Conservation

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The Getty Conservation Institute (GCI) works internationally to advance the field of conservation through scientific research, field projects, education and training, and the dissemination of information in various media. In its programs, the GCI focuses on the creation and delivery of knowledge that will benefit the professionals and organizations responsible for the conservation of the visual arts.

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Front cover: **A condition assessment team carrying out a survey of the Our Lord in the Attic Museum in Amsterdam. This historic building was the site of a clandestine Roman Catholic church in the mid-1660s and is today a museum, as well as once again a place of religious worship. In a collaborative project, the GCI and the Netherlands Institute for Cultural Heritage are working with the museum's director and staff to study the impact of visitors on the indoor environment of the building, on its interiors, and on its collections. Information from the project's research will be used in developing a preventive conservation case study.** ***Photo:*** **Paul Ryan.**

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From the Outside In

Preventive Conservation, Sustainability, and Environmental Management

In the past half century, expectations of thermal comfort in North America have been shaped by the increased availability of climate control technology and equipment and by the comparatively low cost of operating these systems. As conservation professionals, we have come to expect that climate control technology can alleviate the potential damage to museum collections from extremes and fluctuations in temperature and relative humidity. Both expectation levels—comfort and conservation—have resulted in sophisticated, energy-intensive climate management systems for old and new buildings.

In the latter part of the same period, the climate science community arrived at the overwhelming consensus that global consumption of fossil fuels significantly contributes to higher atmospheric temperatures, changes in climate patterns and precipitation, and rising sea levels.

Against this backdrop, as stewards of cultural heritage, we should review our current approaches to environmental control and revisit traditional building design and use as part of our environmental management strategies for collections. This may give us solutions that promote not only the conservation of our material culture but also the conservation of our global environment.

The Interior View and How We Got There

After World War II, the increased availability of environmental systems, especially air-conditioning, for human comfort and industrial applications provided the museum community with the technology to control the interior conditions of collection spaces. Coincident with the availability of hardware was the accessibility of fuel and electric power to operate these systems, generally at favorable costs, especially in the case of electric power.

In 1969, when Reyner Banham published his seminal book *The Architecture of the Well-Tempered Environment,* air-conditioning was an expensive option on American cars, and central air-conditioning had become available in new postwar housing. Nearly thirty years later, historian Gail Cooper noted in *Air-conditioning America: Engineers and the Controlled Environment, 1900–1960,* "Largely as a consequence of modern design and construction imperatives, then, air-conditioning moved quite rapidly from a luxury to a necessity in the building industry." When the National Building Museum presented the 1999 exhibition *Stay Cool! Air Conditioning America,* 90 percent of newly constructed American homes featured central air-conditioning, and two-thirds of existing homes had central air-conditioning, while one-third had room or window air conditioners. Also in 1999, penetration of factory-installed air-conditioning in the American automobile and light truck market approached 100 percent.

Across the United States, the availability of year-round interior climate control in buildings and vehicles has profoundly changed public and personal expectations of environmental comfort and the individual's relationship with the natural environment. Systems not only automatically intercede in controlling the interior environment; in addition, building design evolved to eliminate many of the traditional features for individual control, such as operable windows and shading devices.

In the span of one generation, most people in the United States have come to expect that personal environmental comfort will

By Michael C. Henry

An early 1940s advertisement for a General Electric air conditioner. In the latter part of the twentieth century, air-conditioning came to be a standard way for many museums to control the indoor climate of exhibition and storage spaces. *Photo:* © Schenectady Museum: Hall of Electrical History Foundation/Corbis.

be maintained by heating and air-conditioning systems. In the course of this change, we have become disconnected from the seasonal shifts of climate, its nuances, and its daily manifestation as weather. Our observations of weather and climate are largely secondhand, reported by media meteorologists or Internet weather services, with an emphasis on the catastrophic extremes that strain our mechanical systems and energy supply infrastructure, upsetting our artificially maintained comfort.

The Building as a System

It is important to recall that many older buildings predating the development of four-season climate management systems typically have some inherent capability to moderate external influences on interior conditions. In these older structures, the building itself was the system for ventilation and human comfort. The design and construction of these buildings relied on certain materials, an overall form, and horizontal and vertical communication between interior spaces. A key component of the interior conditioning of older buildings was occupant operation of building features—such as windows, doors, and shutters or shading devices—which moderated the influence of the exterior on the interior while capitalizing on favorable external aspects, such as breezes, for ventilation and comfort.

By contrast, the majority of buildings from the late twentieth century rely on centralized mechanical systems to moderate the effects of the exterior climate on the interior conditions. In these buildings, should the mechanical systems fail to operate or receive the necessary electrical power, the combination of building materials, building form, and spatial arrangement may actually exacerbate the adverse effects of the outside environment on interior conditions.

Older buildings that have been retrofitted with contemporary mechanical systems are likely to have had modifications so that they perform more like modern, tightly sealed buildings. James Pitot's early nineteenth-century house on Bayou Saint John in New Orleans, currently the subject of a Getty-funded Conservation Planning Grant, is a typical example of the impact of central systems. A traditional two-story Creole cottage, the house has numerous features to moderate the effects of the hostile New Orleans climate. Deep galleries protect the interior spaces from sun and driving rain. The second-floor galleries are intended to provide protected exterior living spaces, the importance of which is evidenced by the presence of architectural trim such as baseboards and, in some instances, chair rails. Interior spaces are configured for cross ventilation through multiple doors and windows that open onto the protected galleries. The house incorporated seasonal operating features, no longer extant, such as curtains and shades hung above the gallery railings to provide privacy and to exclude insects when the galleries were transformed into living spaces in the hot summer months. The original loose-fit slate roof resisted wind uplift from tropical storms, and the heated mass of the roof created a nighttime

Two views of the James Pitot House, a nineteenth-century traditional Creole house in New Orleans. The building's original architecture included features to mitigate the city's hot and humid environment, including galleries to protect the interior spaces from sun and driving rain and to provide residents with protected outdoor living spaces. *Photos:* Michael C. Henry.

thermosiphon, exhausting room air into the attic through the second-floor ceilings constructed from gap-spaced painted boards, cooling the rooms below.

With the introduction of central air-conditioning into the Pitot House in the late twentieth century, the building underwent a variety of changes. The ventilating ceiling was closed off with attic insulation, and the roof was replaced with tight-fitting composition shingles and roofing felts. The attic is no longer a solar-powered passive ventilator, and the doors and windows to the galleries must be kept closed to stabilize the conditioned interiors. Ephemeral and fugitive methods of managing the climate of the interior of the gallery, such as the gallery curtains seen in an 1830 sketch, have long since disappeared.

These losses are not unique to the Pitot House. They are examples of losses of climate-specific operative features at many older buildings that have been retrofitted with centralized heating and air-conditioning systems. These changes illustrate the subtle transformation that takes place when the decision is made to mechanically control the interior climate for occupant comfort or collections conservation or when it is necessary to secure or seal the structure against pollutants, pests, or unwanted entry.

Contrast the losses of historic environmental management features at the Pitot House with the National Historic Landmark

Gibson House (1859) in Boston, which has not been air-conditioned and retains its original three-story-high ventilation and light shaft. The shaft, a functionally sophisticated and architecturally refined feature, distributed heated air to upper floors in winter and exhausted hot air from all floors in summer, while distributing much-needed natural light to windowless interior spaces and the stair hall. Building occupants operated the interior window sashes according to need, as indicated by the thermometer placed by one such window.

The impacts of centralized systems are compounded in older buildings considered historic by virtue of their architectural, historical, or cultural significance. In historic buildings, the interior environmental management must also address the preservation issues posed by the building itself. The dual mandate to preserve historic building fabric and prevent deterioration or damage to the collections sets the stage for potentially competing or conflicting objectives.

In responding to the tension between buildings and collections, the 1991 New Orleans Charter, adopted by the American Institute for Conservation of Historic and Artistic Works and the Association for Preservation Technology International, endorses balancing the need to involve collections professionals as well as building professionals in decision making. Nonetheless, the presumed necessity of a retrofitted centralized heating and air-conditioning system for comfort and conservation will ultimately drive many of the decisions to alter the building envelope and eliminate the operability of original climate management features. These issues were recognized in the engineering, architectural, and conservation communities, and as a result, professional guidelines were developed to resolve the tension between environmental control and building type (*American Society of Heating, Refrigerating, and Air-Conditioning Engineers Handbook,* chap. 21).

As various monitoring devices and methods were developed, environmental monitoring became an increasingly important component of managing the environment in museums. With the advent of solid-state digital data loggers for measuring and recording environmental conditions, monitoring became increasingly economical. These devices were quickly embraced by museum professionals. The digital data collected could be readily analyzed and presented with personal computer software, thus alerting collections stewards to the variations in temperature and relative humidity in their museum, library, or archives spaces.

In some instances, the data presentation and digital display could imply a level of measurement precision that exceeded the performance specifications of the logging device and the variability of the conditions being measured. One outcome was the expectation that the capability to precisely measure interior conditions implied a capability to control, with the same degree of precision, the machinery and systems that maintained the interior conditions. This expectation tended to be codified in environmental specifications for collections conservation.

Engineers, architects, and mechanical contractors, being problem solvers by training and inclination, were responsive to the challenge of close control for collections environments. However, the resultant systems came at a premium in installation and operating costs. Furthermore, the complexity and lack of transparency of the control systems served to distance museum personnel from the very systems intended to protect the collections.

Increasingly, as building occupants, we are less adaptive to exterior conditions, choosing to rely on systems to provide near-uniform conditions regardless of place, activity, or time. From a conservation standpoint, this view is reinforced by our professional focus: a museum professional will be object or collection oriented, while an engineer will be oriented to the design of a control system for a well-defined and contained environment.

In the long term, this tightly focused, interior-centric point of view will prove unsustainable without some accommodation of larger factors, including the building, the exterior environment, and the global climate.

The Global View and Climate Change

In February 2007 the Intergovernmental Panel on Climate Change (IPCC) issued its fourth assessment on the future of global climate, *Climate Change 2007: The Physical Science Basis* (www.ipcc.ch). The IPCC, an international network of leading climate scientists, concluded that the link between human activity and increased global warming is "unequivocal." The report states that of the human activities that contribute to global warming, the largest influence is the generation of carbon compound emissions from fossil fuel combustion for transportation, for the generation of electricity for uses such as lighting and cooling, and for heating.

The IPCC report identifies several future climate trends in the twenty-first century, all of which are directly related to human activity:

- warmer and fewer cold days and nights over most land areas,
- warmer and more frequent hot days and nights over most land areas,
- more frequent warm spells or heat waves over most land areas,
- more frequent heavy rainfalls over most land areas,
- increased drought in areas affected,
- increased intense tropical cyclone activity,
- increased incidence of extreme high sea level.

The Gibson House, a nineteenth-century Italian Renaissance-style home in Boston. This National Historic Landmark has retained its historic environmental management features, including a three-story ventilation shaft designed to distribute warm air in the winter and vent hot air in the summer. *Photos:* Courtesy of the Gibson House Museum, Boston, and Michael C. Henry.

The report also notes a future increase in atmospheric moisture vapor; depending on air temperature, this change may result in increased relative humidity.

As stewards of cultural heritage, we cannot afford to look at these trends as merely a problem for environmental scientists, industry, or government. Climate change and global warming are of great importance to cultural heritage stewards in two respects: because of their impact on cultural heritage and because of the ways in which mitigating this impact contributes to global warming.

First, consider the potential impact of climate change on conservation of cultural heritage, particularly cultural landscapes and fixed property, such as buildings. In 2005 the Centre for Sustainable Heritage (CSH) at University College London released its milestone study *Climate Change and the Historic Environment*. Based on 2002 projections for trends in climate change in the United Kingdom, CSH evaluated the possible consequences of those projected trends on UK cultural heritage resources. The implications are sobering.

Rising sea levels are a real concern. Less obvious climatic factors threaten as well. Changes in the extrema range, intensity, and frequency of climate variables such as temperature, atmospheric moisture, wind, and rainfall will lead to acceleration of existing deterioration mechanisms or to the initiation of new mechanisms. Buildings, the first line of defense for the collections, may lack the capacity to resist higher wind loads. The rainwater systems of buildings and sites may be undersized for more intense but less frequent rainfalls, leading to excess surface water or even flooding. Changes or variations in soil moisture can change soil volume, leading to stresses and cracking in foundations. Some of the problems projected by the CSH study are already being experienced in the United Kingdom and Europe. While the study focuses on the United Kingdom, the study provides a sense of the type and scale of effects that might be experienced by cultural heritage resources elsewhere.

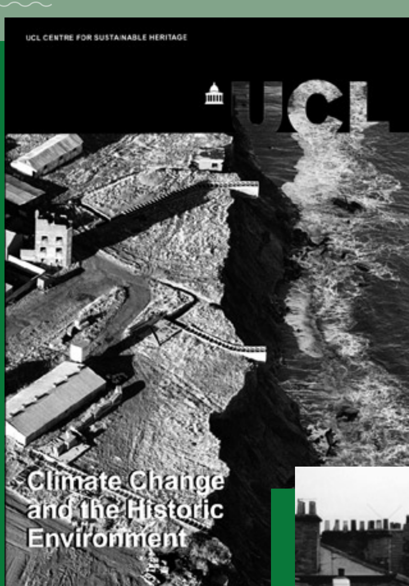
The costs of mitigating the risks or repairing the resultant damage from these new climate factors will be great. In the case of catastrophic climatic events, there will be cultural heritage losses that cannot be restored, as in the recent devastation of New Orleans and the U.S. Gulf Coast. In such circumstances, given the larger societal priorities, cultural heritage needs are not likely to be adequately funded.

In addition to the direct effects of climate change on cultural heritage, we must be aware of how our actions in cultural heritage conservation contribute to the generation of the carbon compounds that lead to global warming. For example, in the United States, it is estimated that air-conditioning accounts for up to 20 percent of our electrical power use, 71 percent of which is generated by burning coal, petroleum, or natural gas. The energy cost of close artificial control of interior environments is higher than for more relaxed control, especially with respect to relative humidity. Therefore, tight performance targets for artificial interior environments for collections of all types, significance, and value add to the electrical power needs and fossil fuel consumption for buildings and sites. Unless our systems are powered by carbon-neutral energy sources, such as wind or photovoltaic power systems, we are contributing to the primary factor in global warming. As Pogo, the cartoon strip philosopher, commented on the state of the environment in 1971, "we have met the enemy and he is us."

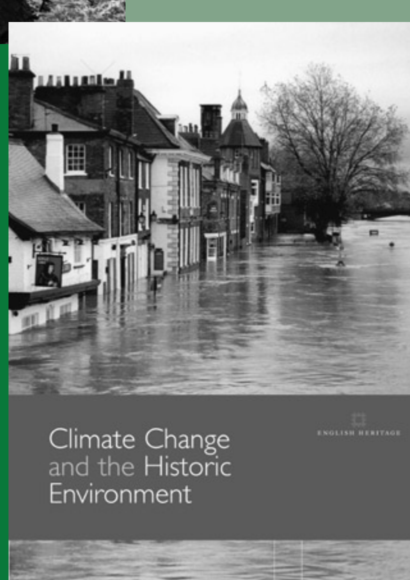
Measures for protecting cultural heritage must not contribute to the exacerbation of the very climatic effects that can threaten its longevity. Protective activities could set up a positive feedback loop that intensifies, rather than attenuates, the conservation problem and its costs. As global warming increases the extrema and range of exterior conditions such as temperature and relative humidity, we cannot respond by tightening control of the interior environment with higher capacity mechanical systems that consume more energy and emit more carbon compounds.

Sustainability: Integrating the Viewpoints

Our stewardship responsibilities to future generations are not limited to the protection of material evidence of our significant objects, buildings, or landscapes. Our unwritten intergenerational compact requires that we transmit this cultural legacy within an environmental, economic, and social context that allows for viable stewardship in the future. This principle is a fundamental tenet of sustainability.



In 2005 the Centre for Sustainable Heritage at University College London (UCL) produced a report—with support from English Heritage and the United Kingdom Climate Impacts Program—on the potential impact of climate change on the historic environment in the United Kingdom. The following year, English Heritage issued a policy statement on the subject (below), based in part on the UCL study.



A sustainable approach to cultural heritage is an overarching philosophy that should permeate our thoughts and actions. Environmental management, one aspect of the implementation of this philosophy, is singularly important because of its consequences for cultural heritage conservation, energy consumption, and capital and operating costs.

Revisiting our environmental management strategies for preventive conservation in the light of a sustainability mandate is critical. Environmental management is a large component of the energy consumption and carbon emissions at our institutions and sites. We can reduce the potentially adverse impact of our environmental management strategies if we:

- redefine our performance criteria for conservation environments by taking into account the robust qualities and vulnerabilities of the collections when compared to the exterior environmental threats specific to the location;
- reduce carbon emissions (and operating costs) without necessarily reinvesting in new heating and air-conditioning systems, by implementing broader criteria for interior environmental control;
- account for, and fully credit, the passive and operable features of the building that can moderate the environment and afford protection for the contents and collections, and rely on these features rather than on mechanical systems to the extent practical;
- improve or enhance the inherent environmental performance qualities of the building envelope;
- evaluate new or alternative environmental management technologies as part of systems replacements in the near future;
- consider the feasibility of carbon-neutral power generation, such as wind- or solar-generated electricity, for specific energy needs;
- plan for new buildings that moderate the exterior environment without excessive energy consumption.

As we undertake these new approaches to environmental management, it is important that we inform and educate the public as to the need for our action and how we are addressing that need.

In striking a balance between collections stewardship and environmental responsibility, we will undoubtedly face competing needs that challenge our past assumptions and practice. However, it is likely that we will also discover new opportunities to enrich our interpretation of both collections and historic buildings.

Michael C. Henry, Principal, Watson and Henry Associates, is an engineer and architect who has worked extensively in the field of historic preservation and on environmental issues of historic buildings housing collections. He teaches in the Graduate Program in Historic Preservation at the University of Pennsylvania and was 2005–06 Fulbright Distinguished Scholar at the Centre for Sustainable Heritage, University College London.

Passive Design, Mechanical Systems, and Doing Nothing

A Discussion about Environmental Management

Dialogue

Tim Padfield, a freelance consultant in preventive conservation, received his master's degree in chemistry from Oxford University and his doctorate in building physics from the Technical University of Denmark. He has worked in conservation at the Victoria and Albert Museum, the Smithsonian Institution, and the National Museum of Denmark.

Franciza Toledo earned her doctorate at the Department of Conservation, Institute of Archaeology, University College London. A former member of the GCI's Science department, she is currently a private researcher and consultant in preventive conservation in Brazil.

Ernest Conrad is president of Landmark Facilities Group, an engineering and design firm based in Connecticut that specializes in museums, libraries, historic structures and their collections. A graduate of Drexel University with a master's degree in environmental engineering, he has been involved in the design of climate control systems at a number of cultural institutions, including the National Gallery of Art, the Frick Collection, and the Library of Congress. Conrad is a licensed professional engineer and LEED Accredited Professional.

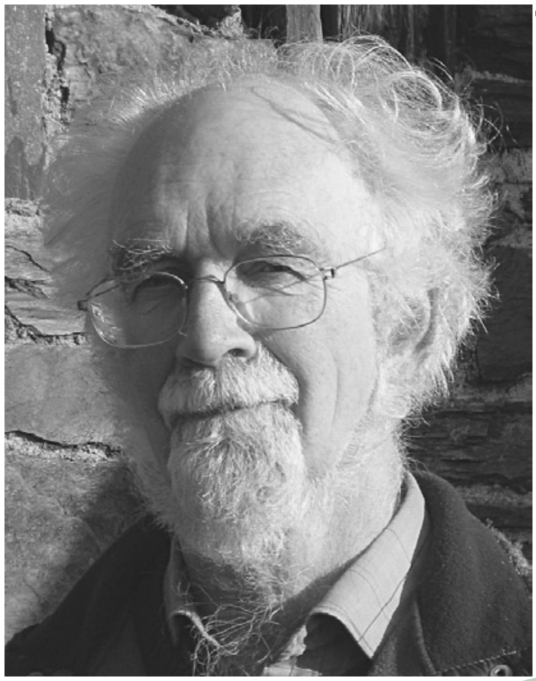
They spoke with Shin Maekawa, a senior scientist with GCI Science, and with Jeffrey Levin, editor of Conservation, The GCI Newsletter.

Jeffrey Levin: *Recently, the issue of climate change and its impact on the historic environment has been the subject of study and debate. Some believe that managing the environment of a museum, library, historic house, or other cultural resource has to take into account broader environmental issues, such as climate change impacts and the need for all building owners to reduce energy use to limit increases in global carbon levels. Is there much interest in addressing these museum environments in a way that reflects a larger obligation to the global environment?*

Tim Padfield: There is one museum for approximately every three hundred thousand ordinary houses. One can worry about burning up more energy in a museum, but that, in fact, has no practical influence on the world at all. We should treat museums as museums and not worry too much about the rest of the universe.

Ernest Conrad: If you compare the amount of energy a standard house consumes to what a[n HVAC environmentally controlled] museum consumes, a museum is an energy machine. It gobbles up so much power controlling temperature, humidity, and the filtration of pollutants. The total energy bill for a year of a house that has no air-conditioning is about one dollar a square foot. At museums, it is upward of about four dollars a square foot. That's a major difference. I wouldn't discount it.

Franciza Toledo: I think we have had advances because there are now many physicists, engineers, and architects conducting research on



"Sustainability is the idea of using cunning, looking at what people did in the past, adding that to modern physics, and generally designing things that you're proud of because you didn't drag in a whole lot of electricity and energy."

—Tim Padfield

more and other ways of controlling indoor climates and reducing energy consumption. I think we have made progress.

Levin: *Tim, couldn't it be said that those in the museum field have a responsibility to exercise leadership in developing systems that are more conscious of broader environmental concerns?*

Padfield: What you're doing is pushing some moral idea onto straightforward management. I agree that museums use too much energy, but they're not going to destroy the planet. The planet has a good deal more resilience than we realize. Museums are simply badly designed, and that's a different point. What's significant is not the amount of energy that a museum uses but the fact that it uses skilled people who are on call at great expense because air-conditioning is complicated. Don't worry about the planet, but get on with designing a building that functions. Your conscience will clear up automatically by doing that.

Conrad: I design climate control systems at museums—and a rise of a couple of degrees centigrade worldwide won't make a lot of difference to the design of the systems. The real difference with global warming is not so much a slight increase in temperature, but in extreme weather changes. Hurricane Katrina is a perfect example. We're going to see weather extremes occur, which are going to affect buildings through floods and things of that nature. That's the major risk.

Levin: *Are people in the museum field thinking about the extremes that global warming is going to create?*

Conrad: One thing the museum community has done well is to develop disaster recovery plans. When a catastrophe is predicted, they can react. Before Katrina hit, the museum industry moved things to high ground. They had plans in place for disaster recovery. So that's one good thing—the planning in advance. The other thing that we're doing is in smaller house museums. Many of these places can't afford a high electric bill, and so we have a method where instead of using a thermostat, we just have a humidistat that controls temperature; we call this humidistatic heating. For every one degree Fahrenheit I change temperature, I can change the relative humidity two percentage points just by moving the temperature around. But if global warming raises the temperature a little bit, it will make it much more difficult to use these low-cost types of solutions.

Levin: Sustainability *is a popular buzzword that is open to different interpretations, depending on the context of its use and perhaps the personal beliefs and biases of the user. How do each of you define it?*

Padfield: *Sustainability,* in the museum context, is almost the same as *durability.* It means to devise a building that functions on its own. Sustainability is a reward for laziness. A building should function without all these electronic sensors and computer models. Sustain-

"The real challenge is for architects and building engineers to design more climate responsive buildings."

—Franciza Toledo

ability for me, a person who has had a lifetime's experience of air-conditioning that doesn't work, is building a museum in thick mud where the climate is appropriate—a museum in the middle of the hot desert where you want to keep the temperature down. In other words, sustainability is the idea of using cunning, looking at what people did in the past, adding that to modern physics, and generally designing things that you're proud of because you didn't drag in a whole lot of electricity and energy.

Toledo: I would define *sustainability* as the ability to live according to the resources available. We have a saying, "not to take a step larger than the legs." But this cautious policy in a way hinders material development. Therefore, *sustainability,* despite being a popular word, is, in practice, not very popular. We do not see many examples. I do agree that buildings are not properly designed. It's architecture for the sake of architecture. It's easier to design without any sort of constraint and then to take care of the climate by installing an artificial system. The real challenge is for architects and building engineers to design more climate responsive buildings. Then, even if a mechanical system is necessary, much less is required because you are using a proper design and building materials.

Conrad: When people talk about sustainability and durability, they tend to mean status quo—we're not adding to the problems of the environment. But the status quo is not going to work. We're in such a disaster state now, we have to go back in the other direction. There is a program in the United States called 2030. Many mayors have bought into this program with ASHRAE, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers. They have mandated in their cities that by the year 2030, we will no longer produce carbon products. We will become neutral to carbon-product generation, which is all the fossil fuel emissions. What they're saying is we have to go backwards and get the planet back to the better place where it once was.

Levin: *But is that in conflict with what Tim suggested? Tim was talking about ways to minimize the use of things that are going to produce those carbon products, correct?*

Padfield: Yes. I think all three of us are just saying the same thing, but from interestingly different career experience.

Levin: *Franciza, you were suggesting that in your region, there aren't many examples of passive climate control. What are the reasons for this?*

Toledo: Because it's very difficult to control high temperature and relative humidity passively. We can use ventilation, which is good for the building itself and for visitors, but not for collections.

Padfield: Temperature definitely rots things faster, but many things rot very slowly in museum collections, so I'm wondering if we're being, in effect, bombarded with standards. The standard that I see is one actually based on human comfort. When you talk about the high temperature, is it because all your visitors are sweating or because you're worried about the objects?

Toledo: Because our visitors are sweating. Most of the objects are doing fine. We just have problems with chemically unstable collections. When it comes to attending to a collection's physical needs and to human needs, we have climate control for the sake of human comfort.

Conrad: Lower humidity is a major player in preservation. We have difficulties when we get into tropical areas where you need to reduce the relative humidity to prevent things like mold and dry rot. You get into the expensive refrigeration systems, and reheat systems, and things of that nature.

Padfield: My experience is that actually there's more mold growth in cold climates, and it's caused by condensation. Most of the mold that I have seen is a consequence of temperature gradient—having a warm building in a cold climate and having condensation occur. As you move to hotter climates, you get much less difference between inside and outside temperature, and you don't get these gradients. Franciza, can you comment on that?

Toledo: We have to control just humidity, not temperature, in order to avoid mold growth. When we have air-conditioned buildings, we cannot afford running them continuously. When you turn them off at the end of the day, hot and more humid air has contact with cooler surfaces. This is when we have mold growth. But when you have a stable, naturally ventilated building, it's very rare to have mold develop.

Padfield: I think Franciza and I do agree, because what we're saying is that mold growth is usually man-made, in the sense that for one reason or another you generate a temperature gradient or sudden temperature disparity. I live in Devon [England], a very wet area—it just rains almost continuously. But you don't notice any particular rot with anything that's out in a barn. The RH [relative humidity] is 99 percent, but there's absolutely no temperature difference anywhere, and therefore it never gets to 100 percent. Mold growth usually in practice needs condensation before it will start.

Conrad: That's because for mold to do its best, it needs pure water—and that's what condensation is. As soon as you introduce anything that changes acidity or alkalinity, it's toxic to the mold.

Levin: *Are you saying that with stable relative humidity, you're going to reduce some of these problems?*

Padfield: It's not so much stable as uniform. In other words, if you have a temperature gradient, you get condensation. The temperature can go up and down, but as long as everything follows, you won't get into trouble. That's why in humid regions you need lightweight buildings so there is no thermal inertia, whereas in northern Europe we have, for various reasons, some rather heavy buildings that we value, such as churches, which are massive. It's very common to find condensation in those buildings simply because they've remembered the cold of the night. When you open the door to let people in during the day, the warm morning air comes in and condenses immediately. That's caused by a temperature gradient or a temperature difference.

Toledo: Yes, Tim, but we have some massive thick-walled buildings in the north of Brazil. In the past they were palaces, now they are museums, and they behave okay, maybe because of cross ventilation. We don't see signs of condensation in those buildings, not even when opening the doors in the morning. We have to measure it, but visually it's not occurring.

Levin: *What are the most promising developments in sustainable systems that are low energy and low cost—and what are the obstacles to the development of these systems?*

Conrad: In storage areas and smaller spaces, we have been using this process called hot gas reheat. If you think about a window air conditioner, it blows cold air into the room and hot air out the other side. If you take that heat on the other side and heat the air back up again, you can do dehumidification by using that heat for free. We've been doing that on a smaller scale, and we're starting to do it on a larger scale. It eliminates the extra energy that you waste by adding heat to a cooled airstream. It's become a great way for people to be able to do dehumidification and have it be affordable. The other thing is geothermal systems, which are becoming all the rage. These are saving anywhere from 40 to 60 percent of heating costs during wintertime. The downside is that they're very expensive to install. But they're becoming very popular.

Padfield: The most promising technology is to do nothing—and this we have demonstrated in archives. Consider that rather specialized aspect of museums, which is storing old things. Almost all over the world, there is no need to have any air-conditioning in archives because the air exchange rate is so small that with passive humidity buffering with materials—often the stored materials themselves and massive walls—nothing is needed. It baffles me that no one recently thought of doing nothing. I think that's because we live in a busy civilization where if you say you don't need to do anything, people lose money. Ernest would be out of work. And the architect's fee would be reduced because there is no mechanism. So that's the promising technology—do nothing.

Conrad: I need to comment on that.

Padfield: But just to finish my spiel, the obstacles are conservators. They quote standards that have such narrow bands of temperature and relative humidity that they can only be achieved by mechanical air-conditioning. There are psychological pressures on the experts, the people who sit on standards committees, to take the best available technology, regardless of whether there is any fundamental science that supports it. That's the obstacle to the lazy technology, which is doing nothing. An archive, which I won't name, has been functioning perfectly except that it has had temperature extremes that went up to 24°C and down to 13°C. The standard doesn't allow this. So now they're putting in air-conditioning—not to improve the climate by any scientific criteria, but simply to make it conform to the British standard for archives.

Conrad: In theory, Tim is absolutely correct. When you think about the influences on a room or a building, there are only six of them. Things like the heat from lights or heat passing through the walls or windows. You can make all these things go away. The only one that you can't make go away is infiltration. One item of infiltration is water. When it's in vapor form, it will pass through materials and get inside facilities. It takes a very small amount of energy to control that. So, in effect, what Tim is saying is correct. It doesn't take much to do climate control in a very well-designed archive, because all you have to deal with is infiltration. But if you try to do it in a building that has skylights and windows and all these other things, you get yourself into trouble.

Toledo: We should rely more and more on the building itself. We do try, but the examples are still few and new. I wonder why there have not been many articles published on a more passive approach to museum buildings. Passive design in the tropics is very much toward human comfort. But we haven't seen publications on museum passive design. Because you have to fulfill human needs, the collection's needs, and the building's needs.

Padfield: Museums are often designed to be prestigious buildings and to dominate their surroundings. By good fortune, museums started off in what you could call classical revival, and most of these museums are, in fact, massive buildings. So by chance, the prestige architecture of many museums is exactly climatically right. They're massive, often have relatively small openings and high ceilings. The problem now is that we're constructing a second round of massive museums, and the architects are building as though they were designing aircraft. Take the Denver Art Museum. The walls are flying out in all directions. You can't possibly build that wall massive—it will fall down. The prevailing idiom of pompous architecture now is unsuited to the museum purpose of making a naturally calm interior climate.

Conrad: I tend to agree with Tim. It seems to me that with some new museums, people are coming to see the building, not the collections. The architect is making such a statement that they don't even know where the collections are. In fact, they can't even find a flat wall to put them on.

Levin: *In terms of the design of buildings, how should the character of the local environment be factored into the process?*

Padfield: Before even thinking about how it's going to look, you should think about the materials. Is it going to be mortar and brick, for example? Will that suit the climate? Look at the possibilities of the local climate and the local geology to give you a start in designing a building, and do that before you invite in the architect.

Conrad: Not too long ago I was in Beijing and was asked to help design a system to protect a historic building (see p. 21). In looking at the local situation in Beijing, the number-one thing for preservation is not so much temperature or relative humidity but the dust that comes off of the desert. The dust particles are like razor blades, and when they get on materials, it is very difficult to clean the materials without abrading them. So in our design strategies, the focus was on filtration to keep dust out of the building.

Toledo: We have had experience in dealing with local climate, buildings, and professionals, and the problem I see with alternative climate control systems is maintenance. All these devices or systems require an active role on the part of the users. In the short term we can rely on the maintenance or even rejuvenation of these passive buildings, but in the long run it is hard, and if people do not follow the routine of, say, opening and closing windows, changing filters, et cetera, it doesn't work. Requiring users to do things in order for these devices to be functional is an obstacle.

Shin Maekawa: *There are a couple of ways of doing things. One way is to make the system complicated so that it can handle all sorts of situations. The other option is to use people to help the system run better. The latter option is really more sustainable, but then, surprisingly, people are not quite aware. They think a sustainable building doesn't require anything.*

Padfield: There's also an element of shame. For instance, guards in a museum can regard it as demeaning to be asked to look after opening and closing a window. On the other hand, it's very culturally dependent. In the culture that I have known most recently, the opposite happens. As soon as the guards realize that they're playing an interesting and effective role and not just standing around waiting for something to be stolen, they perk up and take an interest. You don't have to automate everything in life. People get bored and, in a strange way, resentful.

Levin: *Now we're not even talking about mechanical systems—we're talking about psychological systems.*

Toledo: Yes, because guards don't want to be opening or closing things or pushing buttons or going around doing an audit. This is maintenance, so museum sustainability doesn't work. Not in Brazil, at least.

Levin: *So the notion of a sustainable or passive system that doesn't involve some human involvement is a myth. You still have to have some human beings doing some things.*

Toledo: Exactly. And this is for me the major obstacle for this alternative way of controlling climate in museum buildings.

Conrad: Because of the Internet, we are now designing climate control systems that are Web-based. That means all the parts that control the climate in the space are controlled through a computer, and the computer is hooked up to the Internet. I can sit at my desk in Connecticut, dial up any one of the museums that I have designed in the last couple of years, and see exactly what's going on. That gives you the ability to have a fast response to problems that crop up. It's a wonderful technique to minimize waste and to keep systems running in good order.

"One thing I can say is everything made by man eventually fails. . . . If I'm not monitoring my building, how do I know what damage is going to start to occur?"

—Ernest Conrad

Padfield: It's always nice to be reminded of American optimism, but I get the impression that Franciza and I, belonging to older and more cynical civilizations, are actually heading towards designing buildings that can endure neglect, which is almost the opposite to what you're saying, Ernest. My feeling is that a building that can be totally ignored, certainly for a weekend, is inherently more sustainable. In effect, we should be building fail-safe buildings. If the Internet blows up because eventually spam mail goes supernova, then the building will just cruise along.

Toledo: Everything starts okay, but in the long run people tend not to do their jobs.

Padfield: You're talking about human activity. My idea of passive is that you can forget to open and close the windows and it may go bad, but it will go bad slowly. I think the biggest problem is that mechanical high-tech control actually demands a lightweight building with insulation close to the surface, so that any error can be corrected by the mechanism rather quickly. My design approach is exactly the opposite—make the building so massive that the temperature can't go wild because it has such huge inertia.

Conrad: One thing I can say is everything made by man eventually fails. Guaranteed. So I get back to the monitoring. If I'm not monitoring my building, how do I know what damage is going to start to occur? I agree with simplicity, but we still have to be able to see what's going on and catch faults, because failures will occur. A roof leak is a perfect example of the damage that can occur in a building if it goes undetected. It's massive damage.

Padfield: Yes, I entirely agree. But you can monitor the roof with some electronic device that works over the Internet, or you can build a roof that slopes instead of it being flat, so it takes a lot more deterioration before any damage occurs. I'm not arguing against what you're saying—I'm saying that the design looks at everything. Make a roof that is inherently fail-safe. You can still monitor it, but at least a weekend won't do any damage.

Levin: *Tim, earlier in our conversation you seemed to suggest that current environmental standards were not particularly useful.*

Padfield: All our low-energy initiatives come up against this belief in the absolute power of standards. It's almost a religious belief in the power of a standard to somehow guarantee that something is going to be good. We as a profession should go back and look at the fundamental science of decay that underpins the standards, and see if they match. I feel they don't. Firstly, I think everything is too hot, because the first thing we know about decay of anything organic is: The cooler the better. The second thing is: Relative humidity value is overrated. The difference in decay between 75 and 40 percent relative humidity is significant, but compared to a drop in temperature, that difference means nothing. I would like to see standards that are related to and quote the underlying science on which they're based. At the moment, they don't. The standard is simply a legal document that gets fossilized in our consciousness. Finally, any standard that does not enforce measurement of whether the building complies is meaningless. Why build to a standard without also building into the contract that monitoring will be done? In my experience it is unbelievably difficult to get climate data more than six hours old.

Conrad: Well, in virtually every system that we now design for a building, we leave behind the permanent capability to measure and monitor conditions. For example, we put probes into walls to monitor the moisture migration rates and use this as an early warning device when the actual systems are running in the building. That's been going on in my firm for over ten years. We're finding people more and more consciously doing monitoring over long periods. Years of records are being created, and this wonderful world of digital makes it easy to store this stuff without a file cabinet full of hygrothermograph records.

Padfield: It's easier to lose digital storage than paper storage, in my experience.

Conrad: That is true. Make copies!

Maekawa: ***I think the climate standard is coming more from North America or Europe. When we deal with climates like Egypt, temperature is quite high but we don't see objects decaying quickly. For instance, in the pharaonic tombs in the Valley of the Queens, temperature is 29°C all the time, relative humidity is somewhere between 40 and 50 percent, and the mummies have survived for more than two millennia. Relative humidity is definitely a big issue, but low temperature is not that crucial. In the tomb environment, ancient material survives for a long, long time.***

Levin: ***How much collaboration is there today between architects, engineers, and conservators in addressing some of these questions?***

Conrad: The collaboration is getting better. A hundred years ago, the architect was totally in charge, and the systems that went into these buildings were fairly simple. But now because of codes, regulations, and other kinds of things, they are much more complex, and it takes three people to design a building envelope that's going to work right: the architect, who's in charge of the shape and color; the structural engineer, who's got to make the thing stand up and hold things; and the mechanical engineer, who gets involved in the performance of the building from an insulation, infiltration, and moisture migration standpoint, which is very new to a lot of people. They don't teach much of that. It's only recently that mechanical engineers have even been up to speed on how this stuff works. There's just not that much published about it.

Toledo: I think collaboration among architects, conservators, and engineers is getting better. But the lack of dialogue is due to our education. Architects deal with buildings. Conservators deal with collections. I think we should look at both. It is one whole thing. But it's getting better, yes.

Padfield: I would add that the collaboration, in terms of people's willingness, is there. But the problem is that the skills don't overlap. It's a matter of education. For instance, people don't understand the interaction of temperature and relative humidity and absolute humidity and thermal diffusivity. These concepts are necessary in order to design a sustainable building, but architects don't understand them. It's not in their syllabus. More surprising, engineers don't understand them either. My feeling is—and I hope I am not insulting Ernest's profession too much—that engineers are told an awful lot about what to do and given the formulae, but they're not really brought up as physicists. It's a trade rather than a science. And as science gets more advanced, there are fewer people who have had a truly fundamental education. What's really needed is a combination of education—education that has to be practical—and getting some demonstration buildings done. That means going for a small museum that's cheap to build and where mistakes don't matter—use it as a demonstration, and in that way build up confidence. You're not going to break the tradition of prestige buildings with prizewinning architects.

Conrad: ASHRAE produces textbooks for engineers to use in their design, and before 1999, the textbook that ASHRAE produced included a total of one paragraph talking about how to design for a museum—that was it. In 1999 a group of us created a whole chapter in ASHRAE handbooks specifically on the design of museums, libraries, and archives. So it's only seven years that engineers have had the materials available to them to help them understand moisture migration and things like that. They didn't know about it.

Padfield: Although there is much to admire in that ASHRAE chapter, it actually has nothing about not using air-conditioning. It's still not quite fundamental enough. I understand that ASHRAE is a business and its clients are, of course, air-conditioning installers. But there is, nevertheless, a simpler physics that belongs in that chapter about how far you can go in moderating the climate inside a building without doing any installation at all.

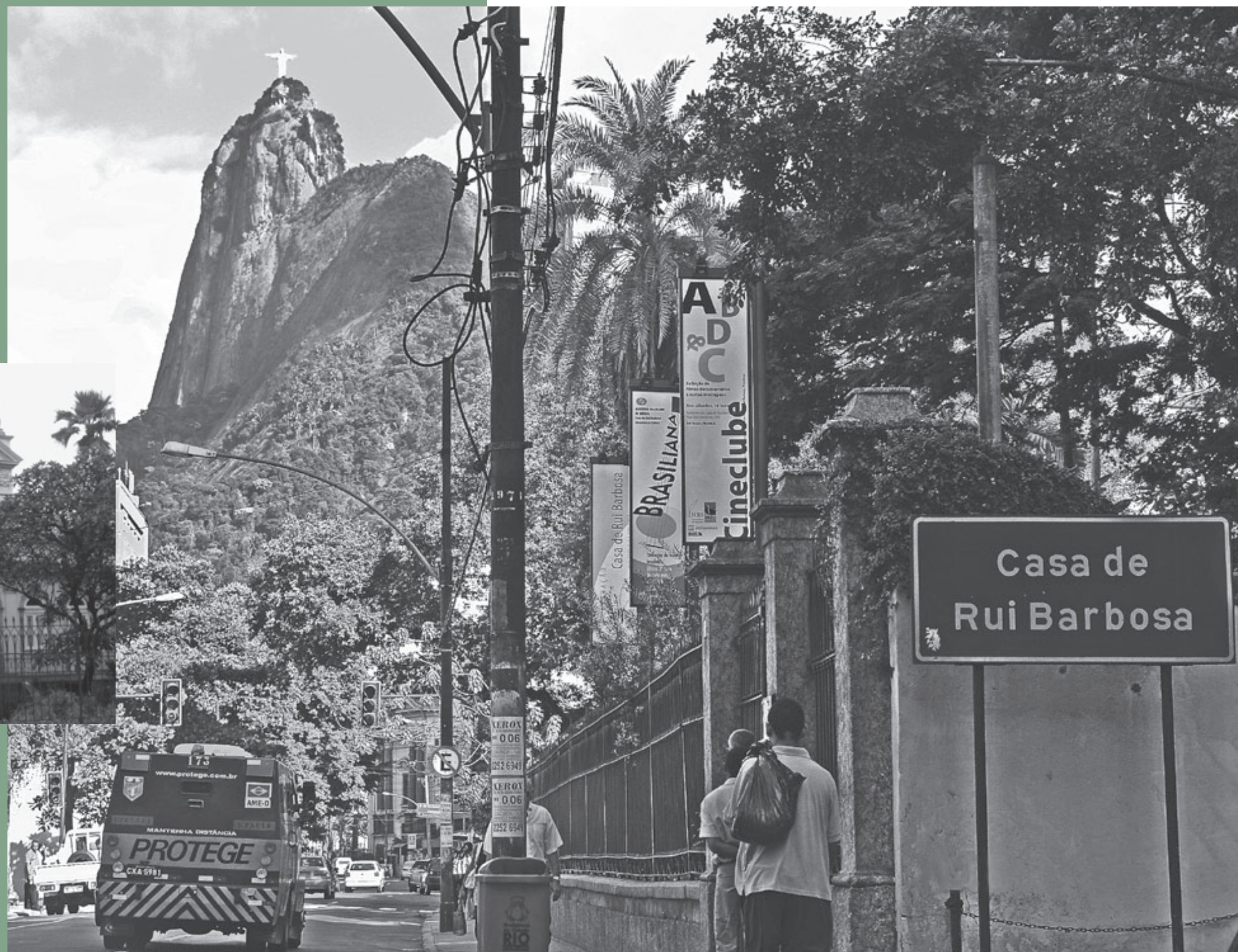
Toledo: We've had some successful approaches to climate control. We successfully reduced energy bills by one-fifth at the storage space of the Emilio Goeldi Museum in Belém [Brazil] just using intermittent ventilation and dehumidification [see page 17]. We reduced the energy consumption and yet we succeeded in maintaining a stable relative humidity. Of course, it's hot inside because we are not controlling temperature, just relative humidity, and people complain about this.

Maekawa: ***Wasn't the director of the museum especially concerned about the cost of energy?***

Toledo: Yes. Seventy percent of the annual budget was spent in energy to run air-conditioning in their storage spaces.

Levin: ***Is reducing cost ultimately the best incentive that we have for making changes in the way that we handle these problems?***

Toledo: Yes, energy saving and budget are strong reasons. But I think we should find other ways of raising awareness for new approaches to climate control.



Right: Location of the Casa de Rui Barbosa Museum in urban Rio de Janeiro. Situated near a major thoroughfare, the museum must contend with significant air pollution and dust levels, in addition to the effects of the tropical environment. *Photo:* Shin Maekawa.

Above: The Casa de Rui Barbosa Museum. The eighteenth-century masonry building, declared Brazil's first house museum in 1930, houses collections of art, furniture, automobiles, and books. Approximately ten thousand people visit the site annually. *Photo:* Vincent Beltran.

Collections Care, Human Comfort, and Climate Control

A Case Study at the Casa de Rui Barbosa Museum

By Shin Maekawa and Vincent Beltran

An important tool for preventive conservation is establishing climate control over the environment in which a collection is housed. Reducing relative humidity (RH) and temperature can slow the aging of materials, while decreasing fluctuations in both can limit cycles of swelling and contraction that may lead to the development of fractures. Attack by molds, bacteria, and insects can also be thwarted by minimizing extended periods of humid conditions, which foster microbial growth.

Cultural institutions have generally used conventional air-conditioning or heating, ventilation, and air-conditioning (HVAC) systems as the primary means of climate control. While HVAC systems are capable of moderating the environment for both collection preservation and human comfort, use of typical systems can pose significant obstacles. Excessive capital, operational, and maintenance costs and installation difficulties for historic structures are among the major hurdles.

The Getty Conservation Institute has sought to reduce reliance on conventional air-conditioning systems for collections climate control through the research and application of alternative climate control strategies. Over the last decade, two related GCI projects have investigated climate control alternatives to conventional systems, concentrating on hot and humid regions where microbial activity poses the overwhelming risk to collections.

Alternative Climate Control

Initiated in 1997, the Collections in Hot and Humid Environments project researched and developed an economically sustainable climate control system that can mitigate the risk of biological damage to collections by eliminating prolonged periods of high RH and reducing overall RH levels. The system integrated the use of humidistat-controlled ventilation with either heating or dehumidification, and during several field applications it proved effective and technologically simple.

The subsequent collaborative-based Alternative Climate Controls for Historic Buildings project, begun in 2002, developed case studies that involved local engineers, architects, and contractors in formulating and implementing climate control designs. The case studies (see *Conservation,* vol. 19, no. 1) included:

- the Valle Guerra Museum storage facility for the Organismo Autónomo de Museos y Centros del Exemo Cabildo Insular de Tenerife (OAMC) in Tenerife, Spain;
- the storage facility of the Amazonian enthnographic collection of the Emilio Goeldi Museum in Belém, Brazil;
- Hollybourne Cottage in the Jekyll Island National Historic Landmark District in Jekyll Island, Georgia, USA.

Responsibility for system operation, maintenance, and monitoring at each site has been transferred to the respective project partner, and recent results for these case studies have been presented at conferences and in various publications (the GCI maintains an advisory role with each institution). Before transfer, environmental monitoring of the systems verified the successful reduction and stabilization of RH levels to below 70 percent.

The economic benefit of alternative climate control strategies over use of conventional HVAC systems was also confirmed. Compared to a typical HVAC budget, capital costs for each case study were reduced by 75 percent to 90 percent, while savings in operational and maintenance costs ranged from 80 percent to 90 percent.

Comfort and Preservation

The primary objective of these field studies was to establish an appropriate environment for both the collection and building; human comfort was of secondary importance. This hierarchy was due in part to the type of interior space in each case study. The Valle Guerra and Goeldi Museum storage facilities, which house mixed-media collections, receive only limited research and conservation visitation. Hollybourne Cottage, which does not contain a collection, is also the site of only intermittent visitation.

While the ability of the climate control system to establish a safe environment for a collection was confirmed, its capability to provide for human comfort while maintaining this environment remained untested. If the system could also satisfy human comfort levels, the potential application of this low-cost, relatively simple GCI-developed system could be widely expanded. With ten thousand visitors annually, the Casa de Rui Barbosa Museum in Rio de Janeiro,

The Constitution Room houses the majority of the book collection at the Casa de Rui Barbosa Museum and, along with the adjacent rooms, is the focus of the GCI-designed climate control system. *Photo:* Shin Maekawa.

Brazil, provided an ideal venue for testing the applicability of the climate control strategy in a setting where human comfort was an important consideration.

Rui Barbosa de Oliveira—a prominent Brazilian humanist, writer, jurist, and statesman who played a major role in the 1891 drafting of the first republican constitution of Brazil—occupied his residence from 1893 until his death in 1923. The following year, the eighteenth-century masonry building was purchased by the government, along with Barbosa's extensive library and archives; in 1930 it was declared the first Brazilian house museum. The Barbosa collection includes artwork, furniture, and several automobiles. However, the library collection—consisting of thirty-seven thousand books covering law, humanities, and culture—is considered the heart of the museum.

Management and preservation of the Casa de Rui Barbosa Museum are the responsibility of the Fundação Casa de Rui Barbosa (FCRB), a federal public institution connected with the Ministry of Culture. In 2004 the FCRB; the Fundação Vitae Apoio á Cultura, Edução, e Promoção Social; and the GCI established a project with the goal of improving the interior conditions of the museum—particularly in the rooms that make up the library—by addressing human comfort as well as preservation.

Prior to installation of a climate control system, the Casa de Rui Barbosa Museum's building, environment, and collection were assessed to guide development of conservation strategies. The building assessment examined existing structural conditions and modifications to the original design, while the environmental assessment characterized the climate and pollution level of the library and exterior. The collection assessment documented the condition of objects in the library, including books and furniture.

Evaluations of the building and its environment were instrumental in identifying the importance of reinstating the original passive climate architectural features of the building that were currently obstructed. The building assessment clarified the original airflow path in the library space, which vented warm air through the ceiling into the attic and then to the building's exterior via loosely stacked roof tiles. A subsequent roof installation of a synthetic membrane, to guard against heavy rainfall and dust, eliminated this passageway. Similarly, the closure of wall openings in the cellar, to allow for its use as storage and temporary exhibition area, prevented ventilation. The environmental assessment documented the resulting accumulations of heat and moisture in the attic and cellar, respectively. The new climate control system sought to incorporate the spirit of the original design, improving the climate not only in the library but also in the connected problematic spaces of the attic and cellar.

The environmental assessment also detailed the existing climate in the library space, where using window ventilation resulted in large fluctuations in temperature and RH, as well as high levels of pollution and dust. Recommendations called for eliminating window ventilation and installing filtered mechanical ventilation and dehumidification. Although the microenvironment of the library's cabinets, where books are stored behind glass-paneled doors, provided some protection from air pollution and dust, a climate control system could further reduce and stabilize RH, temperature, and dust levels.

The Climate Control System

The climate control system implemented at Casa de Rui Barbosa is similar in concept to previous case study installations. In the library, maintaining an appropriate environment of less than 65 percent RH—below the RH threshold for microbial growth—relies on humidistat-controlled ventilation and dehumidification. The presence of humid interior air and the availability of exterior air with low RH trigger the ventilation mode (operation of supply and exhaust ventilators or fans). The dehumidification mode (carried out by a small air-conditioning split unit with a reheat coil) reduces interior RH levels when this arid exterior reservoir is unavailable.

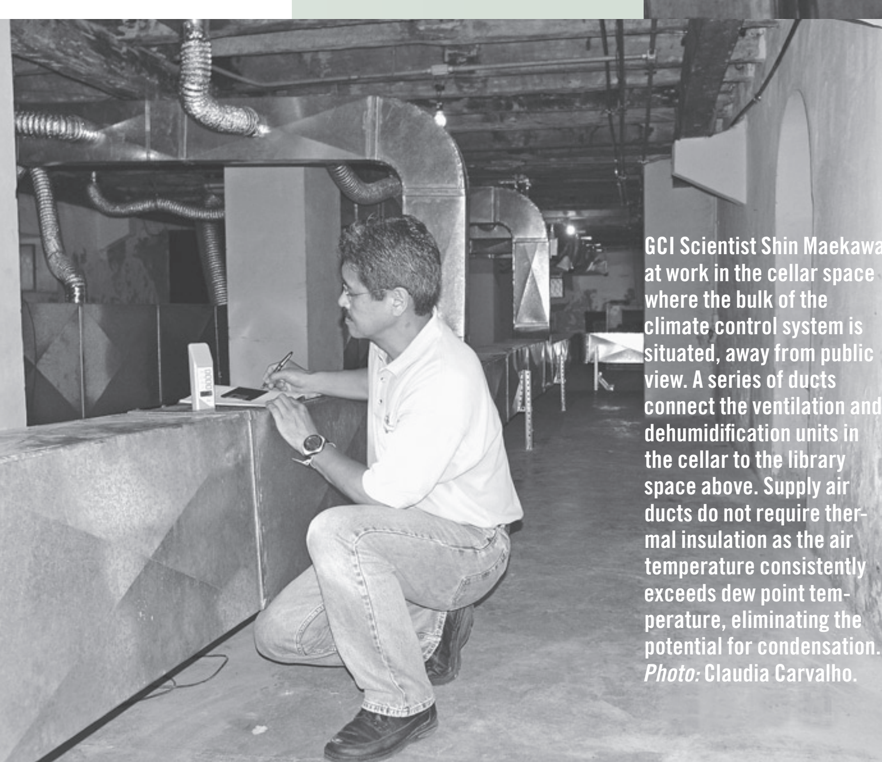
Addressing human comfort while still meeting preservation needs, however, involved additional considerations for the climate control system. Indoor fresh air requirements typically call for a rate of seven to eight liters per second per person to limit buildup of carbon dioxide, moisture, and body odor. Although the ventilation mode provided adequate fresh air to the building's interior, the use of the dehumidification mode alone could not. Thus, a hybrid mode was introduced that triggered dehumidification and ventilation simultaneously—but only during visiting hours. This continuous movement of a large volume of air through the climate-controlled space also promotes a cooling sensation of the skin surface by increasing transpiration, thereby enhancing human comfort.

Although not capable of the level of temperature control provided by conventional air-conditioning, the climate control system at Casa de Rui Barbosa did reduce maximum temperatures. Generally set at 32°C for unoccupied spaces—a typical summer daytime temperature in the region—peak interior temperature at Casa de Rui Barbosa was lowered to 28°C in an effort to improve human comfort. This reduced set point also protects against condensation within the building and ductwork, as it remains above peak dew point temperatures recorded on the most humid days in Rio de Janeiro.

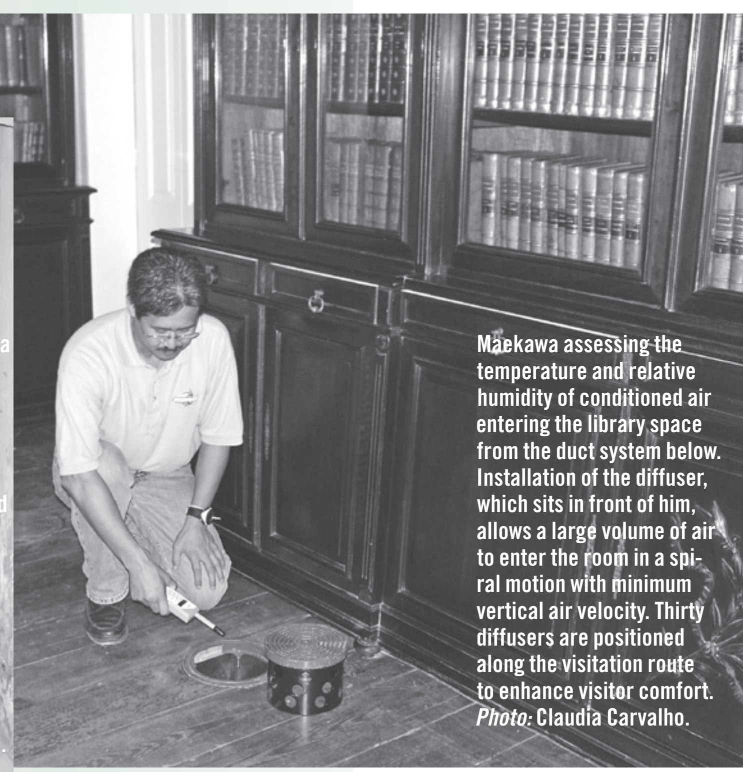
The design of the Casa de Rui Barbosa system differs dramatically from those implemented in previous case studies. Located in the cellar away from public view, the supply ventilator and dehumidification units are connected to the library space by ductwork to diffuser grills on the library floor; the diffusers deliver the conditioned air into the room with minimal vertical air velocity. Once supplied, the conditioned air is either returned to the dehumidifier via floor grills or exhausted to the exterior through the ceiling and attic by a fan positioned in a duct leading to the attic skylight. Mechanical ventilation is also provided in the cellar through restored wall openings fitted with filters. A programmable logic control unit controls return and exhaust air, as well as ventilation and dehumidification, by comparing RH and temperature conditions for the exterior and library.

In October 2006 an initial trial of the Casa de Rui Barbosa system conducted on a typical spring day—air temperature of 27°C and 80 percent RH—successfully produced a stable library environment of 25°C and 62 percent RH. System performance will be monitored for the next year to assess its effectiveness during a range of outside environmental conditions.

The long-term success of the Casa de Rui Barbosa system will represent a significant advance in the Alternative Climate Controls for Historic Buildings project. As evidenced by installations at storage and noncollection spaces, the GCI-developed climate control system can produce an environment that minimizes risk for collections in a manner that, relative to conventional HVAC systems, is low in cost, is easy to use and modify, and requires little maintenance. The Casa de Rui Barbosa installation furthers this research by providing for human comfort within the boundaries of an appropriate environment for collections. The ability of the alternative climate control system to address the environments of both visited and nonvisited spaces will greatly broaden its potential use.



GCI Scientist Shin Maekawa at work in the cellar space where the bulk of the climate control system is situated, away from public view. A series of ducts connect the ventilation and dehumidification units in the cellar to the library space above. Supply air ducts do not require thermal insulation as the air temperature consistently exceeds dew point temperature, eliminating the potential for condensation. *Photo:* Claudia Carvalho.

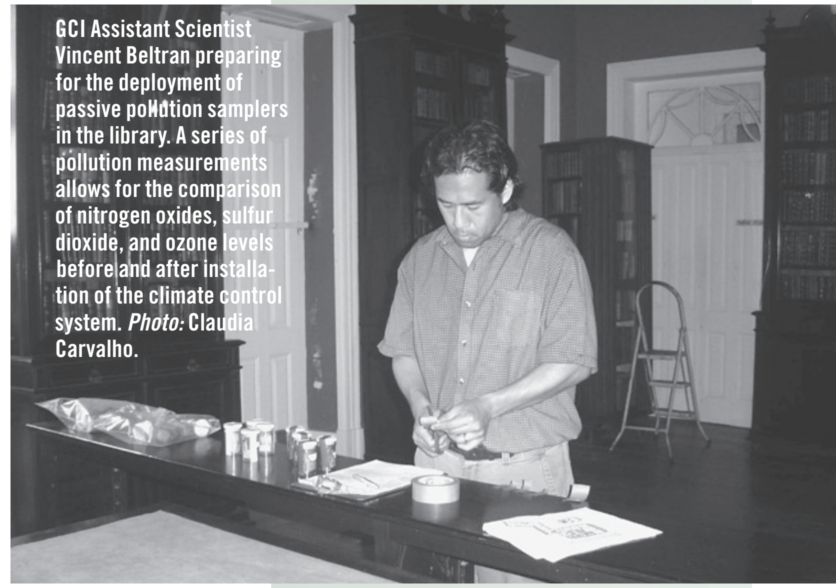


Maekawa assessing the temperature and relative humidity of conditioned air entering the library space from the duct system below. Installation of the diffuser, which sits in front of him, allows a large volume of air to enter the room in a spiral motion with minimum vertical air velocity. Thirty diffusers are positioned along the visitation route to enhance visitor comfort. *Photo:* Claudia Carvalho.

Dissemination and Collaboration

The Casa de Rui Barbosa climate control system represents the fourth and final case study of the Alternative Climate Controls for Historic Buildings project. While results have been disseminated in numerous presentations and publications, the GCI also plans to mark the closure of the five-year project by consolidating the research from all case studies into a comprehensive publication that will elucidate the concepts behind the climate control approach and provide details on the design, installation, and operation of each case study.

The development of new and important avenues of environmental research will depend largely on a critical evaluation of the current status of heritage climate control. To further this process, the GCI and OAMC organized the Experts Roundtable on Sustainable Climate Management Strategies in April 2007 in Tenerife. This multidisciplinary forum convened an international gathering of experts in heritage preservation whose discussion focused on recent approaches to environmental management in a broad range of contexts, including results from the GCI's Alternative Climate Controls for Historic Buildings project. It is hoped that this meeting will stimulate development of collaboration to further the accessibility of climate control strategies to the cultural community.


GCI Assistant Scientist Vincent Beltran preparing for the deployment of passive pollution samplers in the library. A series of pollution measurements allows for the comparison of nitrogen oxides, sulfur dioxide, and ozone levels before and after installation of the climate control system. *Photo:* Claudia Carvalho.

Shin Maekawa is a senior scientist and Vincent Beltran is an assistant scientist with the GCI's Science department.

Environmental Management in China's Forbidden City


Photo: Richard Ross

Because of its expertise in researching and developing alternative climate control systems, the GCI is assisting with a climate control system for Emperor Qianlong's Lodge of Retirement, an eighteenth-century compound in the Forbidden City palace in Beijing. Part of a larger effort spearheaded by the World Monuments Fund to restore the Qianlong Garden complex, this initial system will serve as a model to guide the environmental management of similar structures in the Forbidden City.

In May 2006 Shin Maekawa of the GCI and Ernest Conrad of Landmark Facilities Group were invited to develop a concept and specifications for a climate system that could be installed in the Lodge of Retirement's theater structure. Unique due to its merging of Western influence and Chinese aesthetic, the interior decorations of the theater, including trompe l'oeil murals, have deteriorated, partly because of exposure to extreme levels of relative humidity (RH) and temperature.

The new climate control system combines particulate filtration and dehumidification. Both strategies will be utilized during most of the year to reduce dust levels and limit peak interior RH to below 60 percent, protecting materials from fungal attack. Internal temperature will also be restricted to a maximum of 27°C to provide human comfort. Winter operation, however, will employ only air filtration, allowing interior RH and temperature to drift toward minimum values of 30 percent and below 0°C. This method avoids the potential for condensation that a more active climate control system might exhibit when attempting to heat and humidify air.

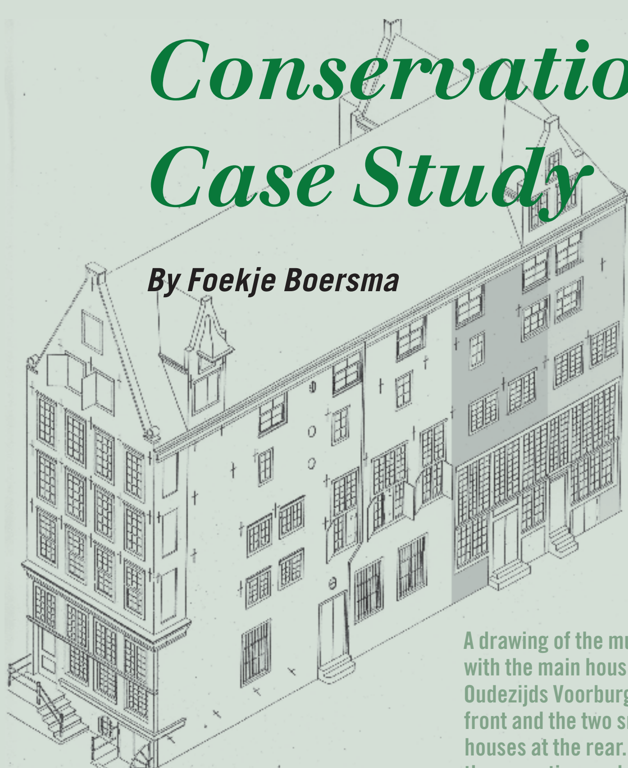
The Architectural Design and Research Institute at Tsinghua University carried out local fabrication and installation of the climate control system during March 2007.

Exterior view of the Our Lord in the Attic Museum (center). This seventeenth-century Amsterdam canal house became the site of a clandestine Roman Catholic church in the mid-1660s. Open celebration of the Catholic Mass was outlawed in the Dutch Republic in 1581, leading to the creation of a number of house churches. *Photo:* Paul Ryan.

Our Lord in the Attic

A Preventive Conservation Case Study

By Foekje Boersma



A drawing of the museum, with the main house on the Oudezijds Voorburgwal in front and the two smaller houses at the rear. These three contiguous houses make up the property, a typical Amsterdam merchant's house. The church was built in the top floor rooms designed for the storage of goods. *Drawing:* Courtesy of the Our Lord in the Attic Museum.

In teaching preventive conservation, real-life examples are of great value. They expose students to the range of issues that must be considered when developing preventive conservation and management strategies for museum collections, buildings, and other cultural sites. The stakeholders involved in the decision making bring different kinds of expertise, experiences, and arguments to the table—all of which have to be borne in mind if preventive conservation strategies are to be successful and sustainable. There is not just a single approach to preventive conservation.

The Getty Conservation Institute's Education and Science departments are collaborating on a series of didactic case studies designed to illustrate the interrelated issues affecting the practice of preventive conservation and the decision-making process. The cases, describing actual museum situations, will present various scenarios for decision making and for balancing the requirements of the collection and the building with the mission, values, and operations of the museum. The case studies will be made available on the GCI's Web site, as well as on CD/DVD and in print format, and they will be applicable to classroom use in academic programs in conservation, museum studies, and architecture, as well as mechanical engineering and environmental studies. They will provide an important opportunity for students to explore the complexities involved in weighing options and making decisions, while exposing them to other professionals' areas of expertise. Experts already working in heritage preservation may also use the case studies as a source of information and reflection. The case studies can thus contribute to greater interdisciplinarity in the care and management of buildings, collections, and sites.

A Hidden Treasure in Amsterdam

The first of the GCI case studies, currently in progress, deals with preventive conservation in the context of a rather remarkable historic house museum. In the old city center of Amsterdam lies Museum Ons' Lieve Heer op Solder (Our Lord in the Attic Museum), a house museum with an unusual name and history. On the outside it appears to be an ordinary seventeenth-century Amsterdam canal house. Inside it holds an unusual surprise—a Catholic church in its attic.

The property, located on a canal in Amsterdam's red-light district, dates to the early seventeenth century and is made up of three contiguous houses, connected at the upper stories. It is a typical Amsterdam merchant's house, characterized by top floors designed to serve as storage space for commodities.

Jan Hartman, a German Catholic who moved to Amsterdam to make his fortune in trade, bought the property in 1661. Extensive work on the house between 1661 and 1663 included not only the

A view of the church altar. Creation of the church required major modification to the interior of the building—structural floor beams were cut to create an open space and galleries. In addition, cast iron tension rods were installed to fix the galleries to the roof. *Photo:* Paul Ryan.

installation of a splendid, luxurious parlor (the Sael), but also a clandestine Catholic church, seating approximately one hundred fifty people and built in the attics of the contiguous houses.

Why create a Catholic church in the attic of a merchant's house in Amsterdam, and why did it have to be used clandestinely?

In the sixteenth century, the Catholic Spanish Hapsburg royalty ruled the Low Countries, where Protestants, primarily Calvinists, formed a significant minority. The harsh measures installed by the Spanish kings caused increasing grievances, and in 1581, seven northern Dutch provinces declared their independence from the Spanish throne.

The same year, the new Dutch Republic officially forbade the open practice of the Catholic Mass. However, many Dutch Catholics remained faithful to the Catholic Church, and private churches were not unusual in the northern Netherlands in the seventeenth century. (The church in the attic, one of a number of such house churches in Amsterdam, is the only one still in use today.) Because of the religious tolerance at the time, clandestine churches were permitted, but they were not allowed to be recognizable from the street. Creation of the church, Ons' Lieve Heer op Solder, required major modification to the interior of the building—the structural floor beams carrying the fifth and sixth floors were cut in the middle to create an open space in the center and galleries along each side.

The hidden church was in use from about 1663 until 1887, when its much larger nearby successor, Saint Nicolas Church, was dedicated. That year, a group of Amsterdam Catholics who had formed the Amstelkring Foundation bought the building to save it from demolition. Museum Ons' Lieve Heer op Solder (formerly also known as Amstelkring) was opened to the public the following year.

Today this attractive merchant's house is still open to the public, and, apart from the church, several period rooms can be visited as rare surviving examples of their time. Since 1951, when Mass was reinstated at the church by a group of Amsterdam Catholic artists, the site has also been in use for weddings, baptisms, lectures, concerts, and special events.

The parlor in the main house—a rare example of a grand seventeenth-century Dutch interior. *Photo:* Paul Ryan.

Research at the Site

The mission of the Our Lord in the Attic Museum—like that of many historic house museums—requires that preservation be balanced with access. Allowing visitation causes stress on the building and its collection—for example, the wear and tear on original wooden floors and stairs caused by visitor movement through the building, as well as the increased risks of unintentional damage to and theft of objects, which are on open display in the period rooms. Increasing visitor levels (ninety-two thousand in 2006) have challenged conservation efforts and also threaten visitor enjoyment, since rooms, hallways, and stairs in the building are relatively small and readily feel cramped.

One issue is the control of the indoor environment for visitor comfort and for the safekeeping of the collection and the building. In summer months—and especially during events in the church—indoor temperatures rise, and visitors feel uncomfortable and sometimes dizzy. In winter, severe condensation often occurs on the inside of the windows. Museum staff is interested in knowing more about how the indoor climate affects the collection and the building, and in learning if improvements can be made.

Visitor movement is also an issue. The routing through the building requires visitors to climb up and down steep and narrow stairs, which are common in this type of canal house. In view of the large visitor numbers, the museum is concerned about visitor safety and wear and tear on the building elements.

In a collaborative project, the GCI and the Netherlands Institute for Cultural Heritage (ICN)—working with the museum's director Judikje Kiers and her staff—are studying the impact of visitors on the indoor environment of the building, on its interiors, and on its collections. As part of this work, options for management of the indoor environment are also being researched, in which visitor comfort is balanced with safe conditions for the preservation of the building and its contents.

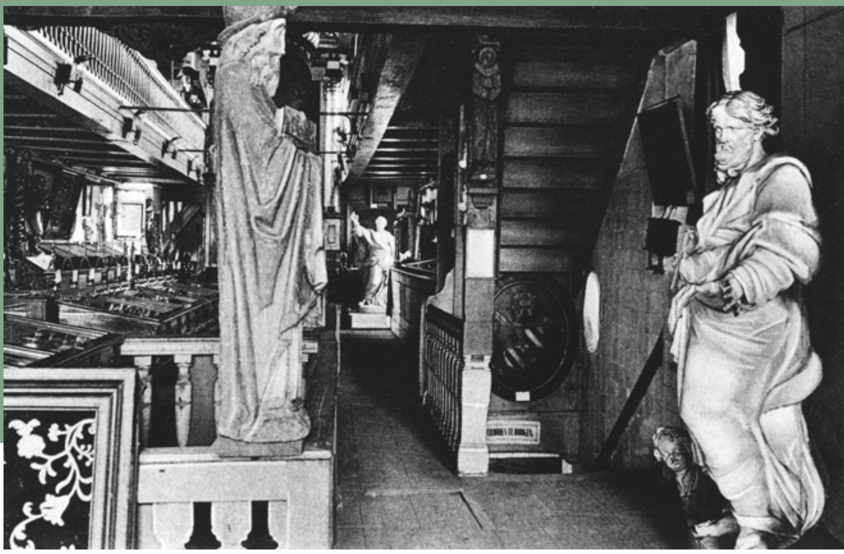
The museum aims to keep alive the cultural and religious heritage of Catholic Amsterdam through care of the building and its associated collection. In addition, it wants to be a hospitable and inspiring meeting place where visitors can reflect upon and share their own religious and spiritual experiences. The museum's director recognizes that the Our Lord in the Attic Museum has an important role to play in current discussions of religious understanding and tolerance. For this reason, visits to this unique cultural site will likely increase in coming years, making it all the more necessary to determine a conservation and visitor management policy that supports the interpretive goals of the museum.

The underlying research of the GCI–ICN museum project encompasses investigation of present and past indoor climate conditions and research on the effect of current visitor levels and use on the indoor environment. Recent climate data were analyzed, and the rate of ventilation was established (with the assistance of the Technical University Eindhoven in the Netherlands); this information provided insights into the performance of the building. Using available historic meteorological records and informed estimates of visitor comfort levels in the past, the project team was able to approximate the indoor climate in the period before central heating was installed.

In addition, an interdisciplinary team consisting of the museum's curators, the facility manager, an architect, two conservators, and two conservation scientists carried out a condition assessment in order to document the current condition of the building, its interior, and the collection, together with their susceptibility to agents of deterioration related to visitor levels. This assessment gave the team a better understanding of the performance of the building and of the type and extent of visitor-induced damage. It was, for example, found that the church has a relatively high air exchange rate, that the amount of wear and tear on the original wooden floors and stairs may indicate the original route of the churchgoers, and that there may be a correlation between damage in the building and the period when central heating was first installed (no measures were in place at that time to compensate for the related decrease in relative humidity during the winter).

Research into museum visitation and church attendance resulted in an approximate determination of the number of people that had gone through this building since the church was built. The total number of church visitors prior to 1887 is estimated at several million. Since the site became a museum, two million more people have visited the site, with annual visitor numbers steadily increasing. This information will be linked to the indoor climate and condition assessments.

Combined with an assessment of the museum's organizational environment (its mission, functions, resources, and institutional activities), the research generated a wealth of information, important for making informed decisions about building, collection, and visitor management.

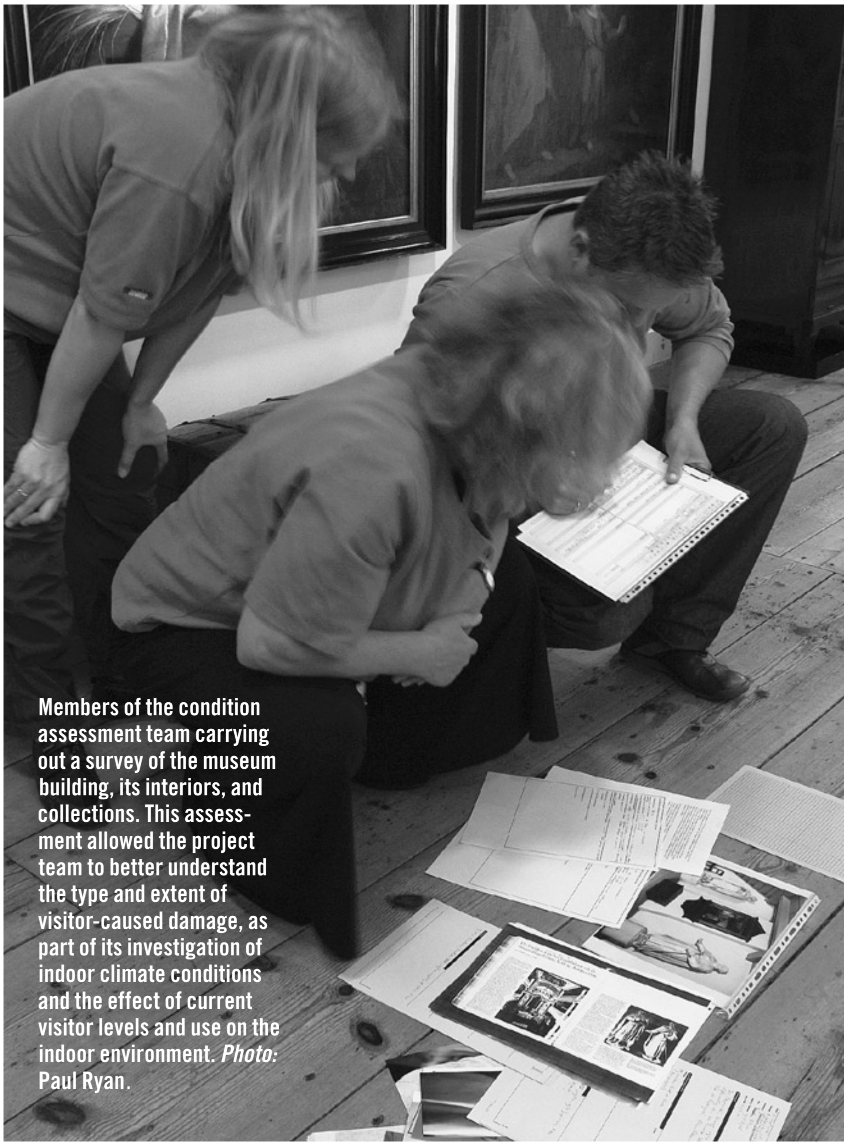


A late-nineteenth-century photograph of the first museum display in the church. After ceasing to be used as a parish church in 1887, the church in the attic was opened to the public as a museum the following year. *Photo:* Courtesy of the Our Lord in the Attic Museum.

The Case Study

Information from the project's research will be used in the case study, which will address issues such as acceptable indoor climate limits for the building, the collection, and the visitors; visitor impact on the indoor environment; and the relationship between the number of visitors and mechanical damage to the collection and the building. The case study will also raise important questions: What is acceptable damage? Can—or should—a maximum visitor number or carrying capacity be established for the museum? What do the different experts mean when referring to protection, conservation, restoration, repair, and maintenance of both a building and its collection? How does the museum decide which action is appropriate? And finally, how does the public react to the message of the museum?

This particular preventive conservation case study, as mentioned, will be made available to academic programs through the GCI's Web site, as well as in CD/DVD and print format. It will also bring together information from literature, research, and practical experience in the field of historic house museum management. It will assist Our Lord in the Attic Museum and similar museums to determine manageable levels of visitation and use. Furthermore, it is intended to contribute to a better understanding between the different stakeholders involved in preserving a historic house museum: museum staff, architects, architectural conservators, collections conservators, conservation scientists, building and environmental engineers, visitors, local officials, and residents. Apart from the preservation of the tangible heritage, this case study will reflect on the importance of preserving intangible heritage by discussing the use of the church in its original function. Finally, it will concretely illustrate the decision-making process that can help create sustainable solutions to the problems of heritage management.



Members of the condition assessment team carrying out a survey of the museum building, its interiors, and collections. This assessment allowed the project team to better understand the type and extent of visitor-caused damage, as part of its investigation of indoor climate conditions and the effect of current visitor levels and use on the indoor environment. *Photo:* Paul Ryan.

Foekje Boersma is a project specialist with GCI Education.

GCI News

Project Updates

Los Angeles Historic Resource Survey

In late 2006, the Getty Conservation Institute and the Office of Historic Resources of the City of Los Angeles completed a request-for-proposals document to solicit proposals from private consulting firms for the creation of a Los Angeles Historic Context Statement and Field Guide to Survey Evaluation. Since 2002 the Getty Conservation Institute has been working cooperatively with the City of Los Angeles and civic stakeholders to research historic resource survey methods and survey usage through the Institute's Los Angeles Historic Resource Survey project (LAHRS).

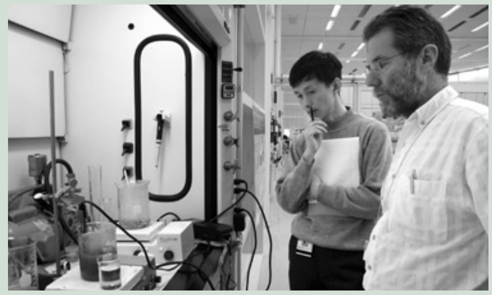
The request-for-proposals document is now being circulated to and considered by consulting firms from around the country. Once a proposal has been selected, the City of Los Angeles will focus on developing survey systems and protocols, testing survey methods, and evaluating the process through pilot surveys. The city's Office of Historic Resources will be responsible for the management of the survey, employing professional standards, ensuring the use of survey data by city departments, and making it available to the public. The GCI, through LAHRS, will provide technical and management support to the city during this period.

In August 2005 the Los Angeles City Council authorized the first comprehensive citywide historic resource survey of Los Angeles. The Getty Trust agreed to provide a matching grant of up to $2.5 million over five years to the city to underwrite a portion of the operating and development expenses and field survey costs.

In addition to its assessment of the purpose and value of a citywide historic resource survey, LAHRS has published the guidebook *Incentives for the Preservation and Rehabilitation of Historic Homes in the City of Los Angeles* to assist homeowners and prospective owners of older properties in Los Angeles to identify financial, tax, and regulatory incentives of benefit to them. The guidebook is available free of charge in PDF format on the Getty Web site at www.getty.edu/conservation/publications/pdf_publications/reports.html.

For more information on LAHRS, visit the Getty Web site at www.getty.edu/conservation/field_projects/lasurvey/index.html.

Asian Organic Colorants Project



Su Bomin of China's Dunhuang Academy and Belgian conservation scientist Jan Wouters discuss the preparation of organic pigment and dyed yarns from the extraction of Japanese pagoda tree flower buds (*Saphora japonica*). *Photo:* Cecily M. Grzywacz.

In June 2006 the Getty Conservation Institute and conservation scientist Jan Wouters launched the Asian Organic Colorants project, a collaborative scientific research project to identify traditional Chinese organic colorants. The project aims to develop a strategy for the analysis of organic colorants used as textile dyes and organic pigments in Asia. The Dunhuang Academy in Mogao, China, and the Wall Paintings Conservation Department of the Courtauld Institute of Art, London, are also participating in the project.

Detection and identification of traditional Chinese organic colorants present a challenge, not only because of the relatively low concentration of these colorants compared with inorganic pigments and binding media but also because many of the biological sources used to create them have not been well studied. Much less is known of these colorants than of the dye and organic pigment sources used in Europe and the Americas.

A review of published literature has identified more than one hundred biological sources, including fresh and dried plants, resins, and insects historically used as colorants in China and surrounding regions. Based on their frequency of citation, over twenty genus-level sources have been selected for further research. The Asian Organic Colorants project will create reference samples from these selected sources on organic and inorganic substrates for study at the GCI laboratories. Lake pigments and dyed silk and wool yarns will be analyzed through liquid chromatography with a photodiode array UV-vis detector and mass spectrometer detector (LC-PDA-MS). Noninvasive and low-invasive techniques will also be used to develop a systematic strategy for the analysis of the colorants. From this analysis, the project will create analytical databases and disseminate this information to the conservation community.

The results of this project will complement the extensive research conducted on wall paintings in Cave 85 at the Mogao Grottoes in Dunhuang, China, by the GCI and the Dunhuang Academy (see *Conservation,* vol. 14, no. 2). The work at Mogao provides a unique opportunity to develop wall painting mock-ups for the evaluation of organic pigments and paints.

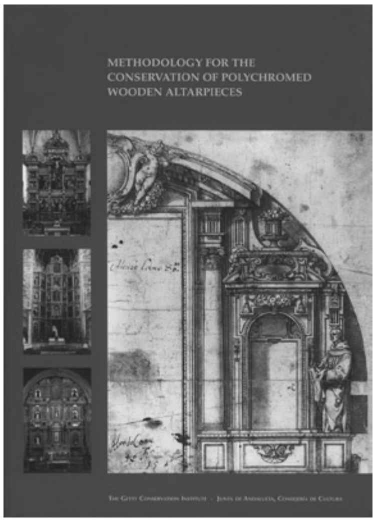
At Cave 85, conservators have identified mineral pigments and binding media in the paintings and have found evidence that organic colorants or lake pigments were also used. The Courtauld Institute of Art will provide critical expertise to the project on the use of historic paints in the Mogao Grottoes.

For more information on the Asian Organic Colorants project and GCI's wall paintings conservation efforts, visit the Getty Web site (www.getty.edu/conservation).

Altarpiece Conservation Methodology Published

The Getty Conservation Institute and the Instituto Andaluz del Patrimonio Histórico (IAPH) are pleased to announce the publication of *Methodology for the Conservation of Polychromed Wooden Altarpieces.* This publication is the result of a 2002 workshop coorganized by the GCI and IAPH which brought together professionals from the Americas and Europe to discuss the need for a comprehensive methodology for the conservation of wooden altarpieces (see *Conservation,* vol. 17, no. 2).

Altarpieces are an expression of faith found throughout the Roman Catholic world. The origin of the altarpiece lies in the medieval liturgical custom of placing relics or images of saints on altars. The layout of altarpieces has varied over time; they have changed from a series of painted panels in the Gothic period to assemblies of grand wooden machinery during the Baroque period. Similarly, the materials employed in their construction have varied: wood was commonly used, although numerous altarpieces were also constructed of stone, alabaster, or marble, or adorned with metal. Both the architectural and decorative features of altarpieces adapted to contemporaneous styles. In its more sophisticated expression, an altarpiece is a complex structure in which architecture and decorative arts are combined. Created to transmit a religious message, these objects of devotion, cherished by churchgoers, are now recognized as the embodiment of a



multiplicity of values—they are artistic and historic objects of great scientific and cultural interest.

Methodology for the Conservation of Polychromed Wooden Altarpieces includes fifteen cases studies presented at the workshop, either as expanded articles or in the synthesized form originally prepared for the workshop. The publication includes a CD-ROM featuring a bibliography—one of the fundamental needs expressed at the workshop—to aid heritage professionals in understanding the history and construction of altarpieces, in selecting appropriate research tools, in determining causes of deterioration, and in choosing intervention techniques.

A supplemental illustrated glossary was also developed. Using the typological references and altarpiece styles presented in the case studies, the illustrated glossary compiles and defines the terminology needed to describe an altarpiece in terms of the composition, constructive systems, materials, and techniques used.

The bibliography and the illustrated glossary will be available in electronic format on both the Getty and IAPH Web sites. For further information, visit the Conservation section of the Getty Web site at www.getty.edu/conservation.

Upcoming Events

OWHC Ninth World Congress

Registrations are now being accepted for the Ninth World Congress of the Organization of World Heritage Cities (OWHC), to be held June 19–23, 2007, in Kazan (Tatarstan), Russian Federation. The Getty Conservation Institute, working with the OWHC, is planning the conference's scientific program, as well as a precongress workshop for mayors of World Heritage cities.

The theme of the Ninth World Congress, "Heritage and Economics," will be examined through four keynote presentations:

- "What Is Heritage Economics?" by David Throsby, Macquarie University, Sydney;
- "How Do You Promote Economic Development Based on Heritage Preservation and Share the Benefits?" by Mona Serageldin, Harvard University;
- "Managing Development Pressures in Urban Heritage Sites" by Eduardo Rojas, Inter-American Development Bank, Washington DC;
- "What Kinds of Practical Tools Can Be Used to Achieve the Goals of Enhancing Both Heritage and Economics in Historic Cities?" by Jean-Louis Luxen, Culture, Heritage, and Development International, Brussels.

Additional conference activities on the theme include roundtable discussions, poster presentations by representatives of World Heritage cities and heritage experts, a public panel discussion among mayors, and a project contest for architecture and business school students of Kazan.

Please visit the Web sites of the Organization of World Heritage Cities (www.ovpm.org/) and its Euroasia regional office in Kazan (www.euroasia-uclg.ru/index) for further information, including details about the precongress mayoral workshop, congress program, and registration form.

A view of the historic city of Kazan, Tatarstan, Russia. *Photo:* Claudia Cancino.

Central, Southern, and Eastern European Photography Symposium

The Getty Conservation Institute; the Academy of Fine Arts and Design, Bratislava, Slovak Republic; and the Slovak National Library are coorganizing a symposium, "Photographic Heritage in Central, Southern, and Eastern Europe: Past, Present, and Future," to be held November 5–8, 2007, in Bratislava. The gathering will focus on photographic history, research, and conservation in the countries of Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Macedonia, Moldova, Poland, Romania, Serbia, Slovak Republic, and Slovenia.

The symposium will begin with an overview of photographic conservation, including presentations on the history of photograph conservation worldwide; past and present systems of photograph conservation and education; and important issues relating to the preservation of photographic heritage.

This overview will be followed by presentations from representatives of each participating country detailing their nation's history of photography, notable photographic collections, and past and present work in the preservation of their national photographic heritage.

A roundtable discussion will conclude the symposium, providing an opportunity for the exchange of ideas to benefit the development of photographic research and photograph conservation practice and education in the region.

A nineteenth-century tinted cabinet card from the photographic collection of the Slovak National Library in Martin, Slovak Republic. *Photo:* Dusan Stulik.

For more information on the symposium, including early registration and participation, visit the Getty Web site (www.getty.edu/conservation/science/photocon/index.html), or contact:

Gary Mattison
Department Coordinator
GCI Science
Tel: 310 440-6214
Email: gmattison@getty.edu

Earthen Architectural Heritage Conference

TERRA 2008 10TH INTERNATIONAL CONFERENCE ON THE STUDY AND CONSERVATION OF EARTHEN ARCHITECTURAL HERITAGE

Registration is now open for the Terra 2008 Tenth International Conference on the Study and Conservation of Earthen Architectural Heritage, organized by the Getty Conservation Institute and the Ministry of Culture of Mali, in collaboration with Africa 2009, CRATerre-ENSAG, ICOMOS South Africa, ICCROM, and the World Heritage Centre, under the aegis of ICOMOS and its International Scientific Committee for Earthen Architectural Heritage. The conference will take place in Bamako, Mali, February 1–5, 2008.

This event will provide a unique opportunity to discuss and observe conservation issues particular to sub-Saharan Africa, a region rich in earthen architecture, and to exchange information on the latest research and best practices in the study and conservation of worldwide earthen architecture. Conference themes include:

- earthen architecture in Mali,
- conservation and management of archaeological sites,
- conservation of living sites (cities, settlements, cultural landscapes),
- challenges and opportunities of conservation and development,
- local knowledge systems and intangible aspects of earthen architecture,
- standards and guidelines for new and existing structures,
- seismic and other natural forces,
- advances in research.

In addition, a five-day postconference tour to Tombouctou, Djenné, and the Dogon Country (February 6–10, 2008) and a three-day tour to Tombouctou, Djenné, and Mopti (February 6–8, 2008), for a maximum of ninety participants, will be offered. Organized by a local tour agency in partnership with the Ministry of Culture and local cultural missions, the tours will highlight outstanding examples of the rich and diverse earthen architectural traditions of Mali. Experienced staff and guides of the cultural missions will present all sites to the groups.

Conference registration forms and additional information—including details on conference costs, postconference tours, and travel to Mali—are available on the Getty Web site (www.getty.edu/conservation/field_projects/earthen/earthen_2008_conf.html).

Limited financial assistance will be available to participants from developing countries. Requests for funding assistance should be made as soon as possible and directed to Kathleen Louw (klouw@getty.edu) or Leslie Rainer (lrainer@getty.edu).

Earthen mosque in the village of Ende, in the Dogon Country of Mali. *Photo:* Leslie Rainer.

Staff Profiles

Leslie Rainer

Senior Project Specialist, Field Projects

Photo: Dennis Keeley

Arthur Kaplan

Research Lab Associate, Science

Photo: Dennis Keeley

Leslie's early interests were in literature and language, along with an appreciation of the outdoors. She was born and raised in Denver, where her summers included hiking, rafting, rock climbing, and survival camp.

A trip to Europe led by her high school art history teacher exposed Leslie to European culture, influencing her decision to major in art history and German when she started at Bowdoin College in Maine in 1978. After spending her junior year in Munich, she returned to Bowdoin, where a museum studies class led her after graduation to a summer internship in the frame conservation lab at the Smithsonian American Art Museum. She loved the hands-on aspect of the work and decided on conservation as a profession. Looking back, she feels that she inherited some of the skills used in conservation from her father, a surgeon, and her mother, an artist.

An ICOMOS internship in France was followed by two years in a small village outside Avignon, teaching English and working in a gallery. She also studied at the Lacoste School of the Arts and did an internship at the Peggy Guggenheim Collection in Venice.

Returning home for internships at the Metropolitan Museum in New York and the Philadelphia Museum of Art, Leslie concluded that her interests lay in the conservation of architectural finishes, and she enrolled in an architectural artisanry program in Massachusetts, completing it in 1987. The next few years were spent between Boston and France, where she worked on wall paintings conservation projects. She spent 1990 in Rome at ICCROM, earning a certificate in mural paintings conservation, and at CRATerre-EAG, training in earthen architecture preservation—a course of study ultimately incorporated into the master's degree in conservation of architectural finishes that she earned from Antioch University in Ohio.

In 1993 she consulted on the GCI's project to conserve historic bas-reliefs at the Royal Palaces of Abomey. From 1995 to 1997 she was a GCI senior research fellow while working on the project. She then returned to private practice, continuing to consult on GCI projects. In 1998–99, she was a fellow at the American Academy in Rome.

In 2002 Leslie returned to the GCI to work on projects in China, Africa, and Los Angeles. Currently she is conducting research on grouts and helping to organize a conference in Mali on earthen architecture (see p. 29). She still enjoys fieldwork and her collaboration with colleagues in science and conservation. That particularly includes Arlen Heginbotham, a decorative arts conservator at the Getty Museum, whom Leslie met at the Getty. He is now her husband.

Born in the small city of Bobruysk in Belorussia, Art emigrated to the United States with his parents when he was five years old. The family ultimately settled in Santa Monica, California, where he attended school, showing an early interest in mathematics. As a child, he spent a fair amount of time in his father's shop, where his father, an artist and silkscreen painter, created and printed silkscreen designs for a variety of materials. Art's mother made certain he was exposed to the arts and culture, in part by taking him up to the Getty Villa five or six times a year.

After graduating from Santa Monica High School in 1992, he worked at several different jobs, including coaching children's athletics for the Santa Monica Parks and Recreation Department, before enrolling at Loyola Marymount University. Still uncertain about what he wanted to do, he left the university after two years and joined the United States Marine Corps Reserves, where he served as a radio operator at Marine bases in California.

In 1999 he returned to school, enrolling at California State University, Northridge, where he majored in biochemistry, with the intent of studying pharmacology in graduate school. While there, Art became a student of chemistry professor David Miller, who was collaborating with GCI scientist Dusan Stulik on a project. Art ended up working on another GCI project, the conservation of the fourteenth-century glass mosaic on St. Vitus Cathedral in Prague, by assisting in the analysis of glass samples from the mosaic.

In 2004, as he was applying to graduate school in pharmacology, Art was asked if he wanted to apply for a research associate position with the GCI's Science department. Concluding that work at the Conservation Institute might prove more engaging than dispensing medication, he interviewed for the GCI job and joined the staff in the same year—a year in which he also got married.

Since arriving at the Institute, Art has worked primarily on the Research on the Conservation of Photographs project; in addition, he serves as the coordinator of the GCI Reference Collection of art materials, cataloging samples in the reference collection database. He enjoys the variety in his work, the challenge of trying to solve the scientific unknowns that the work presents, and the opportunity to travel. He is also enjoying his daughter, Emma, born in July.

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