinking globalization, but are increasingly aware of the associated environmental issues.

The National Trust is beginning to practice the slow conservation approach to building conservation projects. This idea means that, instead of undertaking major repairs to buildings when things have gone wrong, we use the "little and often" approach encouraged from the earliest days of the Society for the Protection of Ancient Buildings (SPAB), but with a difference. Where possible, the work is participative. We look for opportunities to involve volunteers and trainees. There is a real danger that traditional building skills will be lost—such as the use of lime mortar, thatching, lead work, and stone masonry; the reintroduction of apprenticeships, based on the care of buildings over a period of years, is an important component of slow conservation. This philosophy also involves the use of local materials and the reuse of materials where possible. The embodied energy of all repairs is considered; thus, lime mortar is favored over cement.

One of the drivers for maintaining constant temperature and RH in museums has been compliance with the rigid standards introduced in the 1980s for international loan exhibitions. Apart from questions that could be asked about the sustainability of transporting collections around the world (although one could argue that this is more sustainable than transporting people to see the artifacts in their home museums), one could also ask questions about whether the sustainability of museums depends on a constant flow of changing exhibitions. Museums have only just begun to grapple with questions about their own sustainability, an issue recognized in the United Kingdom by the Museums Association, whose next major report will be on the subject of museums and sustainability. But perhaps more fundamental is the question posed earlier in this paper about whether museums should be seeking to achieve an "appropriate" rather than an "ideal" museum environment.

Museums should consider a manifesto for slow conservation. I would suggest that for environmental control, such a manifesto should include the following:

- For all their activities, museums should consider the impact on the global environment and should seek to reduce their environmental footprint.
- The environment in museums should reflect the local climate rather than international standards.
- Collections should be sustained by high standards of preventive conservation.

While the following words are taken from the Slow Food manifesto, they could equally well apply to a Slow Conservation manifesto (Slow Food 2007): "None of this means that Slow Food is against progress or technological advances. Far from it, Slow Food is a truly progressive concept that seeks to utilize mankind's ever-expanding knowledge base to retain and develop the diversity of all that is best in our world heritage."

Author Biography

Sarah Staniforth was appointed Historic Properties Director at the National Trust in January 2005. Her responsibilities include the management of the sections that advise properties on archaeology, building conservation, curatorship, conservation of collections, and gardens and parks. From 2002–04 she served as Head Conservator. She joined the National Trust in 1985 as Adviser on Paintings Conservation and Environmental Control. She read chemistry at Oxford University, studied paintings conservation at the Courtauld Institute of Art, and worked in the scientific department of the National Gallery from 1980 to 1985.

References

Erhardt, David, and Marion Mecklenburg. 1994. Relative humidity re-examined. In *Preventive Conservation: Practice, Theory and Research: Preprints of the Contributions to the Ottawa Congress, 12–16 September 1994*, ed. Ashok Roy and Perry Smith, 32–38. London: International Institute for Conservation of Historic and Artistic Works.

Kerschner, Richard L. 1992. A practical approach to environmental requirements for collections in historic buildings. *Journal of the American Institute for Conservation* 31, no. 1: 65–76.

Lafontaine, Raymond H. 1982. Humidistatically-controlled heating: A new approach to relative humidity control in museums closed for the winter season. *Journal of the International Institute for Conservation, Canadian Group* 7, nos. 1–2: 35-41.

Lovelock, James. 1979. *Gaia, a New Look at Life on Earth*. Oxford: Oxford University Press.

———. 2006. *The Revenge of Gaia: Why the Earth Is Fighting Back—and How We Can Still Save Humanity*. London: Allen Lane.

Mecklenburg, Marion F., and Charles Tumosa. 1991. Mechanical behaviours of paintings subjected to changes in temperature and relative humidity. In *Art in Transit: Studies in the Transport of Paintings: International Conference on the Packing and Transportation of Paintings, September 9, 10, 11, 1991, London*, ed. Marion F. Mecklenburg, 173–216. Washington, DC: National Gallery of Art.

Michalski, Stefan. 1993. Relative humidity: A discussion of correct/incorrect values. In *ICOM Committee for Conservation 10th Triennial Meeting: Washington, DC, 22–27 August 1993: Preprints*, ed. Janet Bridgland, 624–29. Paris: International Council of Museums Committee for Conservation.

———. 1994. A systematic approach to preservation: Description and integration with other museum activities. In *Preventive Conservation: Practice, Theory and Research: Preprints of the Contributions to the Ottawa Congress, 12–16 September 1994*, ed. Ashok Roy and Perry Smith, 8–11. London: International Institute for Conservation of Historic and Artistic Works.

National Trust. 2006a. *Manual of Housekeeping: The Care of Collections in Historic Houses Open to the Public*. Amsterdam: Elsevier Butterworth Heinemann.

———. 2006b. Microgeneration: Policy from practice. http://www.nationaltrust.org.uk/main/w-microgen-policy_from_practice.pdf (accessed 13 Nov. 2007).

Padfield, Tim, and Poul Jensen. 1990. Low energy climate control in museum stores. In *ICOM Committee for Conservation: 9th Triennial Meeting: Dresden, German Democratic Republic, 26–31 August 1990: Preprints*, ed. Kirsten Grimstad, 596–601. Paris: International Council of Museums Committee for Conservation.

Sandwith, Hermione, and Sheila Stainton. 1984. *The National Trust Manual of Housekeeping*. London: A. Lane in association with the National Trust.

Slow Food. 2007. Slow food. http://www.slowfood.com/ and http://www.slowfood.org.uk/ (accessed 13 Nov. 2007).

Staniforth, Sarah, Linda Bullock, Robert Hayes, and Andy Singleton. 1997. Conservation heating by cable and radio. *Museum Practice* 2, no. 1: 71–74.

Staniforth, Sarah, and Bob Hayes. 1987. Temperature and relative humidity measurement and control in National Trust houses. In *ICOM Committee for Conservation 8th Triennial Meeting: Sydney, Australia, 6–11 September 1987: Preprints*, ed. Kirsten Grimstad, 915–26. Los Angeles: Getty Conservation Institute.

Staniforth, Sarah, Bob Hayes, and Linda Bullock. 1994. Appropriate technologies for relative humidity control for museum collections housed in historic buildings. In *Preventive Conservation: Practice, Theory and Research: Preprints of the Contributions to the Ottawa Congress, 12–16 September 1994*, ed. Ashok Roy and Perry Smith, 123–28. London: International Institute for Conservation of Historic and Artistic Works.

Thomson, Garry. 1978. *The Museum Environment*. Butterworth Series on Conservation in the Arts, Archaeology, and Architecture. London: Butterworths.

Waller, Robert. 1994. Conservation risk assessment: A strategy for managing resources for preventive conservation. In *Preventive Conservation: Practice, Theory and Research: Preprints of the Contributions to the Ottawa Congress, 12–16 September 1994*, ed. Ashok Roy and Perry Smith, 12–16. London: International Institute for Conservation of Historic and Artistic Works.