The Massachusetts Experiment: The Role of the Environment in Collection Preservation

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ABSTRACT

The Massachusetts Board of Library Commissioners (MBLC) has collected a unique set of environmental data from storage and display areas in hundreds of cultural institutions in the Commonwealth of Massachusetts, in time frames that spanned the heating and cooling seasons of the year. The goal of this research project was to investigate whether this unique resource of data could be organized, distilled, and synthesized into useful environmental management benchmarks and interpretive guidelines that institutions could use to evaluate their own stewardship and compare it to peer institutions. Utilizing an environmental data analysis software program and metrics designed by the Image Permanence Institute (IPI) to identify and compare preservation quality, the researchers created a detailed statistical analysis of indoor and outdoor environments in Massachusetts by season, region, and institution. The research identified the importance of seasonal climatic differences, the fall season being the most problematic preservation environment management challenge. Institutions must pay close attention to temperature control during periods of high humidity when too much cooling can raise relative humidity to dangerously high levels. The benchmarks and environmental management guidelines developed during this project provide valuable information to institutions in Massachusetts as well as those located in the continental climate zone of the United States.

KEY WORDS

Facilities, Management, Preservation, Local History, Environment

Appropriate environmental conditions are crucial for the long-term preservation of archival, library, and museum holdings. The only way to determine if environmental conditions are appropriate and conducive to the long-term retention of the collections is to embark on an environmental monitoring program. Unfortunately, little documentation is published for environmental conditions over time in one institution or multiple institutions. This article is an example of a program of environmental data collection in cultural institutions. It illustrates the benefits of such an undertaking in understanding the conditions that either hinder or benefit the long-term retention of holdings. Moreover, since the data collection occurred over many years and in a significant number of institutions, the conclusions reached through the analysis provided can be applicable to a larger number of institutions overall.

Beginning in 1996, the staff of the Massachusetts Board of Library Commissioners (MBLC), the state library development agency, planned and implemented an environmental monitoring program in more than 500 libraries, archives, museums, municipal town halls, and historical societies.[1] Although the ideal period for monitoring the environment in an institution is at least a full year, monitoring was undertaken for a period of only five months due to a continued waiting list of up to 75 institutions. However, the 5-month period was scheduled to ensure that the monitoring period covered two major changes—winter to spring to summer (February to July) and summer to fall to winter (August to January). Because of this, the data collected over 14 years had the potential to provide significant insights into the storage conditions in a large number of institutions and allowed for a detailed analysis of the data.

In 2008, the MBLC approached the Image Permanence Institute (IPI) at Rochester Institute of Technology, Rochester, New York,[2] about a research project to extract trends and develop new methods for environmental analysis of more than 1,200 datasets collected over 14 years. IPI staff realized that this was a unique opportunity to work with environmental data from a broad range of institutions, covering a large geographical area with varied climates, which had been collected for several years.

This article provides background on environmental conditions and their potential impact on collections, a description of IPI's analysis of the data collected through the MBLC's environmental monitoring program, and broad suggestions for improving the preservation quality of storage conditions.

The Project

The MBLC is responsible for organizing, developing, coordinating, and improving library services throughout the Commonwealth of Massachusetts. In 1996, its staff initiated a statewide environmental monitoring program to document the indoor environmental conditions in cultural institutions in the commonwealth. The purpose was to provide the participating institutions with data on their internal environment and advice on how best to improve the environment to prolong the life of their holdings.

This program has resulted in the accumulation of temperature and relative humidity data from open stacks, special collections departments, municipal vaults, and closed stacks in over 500 libraries, archives, historical societies, and town halls in Massachusetts, as well as outdoor data for every site, between 1996 and the present. Digital temperature/relative humidity dataloggers were used to collect the data for periods of 5 months, in time frames that spanned the heating and cooling seasons of the year. As the dataloggers were installed, specific temperature, relative humidity, light, and ultraviolet readings were taken at each datalogger site using a thermohygrometer (Elsec 764)[3] to set a starting point for the recordings. Similar readings were taken when the dataloggers were retrieved at the end of the 5-month recording period. The MBLC staff then downloaded the data, reviewed them, and provided each institution with a report that summarized the environmental conditions and offered preservation advice based on the analysis of the collected data.

While individual institutions have collected environmental data in their collection areas for long periods of time, such a systematic collection and analysis of both outdoor environmental data and indoor data from cultural institutions has never been undertaken on such an unprecedented scale. As a consequence, the data from such a large number of institutions presented a unique opportunity to extract information useful to both MBLC member institutions and to preservation programs nationwide. While we hoped that the resulting analysis might provide information that could apply nationwide, we also recognized from the beginning that environmental conditions in all parts of the country are different enough that such a goal might not be possible. However, we clearly recognized that the example of monitoring the environment on such a large scale and in so many institutions could serve as a model for other state or regional organizations. The project was funded by MBLC using Library Service and Technology Act funds from the Institute of Museum and Library Services.[4]

We transferred all collected data into a common format and database. Once all duplicate, corrupt, or incomplete data were eliminated, we organized the usable data (estimated at 1,100 datasets) into fields and transitioned them into a second database. This database included a hierarchical structure searchable by region, town, institution type, time period, and various aspects of preservation quality. The Web program used for this project was designed to analyze collected temperature and relative humidity data automatically and to evaluate the preservation quality of the environment in each monitored space.[5] We drew conclusions regarding preservation quality for each primary mode of material decay (chemical, mechanical, mold risk, and corrosion) and made suggestions for reducing the particular risk through environmental management. We developed benchmarks and statistical comparisons based on region, institutional type, and season. Because review of the data identified quite significant seasonal differences, 2 sets of benchmarks were developed, one for the fall and one for the spring season.

Benchmarks developed for this project are based on the median values of the various metrics. The median value is the one for which there are as many results above it as below. This is preferable to the mean (average) value because a few very high or very low results can skew the mean. Both IPI's Preservation Metrics™ and the project benchmarks are discussed later in this article. Benchmarks for comparing any individual dataset against a reasonable set of expectations are very handy in analysis and can serve as the basis for deciding whether to take action to improve conditions or not.

To make this information available to the participating institutions as well as the MBLC administration, the website created by IPI[6] was made accessible to all participating Massachusetts institutions at the end of the project.

Background on Environmental Factors

While a number of environmental factors can cause material decay, including light, air pollution, and vibration, temperature and relative humidity are the most fundamental. They are always present, have the broadest effect on the largest number of items in collections, and act as enablers (or inhibitors) of damage caused by other factors such as light or pollutants. An institution's ability to control temperature and relative humidity directly affects its ability to preserve collections.

Deterioration is inevitable, but modifying the environment can control the rate of deterioration. The 4 primary forms of material decay include

- The threat of spontaneous chemical change in organic materials, or *natural aging*;
- Excessive dryness, dampness, and the associated dimensional change that can lead to *mechanical damage*;
- The opportunity for biological decay or the *risk of mold growth*; and
- The likelihood of *metal corrosion* from excessive moisture in the air.

Temperature and relative humidity each play a significant role in the primary types of material decay—chemical, mechanical, biological, and corrosive. As temperature increases, chemical reactions have a greater chance of occurring. The reverse happens when the temperature decreases. At higher temperatures, biological activity also increases as insects eat more and breed faster, and mold growth increases. Certain materials soften at high temperatures resulting in adhesive failure, sagging, and stickiness in some plastics. This is why cooler temperatures are often recommended for collection storage—cooler temperatures slow the rate of chemical decay.

Relative humidity (%RH) represents how saturated the air is with water vapor and determines the amount of water contained within collection objects. Most organic materials (paper, parchment, leather, textiles, etc.) absorb and release water depending on the relative humidity of the surrounding air. High RH can cause metal corrosion, buckling of paper, fading of dyes, swelling and warping of wood and ivory, softening of adhesives, and an increase in biological activity. Mold growth can become a problem at 65% RH and above. At low RH levels, wood and ivory will shrink, warp, and crack; leather and photo emulsion will shrink, stiffen, crack, and flake; and paper and adhesives will desiccate.

Providing the best environment for collection care begins with knowing the nature of the collection objects themselves and then deciding which forms of deterioration will be of primary concern. For collections primarily made up of organic materials, such as document and paper collections, parchment and leather, textiles and fibers, chemical decay and mold growth are of primary concern. Paintings and furniture, which are composites of several parts and various materials, require an environment that avoids mechanical damage first and foremost.

Most real-world indoor environments are strongly affected by outdoor conditions. They may be heated or cooled to human comfort temperatures, but the large differences in outdoor dew point (moisture content of the air) that occur in summer and winter are not erased by merely heating and cooling. Most indoor spaces, therefore, have quite significant differences in humidity between summer and winter.

IPI's Preservation Metrics

In study after study, IPI observed that heat and humidity were the primary drivers of biological decay, chemical instability, and mechanical damage for a large variety of archival records and museum objects. Although the importance of temperature and relative humidity had been well documented in the preservation research community,[7] few resources were available to help preservation staff understand the impact of their real-life environments on their collections. Recognizing the need for a way to transform large amounts of environmental data into useful algorithms applicable to the daily task of managing the environment for preservation, IPI developed Preservation Metrics.[8]

The incorporation of change over time is a particularly important aspect of these calculations since environments are rarely steady and unchanging. IPI's Preservation Metrics take the amount of time a collection spends in a good versus a bad environment and integrates that into the metric calculation. The ability to calculate the complexities in the relationships between deterioration and temperature, humidity, and exposure time for each major form of decay was a key breakthrough in preservation research. These calculations work best with a full year of collected data, incorporating each season of the year and the associated highs, lows, and fluctuations of temperature and relative humidity.[9] Based on the primary modes of decay, IPI's Preservation Metrics include

- Natural Aging—environmentally induced chemical decay of organic objects, or more broadly, chemical decay—represented by the TWPI (or time-weighted preservation index) metric.
- Mechanical Damage—environmentally induced physical or structural deterioration, primarily affecting hygroscopic material—represented by minimum and maximum EMC (min and max equilibration moisture content) and %DC (dimensional change) metrics.
- Mold Risk—the risk of mold growth based on environmental conditions, particularly high humidity, or more broadly, biological decay risk—represented by the MRF (mold risk factor) metric.
- Metal Corrosion—the risk of corrosion based on environmental conditions, particularly high humidity levels (a chemical decay reaction)—represented by the Max EMC (maximum equilibration moisture content) metric.

Institutions that use IPI's environmental management tools and the Preservation Metrics are able to determine accurately and objectively how well each storage area is performing for collection preservation, how well one environment is performing compared to another, and how various collection materials are faring in a particular location. The numerical, objective nature of Preservation Metrics allows for incremental improvements and measured progress in the storage environment. The objectivity is also beneficial when working to convince institutional administrators of the need for mechanical system improvement.

A simpler representation of metric-based decay ratings is shown in Table 1 using demonstration data. The "OK," "Good," and "Risk" value designations indicate the preservation quality of each monitored location for each mode of decay based on analysis of collected data using the Preservation Metrics.

Table 1. Environment at a Glance

Location	Environment at a Glance			
	Natural Aging	Mechanical Damage	Mold Growth	Metal Corrosion
IPI Library	OK	Good	Good	OK
Library 3	OK	Risk	Good	OK
Main Library	Risk	OK	Good	OK
Prints and Photos	OK	Risk	Good	OK
Rare Books	OK	Risk	Good	Risk

In this example, the environment in the IPI library is good for protecting collections from mechanical damage and mold growth and OK for protecting them from natural aging and metal corrosion. Collections in the Rare Books space by comparison are at risk for both mechanical damage and metal corrosion.

The Role of Dew Point

Another significant element of environmental data analysis is dew point temperature. It is important to understand the role that dew point plays in managing the environment for preservation. Dew point is the temperature at which the air cannot hold all the moisture in it, and water condenses. It is a measure of the absolute amount of water in the air, and it does not change unless the air is humidified or dehumidified by a building's mechanical system. Temperature, relative humidity, and dew point are interrelated variables.

The dew point determines what combinations of temperature and RH will be possible in the storage environment. At a constant dew point, when the temperature goes up, the RH goes down, and when the temperature goes down, the RH goes up.[10] Therefore, the dew point is responsible for determining which temperature will result in which RH. Consequently, institutions that try to improve conditions by lowering storage temperatures without carefully watching the resulting RH may find that the moisture level is much too high for safe storage of vulnerable collections.

To change the dew point of the outdoor air, the mechanical system must have the capacity to add or remove moisture. In buildings with humidity control, the dew point of the indoor air is controlled by the building's mechanical system. When outdoor dew points are high, and the air is warm, the system must both cool the air and wring the moisture out of it. Simply cooling the air is not enough; without dehumidification, the moisture level indoors will be much too high. One of the two basic methods for mechanical systems to achieve this is subcooling followed by reheating (cooling the air to the desired dew point and then reheating it to the desired temperature). The second, less common, method uses a desiccant wheel to dehumidify.

When outdoor dew points are low, a mechanical system must add moisture through humidification. One method is to introduce steam (water vapor) into the supply air stream within the air-handling unit. Another method involves evaporating liquid water directly into the air stream. These methods both cool and humidify the air.[11]

The outdoor climate is very important because it has a profound influence on what happens indoors. All the air in storage and exhibit spaces comes from the outside and is managed by whatever mechanical system is in place in that particular building, if one exists. Comparing graphs of outdoor environmental data with data collected in the storage space at the same time, particularly the dew point temperature graphs, can illustrate exactly what the mechanical systems are doing.

Figure 1 illustrates how elements of a mechanical system deal with the dew point (or moisture level) in the environment. The goal is to manage the amount of moisture and degree of heat in the storage space to appropriate levels. The red line is the outside dew point. The gray line is from a space with no summer dehumidification, leaving the dew point inside the same as it is outside. The blue line is from a space that does dehumidify, keeping the moisture level below 50°F and resulting in a much better storage environment with little opportunity for mold growth or moisture-related damage to collections. However, this space has no winter humidification, which can lead to very dry conditions and the potential for damage to collections. The green line illustrates a system that provides year-round humidity control, maintaining the dew point at a very even level through the year. The yellow line space has a system that maintains humidity control, but allows for some seasonal drift, particularly in the winter season (it also shows some system failures in March of the year illustrated).

Research and Analysis

For its analysis of the MBLC data, IPI relied on the Preservation Metrics and a detailed comparison of indoor and outdoor temperatures. Although the metrics provide the most accurate results when applied to a full year of data, and all associated ups and downs of temperature and relative humidity during

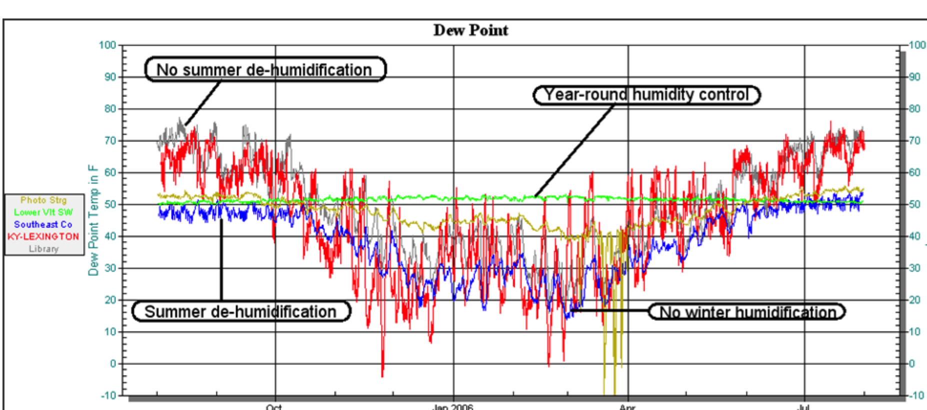

FIGURE 1. This graph charts the management of dew point by mechanical system over the course of a year.

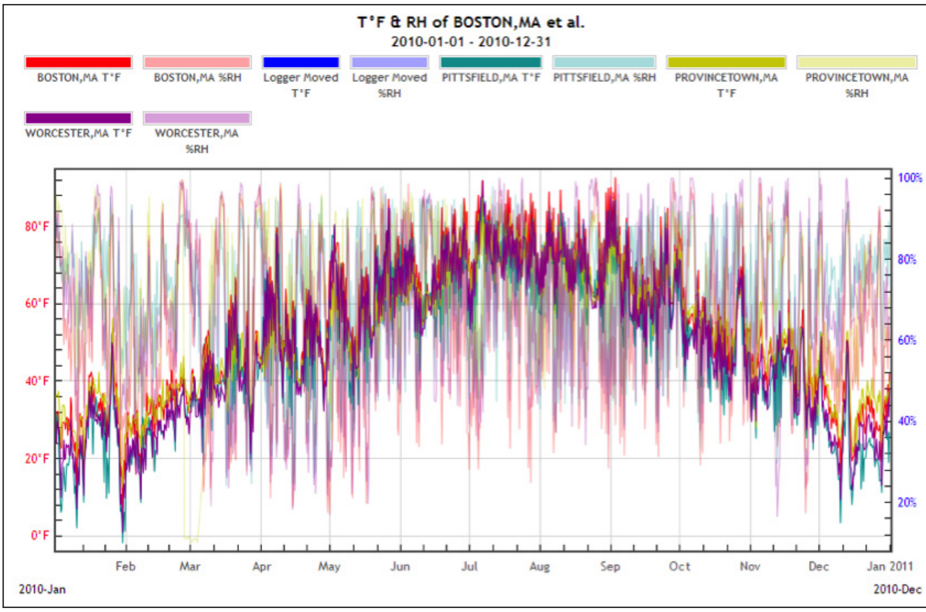

FIGURE 2. This graph shows temperature and relative humidity in five Massachusetts locations over the course of a year.

each season, they can still be effectively applied to data from comparable time periods. Figure 2 shows a full year of temperature and RH data from five locations across Massachusetts.

As noted previously, the data in the MBLC project was collected in spans of about 5 months. One was roughly February through July (referred to as "spring") and the other roughly August to January (labeled "fall"). This was structured to cover the actual heating and cooling seasons from a mechanical point of view. For analysis, IPI created tables of both outdoor (see Table 2) and indoor (see Table 3) data showing the average temperatures, relative humidities, and dew points along with each Preservation Metric for each region of the state. Summaries of all regional data are shown below—one table for Outdoor and one for Indoor Data—each with a yearlong, spring, and fall data average.

Table 2. Outdoor Data Summary Table, 1996–2010

OUTDOOR DATA	Temp	%RH	Dew Point	Natural Aging	Mold Ave.	Mold MAX	%DC	EMC MIN	Corrosion (EMC MAX)
Average of ALL Seasons	54°F	64%	41°F	50	**3**	**22**	1.34%	10.12	**14.91**
Spring Outdoor Data	54°F	60%	39°F	54	**2**	**16**	1.34%	9.26	**14.06**
Fall Outdoor Data	55°F	68%	43°F	46	**3**	**22**	1.34%	11.01	**15.79**

Table 3. Indoor Data Summary Table, 1996–2010

INDOOR DATA	Temp	RH	Dew Point	Natural Aging	Mold Ave.	Mold MAX	%DC	EMC MIN	Corrosion (EMC MAX)
Average of ALL Seasons	70°F	41%	43°F	48	0	**6**	1.28%	5.70	10.28
Spring Indoor Data	70°F	37%	40°F	55	0	**2**	1.24%	5.39	9.82
Fall Indoor Data	69°F	44%	45°F	**40**	0	**6**	1.32%	6.02	**10.76**

Legend for Tables 2 and 3:

- Natural Aging Metric—45 or less is **BAD**, 45 to 75 is **OK**, 75 or more is **GOOD**.
- Mold Growth Metric—0.5 or more is **BAD**, 0.5 or less is **GOOD**.
- Mechanical Damage Metrics—%DC above 1.5% or EMC Min below 5%, or EMC Max above 12.5% is **BAD**; %DC below 1.5 and EMC between 5% and 12.5% is **OK**, %DC below .5% and EMC above 5% and below 12.5% is **GOOD**.
- Corrosion Metric—over 10.5% is **BAD**, between 7.5 and 10.5 is **OK**, below 7.5 is **GOOD**.
- *DC = dimensional change, **EMC = equilibration moisture content

Looking at the indoor temperature data, the two seasons are approximately equal—an average of 69°F in fall and 70°F in the spring. However, the level of moisture differs considerably by season. The fall period was typically damper, with an average dew point of 45°F and 40°F in the spring. Correspondingly, the RH on average was 44% in the fall and 37% in the spring. High levels of moisture caused the greatest risk to collections. Both the mold growth and corrosion metrics indicate a risk of accelerated decay because of high levels of moisture in the environment.

In summary, IPI used all the data collected by MBLC to develop a statistical analysis of the outdoor and indoor environments in Massachusetts' cultural institutions by season, region, and institution type. IPI then created a set of benchmarks, which will allow institutions from across Massachusetts to gauge their performances and identify areas in need of action to improve preservation quality. Although differences were noted by season and region, no major differences were seen between the various types of institutions in the study.

Outdoor Conditions

As noted above, documenting the influence of outdoor conditions on the indoor environment is critically important in understanding the storage conditions of collections. Massachusetts has a humid continental climate characterized by hot summers and cold winters. It receives about 40 inches of rain annually, fairly evenly distributed throughout the year. Summers are warm with average high temperatures in July above 80°F and lows above 60°F. Winters are cold, though less extreme on the coast and colder inland. Typical winter temperatures in the western region average 22°F while the Cape and islands in the southeastern region average 32°F. This variation is due to the moderating effect of the Atlantic Ocean. The climate also varies with elevation, especially in the winter. The central region highlands and the hills of the western region are generally colder and snowier than eastern sections of the state. Overall, the mix of weather throughout the year averages out to about 50% clear, 25% cloudy, and 25% wet.[12] Figure 3 identifies the regions of Massachusetts.

The primary concern seen in the outdoor data is year-round dampness. Moisture levels are highest in the southeastern, central, and western regions during the fall season. This climate promotes mold growth and increases the rate of natural aging and dimensional change. This is particularly true for institutions in the southeastern (Cape Cod) region, where proximity to the sea leads to a high moisture content of the air, which translates to high indoor humidity. This is illustrated in Figure 4, a graph of outdoor temperature and RH for one year in Provincetown, which is located on the extreme tip of Cape Cod. Notice that the RH is between 65% and 95% most of the year.

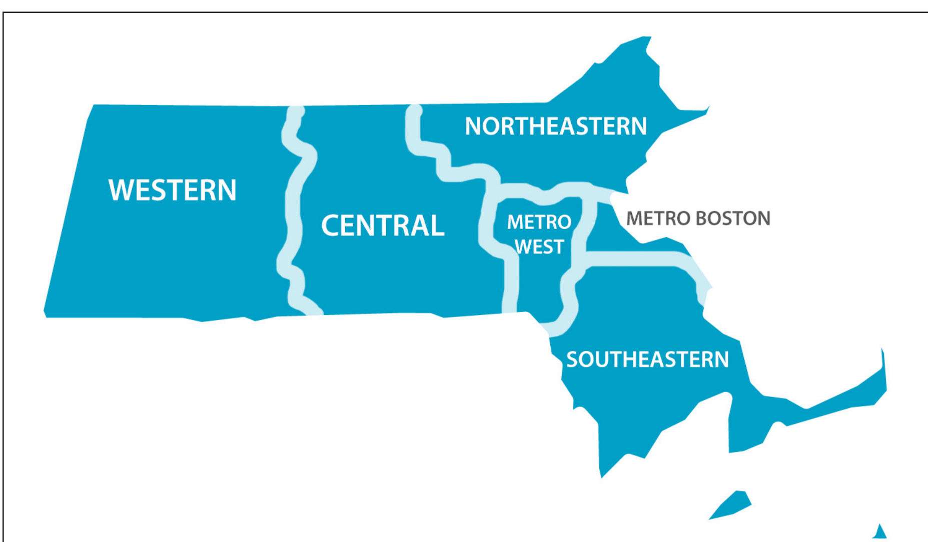

FIGURE 3. Massachusetts can be divided into six regions.

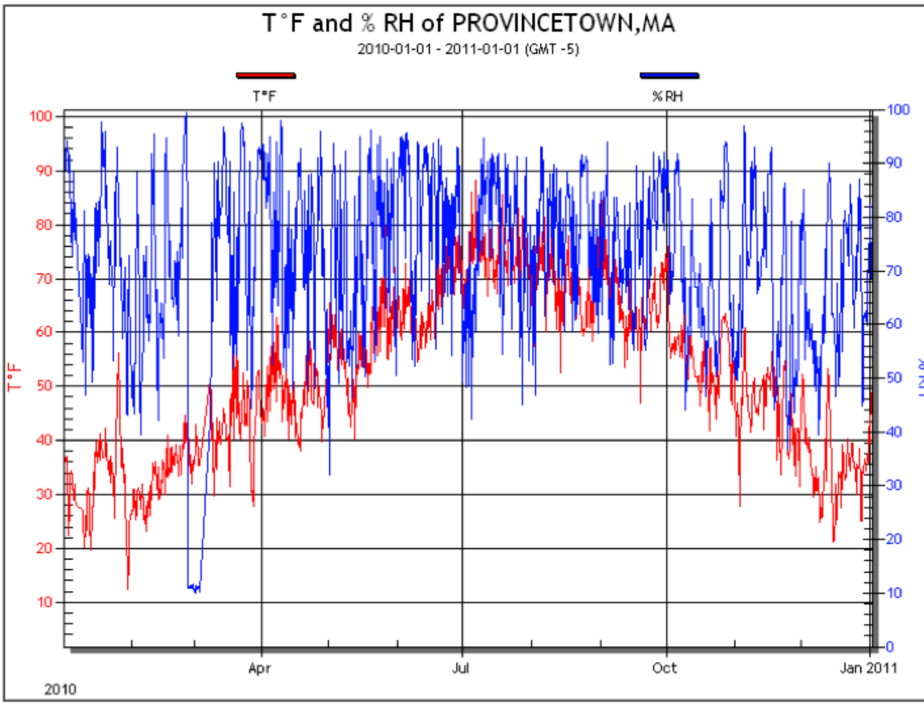

FIGURE 4. This graph shows the outdoor temperature and relative humidity in Provincetown in 2010.

Indoor Conditions

Providing a storage environment that promotes long-term preservation of collection materials has a broad effect on collection stewardship. Over time, high temperatures, improper levels and fluctuations of relative humidity, and uncontrolled light cause the most environmentally induced damage to collections. Knowing the nature of your collections and which forms of deterioration are most relevant to them is essential. Three of the primary modes of decay—mold risk, chemical decay, and mechanical deterioration—are reviewed below as part of the analysis of data in this project.

Responding to the Risk of Biological Decay, Particularly Mold Risk

As noted previously, the greatest risk to collections in the MBLC locations comes from exposure to high levels of moisture, which can lead to mold growth and mechanical damage. Excess moisture also increases the rate of chemical decay. Of the 833 indoor datasets analyzed, 14 (from 12 institutions) had a mold risk factor greater than 1.0, which indicates that mold would have germinated in that space during the measured period. The fact that this represents only

1.6% of the total is encouraging. One significant commonality among these 14 datasets is that 12 come from the fall season. Nearly all the mold risk occurs between August and the middle of October, when the moisture content of the air outdoors is relatively high (dew points of 60°F and above) and continues from the high RH levels during the summer months. The indoor temperature of the datasets where mold risk was observed was relatively cool (65°F to 68°F). The combination of high dew point and low temperature caused the RH to soar above 70% (sometimes much higher). Mold growth becomes a risk whenever the RH remains above 65% long enough for germination to occur. In most cases, the mold risk could have been avoided by keeping the space warmer (heating the air slightly or cooling it less) during those 6 to 12 weeks when the dew point was high. It should be noted that the effect of the desiccation that occurs during the winter months appears to linger because of the heating systems during the late spring and early summer, resulting in lower indoor RH levels.

The general rules of thumb for reducing the risk of mold are

- Keep excursions above 65% RH to a few days or less,
- Avoid high RH at moderate temperatures—use dehumidification to achieve this, and
- Keep summertime dew points as low as possible.

Responding to the Risk of Chemical Decay

In the fall season, the majority of MBLC locations had a satisfactory rate of natural aging. There were 21 datasets from 16 institutions (2.5% of the total) with a dangerously high rate of chemical decay. Of these, 16 were located in the southeastern region, and 12 of those had higher than typical temperatures. Thirteen had higher than typical relative humidity levels. Again, the fall season in the southeast poses the greatest challenge to collection preservation. Data for the spring season showed generally better results. The key in this case is to watch carefully when lowering the temperature in the spaces with a target RH of below 65%. If the air is conditioned in the summer, lower the dew point, which will allow better control of the RH.

General rules of thumb for reducing the rate of chemical decay are

- Make it as cool as possible while still maintaining an RH below 65%, and
- Keep summertime dew points as low as possible.

Responding to the Risk of Mechanical Deterioration

The MBLC data showed that seasonal differences matter when it comes to mechanical decay as well. The risk of environmentally induced mechanical decay (physical stresses in an object caused by absorbing and releasing moisture) was higher during the fall season. This period had somewhat higher incidences of both dangerously low and dangerously high RH than the spring. In general, the same few locations that had a high mold risk also had a high mechanical decay risk due to dampness. The data also showed more overall risk due to dryness during the fall. Transitioning between periods of high and low RH can cause physical stress in vulnerable materials and result in damage to objects. Humidifying and dehumidifying are very important for locations that see wide seasonal fluctuations in RH. Without these capabilities, institutions need to cool more to raise the RH or heat more to lower it to acceptable levels.

The rules of thumb for reducing mechanical damage from wide extremes and rapid fluctuations of RH are

- Keep excursions below 20% RH or above 65% RH as short and infrequent as possible through the use of humidification and dehumidification, and
- Keep wintertime dew points from being too low and summertime dew points from being too high.

MBLC Benchmarks and Guidelines

An important lesson for institutions in all regions of Massachusetts, but especially for those in the more humid southeastern region, is to pay close attention to controlling temperature during the times of year when the amount of moisture in the outdoor air is high—typically August through October. Cooling the air too much during these times raises the RH to dangerous levels. It is vital to consider both temperature and RH, and not just assume that cooler temperatures will always be better for preservation. Very high RH can harm collections faster than a period of moderately warm temperatures, so sometimes it is better to trade off a little warmth to avoid getting into conditions where mold would grow. In addition, during the low RH winter season, institutions should avoid overheating storage and display areas. The high temperatures work against collection preservation by drying objects out excessively and also driving up energy costs needlessly.

As previously noted, IPI used the collected data to create a set of recommended benchmark values to allow MBLC institutions to gauge their performances in comparison to others within the same geographical area. The project benchmarks are shown in Table 4. In addition, the risk ratings and preservation quality analysis available in the eClimateNotebook™ database for MBLC can be searched and sorted by region, season, or institutional type, to provide benchmarks for setting priorities and making improvements to replace the vague goal of improving the storage environment.

Table 4. Recommended Benchmark Values

Metric	Spring	Fall
Temperature	70	70
Relative Humidity	36	43
Dew Point	40	45
Mold Risk Factor	0	0
Time Weighted Preservation Index (TWPI)	54	39
% Dimensional Change	1.22	1.32
% Minimum Equilibration Moisture Content (%EMC Min)	5.1	5.7
% Maximum Equilibration Moisture Content (%EMC Max)	9.5	10.6

Because the data are available on a shared website, users can also review their graphs to identify areas in need of improvement and to develop a plan for improving preservation quality. Overall, the information gathered for this project and made available is an excellent resource and learning tool for participating cultural institutions in Massachusetts.

General Conclusions and Broader Implications

The study conducted by IPI on the MBLC data showed that libraries and archival institutions in Massachusetts, on average, maintain a reasonably benign environment for their collections. Temperatures average 69°F, and relative humidity averages 41%. Overall averages, however, can be deceiving. Most institutions do not have tight control over RH and are unable to avoid some degree of winter dryness and summer high humidity. Less than 2% of institutions have serious mold problems. About 6% have environments in which the difference between the driest and dampest extremes is too great, leading to risk of serious mechanical damage. About 5% of institutions experience dangerous dryness, while a similar percentage experience dangerous dampness at one point or another.

Participating institutions who took advantage of the opportunities for environmental monitoring that the MBLC program offered were able to go the website and see for themselves whether their climates were among the few with serious environmental threats to their collections. They were able to see when and what types of risks arose, and gain insights into what they could do about them (such as heating to reduce RH during early fall). They could put their own environments into perspective with peer institutions in their region and across the state.

If other states in the Northeast performed a study as large and long-term as this one, it likely would have similar results to those in Massachusetts. The data show that most institutions have a human-comfort environment for their collections. This has good and bad aspects. From a preservation viewpoint, to be near room temperature and to have RH values that follow the typical winter-low/summer-high pattern found in the Northeast means that collections of fast-decaying materials (such as acidic paper, color photography, nitrate and acetate film, felt-tip pen inscriptions, etc.) are deteriorating rather rapidly. However, some institutions can be at human-comfort conditions (albeit a little cooler on average) and do considerably better in managing the natural aging rate by paying careful attention to the operating patterns of their HVAC equipment. Apart from the fact that archival and library collections would be "happier" at cooler, moderately dry conditions, the study reconfirmed the wisdom that extremes of high and low RH are most dangerous, while showing that a fairly small percentage of institutions experience those immediate, acute dangers. The trick is to know whether *your* environment is among them, and only monitoring can reveal that. Once you have the data, it is even better to know how your institution compares to others, which is where this large, long-term study proved most valuable.

While the conclusions derived from the analysis of data from Massachusetts' institutions are particularly applicable to those institutions, these conclusions might well be applicable to most regions in the continental climate zones of the

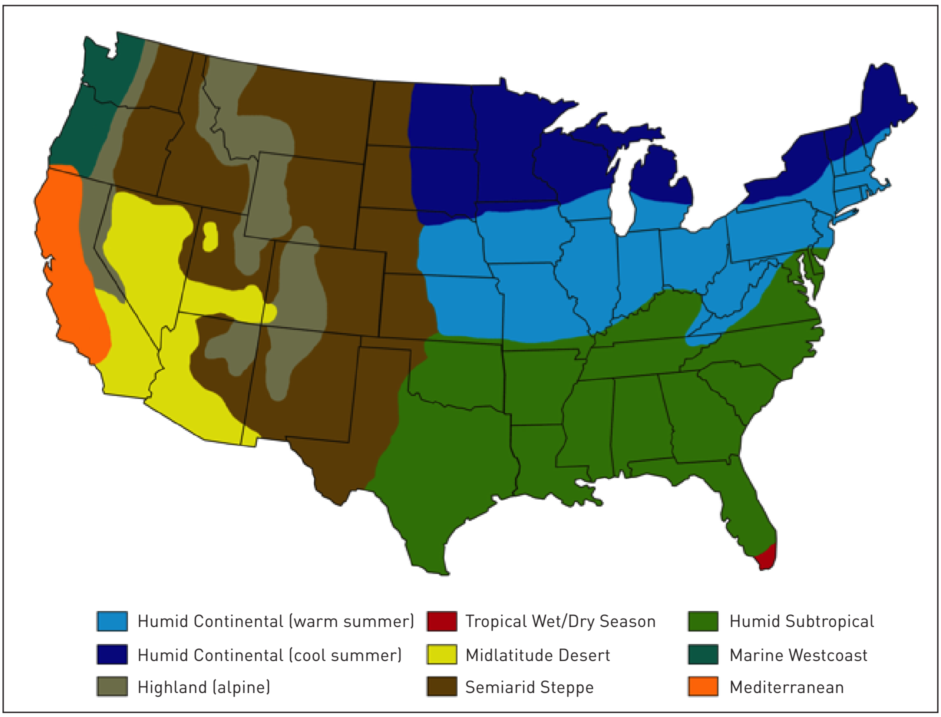

FIGURE 5. The United States can be divided into 9 climatic regions.

United States, where the climates are fairly similar. This would include all of New England, the Mid-Atlantic states, and most of the midwestern areas of the United States as shown in Figure 5.

Overall, it is not the specific Massachusetts conclusions that are important but the impact that the results of such a large-scale monitoring program can have on the care of collections nationwide. All too often, collections-holding institutions have little idea of the environment in which their collections are housed, or they do so for only a short period of time. This environment may be benign (with little in the way of extremes in or elevated levels of temperature or relative humidity), or it may be quite detrimental to the collections (with high relative humidity, elevated temperatures, significant fluctuations in either or both, and other environmental problems such as light, ultraviolet, and pollution issues). Even if collection custodians have a "gut" feeling about the conditions, without monitoring, they will have little idea of the actual conditions and consequently no idea how to ameliorate them for the benefit of their holdings. Furthermore, they will not have reliable data to back up any requests for funds to improve storage conditions.

The data and analysis in this study were specific to Massachusetts. However, the concepts, the implementation of the analysis, and the lessons learned can be applied to other regions of the country. By doing so, collection custodians will be able to take a major step in prolonging the life of their collections.

Notes

1 For additional information about MBLC, see www.mass.gov/mblc;www.mass.gov/advisory/preservation/monitoring.php.

2 The Image Permanence Institute is a nonprofit research laboratory focused on the development of sustainable practices for the preservation of cultural property, www.ImagePermanenceInstitute.org.

3 Elsec 764 is produced by Littlemore Scientific Engineering, Gutchpool Farm, Gillingham, Dorset SP8 5QP United Kingdom, www.ELSEC.com. It is available in the United States from Scientific Sales, Inc., 3 Glenbrook Court, Lawrenceville, N.J., 08648.

4 For additional information, see www.imls.gov.

5 Data management and analysis were done using IPI's Web-based MyClimateData.com program, development of which was funded by the Institute of Museum and Library Services' National Leadership Grant program, 2007–2009. This program was incorporated into IPI's eClimateNotebook.com™ website in June 2012.

6 The website used for this analysis no longer exists, but has been incorporated into our current data analysis website, www.eclimatenotebook.com.

7 Stephen Michalski, A Systematic Approach to the Conservation (Care) of Museum Collections, Canadian Conservation Institute, May 1992; Donald K. Sebera, *Isoperms: An Environmental Management Tool* (Washington, D.C.: Commission on Preservation and Access, 1994); David Erhardt and Marion Mecklenburg, "Relative Humidity Re-examined," in *Preventive Conservation: Practice, Theory, and Research. Preprints of the Contributions to the Ottawa Congress* (London: International Institute for Conservation of Historic and Artistic Works (IIC), 1994), 32–38.

[8] J. Reilly, D. Nishimura, and E. Zinn, *New Tools for Preservation: Assessing Long-term Environmental Effects on Library and Archives Collections* (Washington, D.C.: Commission on Preservation and Access, 1995).

[9] A more detailed description of IPI's Preservation Metrics™ is available at "Preservation Metrics," Image Permanence Institute, https://www.imagepermanenceinstitute.org/environmental/research/preservation-metrics.

[10] You can explore this relationship using IPI's free online tool, the Dew Point Calculator, "Welcome to the Dew Point Calculator," Image Permanence Institute, www.dpcalc.org.

[11] More information on why dew point is important for managing the storage environment is available in the Image Permanence Institute's Climate Notes Newsletter, Issue 3, December 2010, https://www.imagepermanenceinstitute.org/resources/newsletter-archive/v3/dewpoint-important.

[12] *Wikipedia*, s.v. "Climate of Massachusetts," http://en.wikipedia.org/wiki/Climate_of_Massachusetts.

ABOUT THE AUTHORS

Gregor Trinkaus-Randall received his BA in history and MA in library science/archives administration from the University of Wisconsin–Madison. He is the preservation specialist at the Massachusetts Board of Library Commissioners and is also a member of the NEDCC's Advisory Committee, LYRASIS's Board of Trustees, the *U.S.S. Constitution* Museum's Curatorial Committee, and a member of the Digital Commonwealth's Executive Board as well as cochair of COSTEP MA and Project Director for *Mitigation for Memory*, a FEMA Hazard Mitigation grant, and co–project director for *Archival Education for Municipal Clerks*, an NHPRC grant. He is a member of the Academy of Certified Archivists, the Society of American Archivists, the Midwest Archives Conference, and the former president of the New England Archivists. He was elected a Fellow of the Society of American Archivists in 2006 and was the Society's president from 2011 to 2012. In 2012, he was awarded the ALA/ALCTS George Cunha/Susan Swartzburg Preservation Award, and in 2013, he was awarded the New England Archivists' Distinguished Service Award. He has spoken widely on numerous preservation-related topics.

James M. Reilly is a professor in the College of Imaging Arts and Sciences at Rochester Institute of Technology and founding director of the Image Permanence Institute (IPI), a world-class research laboratory devoted to the development of sustainable practices for the preservation of images and cultural property. Reilly leads a team of eighteen staff engaged in preservation research, education and consulting. He is the author of two books on nineteenth-century photography and numerous technical articles. In demand as a consultant to institutions around the world, he has earned recognition from the Academy of Motion Picture Arts and Sciences, the American Library Association, the Association of Moving Image Archivists, and the Society for Imaging Science and Technology. In 2014, Reilly was chosen to receive the Paul Banks and Carolyn Harris Preservation Award from the Association for Library Collections and Technical Services. Under his guidance, IPI has received major grants from the Andrew W. Mellon Foundation, the National Endowment for the Humanities, and the Institute for Museum and Library Services.

Patricia Ford, project manager at the Image Permanence Institute, has worked in collection care and management in cultural institutions for over thirty years, including ten with IPI. Ford is responsible for the overall organization, documentation, and management of environmental project activities at IPI, and serves as a liaison between specialists in the science and technology of environmental preservation and the staff of cultural institutions who work directly with material preservation issues.