An Assessment of Nighttime Lighting Conditions on the Campus of the University of Minnesota-Duluth

Mapping for Safety and Security

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1. Introduction

“Criminals are like roaches, when the lights go on they scatter”

- Michael Coleman, as cited in Busch (2007)

This project originally started out as an investigation into the quality and maintenance of sidewalks in Duluth, to determine the “walkability” of the city, and to measure the factors determining safe walking environments. Following an initial case study of the Endion neighborhood in 2007, however, a series of recent street crimes, such as muggings and assaults of pedestrians occurred in Duluth, and our focus changed to investigating night time walking safety in the city of Duluth. Particularly, the investigation was prompted by the following events:

1. On the night of September 27th, 2008 University of Minnesota-Duluth students Ben Dahlstrom and Matt Foley were walking back to their apartment from a downtown bar when they were approached by a lone individual. As they were walking near the intersection of First Avenue East and Fifth Street, the man started to walk toward them and confronted them with a gun, relieved the two students of their wallets and cell phones and then fled the scene (Stodghill, 2008).

2. On Wednesday night around 8:30 pm of November 19th, 2008 near the intersection of Partridge Street and Kenwood Ave, a UMD student who was walking home from campus, was robbed of his backpack by two individuals
(Swing, 2008). This was the third robbery of a college age individual in the third week of November 2008 and the seventh overall mugging of a college age individual since the Fall 2008 semester began.

It is notable here that in both instances, UMD students were the victims. While it is unclear if students were specifically targeted, these incidents highlight their vulnerability, as they often rely on (or purposely choose) walking home at night. Furthermore, these events were occurring in addition to concerns about crime on and near the campus of the University of Minnesota Duluth. Two examples stand out specifically:

1. In December 2008, UMD campus police reported a dramatic increase in the number of vehicle break-ins across university parking lots (Ludy, 2008).

2. In 2007, a female student of the University of Minnesota-Duluth was walking home when she noticed a disturbing scene that was happening in a dark alley. A man was masturbating and even though he caused no physical harm, it still had an emotional impact on the student (Wilson, 2007). Her feelings of security were gone and she no longer felt safe walking at night in the campus area.

This series of events, and the general interest in walkability, prompted the creation of a research team under the leadership of Dr. Olaf Kuhlke, Associate Professor of Geography, and current Interim Dean of the College of Liberal Arts. In collaboration with Stacey Stark and Steve Graham, both associated with the Geographic Information
Sciences Lab at UMD, the *Duluth Lighting Project* was created, and student researchers were recruited. While two other current research assistants are investigating the lighting conditions in selected Duluth neighborhoods at this point in time, Tom Parent, who conducted the data collection for this case study, and wrote the bulk of this report, completed the work described below as a requirement for his senior project in the Department of Geography.

2. Purpose and Design of this Study

The purpose of this research project was to measure the levels of nighttime light intensity on the campus of the University of Minnesota-Duluth and its surrounding areas. Specifically, we were interested in identifying areas that could be classified as *dark* and/or *unlit*. In addition, our study outlined sources of *light pollution* on campus, or excessive light intensity, to encourage the university to consider limiting its energy use for the illumination of buildings. Most importantly, this project was to have a practical application, in that it sought to provide the campus community and the City of Duluth with maps that outlined these dark zones, so pedestrians could avoid specific areas of low visibility.

To accomplish this task, the entire survey area, i.e. the entire campus of the University of Minnesota – Duluth, was walked with a lux meter to measure the light intensity. Secondly, light intensity rates were compared to previous studies that investigated the relationship between nighttime lighting levels and crime rates. Specifically, we derived the parameters for our study from the work of Robert Samuels (1995, 1995b, 1996). In his reports on studies conducted in Australia, he concluded that
of all the crimes recorded for a given period, only 3% occurred in lighting conditions of 20 lux or more. In contrast, over 40% of all crimes investigated in his studies occurred in low lighting conditions, specifically under 5 lux. We utilized these benchmarks in our study as well and focused on identifying all areas on campus with lighting conditions under 5 lux, arguing that it is these areas in which the likelihood of crime occurrence is much higher than in properly lit areas with conditions over 20 lux. After the campus and surrounding areas were surveyed, the information was integrated into a Geographic Information Systems (GIS) environment. Once in the GIS environment, each street, sidewalk and pathway with lighting conditions under 5 lux was marked and represented as a “Dark Zone”. The GIS environment thus allowed for the creation of maps that identified safe and dangerous zones on campus, and can show students areas to follow and to avoid. Furthermore, the maps created from GIS will also identify places across the campus area where safety can be improved with the implementation of additional lighting. In contrast, we also set out to map all environments on campus where light pollution was measurable, and again used benchmarks from previous studies by other scholars to set the parameters. Several studies in the United Kingdom and Canada agreed that any illumination in residential and commercial areas in excess of 215 lux (or 20 foot candles) should be considered “light pollution”. In the following sections, we review the current literature on the relationship between lighting conditions and crime, and proceed to describe our methodology in more detail. Then, we provide the results of our fieldwork on the UMD campus, and describe potentially unsafe, safe and excessively lit areas.
3. Lighting and Crime: A Brief Review of Literature

Lighting plays a critical role in providing safe environments and security in the nighttime hours. Furthermore, it has a profound impact on criminal behavior. For example, Merry (1981) interviewed young men who lived in a housing project in Boston and had committed robberies there about their choice of victims and crime opportunities. In addition, participants in this study drew cognitive or “memory maps” of the area they lived and pointed out places that were good for robberies. Merry’s results revealed that potential attackers try to commit crimes where the will not be observed. Favorite places included narrow streets and enclosed pathways where visibility and lighting conditions were poor and witnesses nonexistent. Robert Samuels’ (1995b) review of Merry’s work and his own study concurred that in general, dark places and nighttime are preferred for committing crimes, since victims have trouble identifying the perpetrators. Further studies on lighting and crime solidify this connection. For example, the results of a women’s safety audit in Warsaw, Poland (Un-Habitat, 2007) highlighted that the one of the main problems for women’s feeling of insecurity is inadequate lighting of public spaces and that feelings of insecurity were directly linked to the quality, comfort and cleanliness of the area.

The investigation of the relationship between lighting and crime has even been explored for university campus environments before, and it is most prominently exemplified by Samuels (1995a) in his final report on Defensible Design and Security on University Campuses. Here, Samuels explains that “the overriding concern in any application of Crime Prevention Through Environmental Design (CPTED) principles to campus design should be focused on this highest risk time (night), and the highest risk
users – those people who use the campus at night, thus especially those students who live and walk to and from their residential colleges after dark”. Samuels goes on to explain that “circumstances contributing most to feelings of insecurity, overall were walking to colleges and poor lighting” and that “58% of insecure feelings in Colleges occur at night”. His report was based on a survey given to college students and from the respondents of the survey he was able to conclude that the two most important categories for improving safety on college campuses are control over access to college buildings and highly illuminated access paths/roads. Increasing the efficiency of the lighting across a university campus can provide more feelings of security for its students and faculty, even more so than Closed Circuit Television (CCTV). Sebastian Roche agrees with Samuels when he states that “more powerful public lighting could reduce crime” and “improve safety more than CCTV” (Roche, 2007).

However, most crimes committed against university students are occurring off campus in the surrounding residential areas. To protect the campus, its students and faculty – especially those that walk to and from the university – the improvement of lighting must implemented off campus as well. For this project, we thus aimed at identifying dark areas on campus, and those along the main sidewalks that surround the University of Minnesota Duluth.

While we are cognizant that lighting is an effective way to reduce the probability of crime; we are aware that it does not eliminate criminal activity. In their recent study, Farrington and Welsh (2004) found that improved lighting can reduce crime by nearly twenty percent in experimental areas and concluded that “improved lighting should be included as one [emphasis added] element of a situational crime reduction program”.
Street lighting improvements could prevent crime through “situational” approaches that focus on reducing opportunity and increasing perceived risk through modification of the physical environment (Clarke, 1995). The situational approach to crime prevention suggests that crime can be prevented by environmental measures that directly affect offender’s perceptions of increased risks and decreased rewards. Lighting increases the risk that the offender can be seen before the crime is committed and be identified after the attack. It decreases the reward of performing criminal activity without being seen, therefore increases the risk of getting caught and will prevent such crimes from taking place. A study by Ken Pease on the effects of street lighting on crime reduction (Pease, 2000) shows that targeted increases in street lighting have crime prevention effects and that even untargeted increases in street lighting makes residents less fearful of crime and more confident of their own safety at night. Pease also emphasizes that improved lighting in many cities has led to a decrease in vandalism, street crimes, suspicious persons, commercial burglaries and a reduction in overall crime.

Improved lighting is not only an effective measure at reducing crime but also enhances, as Petty (2007) points out, the usability and value of public space. Quality lighting can be seen as an art form in addition to providing a sense of security. The University of Minnesota-Duluth can greatly enhance the safety of its students and the overall aesthetic quality of its surrounding environment by implementing a lighting project. To do so, the places that need increased lighting first have to be identified; and that was the original purpose of this project.

However, in studying lighting, an additional characteristic comes into play: light pollution, or excessive/obtrusive artificial light. Light pollution is a growing problem in
major cities and industrial areas as development expands and more and more artificial light is being used to light areas in the nighttime hours. The most visible effect of the overuse of artificial light is glare in the night sky.

Artificial light pollutes the sky and obscures city dwellers’ views of the stars. Glare also interferes with astronomical observations, making it harder for telescopes to view the stars. In response to this, astronomers are forced to move telescopes farther into remote areas so that the glare caused by light pollution does not affect their observations. Finally, like any other form of pollution, light pollution affects and disrupts ecosystems and the environment.

Light pollution can confuse animal navigation, alter competitive interactions, and influence animal physiology. Studies have shown that light pollution around lakes prevents zooplankton from eating surface algae, which in turn causes algae blooms that kill off the lakes’ plants and lower the water quality (Moore, 2000). Scientists have also documented that nighttime light may interfere with the ability of moths and other nocturnal insects to navigate (Frank, 1988). Night blooming flowers that depend on moths for pollination may be affected by night lighting, as their pollinator has been driven off course and fails to perform their duties. These were just two examples of how light pollution can have an effect on ecosystems, yet there are many more ecosystem components that are being effected every night.

In addition to identifying places on the University of Minnesota – Duluth campus that need an increase in lighting, this project will also set out to indentify lights on the campus area that are contributing to light pollution. As a result, lighting levels and glare could be reduced to save the University energy costs.
4. Methodologies

The central methodological concern of this study was to identify how to measure lighting intensity, and how to map it. How can nighttime lighting conditions be recorded accurately, with what technology? How can areas be identified that need improved lighting?

Setting Benchmarks for low lighting conditions and light pollution

Following the study by Robert Samuels (1995, discussed above), we sought to identify nighttime lighting condition on campus that were lower than 5 lux. In previous studies, this benchmark was identified as the lighting level below which 40% of all nighttime crimes fell in the respective case studies. Thus, for any areas on campus below this benchmark, we recommend that these be considered for the installation of additional lighting.

In contrast, we also mapped light pollution. In 2009, the Royal Astronomical Society of Canada released their *Light Pollution Abatement Program* that stated that outside lights should not exceed a lux level of 215. This report is the benchmark for identifying lights on the UMD campus that contribute to light pollution. Any light that exceeds a lux level of 215 is to be considered a factor to light pollution and contributor of excessive amounts of artificial light.

Measuring Lighting Conditions – Fieldwork and Mapping

To complete this project, the entire campus of the University of Minnesota-Duluth was walked with a light meter. Since the project objective was to find areas that need to
be improved to protect students while walking, only walkways and parking lots on the campus were measured. These are the areas where students are vulnerable to attacks while either walking home on the sidewalks or walking to their vehicles on campus walkways. In the process of walking the entire campus, the lighting conditions were constantly monitored, and lighting intensity under every street or building light on campus was recorded, along with the exact location of the light source (this was accomplished by using a GPS unit). In the continuous monitoring process, when the lighting conditions fell below 5 lux, the extent of this dark area was mapped with the GPS unit. In addition, the location and light intensity of polluting lights were recorded. The coordinates for all campus light sources, and the extent of poorly lit areas, along with the polluting light sources, were mapped onto a campus map by hand. The campus map displayed all buildings, roadways, parking lots, walkways, and street lights in the campus area. After all measurements had been made, they were mapped in a GIS environment using ArcGIS 9.3 software, along with a digital campus map. The resulting maps can be found in the appendices of this paper.

**Measuring Lighting Conditions – The Equipment and Measurements**

When measuring lighting conditions in general, several units of measurement can be used, but commonly, the *lux* is utilized. A *lux* is a measure of light intensity or *lumens*. A *lumen* is the total light output from a light source. If a lamp or fixture were surrounded by a transparent bubble, the total rate of light flow through the bubble is measured in lumens. Lumens indicate a rate of energy flow. Thus, it is a power unit, like Watt or Horsepower (Wulfinghoff, 1999). *Lux* is a metric unit that indicates the density of light
that falls on a surface. It is equal to one lumen per square meter. Lux readings are used to measure the adequacy of lighting and can only tell us about light intensity in a certain area, but reveal nothing about the type of lighting equipment used (i.e. type of light bulb, or type of lighting structure) (Wulfinghoff, 1999). On average, direct sunlight measures 50,000 lux, indoor lighting measures somewhere between 100-1,000 lux; and nighttime lighting conditions under a full moon measure around 1 lux.

Units of lux are measured with a light meter. The light meter used in this project was an EasyView 31 light meter from Extech Instruments. The instrument is able to measure up to 20,000 lux and processes light up to 2.5 times per second. The light sensor is built into the unit. The meter has a MIN/MAX function for finding the lowest and highest lux readings in a project area. This light meter is also able to measure light in footcandles; a measurement based on English measurements equal to one lumen per square foot. The footcandle has become almost obsolete as a unit of measurement, but can still be used in some places. The light sensor is extremely sensitive and must directly face the light source to obtain an accurate reading. A slight tilt of the light sensor can lead to a false reading for the light intensity in a given area.

5. Analysis

Sixty-six areas on the University of Minnesota-Duluth Campus had a lux reading of five or below; and were labeled as “Dark Zones”. Sixty-two lights on campus exceeded lux levels of 215 and were identified as contributing to light pollution. Appendix A shows the final map for this project; displaying the UMD campus area,
including Dark Zones and Light Pollution overlaid on the camps walkways and parking lots.

The majority of “Dark Zones” were located on College Street and St. Marie Street. The “Dark Zones” on campus were either due to inadequate or non-existent lighting, light poles that were not working, or from a vegetation obstruction. The “Dark Zones” on College Street and St. Marie Street were due to inadequate lighting, which is shown in a diagram in Appendix B. Different types of street lighting can create adequate or inadequate lighting conditions, and those found on College Street and St. Marie Street are due to the scattered and ineffective source of lighting present in this area. The lights on these streets fall under the category of “very bad” lighting as illustrated in Appendix B. The light is not directed anywhere and so very little reaches the ground. Only the area directly under the light is well lit, and this creates extensive “Dark Zones” in between each light post. Lux levels in between each light post reached extremely low levels, and in some places were less than 1 lux. These areas should be seen as extremely problematic because visibility is extremely low and these streets (College and St. Marie) are among the main streets that students travel when walking to and from school.

In contrast, the university does have a very efficient lighting system in place in the student housing areas located on Junction Avenue. The map in Appendix C is a representation of this system. Each light on Junction Avenue falls under the “best” category from the figure on Appendix C. The light is directed to the ground and distributed horizontally through mirrors in the light encasement. This creates a safe and well-lit area with few “Dark Zones”. This also encourages a greater amount of human traffic in the night-time hours which helps to deter crime as well. The only “Dark Zones”
that were located on Junction Avenue were due to an obstruction from vegetation. This is represented in Appendix D. The “Dark Zones” on this map were created by hedges that are over eight feet high and block the light, causing a very dark shadow on the walkway. Though there is light in the area, these Dark Zones are still problematic. The hedges offer potential hiding places for street criminals, and provide a Dark Zones for a potential attack.

The lights on campus that exceeded lux levels of 215 were concentrated in five areas across the University. These clusters of lights were all located on main entrances to the school such as; Darland Administration Building, Kirby Plaza, the Labovitz School of Business, Solon Campus Center and the UMD Library. The majority of these lights were high intensity low-level light poles that produce lux levels from 225-300. These lights were located at Kirby Plaza, Darland Administration and the UMD Library. The lights located at the Labovitz School of Business and Solon Campus Center were used only for aesthetic purposes. These decorative lights produced lux levels from 500-1000. The lights at Solon Campus center were globes whose light was not directed anywhere; most of the light coming off of them went directly into the sky and they were one of the biggest contributors to light pollution in the campus area. Appendix E shows two different maps of these clusters of light pollution. The first map shows the lights located at the Labovitz School of Business and the UMD library, where the highest lux level recorded measures over 1100 lux. The second map shows the lights located at the Solon Campus Center and Darland Administration Building where the highest lux level recorded measured over 750 lux.
6. Conclusion

The lighting system on the University of Minnesota-Duluth Campus is not uniform. The surrounding streets to the North and South of campus are problematic as they provide the majority of “Dark Zones” found on or around the campus area. Their lighting system is extremely inefficient and causes multiple areas where lux readings drop below five and in some cases even less than one. The West side of campus, where the majority of the student housing areas are located, has a safe and efficient lighting system. Here, the light is evenly distributed along the walkways and in the parking lots. Personal feelings of security are likely to be much higher in this area of campus than others. Consequently, we observed that there is also a higher level of human traffic in the nighttime hours on this part of campus than in any other. The center of campus is characterized by lights that produce extremely high levels of light intensity, focused on illuminating the main entrances to the University, and key buildings.

We encourage the university to review the lighting system across the entire campus, and recommend that the lighting system used near the student housing areas, where appropriate street lighting technology is used, should be established across the entire campus area. Implementing this system in areas such as College Street and St. Marie Street could deter crime, provide students with a stronger feeling of safety, and encourage more nighttime walking.

The university can also reduce energy by reviewing the lighting systems used for the entrances of Kirby Plaza, Darland Administration Building, the Labovitz School of Business, Solon Campus Center and the UMD Library. Lights at these buildings produce high levels of intensity that use unnecessary amounts of energy.
This project sampled just a small portion of the city of Duluth. Most of the students who walk to the University come from areas that were not surveyed in this study. Thus, we recommend that this project be continued and expanded into the outlying neighborhoods that surround the University of Minnesota-Duluth to better protect the school’s students. Eventually, a light assessment should be done across the entire city of Duluth, so dangerous and overly lit areas across the city can be identified and improved.
Sources


Judd, B, Samuels R. and Barton, J. (2005), The Effectiveness of Strategies for Crime Reduction in Areas of Public Housing Concentration


Appendix A

A Light Assessment of The University of Minnesota-Duluth Campus

- Dark Zones
- Light Pollution
- Walkways
- Parking Lots
- Roads
- University Buildings
- Sports Fields
- Water

* Dark Zones consist of areas with LUX readings of 5 or below

* Light Pollution points consist of lights on campus that are producing levels of 215 LUX or higher

Light data collected by Tom Parent from 04/01/2009 to 05/04/2009

Base Map: GISL, UMD 2009

Created By:
Tom Parent, 2009
Appendix B

A Light Assessment of The University of Minnesota-Duluth Campus

- Dark Zones
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* Dark Zones consist of areas with LUX readings of 5 or below

* Light Pollution points consist of lights on campus that are producing levels of 215 LUX or higher

Light data collected by Tom Parent from 04/01/2009 to 05/04/2009

Base Map: GISL, UMD 2009

Created By:
Tom Parent, 2009
Appendix C

A Light Assessment of The University of Minnesota-Duluth Campus

- Dark Zones
- Light Pollution
- Walkways
- Parking Lots
- Roads
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- Sports Fields
- Water

* Dark Zones consist of areas with LUX readings of 8 or below.
* Light Pollution points consist of lights on campus that are producing levels of 215 LUX or higher.

Light data collected by Tom Parent from 04/01/2009 to 09/30/2009.

Base Map: GISL, UMD 2009

Created By: Tom Parent, 2009
Appendix D

This map is an example of a vegetation obstruction causing a Dark Zone.