SUSTAINABILITY AND THE MODERN LIBRARY

HONORS COLLEGE THESIS
BALL STATE UNIVERSITY
BY: ERIC S. ANDERSON
ADVISOR: ROBERT J. KOESTER
Sustainability and the Modern Library

An Honors Thesis (HONRS 499)

by

Eric Anderson

Thesis Advisor

Robert J. Koester AIA, LEED AP

Professor of Architecture

Ball State University
Muncie, Indiana

May 2017

Expected Date of Graduation

May 2017
Abstract

Sustainability is increasingly imperative for contemporary architects to understand. Yet high performance architecture, and its myriad of applications, is an incredibly broad topic. Thus, this research thesis presents a highly focused study of sustainable architecture through the lens of one specific building type, the library – namely modern ones. Manifesting themselves in countless architectural styles and forms, libraries have a long, rich history throughout civilization. Similar to museums or churches, they are often defining structures in their urban fabric and constructed with a sense of longevity in mind. In the 21st century, sustainability is integral to the success of any long-lasting building. Modern libraries can and should exemplify these sustainable practices as well as adapt to changing societal and programmatic expectations for the digital age.

Acknowledgements

First and foremost, I would like to thank my advisor, Professor Robert Koester from the College of Architecture and Planning. His guidance and insight were vital to the completion of this thesis. I am deeply indebted to him for his ceaseless input, support, patience, and mentorship. Thank you Bob for all you have done - it was above and beyond what I deserved.

Secondly, I would be remiss to not acknowledge my wonderful parents. Throughout my college career, they have been nothing but supportive and I own so much of my success to them. I have been so fortunate to be surrounded by a stable, loving family and for that I truly feel blessed. Mom and Dad, thank you from the bottom of my heart.
TABLE OF CONTENTS

Sustainability and the Modern Library

Section I

Green vs. Sustainable: The terminology of High Performance Architecture

A Brief Overview of Green Building Certification

Section II

Case Study One: The Clinton Presidential Library

Case Study Two: The Seattle Central Library

Case Study Three: The Tozzer Anthropological Building

Case Study Four: The Halifax Central Library

Cross Comparison, a Sustainability Matrix

Section III

Sustainable Criteria: the Pragmatic and the Aspirational

Design Guidelines for the Green Library

Section IV: Appendix

BREEAM Precedent Inventory

LEED Precedent Inventory

Image Credits
Process Analysis Statement

This research thesis is divided into four distinct sections. Section one is an introduction to preparatory topics regarding sustainability. These topics will reappear throughout this thesis. Part one of section one discusses terminology related to high performance architecture while part two provides a brief overview of what green building certification systems are and how they function. Section two presents case studies of four architecturally significant modern libraries. All libraries have attained a certification of LEED silver or higher. For a cross comparison of techniques implemented, see matrix at end of section. Section three discusses best practices for library designers seeking to marry high design with high performance. This section establishes a framework of both procedural and architectural techniques commonly used to create successful contemporary libraries. Thesis concludes. Lastly, the fourth section is an appendix listing contemporary libraries which display both a high level of design and at least one LEED or BREEAM certification. Most constructed within the last ten years. In depth discussion of underlined libraries can be found in section two.
SECTION ONE
SUSTAINABILITY _1 0 1

An introduction to preparatory topics regarding sustainability. These topics will reappear throughout thesis. Part one discusses terminology related to high performance architecture while part two provides a brief overview of what green building certification systems are and how they function.

Figure 1.0 (Page 5): The Library of Brimingham, certified BREEAM Excellent, exemplifies a growing number of high performing, high profile library projects.
GREEN VS. SUSTAINABLE: THE TERMINOLOGY OF HIGH PERFORMANCE ARCHITECTURE

Sustainability and green building are becoming ubiquitous criteria in architecture. Specifically, high-performance buildings are emerging as the expected standard for contemporary projects.

The terms “green” or “sustainable,” and to a lesser extent “eco,” are often tacked in front of the word architecture to convey that a design typifies an environmentally conscious response. Although these words are regularly used interchangeably, “green” and “sustainable” are typically seen as not true synonyms, but the different nuances of their meanings is debated. In an article explaining green building, the USGBC states the following: “Sustainability means creating places that are environmentally responsible, healthful, just, equitable, and profitable. Greening the built environment means looking holistically at natural, human, and economic systems and finding solutions that support quality of life for all” (Knox). The US Green Building Council (USGBC) defines green building as resulting from “an integrative process that focuses on the relationship between the built environment and the natural environment.”

Many additional sources often deem “green” to be a broader catch-all term, noting that “sustainable” has a more precise definition. Mercedes Marty, a writer for the Australian architectural news outlet Sourceable, differentiates “green” from “sustainable” in that sustainability must manage resources wisely enough to not compromise future generations. She states “the importance of sustainability lies in the ‘future’ factors, which set a higher standard than those used to define green building.” Other authors argue that green practices may over emphasize or focus on only one leg of the triple bottom line, namely the environmental component. Sustainability on the other hand should, by definition, address economic vitality and social equity in addition to the environment health (Yanarella, Levine, & Lancaster 296-97). Annette Burgard, writing for Sefaira, a company that produces software capable of analyzing building performance, contends green could encompass everything from net zero energy to simply putting a few solar panels on a roof. In her view, the primary difference between the terms deals with implied connotations, with green suggesting natural and sustainable leaning towards data-driven. Ultimately, she concludes that reducing carbon intensive practices is what really matters, an observation that will carry throughout this thesis.

Figure 1.1 (Page 7): Green roofs, such as this one atop the Vancouver Central Library, are an effective and popular feature in many high performance buildings. Building designed by Moshe Safdie.
Beginning in the 1990s, third party assessment methods began to be used to rank how well buildings performed in regards to sustainability practices. The first of these, launched in the United Kingdom, was the Building Research Establishment Environmental Assessment Method, or BREEAM for short. In 2000, the non-profit U.S. Green Building Council (USGBC) debuted an American green building certification system called Leadership in Energy and Environmental Design (LEED). Subsequently, numerous other organizations have released comparable certification systems such as Green Globes or the Living Building Challenge.

While BREEAM and LEED are not identical, they share many of the same principles and are among the most widely used building sustainability certifications in the world. In each system, a project receives credits for sustainability features incorporated into the design, with a higher amount corresponding to a higher certificate of distinction. Both are used internationally, but the bulk of each method’s certifications can be found in their respective countries of origin. Because of its stronger domestic presence, this thesis will focus on LEED certified projects.*

As a holistic system, LEED encourages the creation of buildings which “complement our environment and enhance our communities.” For users, these benefits translate to energy conservation, use of more environmentally-benign building materials, and saving money for building operations over the facility’s lifespan. Now in its fourth edition, LEED (v4) continues to be used to assess buildings but caters certifications to more specific types and phases of building development and climates. The v4 rating system categories are as follows: building design and construction (BD+C), interior design and construction (ID+C), building operations and maintenance (O+M), neighborhood development (ND), and homes (HOMES). Following the review process, a LEED project is awarded distinctions based on credits accrued: certified (40-49 points), silver (50-59 points), gold (60-79 points), and platinum (80 or more points). LEED’s scope is broad and its areas of focus are varied including issues such as indoor environmental quality, water efficiency, siting, and educational awareness – for occupants and the general public.

The precedent research which follows focuses on modern libraries which have attained the certification of LEED silver or higher; wherein are presented tactics used to reach this benchmark.
Citations


* For further reading, see Section V for a listing of some notable BREEAM certified libraries.
SECTION TWO
LIBRARY CASE STUDIES

Case studies of four architecturally significant modern libraries. All libraries have attained a certification of LEED silver or higher. For a cross comparison of techniques implemented, see matrix at end of section.

Figure 2.0 (Page 11): From left to right, The Clinton Presidential Center, The Seattle Central Library, the Tozzer Library, and the Halifax Central Library.
CASE STUDY ONE:
THE CLINTON PRESIDENTIAL LIBRARY

PROJECT STATS
Location: Little Rock, Arkansas
Architect: Polshek Partnership (Since renamed Ennead Architects)
Client: The Clinton Foundation
Construction Start Date: December 2001
Completed: November 2004
Floor area: 167,000 square feet
LEED Certifications:
  Silver (2004, New Construction)
  Platinum (2007, Existing Buildings)
  Platinum Recertified (2014, Operation & Maintenance)
The William J. Clinton Presidential Center exemplifies an ongoing commitment to sustainable practices. Upon its completion in 2004, the library received a LEED Silver certification for new construction. This gave the library the distinction of being the first presidential library to earn a LEED certification. Additionally, in 2005, the Green Building Initiative awarded the library two Green Globes. Making this list even more impressive, the facility garnered a post-occupancy LEED Platinum certification for existing buildings, an unprecedented move for a federally maintained building. It has subsequently been recertified at this top level of distinction.

Sitting on a 27 acre riverfront site, the library itself is the main feature of the Clinton Presidential Center. The site was selected not only because of its location along the Arkansas River but also as a means to revitalize a blighted portion of Little Rock (Hennick 38). In an effort to contextually unite with the six bridges nearby, the building cantilevers out towards the river. The concept of bridging moreover expresses Clinton's vision for his post-presidency role as a builder of bridges from "yesterday to tomorrow" (Ennead). The planning process for the library and presidential center began during Clinton's second term. When construction broke ground in 2001, LEED was still very much in its infancy. Nevertheless, energy efficiency became an important part of the design planning with a number of sustainability technologies being integrated into the building.

One key example of this integration dealt with the building envelope. The main façade faces west toward downtown and consists primarily of glazing. In order to ensure solar screening, a double skin curtain wall system was put in place. Two long, parallel glass walls run the length of the building forming a ten foot wide interstitial corridor. The outer wall functions as a rain screen and provides solar protection and insulation from outside sound. This wall uses low-iron tempered glass panels attached at the corners by spider clips. Low iron glass is known for its clarity and lack of color distortion. Custom laminated onto these panels are very thin white and black lines which help deflect a portion of the solar energy away from the surface. The inner wall, which forms the library's true climate boundary, consists of low-iron, low-emissivity-coated insulating glass panels. Low-emissivity (low-e) reduces the amount of UV and infrared light passing through the glass, equating to glass with better thermal performance (Murray 108).

The building also earned points towards its initial LEED Silver certification for material and mechanical systems decisions. The library utilizes demand-controlled ventilation and a radiant

**Figure 2.1.1 (Page 12):** The Clinton Presidential Center in the context of its site.

**Figure 2.1.2 (Above):** Wall section through the building's west facade.
floor heating/cooling system (Arens 5). In fact, about ten miles of tubing are embedded in the concrete floor slabs. Additionally, the ceilings are made of recycled aluminum and bamboo, a rapidly renewable resource (Chusid 4).

Taking further strides towards sustainability, the Clinton Foundation and the building managers began working to specifically achieve a post-occupancy LEED Platinum certification as per the O+M criteria list. One of the most significant improvements came in 2007 when the library was capped with a green roof. This new green roof better insulated the building’s interior, reducing heating and cooling demands, and provided an opportunity for storm water management. The vegetation naturally filters the storm water, which is then stored on-site and used for a slow-drip irrigation system, minimizing watering needs. Further enhancing the roof, 306 mounted solar panels now provide power for a portion of the presidential center’s overall energy demand. The on-site facility manager contributed to the LEED certification by reducing waste, increasing recycling, using more environmentally-benign products, and improving indoor environmental quality through selection of low VOC (volatile organic compound) paints, adhesives, and sealants. While it is often impossible to entirely eliminate them from a project, LEED aims to reduce their presence as much as possible. Today the library can boast that it uses 92% green cleaning products and recycles 100% of all its durable goods. It uses 34% less energy compared to other comparable buildings (“Commitment to Sustainability”).

Citations


CASE STUDY TWO: THE SEATTLE CENTRAL LIBRARY

PROJECT STATS
Location: Seattle, Washington
Architect: Joint venture between the Office of Metropolitan Architecture (OMA) and LMN Architects
Client: The Seattle Public Library
Construction Start Date: 2002
Completed: May 2004
Floor area: 404,000 square feet
LEED Certification:
Silver (2004, New Construction)
The Seattle Central Library, designed by OMA with LMN Architects, has received praise for its bold form, structure, and use of technology. It is arguably one of the highest-profile and most discussed American libraries constructed in the 21st century. With so much emphasis on its unique concept and aesthetic value, the Central Library quietly garnered a LEED Silver certification following its completion in 2004. The Seattle Central Library serves as a good comparison to the Clinton Presidential Library. Both were opened in the same year, yet they look very different and use different green criteria to achieve the same level of LEED certification.

As with the previous precedent, the first sustainable measures start with the site. Underground parking reduced the heat island effect and drought tolerant trees were planted along the building’s perimeter to assist with shading. Even the site itself can be thought of as recycled, as the new library sits in the same spot as the one it replaced. In addition to erosion control during construction, 75% of the total demolition and construction waste was recycled.

Both the Seattle Central Library and the Clinton Library (as a platinum rating) display a concern for water efficiency. Seattle code requires buildings to have an on-site detention tank to deal with storm water. The 40,000 gallon tank located in the Seattle Central Library increases the size of the detention tank by 50%, doubling its function as rainwater collection for landscape irrigation. Fixture selection, namely waterless urinals and metered faucets, help to reduce the overall water demand inside the building. A Dolphin Water Treatment System provides chemical free filtration for the building’s two large cooling towers. This system is estimated to save over 900,000 gallons of water each year.

Another area of common ground between the two libraries is their use of high performance glazing on the building envelope. Given that almost the entirety of the Central Library is covered in vision glass, ample daylighting reaches 90% of regularly occupied spaces (Seattle Public Library). A high level of transparency was desired in order to visually connect users with their urban surroundings. Yet this in turn generated concerns regarding glare and energy efficiency. The engineering team not only leveraged advance computer modeling for structural analysis but also used digital model to determine which portions of the façade would receive the most sun exposure. These models accounted for the natural sun path over Seattle as well as the shadows cast by adjacent buildings (McKinlay, Beaman, and Carlson 67). Around 50% of the insulated glazing panels utilized two layers of low-e glass with...
a 2mm airspace between them. This airspace contained krypton, an inert gas. For panels with the most heat gain, an additional aluminum mesh float in the airgap. This mesh screens and reduces glare from direct sunlight while still maintaining a level of transparency (LMN, Curtain Wall Design). Given the strong emphasis on natural lighting, photocell sensors automatically shut off the artificial lighting system when there is sufficient daylight in a space (McKinlay, Beaman, and Carlson 67).

In terms of indoor environment, the library surpassed the industry standard for air quality. During the construction process, a high air quality plan was implemented for the construction crew. Carpet finishes were selected that off-gas low amounts of airborne toxins. As a conscientious response to the building’s expansive glazing and unique volumes, the air-handling system was divided into different categories. High-velocity jet nozzles deliver conditioned air straight to the glazing while the diffuser-fed interior spaces can be controlled independently, allowing for greater control when responding to external temperature changes. Furthermore, the ventilation system incorporated carbon dioxide sensors. These sensors have a twofold role: they safeguard against carbon dioxide levels exceeding 530 ppm (parts per million) and help reduce ventilation when spaces have fewer occupants. The sensors tie back to the building’s energy management system which, upon sensing a decrease in carbon dioxide levels, in turn decreases ventilation from the outside. This ultimately equated to energy savings.

Citations


CASE STUDY THREE:
THE TOZZER ANTHROPOLOGICAL BUILDING

PROJECT STATS
Location: Harvard University Campus, Cambridge, Massachusetts
Architect: Kennedy & Violich Architecture
Client: Harvard Faculty of Arts and Sciences
Construction Start Date: 2012
Completed: May 2014
Floor area: 35,000 square feet
LEED Certification:
Gold (2015, New Construction)
The Tozzer Anthropological Building, praised for both its architectural and sustainable merits, illustrates how a deteriorating existing library can be reborn into a new, efficient facility. The initial Tozzer Library suffered from an internal mold infestation so severe it eventually rendered the building unsafe. Gutting the library to just its floor plates and fire stairs, the design by Kennedy & Violich Architecture significantly revamped the original 1971 structure (Carodine and Wood). The redesign, in addition to providing the Anthropology Department with a better home, acknowledged contemporary trends in library programming by transitioning "away from purely collection storage to a state-of-the-art, collaborative research and study space" (Hammer). So while the first two floors still contain the reading rooms, book stacks, offices, and support spaces one would except in a library, the other stories now serve the holistic needs of a contemporary academic setting.

Completed in 2014, the reopened Anthropological Building maintained the building's footprint while adding two new stories of usable space. This was accomplished by topping the building with a highly insulated copper clad, mansard-esque roof. The roof's rotated volume was formed to capture daylight for the large internal light well, illuminating the building's core space. To maintain a consistent campus material vocabulary, Harvard stipulated the new building had to be covered in brick (somewhat to the architect's chagrin). While this did not necessarily inform sustainability objectives, Kennedy & Violich Architecture used this constraint as a design opportunity. The building's main entrances are announced highly expressive brick corbels.

Elsewhere on the building envelope, applications of glass celebrated the facility's more modern character. The building's windows, many of which protrude from the façade by four to seven inches, took special consideration to build. Wausau, a window and wall system manufacturer, carefully worked to realize this design and firmly understood the project's sustainable objectives. Similar to the prior case studies, laminated glass with a low-emissivity coating was selected for its superior thermal properties (West). Interestingly, the windows can be occupant-operated, allowing for seasonal natural ventilation - a feature often barred from institutional applications.

Mechanical and electrical systems were another important consideration for improving energy efficiency. A hydronic chilled beam system allowed for the building's temperature to be controlled more effectively than a traditional forced air system. Numerous sources note the ample amount of diffuse natural light.
permeating the building’s interior. Like the Seattle Public Library, the lighting design ensured that the use of artificial light responded dynamically to interior conditions. Automatic controls included occupancy sensors and daylight dimmers. These interventions, coupled with the previously mentioned daylighting, reduced lighting energy consumption by about 50% when compared with a baseline ASHRAE compliant energy model.

The Tozzer Building’s selection of low VOC finishes and materials contributed significantly to the indoor environmental quality. To further maintain healthy air quality, all rooms in which chemical mixing occurs required automatic closing doors and exhaust vents. These measures prevented flumes from leeching into adjacent spaces. To lessen water demand, the design specified that all plumbing fixtures be low-flow, resulting in a 38% decrease.

During the building process, an impressive 95% of the total construction waste was diverted from landfills. Furthermore, 22% of the entire materials cost consisted of recycled content (Harvard University, Faculty of Arts and Sciences). It is worth noting that the entire project budget was only $12.5 million - although final construction costs did run up to $16 million (Volner). Considering that the other three case studies analyzed in this thesis all had budgets exceeding $50 million, this particular precedent highlights that sustainable practices need not be omitted from projects with diminutive funding. Overall, the building operates on 30% less energy than its former self, fulfilling Harvard’s desire to realign the Tozzer Anthropological Building with its vision for a sustainable future.

Citations


CASE STUDY FOUR:
THE HALIFAX CENTRAL LIBRARY

PROJECT STATS
Location: Halifax, Nova Scotia, Canada
Architect: Schmidt Hammer Lassen Architects and Fowler Bauld & Mitchell LTD
Client: Halifax Regional Municipality/ Halifax Public Libraries
Construction Start Date: 2011
Completed: 2014
Floor area: 14,500 square meters (approximately 157,000 square feet)
LEED Certification: Gold (2016, New Construction)
Schmidt Hammer Lassen Architects, one of the two firms responsible for the Halifax Central Library, boldly declared that their newly designed facility “is the most significant public building to be built in Halifax in a generation.” Indeed, the cantilevered glass volumes proved to have not only a striking visually quality but a revitalizing effect on the surrounding area. Since its opening in 2014, many outlets have even described it as a “civic landmark” and “community center.” As this thesis’ final case study, the Halifax Central Library affords a look at not only another building imbued with considerable societal, architectural, and sustainable worth but also a LEED-certified project located outside the United States.

To a far greater extent than with the previous case studies, literature about the Halifax Central Library repeatedly stressed how the community directly informed the design team’s work. “The public consultation sessions clearly showed that ‘green design’ is a high priority for the public” (Solterre Design). This community-focused mentality was reflected in the building’s programming. The top volume, being the space with the best views of the city and harbor, was playfully dubbed the “Halifax Living Room.” The generous atrium contains a labyrinth of stairs and bridges, connecting the five floors of the facility in a dynamic manner. This atrium, not unlike the Tozzer Library, is topped with a skylight, allowing for abundant daylighting in the building’s center.

Similar to the Seattle Central Library’s iconic status, one could describe the Halifax Central Library as a positive example of visually-disruptive modern architecture. In each case, the façade consists extensively of glazing. In spite of this glassy skin, only 43% of the Halifax Central Library’s exterior walls are actually transparent. The remaining 57% are heavily insulated glass panels with “a soy based spray foam achieving overall insulation values of R25 and greater” (Solterre Design). Custom frit patterns add a visual texture to the glazing, both attracting visitors while minimizing bird impacts. Although much of the glass is opaque, 90% of regularly occupied interiors spaces still has access to views. In order to lessen glare and leverage passive solar heating, floor-to-ceiling glass panels were reserved only for the building’s north and south elevations. Solid, insulated building cores containing elevators, stairs, and mechanical shafts were meanwhile positioned near the east and west facades.

Attention to a highly insulated building envelope continued with the roof design, which has a rating of R30. Most of the roof surfaces are green roofs supporting vegetation and reducing storm water runoff. Unlike other case studies, the design for the Halifax Central Library specially omitted a plant irrigation system, as all

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{The Central Library's form is said to be inspired by a stack of books.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Wall section. The portions of glazing with an added layer of insulation denote applications of opaque glazing, rather than transparent.}
\end{figure}
Citations


landscape selected should be able to thrive on natural rainfall alone. This translated to a landscaping palette of mostly hardier native species. While no irrigation system was present, the Halifax Library does utilize a rainwater collection cistern. The gathered rainwater passes through two filtration systems before ending up in low-flow toilets and urinals. These strategies resulted in water consumption rates 64% lower than comparable buildings of its size.

In terms of mechanical systems, the building's entire HVAC and lighting systems are controlled digitally. Light fixture selection specified efficient fluorescents and LEDs only. On the exterior, lighting is programmed to coordinate with astronomical time, meaning it is in sync with local sunset and sunrise. On the interior, ceiling lights tie back to sensors which will dim during daylight conditions and turn off when a space is vacant. Carbon dioxide sensors likewise inform the ventilation to appropriately respond to occupant demand. On the first and fifth floors, areas with taller transparent glazing have an in-floor radiant heating and cooling system to condition these the spaces. Energy conservation further improved through the selection of highly efficient heat recovery ventilation and chiller.

As was the case with the three prior studies, the specification of low VOC products yet again played a role in ensuring indoor air quality. During the building's erection, the construction manager was responsible for implementing a waste management plan. This diverted roughly 77% of the construction and demolition waste away from landfills. Additionally, recycled content accounts for more than 21% of the materials used in the library. Of all the wood products used in the building, 90% were sustainably harvested. Sources repeatedly described the interior finishes as high quality, durable, and tasteful (CertainTeed). Many of the building's interior spaces can also be rearranged for changes in use. This flexibility allows the Halifax Central Library to adapt and grow as it serves the city for decades to come.
Figure 2.5.0 (page 29): Matrix showing points of commonality amongst the four case studies.

*Chart is not intended to be comprehensive listing of every point discussed.
## Case Study Cross Comparison

<table>
<thead>
<tr>
<th>LEED Certified</th>
<th>Clinton</th>
<th>Seattle</th>
<th>Tozzer</th>
<th>Halifax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Occupant LEED Certifications</td>
<td>Silver (x2)</td>
<td>Silver</td>
<td>Gold</td>
<td>Gold</td>
</tr>
<tr>
<td>Project Budget (in USD)</td>
<td>$165 M</td>
<td>$165.9 M</td>
<td>$12.5 M</td>
<td>$57.6 M*</td>
</tr>
</tbody>
</table>

*Cost in Canadian Dollars

### Architectural & Structural Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Clinton</th>
<th>Seattle</th>
<th>Tozzer</th>
<th>Halifax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Considered a &quot;landmark&quot; in city's downtown</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Outwardly expressive structure</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of cantilevers</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Atrium volume exceeds two stories</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>At least five stories high</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

### Site Selection & Construction

<table>
<thead>
<tr>
<th>Feature</th>
<th>Clinton</th>
<th>Seattle</th>
<th>Tozzer</th>
<th>Halifax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive impact on adjacent area</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Reused existing building footprint</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75% or more of construction waste recycled</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 20% of building is recycled material</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

### Building Envelope

<table>
<thead>
<tr>
<th>Feature</th>
<th>Clinton</th>
<th>Seattle</th>
<th>Tozzer</th>
<th>Halifax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glazing accounts for majority of skin</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Glass with Low-E coating</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Fritted / laminated patterns on glazing</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>50% or more of building skin opaque</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

### Building Systems

<table>
<thead>
<tr>
<th>Feature</th>
<th>Clinton</th>
<th>Seattle</th>
<th>Tozzer</th>
<th>Halifax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydronic conditioning (in floors/beams)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Conditional sensors tied to building systems</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Use of solar panels</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Indoor Environment

<table>
<thead>
<tr>
<th>Feature</th>
<th>Clinton</th>
<th>Seattle</th>
<th>Tozzer</th>
<th>Halifax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection of low-VOC products/finishes</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Praised for daylighting</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Praised for acoustics</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

### Water Management

<table>
<thead>
<tr>
<th>Feature</th>
<th>Clinton</th>
<th>Seattle</th>
<th>Tozzer</th>
<th>Halifax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainwater collection system</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Low flow fixtures</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Green Roof</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainwater based plant irrigation system</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
SECTION THREE
GUIDELINES FOR THE GREEN LIBRARY

Discussion of best practices for library designers seeking to marry high design with high performance. Establishes a framework of both procedural and architectural techniques commonly used to create successful contemporary libraries. Concludes thesis.

Figure 3.0.0 (Page 35): The warm interior of the East Boston Branch Library. This library received its LEED Gold certification in 2014.
Discussions about high performance architecture often focus on technical strategies used to meet certain quantifiable metrics. While these aspects of a project cannot be overlooked, they should not be decoupled from discussion of a building’s design and goals. The systems that permeate a building, usually calculated by or with an engineering team, must integrate cohesively to the architect’s initial concept. For architects, this becomes an imperative point to keep in mind. The most successful sustainable architecture is not merely the by-product of a good engineering staff checking off boxes on a score card. Additionally, there is now the expectation that green solutions should not come at the expense of a building’s aesthetic appearance. Simply tacking on more solar panels will not cut it. The onus of sustainability lies on all members of the design team, and that starts with the architect.

With this in mind, sustainable criteria be thought of as falling into one of two camps: pragmatic or aspirational. Pragmatic criteria are generally more technical in nature, often dealing with calculable metrics and set benchmarks. These criteria usually address a highly specific need and can be measured or quantified. For instance, a rainwater collection system may help a facility to conserve a certain percentage of potable water annually. Or, by installing a more efficient heating and cooling mechanical system, the overall energy consumption may be reduced by “x” amount. Pragmatic criteria address how and how effectively a building performs. Aspirational criteria, on the other hand, are more difficult to measure. These criteria would include things such as how a building invigorates the community, inspires its users, or improves the land it occupies. In many ways, aspirational criteria deal with the immaterial implications of architecture, which have a profound impact on the way one experiences a space.

As an exercise, I have examined the LEED v4 scorecard and attempted to identify which points could be considered pragmatic and aspirational. It is worth noting that this is by no means a true dichotomy and, when classifying sustainable criteria in such a manner, it comes with a degree of subjectivity. Nevertheless, it is a useful way of observing that LEED takes into consideration both pragmatic and aspirational concerns. For example, “storage and collection of recyclables,” a required point under the Materials and Resources section, is rather clearly a pragmatic criteria. Either the facility recycles or it does not. Conversely, under the Indoor Environmental Quality section, “quality views” can be considered an aspirational goal. One would be hard pressed to measure quality
views yet, it is human nature to desire a visual connection to the outside world. Aspirational criteria, such as quality views, stir the soul in a way pragmatic criteria often do not.

Inspired by the eight point LEED v4 Checklist, this fourth section proposes another eight point framework architects should leverage when approaching library. Broad-spectrum sustainability strategies like local sourcing of materials or utilizing renewable resources have been intentionally omitted from the Guidelines for the Green Library because these are tactics every new project should already take into consideration. Four of the criteria have been deemed pragmatic and the other four aspirational. Libraries exemplifying these practices are discussed as well as how each criteria ties into building performance.

**Figure 3.0.1 (Above): A view looking upward inside the Surrey City Centre Library. In 2014, the project earned LEED Gold certification.**
**LEED v4 for BD+C: New Construction and Major Renovation**

**Project Checklist**

### Location and Transportation

<table>
<thead>
<tr>
<th>Credit</th>
<th>Details</th>
<th>Score</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️</td>
<td>LEED for Neighborhood Development Location</td>
<td>16</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Sensitive Land Protection</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>High Priority Site</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Surrounding Density and Diverse Uses</td>
<td>5</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Access to Quality Transit</td>
<td>5</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Bicycle Facilities</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Reduced Parking Footprint</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Green Vehicles</td>
<td>1</td>
<td>X</td>
</tr>
</tbody>
</table>

### Sustainable Sites

<table>
<thead>
<tr>
<th>Credit</th>
<th>Details</th>
<th>Score</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️</td>
<td>Construction Activity Pollution Prevention</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Site Assessment</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Site Development - Protect or Restore Habitat</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Open Space</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Rainwater Management</td>
<td>3</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Heat Island Reduction</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Light Pollution Reduction</td>
<td>1</td>
<td>X</td>
</tr>
</tbody>
</table>

### Water Efficiency

<table>
<thead>
<tr>
<th>Credit</th>
<th>Details</th>
<th>Score</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️</td>
<td>Outdoor Water Use Reduction</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Indoor Water Use Reduction</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Building-Level Water Metering</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Outdoor Water Use Reduction</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Indoor Water Use Reduction</td>
<td>6</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Cooling Tower Water Use</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Water Metering</td>
<td>1</td>
<td>X</td>
</tr>
</tbody>
</table>

### Energy and Atmosphere

<table>
<thead>
<tr>
<th>Credit</th>
<th>Details</th>
<th>Score</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️</td>
<td>Fundamental Commissioning and Verification</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Minimum Energy Performance</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Building-Level Energy Metering</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Fundamental Refrigerant Management</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Enhanced Commissioning</td>
<td>6</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Optimize Energy Performance</td>
<td>18</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Advanced Energy Metering</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Demand Response</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Renewable Energy Production</td>
<td>3</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Enhanced Refrigerant Management</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>✔️</td>
<td>Green Power and Carbon Offsets</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Materials and Resources</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Y</td>
<td>Prereq</td>
<td>Storage and Collection of Recyclables</td>
<td>Required</td>
</tr>
<tr>
<td>Y</td>
<td>Prereq</td>
<td>Construction and Demolition Waste Management Planning</td>
<td>Required</td>
</tr>
<tr>
<td>Credit</td>
<td>Building Life-Cycle Impact Reduction</td>
<td>5</td>
<td>X</td>
</tr>
<tr>
<td>Credit</td>
<td>Building Product Disclosure and Optimization - Environmental Product Declarations</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>Credit</td>
<td>Building Product Disclosure and Optimization - Sourcing of Raw Materials</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>Credit</td>
<td>Building Product Disclosure and Optimization - Material Ingredients</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>Credit</td>
<td>Construction and Demolition Waste Management</td>
<td>2</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0</th>
<th>0</th>
<th>0</th>
<th>Indoor Environmental Quality</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Prereq</td>
<td>Minimum Indoor Air Quality Performance</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>Y</td>
<td>Prereq</td>
<td>Environmental Tobacco Smoke Control</td>
<td>Required</td>
<td>X</td>
</tr>
<tr>
<td>Credit</td>
<td>Enhanced Indoor Air Quality Strategies</td>
<td>2</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Low-Emitting Materials</td>
<td>3</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Construction Indoor Air Quality Management Plan</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Indoor Air Quality Assessment</td>
<td>2</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Thermal Comfort</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Interior Lighting</td>
<td>2</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Daylight</td>
<td>3</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Quality Views</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Acoustic Performance</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0</th>
<th>0</th>
<th>0</th>
<th>Innovation</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit</td>
<td>Innovation</td>
<td>5</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>LEED Accredited Professional</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0</th>
<th>0</th>
<th>0</th>
<th>Regional Priority</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit</td>
<td>Regional Priority: Specific Credit</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Regional Priority: Specific Credit</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Credit</td>
<td>Regional Priority: Specific Credit</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0</th>
<th>0</th>
<th>0</th>
<th>TOTALS</th>
<th>Possible Points: 110</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Certified: 40 to 49 points, Silver: 50 to 59 points, Gold: 60 to 79 points, Platinum: 80 to 110</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.0.2 (Pages 34 and 35): Losely classifying each item on the LEED v4 scorecard as either pragmatic or aspirational in nature.
While site selection is often outside of the architect’s control, the way in which a structure engages its site becomes an integral component of its design. This is of course pertinent for modern libraries.

Site integration is a two headed beast. Firstly, and it perhaps goes without saying, a library should respond to its context. This holds true for most any building type. The Seattle Public Library clearly illustrates site responsiveness through its careful glazing treatment. As discussed in the case study, the design team took into consideration not only the sun’s path but also the shadows cast by neighboring structures and the building’s own geometry. Another striking precedent is Montreal’s LEED Platinum Bibliothèque du Boisé. This recumbent library abuts a large park and unfolds into its surroundings, being described as a project where “architecture is landscape and landscape is architecture.”

Secondly, and more specific to the library typology, there is the responsibility to actively enhance a site. While all building designs should augment the built environment, libraries, being community-centric institutions, are especially obligated to better their respective city, campus, or neighborhood. This means seeking betterment for the community at large, not just the immediate parcel of land the structure is situated upon. For instance, the Clinton Library ameliorated an unkempt, underutilized segment of the Little Rock’s riverfront. This in turn catalyzed adjacent development with Heifer International relocating their headquarters to a nearby property. The library can become a destination in the city, drawing people toward it and spurring growth.
Figure 3.1.1: The Clinton Presidential Library sits amid its lush campus. The Heifer International Headquarters can be seen in the background.

Figure 3.1.2: Bibliothèque du Boisé integrates well with the neighboring green space at Parc Marcel-Laurin.

Figure 3.1.3: Located by a former dock in London, the southern facade of the Canada Water Library angles outward to celebrate its position along the water’s edge.
A facade is a building's public face. This outer skin often acts as a billboard of sorts, conveying a building's mission and function. For libraries, a typology sometimes pegged as merely antiquated housing for an antiquated technology (i.e. the physical book), it is vital that the building's outward face announces its continued relevance in an Internet-dominated world.

Many librarians keenly recognize that the role of their institution continues to change in the digital age. As such, librarians are offering a wider range of services to their patrons, greatly expanding the library's role. Modern architecture thus becomes a fitting vehicle by which to broadcast the dynamism present in the best contemporary libraries. To be clear, this is not a call for society to abscond from grand beaux-arts structures of the past. Rather this is the belief that new construction or major renovation affords the opportunity to represent the library in an updated light, one which may positively alter people's perceptions. Simply put, a library's architecture should align with its ideals. If its mission is to be a progressive center of learning, then the appearance can reinforce this. The Birmingham Library in England demonstrates the concept of the expressive facade remarkably well. Its colorful, rich exterior adds visual vibrancy to the downtown center and declares that the library is anything but static or archaic.

This notion of expressiveness may manifest itself to varying degrees. On one extreme, a library like the Seattle Public Library looks strikingly futuristic despite being well over a decade old. On the other side of the spectrum, the Tozzer Anthropological Library shows an appropriate level of modernist restraint in order to avoid visual dissonance with its campus surroundings. The appendix section contains many additional examples.
FIGURE 3.2.1: The expanded King Fahad Library in Jeddah, Saudi Arabia populates its extraordinary facade with a network of tensile fabric sunshades.

FIGURE 3.2.2 (Top Left): The Library of Birmingham is truly a landmark building. In 2014, it was the United Kingdom's 10th most popular visitor attraction, coming in ahead of destinations like St. Paul's Cathedral and Stonehenge.

FIGURE 3.2.3 (Top Right): Masdar City, a planned development project in Abu Dhabi, strives to become the leading example of sustainability urban growth in the future. The bristling library at Masdar Institute is no exception to this green credo.

FIGURE 3.2.4: Expressive facades need not be ostentatious. Note how the facade of the Tozzer Library, although distinctively modern, respects the color palette and proportions of its collegiate context.
People crave connection – connection to not only others but to their community and the world around them. In architecture, transparency is often the most effective means to facilitate visual connection. This visual connection may coalesce interior with exterior, building with campus, new with old, sequestered with accessible, and so on.

Although there are numerous applications, transparency most commonly manifests itself in glazing. Indeed, modern architecture seems to have a symbiotic relationship with glass at times. The large majority of great, modern libraries – Yale University’s Beinecke Rare Book & Manuscript Library being perhaps the most notable exception – leverage glass for its affecting and beneficial qualities, namely daylighting and views.

Yet simply coating a library in glazing is no guarantee for success. As discussed in the case studies, clear and translucent materials come with a myriad of concerns that a good design team will carefully account for. In other words, the issue of transparency and building performance is far more complex than simply specifying low-emissivity windows.

From a practical stance, access to ample daylight reduces dependence on artificial lighting and aids reading. Furthermore, glass psychologically and symbolically minimizes the confines of the wall. This unfeeters the library, allowing it to flow outward and become more extrospective in nature. Transparency lends itself to space making befitting of modernity.
Figure 3.3.1 (Page 41): The light filled "living room" atop the Halifax Central Library offer patrons a wonderful vista overlooking their city.

Figure 3.3.2 (Above): Transparency is not just for walls. At the Jasper Place Library in Edmonton, skylights puncture the building's undulating concrete roof.

Figure 3.3.3 (Left): Located at the heart of the British Library, King George III's historic book collection remains visible to the public thanks in part to the use of tall, transparent interior walls.
Grand reading rooms with soaring bookshelves and high, ornate ceilings were a fixture of many historic libraries. Today, contemporary libraries continue to regularly feature breathtaking central volumes but, this tradition has evolved and morphed. Frequently these spaces relate to the building’s internal circulation paths. Libraries such as the Library of Birmingham, Tozzer Anthropological Library, and Chinatown Branch of the Chicago Public Library all exhibit this trait. In older neoclassical libraries a central space was regularly capped with an ornate dome. In modern libraries, skylights crown these central volumes, permitting daylighting to permeate deep into the building’s core. This permits natural light to reach a much higher percentage of occupied spaces than exterior windows alone. Alternatively, a multistory atrium may tie back to a building’s ventilation strategies. In the Seattle Public Library return air gets collected from throughout the building and sent to the top of the atrium where it is vented outside.

Not unlike transparency, a central volume significantly influences the interior “feel” of a library. The expansiveness of these voids may provide a much needed counterbalance to the tighter, more intimate spaces of bookshelves and study rooms. This central volume commonly doubles as an architectural centerpiece as well; affording the architect the chance to sculpt a broad gesture. For instance, in the University of Aberdeen’s Sir Duncan Rice Library, a series of holes in the floor plates skew one’s perspective and create an arresting architectural experience (see Figure 4.4.3). A similar motif was masterfully executed at the Helsinki University Main Library.

Large central rooms also can appear in contemporary libraries as auditoriums to host lectures, conferences, or even concerts.
FIGURE 3.4.1(42): Rotundas are a timeless tenet of library design. In the Library of Birmingham's rotunda, escalators offer patrons a refreshing means of circulation, rather than relying solely on monumental stairs.

FIGURES 3.4.2 AND 3.4.3: Although found in opposite corners of Europe, these two remarkable libraries leverage a very similar strategy to create an unforgettable, almost surreal interior experience. The Sir Duncan Rice Library (right) and the Helsinki University Main Library (left).

FIGURE 3.4.4: Although Dublin's Trinity College is home to multiple modern libraries, they are largely overshadowed by the Old Library's tourist laden “Long Room.” Rising eight stories high, the Ussher Library's tall, thin atrium creates an impressive space in its own right. This central volumes delineates the building's program in two halves: one side houses books and media, the other holds study spaces and quiet lounges.
Libraries must strive to allocate appropriate amounts of space for both media and social roles. Conventionally, libraries are known as being media repositories – which nowadays includes not only books but also magazines, journals, audio, periodicals, movies, and variety of other materials. Yet the future of this catalogue seems uncertain. The digital age has decentralized knowledge, significantly altering the way society views and consumes such media.

In his TED talk, architect Joshua Prince-Ramus, founding partner at OMA New York, described how his team approached spatial programing for the Seattle Central Library. He states that books are a technology and that moving forward “it’s a form of technology that will have to share its dominance with any other form of truly potent technology or media.” In other words, while it is unlikely future libraries will ever be entirely devoid of books, the amount of square footage books occupy will need to decrease. Instead, a greater share of the library will be devoted to either newer technologies, like computers and 3D printers, or social functions, such as adult education or juvenile engagement.

Located on North Carolina State University’s campus, the James B. Hunt Library is one library which contains a wealth of diverse programmatic conditions. In addition to the reading rooms and study lounges typical of library design, the Hunt Library also houses media production studios, a virtual reality usability lab, an “idea alcove,” a makerspace, and many other unique rooms. The facility is able to accommodate all these additional functions thanks in large part to its bookBot. The bookBot is an automatic retrieval system in which a robotic crane pulls a selected item from a warehouse of high-density shelving. The climate-controlled system can store up to two millions items and requires one-ninth the square footage of conventional shelving. Similar automatic book retrieval system have been implemented at University of Chicago’s sleek Mansueto Library and the Macquarie University Library in Sydney, Australia.
Figure 3.5.1 (Page 44): At first glance the Joe and Rika Mansueto Library appears to be missing its most valuable asset: books. But looks can be deceiving – the catalog is still there, it has just been moved underground. All media is now accessible through an automatic retrieval system.

Figure 3.5.2 (Above): Libraries such as the James Hunt Library are indicative of what the typology’s future may look like.

Figure 3.5.3 (Left): Cafés or even full scale restaurants are among the growing range of amenities to be found in modern libraries. The topmost level of Amsterdam’s Openbare Bibliotheek features a restaurant and scenic vantage point.
Libraries are closely associated with learning. As a building type, they have come to symbolize erudition and the on-going acquisition of knowledge. It is thus fitting that libraries take on an instructive role in their community. On one level, this means providing patrons with useful programming or workshops. Of course, these are responsibilities handled by librarians and library staff, not architects.

Nevertheless, the architect does still have a role to play in community education. Sustainable features result from conscientious efforts to improve building performance. Furthermore, LEED certification often represents a willingness by project stakeholders to invest additional time and money up front for a more environmental benign end product. Any green building certification is usually touted as a high accomplishment and should be seen as a point to celebrate and make known. The design team should do all they can to inform the public of the sustainable features a building contains.

For the Halifax Central Library, the design team wrote a clear, explanatory report running through the what, the why, and how they achieved a LEED Gold certification. This report is easily accessible on the Library’s website and is intended for wide dissemination. Tours are available which highlight the building’s sustainable features. Informative signage was also placed throughout the building to educate users. The project team even went so far as to contact journals, magazines, and local press outlets. According to the aforementioned report, this educational campaign was done to “educate the occupants on the benefits of LEED buildings, develop and encourage an understanding of the unique working systems that function in their building, foster a sense of pride and ownership for the building, and to stimulate conversation and curiosity for sustainability, green design and LEED buildings.”
FIGURE 3.6.1 (Page 46): As modern libraries continued to deemphasize the physical book, library designers should be weary of using “stacked books” as a design concept; for such a motif is not only trite but also one which belies the institution’s evolving essence. A more apropos parti is found at Free University’s Philology Library. The curvaceous form, designed by Foster + Partners, is intended to evocate the sinuous, inner structure of the human brain.

FIGURE 3.6.2 (Top Left): Solar sails along the front face of the Burton Barr Central Library.

FIGURES 3.6.3 AND 3.6.4: Due to its proximity near an “L” stop (Chicago’s subway system), the green roof that crowns the Chicago Public Library, Chinatown Branch can be easily seen by the public.
Imbuing a building with longevity is no short order. In a perfect world, every project an architect designs would stand the test of time. Yet reality paints a different picture. Societal preferences waver, demographics shift, and new technologies emerge. Countless other parameters may arise during a building's lifespan that may be hard to predict or altogether unforeseen during the design process. In spite of these challenges, there are still steps an architect can take to help ensure a library will last.

The notion of “staying power” closely relates to building life cycle assessment yet, it is not one in the same. Building longevity is holistic in nature and requires strategies beyond just assessing performance. A design that accounts for a degree of flexibility allows for inevitable change to smoothly play out. By contrast, a rigid layout can impede future growth by forcing library staff to run the facility in only one specific manner. As an example, imagine if a library needs to move part of its collections to the other side of the building to make room for a new computer lounge. Depending on the original design, this may be an easy adjustment or a significant challenge. In the Halifax Central Library, each floor has the structural bearing capacity to support library collections loads, freeing the bookshelves to be placed anywhere. The logic of the structural grid logic also means the layout of the interior partition walls, mechanical, or electrical systems can be easily reconfigured.

Selection of durable finish materials can contribute to a building’s lastingness. As noted in the LEED guidelines, material selection is a factor in sustainability and occupant health. A strong material palette instills a space with added valued, complimenting a space’s intended uses. Having a building that people visit, cherish, and wish to preserve is a form of sustainability in and of itself, for it conserves far more resources than building anew.
Figure 3.7.1: Elegant and arched, the Hachioji Library was completed in 2007 by Toyo Ito & Associates. Compared with 2006 figures, the library now receives more than twice as many visitors.

Figure 3.7.2 (Top Left): The unique TU Delft Library slopes out of its campus landscape, creating an inhabitable and popular roof lawn where college students congregate. Designed by Mecanoo.

Figure 3.7.3: Besides being known for its rainbow floors, the Czech National Library of Technology held an international competition to recruit an artist to decorate its interior. Dan Perjovschi won and his work was applied directly to the atrium walls.

Figure 3.7.4 (Left): Located in a timber rich area of Chile, the Constitución Public Library displays a masterful level of craftsmanship with locally sourced materials.
In chapter two of his book *Contemporary Library Architecture: A Planning and Design Guide*, Ken Worpole describes successful libraries as a “memory bank.” In his own words, this concept frames libraries as “a public space where past, present, and future fruitfully meet.” He suggests these are destinations where individuals can commune with the great minds of the past. This in turn informs the learner and he or she walks away being hopefully inspired for their path forward. In many ways, this is the highest role of the library, the very reason the building types continues to endure.

Although it may sound like a lofty aspirational criteria, “memory banking” is far more than a romantic notion to library designers. For example, the Library of Birmingham’s design brief states it “will gather, preserve, present and help interpret the collective memory and identity of the city and its communities and surroundings” (qtd. in Worpole). The compounding of knowledge from one generation to the next is a cornerstone of human progress. Much of history and culture revolves around the narratives we collectively believe. The library exists to facilitate this continuity of knowledge and culture. It is an unseen process but nevertheless an integral part of its existence. Louis Kahn, a preeminent twentieth century architect, said, “a great building must begin with the unmeasurable, must go through measurable means when it is being designed and in the end must be unmeasurable.” This could not be more true for the modern library; a space which aims to be and instill the unmeasurable.
Figure 3.8.1 (Page 50): The pristine Stuttgart City Library by Yi Architects is one of this decade's most extolled libraries.

Figure 3.8.2 (Above): The future of the library looks bright with many of the world's most renowned architects taking on library design. Rendering for the new Calgary Central Library designed by Norwegian firm Snøhetta. Completion expected in 2018.

Figure 3.8.3 (Left): Louis Kahn's Exeter Academy Library endures as a sophisticated, timeless facility; truly one of the crowning achievements from an earlier generation of modern library design.
SECTION FOUR
PRECEDENT APPENDIX

Listing of contemporary libraries displaying both a high level of design and at least one LEED or BREEAM certification. Most constructed within the last ten years. In depth discussion of underlined libraries can be found in Section Two.
BREEAM PRECEDENT INVENTORY

CANADA WATER LIBRARY
Location: Southwark, London, England
BREEAM certified: Very Good
Architects: CZWG Architects
Year completed: 2011

CARDIFF CENTRAL LIBRARY
Location: Cardiff, Wales
BREEAM certified: Excellent
Architects: BDP Architects
Year completed: 2009

THE HIVE, WORCESTER LIBRARY
Location: Worcester, England
BREEAM certified: Outstanding
Architects: Feilden Clegg Bradley Studios
Year completed: 2012

LIBRARY OF BIRMINGHAM
Location: Birmingham, England
BREEAM certified: Excellent
Architects: Mecanoo
Year completed: 2013

McCLAY LIBRARY, QUEEN’S UNIVERSITY BELFAST
Location: Belfast, Northern Ireland
BREEAM certified: Very Good
Architects: Shepley Bulfinch
Year completed: 2009

KEW HERBARIUM, LIBRARY, ART & ARCHIVES WING
Location: London, England
BREEAM certified: Excellent
Architects: Cullinan Studio
Year completed: 2009

SIR DUNCAN RICE LIBRARY, UNIVERSITY OF ABERDEEN
Location: Aberdeen, Scotland
BREEAM certified: Excellent
Architects: Schmidt Hammer Lassen
Year completed: 2012
BIBLIOTHEQUE DU BOISÉ
Location: Montreal, Québec
LEED certified: 2015, Platinum (52/70 - NC 1.0)
Architects: Consortium Labonté Marcil, Cardinal Hardy, Eric Pelletier
Year completed: 2014

BILLINGS PUBLIC LIBRARY
Location: Billings, Montana
LEED certified: 2015, Platinum (80/110 - BD+C: New Construction v3)
Architects: Will Bunder Architects
Year completed: 2015

BURTON BARR CENTRAL LIBRARY
Location: Phoenix, Arizona
LEED certified: 2010, Silver (40/85 - O+M: Existing Buildings v2)
Architects: Will Bunder Architects
Year completed: 1995

CEDAR RAPIDS PUBLIC LIBRARY
Location: Cedar Rapids, Iowa
Architects: OPN Architects
Year completed: 2013

CHICAGO PUBLIC LIBRARY, CHINATOWN BRANCH
Location: Chicago, Illinois
LEED certified: Certification Pending, Candidate for LEED Gold
Architects: Skidmore, Owings & Merrill
Year completed: 2015

CHILDREN’S LIBRARY DISCOVERY CENTER
Location: Jamaica, New York
LEED certified: 2014, Gold (40/69 - BD+C: New Construction v2.2)
Architects: 1100 Architect
Year completed: 2011
LEED PRECEDENT INVENTORY

CLINTON PRESIDENTIAL LIBRARY
Location: Little Rock, Arkansas
LEED certified:
2004, Silver (New Construction);
2007, Platinum (Existing Buildings);
2014, Platinum (recertified) (84/110 – O+M: Existing Buildings v3)
Architects: Polshek Partnership
Year completed: 2004
Refer to Case Study One

EAST BOSTON BRANCH LIBRARY
Location: Boston, Massachusetts
Architects: William Rawn Associates
Year completed: 2013

HALIFAX CENTRAL LIBRARY
Location: Halifax, Nova Scotia
LEED certified: 2016, Gold (45/70 – NC 1.0)
Architects: Schmidt Hammer Lassen and Fowler Bauld & Mitchell Ltd.
Year completed: 2014
Refer to Case Study Four

JAMES B. HUNT JR. LIBRARY
Location: Raleigh, North Carolina
LEED certified: 2013, Silver (51/110 – BD+C: New Construction v3)
Architects: Snohetta
Year completed: 2013

JASPER PLACE LIBRARY
Location: Edmonton, Alberta
LEED certified: 2016, Gold (40/70 – NC 1.0)
Architects: HCMA and Dub Architects
Year completed: 2012

MILL WOODS LIBRARY
Location: Edmonton, Alberta
LEED certified: Certification Pending, Candidate for LEED Silver
Architects: HCMA and Dub Architects
Year completed: 2015
LEED PRECEDENT INVENTORY

NEW YORK PUBLIC LIBRARY, BATTERY PARK CITY BRANCH
Location: New York, New York
LEED certified: 2016, Gold (51/110 - ID+C: Commercial Interiors v2.0)
Architects: 1100 Architect
Year completed: 2010

THE ORCHARD SCHOOL LIBRARY
Location: San Jose, California
LEED certified: Gold
Architects: HMC Architects
Year completed: 2011

SCOTTSDALE PUBLIC LIBRARY, APPALOOSA BRANCH
Location: Scottsdale, Arizona
LEED certified: 2010, Gold (46/69 - BD+C: New Construction v2.2)
Architects: DWL Architects + Planners
Year completed: 2009

SEATTLE CENTRAL LIBRARY
Location: Seattle, Washington
LEED certified: 2004, Silver (34/69 - BD+C: New Construction v2)
Architects: OMA and LMN
Year completed: 2004
Refer to Case Study Two

SURREY CITY CENTRE LIBRARY
Location: Surrey, British Columbia
LEED certified: 2014, Gold (39/70 - NC 1.0)
Architect: Bing Thom Architects
Year completed: 2009

TOZZER LIBRARY, HARVARD UNIVERSITY
Location: Cambridge, Massachusetts
LEED certified: 2015, Gold (76/110 - BD+C: New Construction v2.09)
Architects: Kennedy & Violich
Year completed: 2014
Refer to Case Study Three

NB: Listed Canadian libraries certified by the CaGBC, Canadian Green Building Council. All others certified by the USGBC.
IMAGE CREDITS

Cover Photo


Section One

Figure 1.0

Figure 1.1

Figure 1.2

Section Two

Figure 2.0 - Center Left

Figure 2.0 - Center Right

Figure 2.0 - Far Right

Figures 2.1.1 and 2.1.3

Figure 2.1.2
Drawing from page 111 of Contemporary Curtainwall Architecture by Scott Murray. Print.

Figure 2.1.4

Figure 2.1.5

Figure 2.1.6

Figure 2.2.1

Figure 2.2.2
Drawing from page 128 of Contemporary Curtainwall Architecture by Scott Murray. Print.

Figure 2.2.3

Figure 2.2.4
Drawing from page 131 of Contemporary Curtainwall Architecture by Scott Murray. Print.

Figure 2.2.5

Figure 2.2.6

Figures 2.3.1, 2.3.2, 2.3.3, and 2.3.4

Figure 2.3.5
FIGURE 2.3.6

FIGURE 2.4.1

FIGURE 2.4.2 AND FIGURE 2.4.6

FIGURE 2.4.3 AND FIGURE 2.4.4

FIGURE 2.4.5

SECTION THREE

FIGURE 3.0.0

FIGURE 3.0.1

FIGURE 3.1.1

FIGURE 3.1.2

FIGURE 3.1.3

FIGURE 3.2.1

FIGURE 3.2.2

FIGURE 3.2.3

FIGURE 3.2.4

FIGURE 3.3.1

FIGURE 3.3.2

FIGURE 3.3.3
Image supplied by thesis author.

FIGURE 3.4.1

FIGURE 3.4.2
Image supplied by thesis author.

FIGURE 3.4.3

FIGURE 3.4.4
IMAGE CREDITS

Figure 3.5.1

Figure 3.5.2

Figure 3.5.3
Photo sourced from FlickrRiver.com. Photographer Frank van der Most. Web. http://www.flickrriver.com/photos/42212091@N00/sets/72157605771289144/

Figure 3.6.1

Figure 3.6.2

Figure 3.6.3

Figure 3.6.4
Image supplied by thesis author.

Figure 3.7.1

Figure 3.7.2

Figure 3.7.3
Image supplied by thesis author.

Figure 3.7.4

Figure 3.8.1

Figure 3.8.2

Figure 3.8.3

Section Four
(In order of listing.)

Canada Water Library

Cardiff Central Library

The Hive, Worcester Library

Library of Birmingham

McClay Library, Queen's University Belfast

Kew Herbarium, Library, Art & Archives Wing
IMAGE CREDITS

Sir Duncan Rice Library, University of Aberdeen

Bibliothèque du Boisé

Billings Public Library

Burton Barr Central Library

Cedar Rapids Public Library

Chicago Public Library, Chinatown Branch
Image supplied by thesis author.

Children’s Library Discovery Center

Clinton Presidential Library

East Boston Branch Library

Halifax Central Library

James B. Hunt Jr. Library

Jasper Place Library

Mill Woods Library

New York Public Library, Battery Park City Branch

The Orchard School Library

Scottsdale Public Library, Appaloosa Branch

Seattle Central Library

Surrey City Centre Library

Tozzer Library, Harvard University