UNINTENDED CONSEQUENCES: HOW THE USE OF LEED CAN INADVERTENTLY FAIL TO BENEFIT THE ENVIRONMENT

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ABSTRACT

Unintended consequences invariably accompany regulations and standards. This study examined whether the LEED rating system creates any negative inadvertent environmental effects and, if so, what they are. In effect, can doing something that is not sustainable ever help a project get a higher score? The research tool consisted of semi-structured interviews with construction management personnel responsible for the LEED aspects of projects. The study looked at specific LEED certified projects around the southeastern United States. These interviews gathered project specific information about the company responsible for building, the interviewee's experience and views, and the general project. Most importantly, the interviews collected data on any instances of negative unintended environmental effects. Of the 16 projects considered, two included cases of unintended effects. Both cases resulted from situations in which the project location made the otherwise beneficial LEED requirement inappropriate. The study recommends ways to help prevent other similar instances of negative unintended effects. Ultimately, sustainability is best advanced by using LEED certification as an aid not an objective in the journey towards environmentally friendly buildings.

KEYWORDS

LEED, sustainability, green building, unintended consequences

INTRODUCTION

Regulations and laws invariably create unintended consequences. Many times these consequences work against the original goal of the regulation. For example, certain aspects of the Comprehensive Environmental Response, Compensation and Liability Act, popularly known for establishing Superfunds, has diverted money intended for toxic waste cleanup sites into litigation. The study of unintended consequences makes up a large part of the material of law and public policy. Inadvertent consequences go beyond the scope of government and even affect many aspects of the construction industry. Unintended consequences can influence the environmental outcome of green building rating systems.

Research Question

This study seeks to answer the question of whether there are any unintended, negative environmental consequences of seeking LEED certification for buildings from a construction point-of-view and, if so, what they are. The goal is not to examine the precise environmental effects of certain LEED credits, but to consider aspects of implementing the system that may not be as environmentally beneficial as intended. The study will primarily consider *LEED for New Construction and Major Renovations* (LEED-NC). This particular system of the LEED family of rating systems is the oldest and most widely used and thus offers the best opportunity to investigate unintended consequences. The research will focus on the possible inadvertent results from the perspective of those managing construction. The construction management perspective is, of course, limited. Many problems are not likely to appear until after building occupation. Additionally, these problems may not come to the attention of those responsible for managing construction. Other perspectives, like those of architects, civil engineers, and facilities managers are all valid but go beyond the scope of the present work. A comprehensive study that considers numerous stakeholders from each project would enhance the

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findings of this initial work and should be considered for future research.

However, such a study would require major investments in time and money that greatly exceed those presently available to the authors. The paper will consider cases identified by construction professionals in which LEED inadvertently produced harmful environmental effects.

Significance

The topic of unintended environmental effects merits investigation for four reasons. First, if LEED sometimes gives points for unsustainable practices, it unwittingly contributes to unsustainable construction. The American building industry stresses the environment enough without the well-intended efforts of green building contributing added strain. This potential problem gives the most important reason for considering this topic. Secondly, much of the system's appeal to the general building community comes from the users being able to select credits with confidence that meeting the requirements will help the environment. If LEED gets a reputation for encouraging practices that are sometimes unsustainable, LEED and the green building movement are likely to suffer. Thirdly, this study will help sustainable construction comply with the maxim that "you can't improve what you don't measure." Assessing how well LEED meets its environmental goals will help make improvements to overcome deficiencies. Fourthly, LEED's validity will be enhanced if the study yields no significant instances of negative unintended consequences.

LITERATURE REVIEW

The LEED rating system has been the subject of very extensive written material. A number of credible websites provide extensive information on the topic. For example, the United States Green Building Council (USGBC) website offers a wealth of official information on LEED. The Avery Index of Architectural Periodicals, a Columbia University associated comprehensive architecture and related disciplines search engine, returned 57 articles in response to a key word search of "LEED". Articles on LEED come from a wide variety of perspectives and types of sources. For example, the magazine *Heating/Piping/Air Conditioning Engineering* has published extensively on LEED from a mechanical engineering perspective (Ivanovich, 2004). Additionally, the *Urban Land* magazine has considered LEED from a planning perspective (Lassar, 2005). Other magazines consider LEED from architecture and landscaping perspectives (Kevin, 2005; Solomon, 2005). In addition to trade magazines, a variety of journals have published on the topic (Restivo, 2005; Bilderbeck, 2004). Books on sustainable design have also considered LEED. For example, the rating system provided some of the organization of and is a central topic in *Sustainable Construction: Green Building Design and Delivery*, a textbook written by Charles Kibert (2005), a leading expert on sustainability.

In spite of the large amount of material on LEED, little addresses whether or not it has produced any unintended consequences. One scholarly article on sustainable construction addresses what it refers to as "green intentions—black results" (Demaid & Quintas, 2005, p. 607). This article, however, does not consider the issue in relation to LEED. There are only four other available written pieces that seem to directly address unintended consequences within the LEED system. Two of these short pieces consider the potential negative side effects of LEED policy for refrigeration use (Ivanovich, 2004; Sachs, 2004). Ivanovich's (2004) article in *Heating/Piping/Air Conditioning Engineering* discusses the unintended consequences of *Energy Credit 4 in LEED-NC 2*.1. This credit gives a point for not using hydrochlorofluorocarbon (HCFC) refrigerants. HCFC refrigerants have been linked to ozone depletion; however, systems using HCFC refrigerants frequently consume less energy than ones that use other refrigerants. According to Ivanovich, this credit sometimes merely shifts environmental damage and in some instances may increase degradation (2004).

The proposed, but not adopted, *Credit 4* in the *Energy and Atmosphere* section of *LEED Existing Buildings* would have given a point for replacing CFC-11 with HCFC-123 in existing chillers. This credit gives another instance of potential unintended consequences according to the American Council for an Energy-Efficient Economy (ACEEE) (Sachs, 2004). Interestingly, this credit was not included in the LEED-EB version 2 that was eventually published in 2005 (U.S. Green Building Council [USGBC], 2005). The ACEEE expressed concern

that this credit would inadvertently lower energy efficiency. The proposed credit would have given a point for replacing CFC-11 with HCFC-123 in existing chillers. According to the ACEEE, this credit would have encouraged the retention of chillers that needed to be replaced because of their inefficiency. Additionally, the new cooling requirements caused by other LEED-induced changes, would frequently make old chillers oversized and thus wasteful of energy (Sachs, 2004).

The third instance of unintended consequences concerns *LEED-NC Indoor Environmental Quality Credit 4.3* in version 2.2. This credit gives a point for using low-emitting carpet materials. In this instance the two U.S. Green Building Council committees chose not to change the guidelines for a credit because of potential unintended consequences. The NC Core Committee and the Indoor Environment Quality Committee voted unanimously to defer making a decision on the issue until LEED-NC version 3 (U.S. Green Building Council, 2005). This situation and the LEED-EB issue show that the U.S. Green Building Council considers unintended consequences carefully.

The final source comes from the experiences of Auden Schendler and Randy Udall. Both men have been heavily involved in sustainable construction. In an essay titled *LEED Is Broken: Let's Fix* they recount some of the challenges encountered with LEED and give suggestions for changes. They cite instances involving energy modeling, an electric car recharging station, and indoor environmental control. In the first case the use of energy modeling encouraged sub optimization by rewarding HVAC system efficiency based on comparisons with similar systems not on overall energy consumption. In the other cases, the particulars of the buildings did not align with the assumptions on which the LEED credits were based. The car recharging instance involved an area with few electric cars and the charger is used less than once a year. The indoor environmental quality case resulted from a building designed to have only perimeter areas; this layout made the LEED credit for individual environmental control in non-perimeter areas inapplicable. As the authors noted, this credit could have been easily obtained by making a special interior space to meet the credit requirements (Schendler & Udall, 2005). The limited amount of published work on the unintended consequences of LEED poses some problems to the study, but it also gives the intended investigation more significance. This paper will consider an area of LEED and, in essence, the larger initiative of green building that has not yet received significant attention.

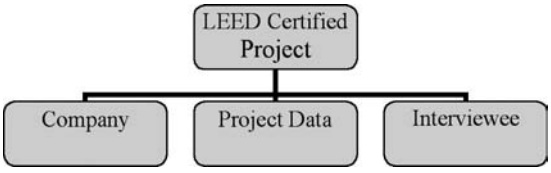
METHODOLOGY

Data Sets and Rationale

Professionals in construction management that have been involved with LEED projects, provided all the data for this study. The study data only came from particular LEED certified projects and included data that is somewhat diverse. The data covered information on the company that built each project, the individual being interviewed, and the specifics of each given LEED project. Refer to Figure 1 for a visual structure for the data.

Information about the company that built a project under consideration was critical to validity. Figure 2 shows the way the questions relate to each other. The study sought out data on projects that are part of the given contractor's core business. This approach helped isolate LEED issues from problems of company inexperience. The study tracked whether the company that built the project under consideration had built LEED certified projects before. The relative newness of LEED and the limited scope of the investigation made it impractical to focus the study only on projects that were the first LEED facility for a company or only on projects after the first LEED project for the company. The issue of company experience with LEED is important and affects the particular project being considered. Because of these considerations, the variable of company experience with LEED was tracked for the data sets. Additionally, the organizational proximity of the other LEED projects was recorded. For companies with multiple

FIGURE 1. Major categories of questions.



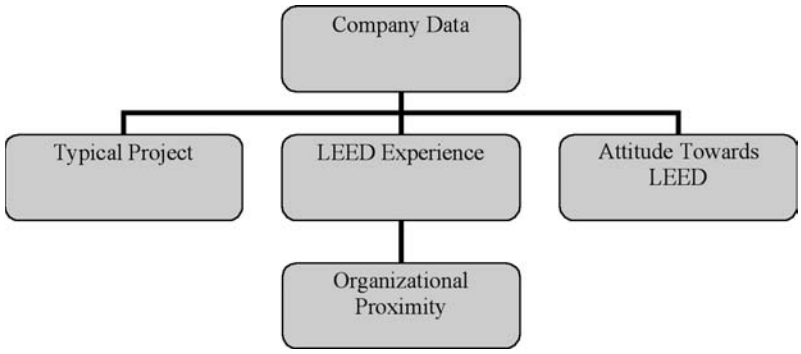


FIGURE 2. Company questions.

offices across the nation, this variable determined if the office that built the project under consideration had also built any of the company's other LEED certified projects. Finally, the company's perspective on LEED was considered. For example, did the company view LEED as a source of competitive advantage or only as something a few clients desire. Tracking these aspects of the company that built a given LEED project helped provide important context for the other data. Refer to Figure 2 for a visual structure for the company data.

Information about the individual being interviewed was also an important part of the data needed for the research. This information addressed four areas. First, the study tracked the person's position during the project in question. The job title data required some interpretation to account for differences in companies. Knowing the responsibilities of the interviewee helped account for his or her perspective. Secondly, the study tracked whether the interviewee had worked on a LEED project before the one under consideration. This variable provided data that gave important insight into the experience of the interviewee. Thirdly, the authors tracked whether the interviewee is a LEED accredited professional. If the interviewee was accredited, the time of accreditation was compared to when the building under consideration was constructed to help gauge the interviewee's grasp of LEED. Fourthly, the person's attitude towards LEED was tracked. This variable could be affected by many areas beyond the scope of the investigation; however, the general attitude of the interviewee towards LEED warranted investigation. These four personal-related variables provided important contextual data and helped in analyzing the unintended consequences cited by interviewees. Refer to Figure 3 for a visual structure for the interviewee data.

Finally, the study considered job-specific information. Data, such as, but not limited to, the size of the project, was tracked. This characteristic provided helpful general data to use in analyzing the other information. Additionally, the contractual framework of the project was considered. The categories followed those developed in a joint study by the Associated General Contractors and the American Institute of Architects (2004). Using design/bid/build, construction manager at risk, construction manager agency, and design-build categories helped in analyzing the unintended consequences and understanding the context of the data from specific projects. The research also tracked the kind of project. This variable

FIGURE 3. Personal questions.

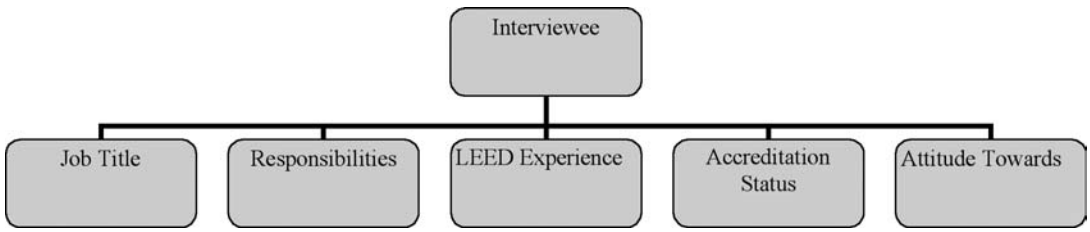
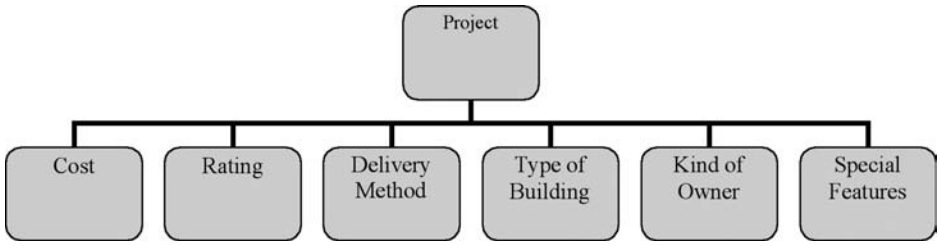


FIGURE 4. Project questions.



consisted of two parts: building type and client. The building type considered the use for which the building was designed, e.g. office, library, or class rooms. Additionally, the study tracked the kind of owner for which the project was constructed, e.g. private school, company, local government. Finally, the study sought to find any special aspect of the projects that might influence the data collected on that particular project. The project-specific information strengthened the validity of the data gathered on unintended consequences. Refer to Figure 4 for a visual structure for the project data.

The core of the data gathered addressed the unintended consequences from the LEED-NC rating. This data considered possible instances involving specific credits. The other data discussed above was gathered to give context, strengthen the validity, and improve the analysis of this core information. The data on unintended consequences addressed any aspect of the rating system in which the interviewees have encountered instances of inadvertent results.

The contacting of interviewees followed a systematic process. First, in an effort to create a manageable scope, the study focused on projects constructed in the Southeast, which included Louisiana, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, the District of Columbia, Tennessee, and northern Florida. LEED credits were specifically designed to give broad applicability across the entire United States, so considering one region should not bias the sample as far as the creator's intent. Additionally, American commercial construction shares a tremendous amount of continuity between regions. This continuity minimizes inference problems when considering other regions. Finally, the details of the findings are *prima face* evidence that the unintended consequences are not due to regional limitations.

In order to identify the needed interviewees, the authors contacted construction companies that operate in the region. The selection of companies to contact was developed from *Engineering News Record* (ENR) lists of companies from the 2005 *Top 400 Contractors* edition. Two of the lists provided the source for which companies to contact. First, the major national contractors were contacted based on the list of "*The Top 50 in Domestic General Building Revenue*". This list tracked the building category that would more likely include LEED projects than any of the other category-specific lists. All of the top 25 companies on the list that had offices in the target area were contacted. The second approach used to identify companies to contact was through the use of the listing of "The Top 400 Contractors" by total revenue (Engineering News Record [ENR], 2005). In this list, all companies based in the target region and in the top 240 companies by revenue out of 400 were contacted (Engineering News Record, 2005). The headquarters of companies based in the study area were contacted. For company headquarters that could not give a conclusive answer about having built any LEED buildings, other offices in the study area were contacted. Additionally, all offices in the study area were contacted for those companies not based in the Southeast. Appendix A gives a table which lists the companies contacted, locations contacted, and the results. For companies with one location listed, the entries were in two groups. First, most are based in the Southeast and their headquarters gave a company-wide answer. In the second group, the company had only one office in the Southeast. Finally, with the exception of Manhattan, all the

southeastern offices were reached for companies not based in the Southeast. In the case of Manhattan, the Atlanta office could not be reached, but two other southeastern offices were contacted.

In retrospect the selection of interviewees should have started with LEED certified projects and not construction companies. However, this approach had the problem of finding what contractor built many of the projects. The USGBC website does not give this information on many of the certified projects. Future study should use this approach if the USGBC made contractor names available for all LEED certified projects. The selection methodology used for the current study, though not ideal, gives a sufficiently rigorous and representative sample.

Upon contacting each company, interviews were sought if the company had completed a LEED-NC project or projects in the study target area. This approach gave a mix of regional contractors and national contractors with a strong southeastern presence. Interviews were sought with personnel from those companies that met the sample rationale given above. Interviews were only sought from personnel that had been directly involved in LEED certified projects.

Analyses Approach

The data, required to identify unintended consequences that resulted from LEED, needed to be primarily qualitative. The heart of the research question could not be effectively investigated by a quantitative approach because the core data needed was not compatible with quantitative analysis. Thus, the research question made the adoption of a primarily qualitative approach essential to the development of an appropriate methodology. However, some of the secondary data, such as project cost, was readily susceptible to quantitative analysis. For example, the information on project size could have been examined through statistical means. This part of the data consisted of some of the information on companies, interviewees, and the projects. Thus, answering the core of the research question relied on information of a qualitative nature, but some of the contextual information could be examined through quantitative means. To answer the research question using the data sets, the study used a qualitative-dominant, quantitative-less-dominant approach. The analysis phase made internal comparisons within the qualitative data directly addressing unintended consequences. The contextual data from the projects was used to look for possible correlations between instances of negative, unintended consequences and the variables tracked. The analysis of correlations provided an essential part of the examination of possible causes of the unintended environmental effects. Finally, the information on instances of negative effects was closely examined to evaluate possible causes.

Research Tools

Choosing a research tool followed some of the same rationale used in determining a methodology. Keeping the research question central, the choice of tool was governed by three primary considerations. First, the kind of data that the tool needed to supply significantly influenced the choice of research tool. Second, the tool had to enable the researcher to obtain valid information. Third, the study had to use a practical research tool given the constraints on collecting data. Data-specific, practical issues, such as the availability of interviewees and accessibility of sites, also influenced the tool selection. The process for selecting a research tool weighed these sometimes competing considerations and found a satisfactory solution.

The kind of data needed to identify unintended consequences of LEED credits could come from four broad categories of research tools. First, the study could use field investigations. This approach faced several problems. The projects would be in some stage of completion, the interviews would have been inconvenient for management personnel, and it would have posed logistical problems. A similar problem of participation would have been raised by the use of a focus group approach. Additionally, many of the employers of the potential members compete against each other making it likely that they would be reluctant to discuss certain issues about a project candidly. The third option would have been to use a survey, but surveys posed problems in the areas of insuring the interviewees understood the issue under consideration and not allowing follow-up questions.

Interviews were the selected research tool option. The interviews were semi-formal. This format addressed the two problem areas of using a survey.

Semi-formal interviews gave more transitivity than informal interviews, improving the validity of the study. The semi-formal interviews also met the study's data needs. Semi-formal interviews, as opposed to informal ones, ensured the needed background company, personal, and project information was collected. In addition, they gave the needed flexibility to ask follow-up questions and helped the study's validity by reducing the chances of misunderstandings by interviewees.

The interviews were conducted by phone to help meet several practical constraints. The interviewees were located around many states, making site visits impractical. Additionally, the use of site interviews would have been more inconvenient for the interviewees. The phone interviews were recorded with extensive notes. On the basis of the considerations mentioned previously, a semi-structured interview research tool best met the particular needs of this study.

FINDINGS

All 49 companies that met the sample guidelines outlined in the *Data Sets and Rationale* section were contacted. Contacting a company led in all but six instances to an interview regarding LEED certified project(s) or determined that the company had not constructed any LEED certified buildings. See Appendix A for more detail. The contacted companies yielded 16 interviews. In all instances, when a person who met the study requirements was contacted, that person was willing to give an interview and was interviewed. Some of the larger companies had relatively formal sustainable construction initiatives and officially designated LEED experts.

Of the companies that had completed LEED certified projects, some were currently building more LEED projects. A portion of the companies had constructed projects built to meet some LEED standards but did not seek a rating. Those companies that had not completed LEED projects, related to LEED in several different and sometimes overlapping ways. Some of the companies had built a number of federal projects that were required to meet LEED standards for a given rating but were not certified and did not pursue certification because the federal government had not yet made LEED certification part of its policy. A number of the companies that had not completed certified LEED projects were building one or more LEED projects at the time of the interview. Some of the companies had not built any LEED certified projects or buildings using aspects of LEED. Appendix C summarizes the findings of the interviews. A copy of the interview sheet appears in Appendix B.

Company Information

The interviewees came from ten companies: Batson and Cook, Brasfield and Gorrie Construction Company, Hardin, Holder, Skanska, Turner, Whiting-Turner, Choate, Winter, and Bovis Lend Lease. These ten companies yielded 16 interviews. Each interview considered a single project.

All the companies regularly build the general type of project that was discussed in their respective interviews. This finding shows that company inexperience did not unduly influence the results. The companies had varying degrees of experience with LEED certified projects. Two companies had not built LEED projects before. The other companies had some experience with LEED, even if it was in other regions of the country. Eleven of the projects were built by companies that had experience constructing LEED projects (at some point) out of the same office that built the project being considered. All but three of the interviews considered their respective companies to have favorable views of LEED. Two of the interviewees gave neutral company attitudes; one stated company policy in favor of sustainability and the other said she could not speak for the owner (the first company B and the company F interviewees respectively from Appendix C). The final interviewee expressed a need for owner commitment (company D).

Personal Information

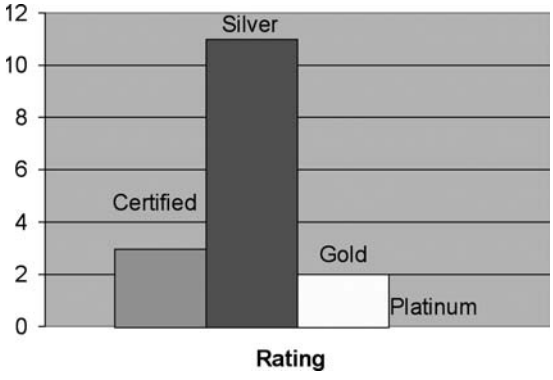
This part of the interview provided extensive data on the interviewees. The interviewees on 14 of the projects worked in the project management part of the projects. These interviewees had the titles of Project Engineers, Assistant Project Managers, Project Managers, and in one case, a LEED Accredited Professional. All but one of the Project Managers worked at companies that use the title without it necessarily meaning that the Project Manager has ultimate responsibility for the entire project. Additionally, one person in field supervision was interviewed—a Su-

perintendent. Finally, one person in preconstruction was interviewed—a Senior Estimator. In addressing their responsibilities, the interviewees for eight of the projects directly referred to responsibilities that involved LEED aspects of the buildings. All the other interviewees worked in areas where they would naturally encounter LEED aspects of the projects. The interviewees had differing degrees of experience with LEED. Nine of them had no previous experience with LEED; the rest had experience varying from attending conferences on LEED to having worked on certified projects. Eight of the interviewees were not LEED Accredited Professionals. The interviewees for the remaining eight projects were LEED Accredited Professionals. The interviewees for three projects were accredited after projects under consideration had been completed. Three of the interviewees were accredited during the projects and the other two were accredited prior to the project under consideration. Finally, the interviews tracked the attitude of the interviewees towards LEED. The interviewees had favorable opinions of LEED. Some offered nuanced attitudes that looked at LEED as a tool to help buildings be more sustainable but not as being synonymous with sustainability.

Project Information

The project information gives important general data on the buildings considered. The projects ranged in cost from $1,200,000 to $80,000,000. The arithmetic mean of the cost was $27,586,000. This cost was only a few thousand dollars above the median cost. The ratings achieved by the buildings ranged from certified to gold. Figure 5 gives data on the ratings received.

FIGURE 5. LEED ratings achieved by projects considered.



The projects considered used three delivery methods. The delivery of twelve projects followed the construction manager at risk arrangement. Of the other four projects, three were built with the design-build approach. The final project used the design/bid/build approach. The interviewee for this building (H) recommended that the design/bid/build delivery method should not be used for LEED projects. The projects considered ranged from a hotel to a data center to a state park building. The status of the project owners varied. Government or associated foundations owned seven of the projects. Non-profit organizations owned three of the buildings, and for profit entities owned five of the remaining buildings. One of the interviewees was uncertain of the status of one of the owners. Eight interviewees did not know of any atypical aspects of their projects that made them unrepresentative for LEED projects. On four projects, the interviewees mentioned items that they considered atypical. Of these, three instances involved graywater systems or cisterns for reducing water use. Although these systems are not a standard part of American construction, they do not make the three projects unrepresentative in a way that might skew the study. The fourth instance involved a project in a park that was required to stay open during construction. The other four responses came on projects that did not record any instances of unintended consequences. Two interviewees cited the kind of project being atypical for LEED-NC. One project was a data center and the other was a laboratory building; both types of projects made some LEED points inapplicable. One interviewee mentioned that a private developer owned the project, and this was not typical for LEED buildings. Finally, on one building, construction had started before a decision was made to seek a LEED rating.

Unintended Consequences

The core of the interviews dealt with whether or not there had been any instances of negative, unintended, environmental impacts from LEED. Of the sixteen interviews only two produced an instance of this situation. The question was fully explained to the interviewees that did not know of an instance of negative unintended consequences. In some cases

they were given an illustration of a possible instance. For the two cases of negative, unintended, environmental effects, the first instance is labeled project A because it involved company A from the chart in Appendix C. The second instance is labeled project D because company D from Appendix C constructed the building.

The first instance of an unintended, negative, environmental consequence involves carbon dioxide sensors. Project A incorporated *Indoor Environmental Quality Credit* 1. The requirements for this credit are given by the USGBC as, "Install a permanent carbon dioxide (CO_2) monitoring system that provides feedback on space ventilation performance in a form that affords operational adjustments. Refer to the CO_2 differential for all types of occupancy in accordance with ASHRAE 62-2001, Appendix D" (2002, p. 50). When the sensors detected CO_2 levels higher than the allowable amount, the HVAC system returned more outside air. However, the outside air contained more CO_2 than the air that was being exhausted. This problem arose because the building was located one and a half blocks from 16 lanes of interstate traffic that are normally highly congested during peak commuter hours. Following the letter of Credit 1 requirements in the *Indoor Environmental Quality* section, caused the air quality to decrease in the building. The credit makes the generally safe assumption that outdoor air will be less contaminated than indoor air. Most buildings are not at risk from outdoor air being more contaminated than indoor air, but in some locations one cannot assess the validity of this assumption without using sensors. Indoor and outdoor sensors should jointly control exhaust airflow in buildings with poor outdoor air quality. Adding an outdoor air sensor ensures a building will meet the intent, and not just the letter, of *Indoor Environmental Quality Credit* 1.

The negative unintended consequence on project D involved the *Sustainable Sites* portion of LEED. Credit 4.2 in the *Alternative Transportation* section gives one point for supplying bicycle storage and changing/shower facilities for 5% or more of the building occupants. This credit, although achieved, did not accomplish the intended goal. Several circumstances prevented the credit from producing the desired outcome. First, the building was part of a state park in a rural area. Secondly, the building location was not conducive to bicycle access; it was described as being on top of a mountain. Third, most of the employees were older and many in bad health. These circumstances limited the use of the bicycle racks and made the use of the changing and shower facilities almost nonexistent. The credit did not achieve the positive outcome sought in this instance. Employees still used gas powered vehicles for transportation, not bicycles. More importantly, the occupied space created a negative environmental impact. Building the bicycle rack, changing area, and shower consumed natural resources ranging from rock to copper to wood. Additionally, the added space for the shower and changing facilities needed to be heated and cooled. If the space was converted for another use, the remodeling would generate waste, thus contributing even more to the negative environmental effects of designing to receive *Sustainable Site Credit 4.2*. Finally, the added upfront cost incurred having sought this credit could have paid for other changes to improve the building's sustainability. In environmental terms, this credit produced negative effects in spite of excellent intentions.

CONCLUSIONS

The data gathered answered the research question. In 14 of the 16 instances, 87.5% of the interviews, construction management personnel closely involved in the LEED certification process were not aware of any instances of negative unintended environmental consequences. In the two instances in which unintended consequences appeared, they each involved one point out of a total of 69 possible points. The ratio of projects with issues to those without suggests that most of those involved with the construction of LEED did not consider LEED to create negative environmental effects. This is a perception and not the conclusion of an extensive study, but those interviewed offered informed opinions. Getting more accurate information on the given jobs would require in-depth investigation at a job specific level. The two instances of a negative unintended environmental consequence raised important issues.

Using the more quantitative data and the other general data gave some insight into the two instances of negative, unintended, environmental consequences. On both projects A and D, the data on the companies gave no variance for the first two ques-

tions. On the question about how the company viewed LEED, company A was very much in favor of it, but the interviewee from company D only expressed the need for owner commitment. Company views of LEED probably related in some way to the instances of unintended consequences, but with the company views split for the two instances, this finding was too limited to warrant drawing any conclusions. The data tracked in both the personnel and project information sections of the interviews gave no information that might help explain the two instances of unintended consequences.

In both cases, the project location was the determining factor for the instances of unintended consequences. In the case of Project D, the mountain top location in a rural area made this credit inapplicable. Without its unusual location Project A would not have given an instance of a negative environmental effect. The two problems would not have arisen if LEED used a rating approach that removed credits that did not apply and kept the difficulty of achieving certification constant. Some rating systems used in other counties follow this approach (Koch, 2005). For example, the Green Star rating system, created by the Australian Green Building Council, removes credits that should not apply to projects. At the same time, the point requirements for ratings shift to account for the inapplicable points (Green Building Council of Australia, 2006). However, changing LEED to more directly account for the non applicable credits would introduce other complexities into the rating system and might lead to problems of determining which credits applied to a given project.

The findings indicated that LEED did in some instances lead to negative, unintended consequences. Ideally, the U.S. Green Building Council would change LEED to remove the possibility of these types of cases. The design and construction communities need to be aware of the possibility of creating negative, environmental outcomes by blindly following LEED. Ultimately, the practitioners of sustainable construction must realize that any rating system only approximately evaluates a building's conformance to the ever evolving ideal of green building. By keeping the goal of sustainability as the primary objective, and viewing LEED as an aide to reaching this goal, building professionals will best contribute to environmentally friendly building.

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APPENDIX A: COMPANIES CONTACTED AS PART OF STUDY

Company	Office Location(s), City–State	Number of Projects Completed or Discussed
Anderson Columbia	Lake City	No LEED projects
APAC	Atlanta–Georgia	No LEED projects
B.L. Harbert	Birmingham–Alabama	No LEED projects
Barnhill	Raleigh–North Carolina	No LEED projects
Barton Malow	Atlanta–Georgia, Chantilly–Virginia, Charlottesville–South Carolina, Jacksonville–Florida	No LEED projects
Batson & Cook	Atlanta–Georgia, West Point-Georgia	No LEED projects
Blythe	Charlotte–North Carolina	No LEED projects
Bovis Lend Lease	Atlanta–Georgia, Charlotte–North Carolina, Raleigh–North Carolina, Washington D.C.	One project completed
Brasfield & Gorrie	Atlanta–Georgia, Birmingham–Alabama, Nashville–Tennessee, Raleigh–North Carolina	One project completed
Brice	Birmingham–Alabama	No LEED projects
Caddell	Montgomery–Alabama	No LEED projects
Choate	Charlotte–North Carolina, Atlanta–Georgia, Charleston–South Carolina, Savanna–Georgia, Raleigh–North Carolina	One project completed
Cives Steel Company	Roswell–Georgia	No LEED projects
Contract	Arlington–Virginia	No LEED projects
Clancy & Theys	All offices	No LEED projects
EMJ	Chattanooga–Tennessee	No LEED projects
H. J. Russell	Atlanta–Georgia	No LEED projects
Hardin	Atlanta–Georgia	Two projects completed
Hoar	Nashville–Tennessee, Birmingham–Alabama	No LEED projects
Holder	Atlanta–Georgia	Five projects completed
John S. Clark	Mount Airy–North Carolina	No LEED projects
Kajima	Atlanta–Georgia	No LEED projects
M.B. Kahn	Columbia–South Carolina, Greenwood–South Carolina, Smyrna–Georgia	No LEED projects
Manhattan	Greenville–South Carolina, Fairfax–Virginia	No LEED projects
Marnell Corrao	All Offices	No LEED projects
McCarthy	Atlanta–Georgia	No LEED projects
Opus	Atlanta–Georgia, Pensacola–Florida	No LEED projects
R. J. Griffin	Atlanta–Georgia, Charlotte–North Carolina, Nashville–Tennessee, Myrtle Beach–South Carolina	No LEED projects
Robins & Morton	Birmingham–Alabama	No LEED projects
Roy Anderson	Gulfport–Mississippi	No LEED projects
Shelco	Charlotte–North Carolina	No LEED projects
Skanska	Atlanta–Georgia, Charlotte–North Carolina, Durham–North Carolina, Nashville–Tennessee	Three projects
Structuretone	Washington D.C.	No LEED projects
Summit	Jacksonville–Florida	No LEED projects
The Facility Group	Smyrna–Georgia	No LEED projects
The Shaw Group	Baton Rouge–Louisiana	No LEED projects
The Stellar Group	Jacksonville–Florida	No LEED projects
Turner	Nashville–Tennessee, Huntsville–Alabama, Atlanta–Georgia	Two projects completed
Turner Industries	Baton Rouge–Louisiana	No LEED projects
W.M. Jordan	Newport News–Virginia	No LEED projects
Whiting -Turner	Atlanta–Georgia, Raleigh–North Carolina	Three projects
Winter	Atlanta–Georgia	One project completed
Yates	Jackson–Florida	No LEED projects
Non-Conclusive Interviews		
AMEC	Washington-D.C.	
CDI	Little Rock–Arkansas	
Centex	Charlotte–North Carolina, Fairfax–Virginia, Nashville–Tennessee	
Haskell	Jacksonville–Florida	
Hensel Phelps	Chantilly–Virginia	
Rogers Builders	Charlotte–North Carolina	

APPENDIX B: INTERVIEW GUIDE

Company Name: _____
Interviewee Name: _____
Date of Interview: _____

Company Information

- Does your company do this kind of project often?
- Has your company done LEED certified project(s) before and, if so, how many?
- What was (were) the organizational proximity of the other LEED project(s)?
- How does your company view LEED?

Personal Information

- What job title did you have during the project?
- What were your responsibilities?
- Did you have previous experience with LEED?
- Are you a LEED Accredited Professional?
- Were you accredited before the project?
- What do you think of LEED?

Project Information

- What was the project cost?
- What rating did the building receive?
- What was the contractual framework of the project?
  - Design/Bid/Build
  - Design/Build
  - Construction Manager at Risk
  - Construction Manager Agency
- What was the building type?
- What was the client's status, e.g. nonprofit organization?
- Were there any special aspects of the project that would make it atypical for LEED projects?

Unintended Consequences

- Were there any unintended consequences in your project in the *Sustainable Sites* section of LEED?
- Were there any unintended consequences in your project in the *Water Efficiency* section of LEED?
- Were there any unintended consequences in your project in the *Energy & Atmosphere* section of LEED?
- Were there any unintended consequences in your project in the *Materials & Resources* section of LEED?
- Were there any unintended consequences in your project in the *Indoor Environmental Quality* section of LEED?
- Were there any other aspects of the project that resulted in unintended consequences?

Other Thoughts

APPENDIX C: SURVEY RESULTS

Questions								
Company Information								
Company	A	A	A	A	B	B	B	C
Kind of Project Often	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LEED Experience	Yes	1	2	Yes	Yes	4	3	Yes
Organizational Proximity	Same	Same	Same	Same	Different	Same	Same	Some
View of LEED	Positive	Positive	Positive	Positive	Neutral	Positive	Positive	Positive
Personal Information *See note at end								
Job Title	PE/PM	PE	PM	PM	Super.	PM	PE	PE
Responsibilities	MEP	LEED	LEED	MEP	Super. Work	LEED	LEED	Some Credits
LEED Experience	Yes	Yes	No	No	No	No	No	No
LEED Accreditation	No	Yes	No	No	No	Yes	No	Yes
LEED A.P. During Projects	N/A	Yes	N/A	N/A	N/A	Midway	N/A	No
View of LEED	Good	Neutral	Good	Good	Good	Good	Good	Good
Project Information								
Cost	35 M	22 M	8 M	122 M	1.2 M	80 M	N/A	60 M
Rating	Silver	Silver	Gold	Silver	Silver	Silver	Silver	Silver
Delivery Method	CM at Risk	CM at Risk	CM at Risk	CM at Risk	CM at Risk	CM at Risk	Design-Build	CM at Risk
Building Type	Comm.	Comm. Higher Ed.	Office	Higher Ed.	Comm.	Higher Ed./Lab.	Comm.	Research/ Higher Ed.
Client Status	Corp.	Non Profit	For Profit	Gov.	Comm.	Non Profit	Gov.	Non Profit
Special Aspects	No	No	No	No	No	No	Yes	No
Unintended Consequences	No	No	No	Yes	No	No	No	No

*Note. PE stands for Project Engineer, APM for Assistant Project Manager, and PM for Project Manager. Other designations such as Senior were tracked but do not appear in the table.

Questions								
Company Information								
Company	C	D	E	F	G	H	I	J
Kind of Project Often	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LEED Experience	Yes	1	Yes	No	No	No	Yes	2
Organizational Proximity	Some	Same	Same	N/A	N/A	N/A	N/A	Same
View of LEED	Positive	Neutral	Positive	Uncertain	Positive	Positive	Positive	Positive
Personal Information *See note at end								
Job Title	PM	APM	PM	LEED AP	PM	Lead Estimator	APM	PE
Responsibilities	PM Work	PM	Overall Respon.	LEED	PM & LEED	Entire Estimate	LEED	LEED
LEED Experience	Yes	Yes	No	Yes	Yes	Yes	No	No
LEED Accreditation	Yes	Yes	No	Yes	No	Yes	Yes	No
LEED A.P. During Projects	During	No	N/A	Yes	N/A	Yes	Midway	N/A
View of LEED	Good	Good	Good	Good	Good	Good	Good	Good
Project Information								
Cost	30 M	5 M	62 M	8 M	25 M	2 M	18 M	30 M
Rating	Silver	Silver	Certified	Certified	Silver	Silver	Certified	Gold
Delivery Method	CM at Risk	Design-Build	CM at Risk	Design-Build	CM at Risk	Design/ Bid/Build	CM at Risk	CM at Risk
Building Type	Research Higher Ed.	Comm.	Comm.	Comm.	Ed.	Comm.	Hotel	Comm.
Client Status	Private	Comm.	Uncertain	Developer	Gov.	Gov.	Gov.	Non Profit
Special Aspects	No	Yes	Yes	Yes	Yes	No	No	No
Unintended Consequences	No	Yes	No	No	No	No	No	No

*Note. PE stands for Project Engineer, APM for Assistant Project Manager, and PM for Project Manager. Other designations such as Senior were tracked but do not appear in the table.