Designing a Sustainable Field

INTRODUCTION

Figure 1. The U.S. Energy consumption by sector (United States Energy Consumption, EIA, 2011).

Why is it important?

Field stations have supplied students with a space to enhance their learning outside of the classroom by providing more first-hand experiences, especially pertaining to science studies (Hiram College, 2012). A field station could host a variety of desirable uses. For example, the building itself can act as a teaching tool to educate visitors about its sustainable operations, (Pilloton, 2007) as well as a research and education facility to better utilize both on and off campus properties. The Leslie Shao-ming Sun Field Station at Stanford University's Jasper

The off-campus properties were visited on multiple occasions. Here, our model was then compared to our personal observations. We observed particular habitats, watershed characteristics, sun visibility, tree density, and access points. A reas with the largest amounts of highly valued parcels were visited most frequently and in each season. By combining the Raster Model with personal observations, three sites were chosen that had the lowest environmental impact, the most favorable and aesthetically pleasing location, and contained the highest solar energy capacity. The sites were plotted using a Garmin GPSMAP 60CSx that were then uploaded to ArcMap10.

Climate Analysis:

We used Climate Consultant 5.3 Beta software and weather data from Glens Falls, NY to conduct our climate analysis. The model generated a "comfort zone" to describe a comfortable range of humidity and temperatures given the amount of clothing a person is wearing and how actively they are working. Based on the results of our surveys, the field station will c046f (used) 3 ()] TJET 1 s

Figure 3. Activity level values for a variety of activities. A building designed to accommodate more active functions requires a lower range of temperatures and a building designed to accommodate more sedentary work requires a higher range of temperatures. For example, a gym, where people are working out is much more comfortable at cooler temperatures.

Figure 4. This cross-section demonstrates how shading can be used to block the higher angle of the summer sun, while allowing the lower angle winter sun to enter the building. These cross-sectional diagrams are used to calculate the length of the overhang using basic trigonometry. (http://www.yourhome.gov.au/technical/fs44.html).

Natural Ventilation

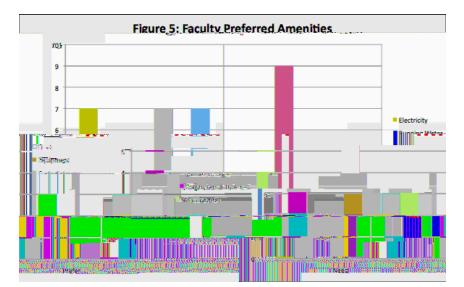
Natural ventilation involves an arrangement of operable windows that allow fresh air to circulate through the building, without creating uncomfortable drafts. (Lechner, 2009)

Solar Thermal Radiant Floor Heating

independent study students there to do either a summer research program or an academic-year research project.

In terms of the physical construction of the field station, the majority of the science professors who would be using the space for labs and field research said they would need electricity and locked storage and would prefer heat in the winter (Figure 5). Other amenities like running water were not as desired.

From these interviews, we also determined that the most important sustainable design strategy to most of our interviewees is low environmental impact on the site (Figure 6). Though this is not necessarily a tangible part to a building, it guides our design process to make the field station blend in with the surrounding woods. Sustainable and/or local building materials was the second most popular item, influencing our research on where to obtain the materials necessary for the construction of the field station.





Student Surveys

92% of the students we surveyed said they would be more likely to take a class if it had some kind of outdoor component. We then focused the rest of our results on the students who said they take lab classes. Out of those 82 students, the majority of them "preferred" certain amenities instead of "needing" them, and even then equipment was the top preference, rather than electricity (Figure 7). Computers and internet were the least desired. The difference in the answers between the professors and the students probably happened because the faculty interviews were more focused on the physical construction of the building and the student surveys leaned more towards how they would use it. So professors were thinking about whether or not they need electricity to do their labs, and students were thinking about how they would do their labs in the woods.

The student surveys did turn up the same results as the faculty interviews for the sustainable design strategy priorities, however. Most students agreed low environmental impact on the site is most important, and that sustainable and/or local building material's is the second most important strategy (Figure 8). Though faculty feedback is more important to us in terms of the design of both the outdoor classroom and the field station, student feedback has the ability to

Climate Analysis

Based on these assumptions, the software determined that comfortable indoor winter temperatures range from 56.2°F to 68.2°F, and in summer, up to 76.5°. The Climate Consultant program then generated a psychometric chart, with the comfort zone highlighted in blue (Figure 9).

Figure 9. Comfort Zone based on weather data from Glens Falls, NY (Climate Consultant 5.3 Beta 2013).

The Climate Consultant analysis determined that heating the building would address an

Figure 10. Improved Comfort Zone, implementing heating, natural ventilation and

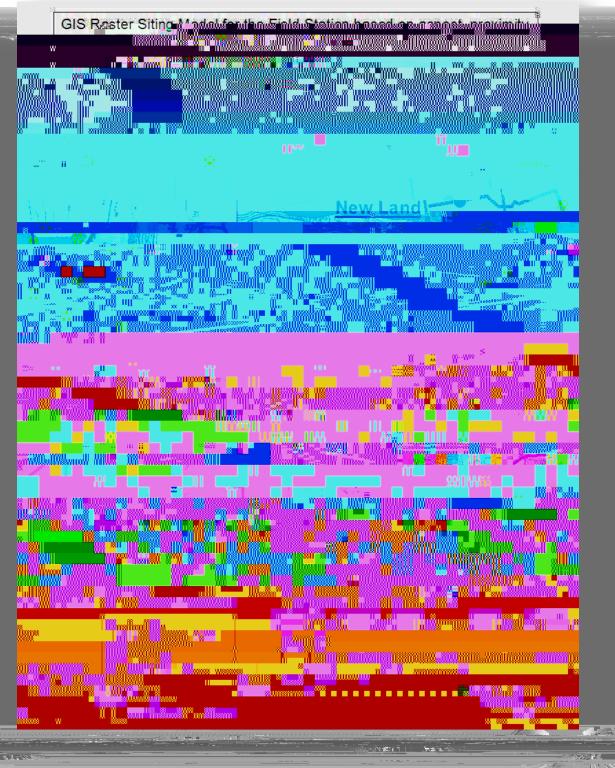


Figure 11. A rcmap10 GIS raster model of Skidmore's properties determines the ultimate site locations for the field station based on the implemented design strategies. The black dots indicate the ultimate location based on site visits and raster output score.

Site 1, Sits atop a hill at 521 feet above sea level within the Stables woods property on the south facing slope at an aspect tilt of 14° west (Figure 12). The high elevation disallows any shade from nearby landscapes to block the sun. The south-west facing slope gives high solar energy capacity by maximizing the sun's seasonal high and low arcing movement east to west. This location is located south of a beaver-created pond, outside of its watershed, but close enough for easy scientific research and environmental analysis. This site is located away from the beaver's habitat to rule out any possible forms of disruption to the habitat. This site is located 15 meters from the mail trail. This site location has a large path; large enough for a truck or tractor that leads to a smaller path roughly a half-mile from its location. The intersection between trails also bisects power lines that could be another potential access point.

Site 2 is also on southwest facing slope at a high elevated location (Figure 13). It sits atop the highest point in both properties at 542 feet above sea level within the New Land woods to the north side of the beaver pond overlooking it. This unique water body provides potential for scientific research and environmental analysis. This site is very unique in its ability to utilize lighting properties such as reflection and refraction off of the large water bodies' surface that increases solar energy capacity and natural day lighting techniques. This large water body also contains less tree density. The beavers and their ecological engineering processes assist in the sunlight availability due to lack of tree density and canopy cover. The site also overlooks the beaver pond but is far enough away to limit disruption. Site 2 is directly off of the main trail, is located 400 meters from Site 1 and 0.78 miles from an entrance beside the Fire Station on Daniels Rd.

Site 3, is located in the northern part of the New Land woods (Figure 14). Site 3 sits at an elevation of 523 feet above sea level just of off the New Land woods back trail, 1.3 miles from a trail entrance off of Daniels Rd. This site is very similar to Sites 1 and 2 in its south-west facing

Figure 12. Site 1's Google Earth photo with the implemented field research Google SketchUp design to scale in the sites exact location.

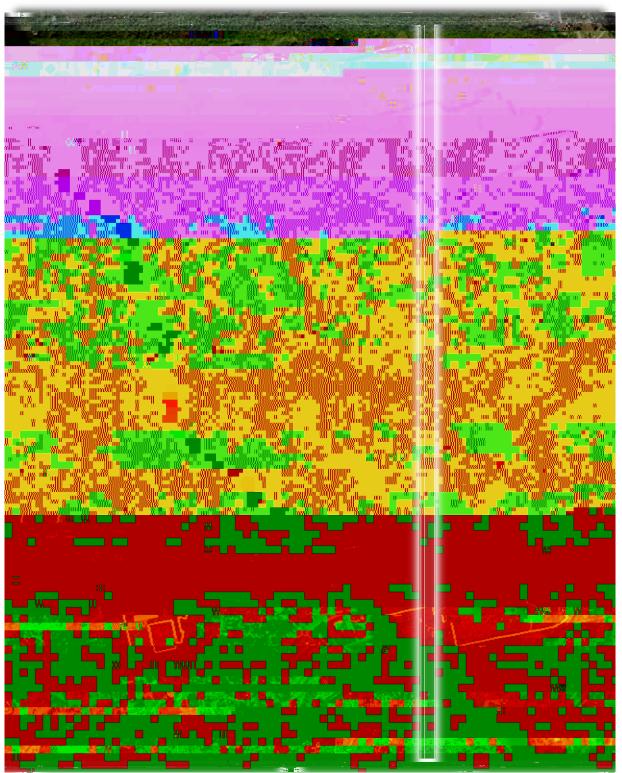


Figure 15. Google Earth satellite surveillance at 19,100 feet of Skidmore's Properties, nearby roads, nearby landmarks, late summer landscape characteristics, and selected sites.

Solar Electric & Solar Thermal Analysis:

Our sites are located at 43° 07' 53.04" W latitude due to the identified GPS locations. In the Northern hemisphere, more specifically the Capital Region of New York, solar designs are created so the angle of the panels is tilted to maximize the amount of electricity (kWh/meter

Figure 17. (upper left) The significance of magnetic declination for the direction of the solar array (IGRF, 2004).

Figure 18. (upper right) The distribution and variation of insolation and annual electrical generation (NREL, 2004).

In terms of aspect, the capital region of New York has specific variables to maximize the solar capacity of the system. At the site of our station, the panels need to be south facing at 14° west due to magnetic declination and the sun's azimuth angle. Each panel, together creating an array, will run east and west to maximize the amount of solar energy that is contacted with a solar system during all of New York's four seasons and their variation in the sun's altitude angle and sun availability.

Peak solar hours span from 9am to 5pm annually. Even though the sun may still be shining before or after the peak sun hours during particular seasons, it does not create enough energy to fully power the system to its capacity. In siting the location of a solar system, elevation is important for two reasons. The closer to the sun an array is, the greater irradiance the array will absorb. The higher a location is, the less likely it is going to be blocked within the peak solar hours by surrounding landscapes, trees, buildings, and other form of mass.

Due to the sites locations in the woods, a grid tied electrical solar system would be impractical. Grid tied solar systems are most commonly found in residential or

Figure 19. Seido5-16 Sunda Evacuated Tube System (left), positioned on the bunk room roof (right).



Figure 20. The design outlay of the solar PV array and solar thermal system on the sketchup model.

Radiant Flooring

Within a radiant flooring system, the under-floor materials include:

- 1600 ft. of 7/8" PEX heat exchanger tubing
- 350 heat diffusion plates, (1) 1000 sq. ft. roll of radiant reflective barrier
- (1) 2-loop slab manifold
- (8) brass adapters
- (4) brass couplings.

Mechanical components include:

- (2) Zone Control kit (thermostats and relays)
- (1) 1 " Expansion and Purge Kit (expansion tank, air eliminator, fill and drain valves
- pressure gauge, and pressure relief valve)
- (2) Grundfos 3-speed cast iron circulator pumps

- (1) 2-zone manifold (factory assembled supply and return manifolds, including all check valves, ball valves, pump flanges, drain valves, in-line thermometers, and misc. mounting hardware).

Figure 21. A closed loop solar thermal radiant floor system.

Table 1: Cost analysis of radiant heating system and its components.

Under floor material total costs	\$2,031.00	
Mechanical component total	\$1,313.00	

The Final Design

Our field station is 1078 square feet. It is made out of recycled barn wood and features a green roof, an intensive battery powered PV system, and an evacuated tube solar thermal system (Figure 22). Natural daylight fills the classroom through the skylights and the clerestory windows, and makes people happier and generally more productive (Figure 23). The green roof covers all visible roof space (Figure 24). We provided a large classroom space to accommodate classes up to 16 students (Figure 25). For the desire for locked storage both inside and outside, we created a large storage closet in the room with the PV batteries (Figure 26). We also created a large exterior storage closet big enough to hold kayaks and other kinds of outdoor equipment (Figure 27). The outdoor storage is not heated and not completely closed, designed intentionally so that if things are wet they can dry out and the space does not get stuffy. There is an upstairs bunk room with 6 beds for overnight capacity (Figure 28).



Figure 22. View of the field station from the south west, showing the PV panels on the south facing roof at a pitch of 28 degrees. The skylights on the roof are arranged to mimic the effect of dappled sunlight filtering through a leafy canopy.



Figure 23. Light from the skylights moves across the room over the course of the day, creating interesting patterns. Daylight reflects off of the light colored wall surfaces and into the room as diffuse light, rather than harsh, direct light, which can create glare.

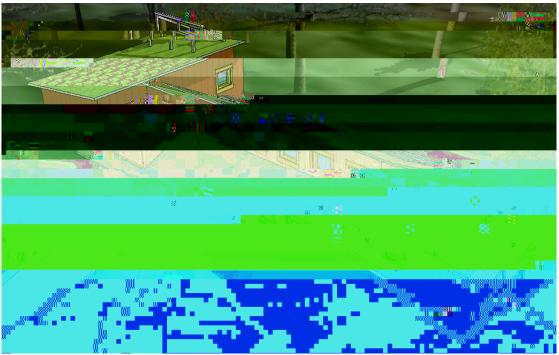


Figure 24. Green roofs will help to visually integrate the building into the surrounding landscape and prevent any contaminated runoff from entering the surrounding ecosystems.

Figure 25. An overhead, plan view of the field station, showing the c12 27tIn0owi9 (plaroo9 (ig)m, i)(on

Figure 27. The second floor bunk room will accommodate overnight stays, which will be

- c. Desks/tables/chairs
- d. Heat
- e. Equipment
- f. Storage space
- g. Computers/internet
- h. Other (please explain)
- 7. In your opinion, which of the following sustainable design strategies are the most important? Please rank 1-6 (1 being the most important)
 - a. LEED standards
 - b. Sustainable and/or local building materials
 - c. Energy efficiency
 - d. Alternative energy
 - e. Storm water management
 - f. Low environmental impact on the site
- 1. Would you use...
 - a. An outdoor classroom in North Woods?
 - b. A field station in the property behind the riding center?
- 2. What sorts of activities would you use these spaces for? Check all that apply
 - a. Lectures
 - b. Labs
 - c. Studio Art
 - d. Creative Writing/Poetry
 - e. Meditation/Yoga
 - f. Storage for supplies and equipment to be used in the woods
 - g. Research
 - h. Other (please specify)
- 3. Please indicate the importance of the following amenities... (Need/Prefer/Doesn't matter)
 - a. Electricity
 - b. Running water
 - c. Heating/cooling
 - d. Furniture
 - e. Equipment
 - f. Locked storage
 - g. Computers/internet
 - h. Whiteboards
 - i. Other (please specify)
- 4.

- d. During the day
- e. Overnight
- 6. In your opinion, which of the following sustainable design strategies are most important? (Please rank 1-6, 1 being most important)
 - a. LEED standards
 - b. Sustainable and/or local building materials
 - c. Energy efficiency
 - d. Alternative energy sources
 - e. Storm water management
 - f. Low environmental impact on the site

REFERENCES

Assisted Home Performance Program with ENERGY STAR." Assisted Home Performance Program with ENERGY STAR. New York State Energy Research and Development Authority, n.d. Web. 29 Oct. 2012. <u>http://www.nyserda.ny.gov/FundingOpportunities/Current-Funding-Opportunities/Assisted-Home-Performance-Program-with-ENERGY-STAR.aspx</u>>.

Bokalders, Varis, and Maria Block. *The Whole Building Handbook: How to Design Healthy, Efficient and Sustainable Buildings*. London: Earthscan, 2010.

Brophy, Vivienne, and J. Owen. Lewis. A Green Vitruvius: Principles and Practice of Sustainable Architectural Design. London: Earthscan, 2011.

Brown, G. Z., and Mark DeKay. *Sun, Wind & Light: Architectural Design Strategies*. New York: Wiley, 2001.

Brunner, Marci. "Solar Thermal Incentive Program." <u>www.nyserda.ny.gov</u>. New York State Energy Research and Development Authority, 10 Dec. 2010. Web. 29 Oct. 2012. <<u>http://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/~/media/Files/FO/Current%20Funding%20Opportunities/PON%202149/2149sum</u> <u>mary.pdf</u>>.

Clarke, Fred W. "The Architect's Role in Urban Regeneration, Economic Development, and Sustainability." *Pelli Clarke Pelli Architects*. N.p., 2012. Web. 02 Nov. 2012. <<u>http://pcparch.com/firm/bibliography/essays/the-architect-s-role-in-urban-regeneration-economic-development-and-sustainability</u>>.

"Concrete Calculator." *ConcreteNetwork.com*. The Concrete Network, 2013. Web. 06 Apr. 2013. http://www.concretenetwork.com/concrete/howmuch/calculator.htm.

Current Funding Opportunities, PONs, RFPs, and RFQs." Current Funding Opportunities, PONs, RFPs, and RFQs. New York State Energy Research and Development Authority, n.d. Web. 29 Oct. 2012. <<u>http://www.nyserda.ny.gov/funding/</u>>.

Dvorak, Bruce, and Astrid Volder. "Corrigendum to "Green Roof Vegetation Findings for North American Ecoregions: A Literature Review" [Landscape Urban Plan. 96 (4) (2010) 197–213]." *Landscape and Urban Planning* 97.2 (2010): 146.

"Ecological Aspects." *Eco Plan Architecture*. N.p., 2012. Web. 28 Oct. 2012. <<u>http://www.ecoplanarchitecture.com/ecological/</u>>.

"Elemental Materials." *First Light House*. Victoria University of Wellington, 2011. Web. 29 Oct. 2012. <<u>http://firstlighthouse.ac.nz/the-house/elemental-materials/</u>>.

"Flooring."

Getter, Kristin L., D. Bradley Rowe, and Jeffrey A. Andresen. "Quantifying the Effect of Slope on Extensive Green Roof Stormwater Retention." *Ecological Engineering* 31.4 (2007): 225-31.

"Green Roof Benefits." *Green Roofs for Healthy Cities*, 2013. Web. 12 Apr. 2013. <<u>http://www.greenroofs.org/index.php/about/greenroofbenefits</u>>.

"Green Roofs Costs." Urban Design Tools

Technologies.
N.p., 15 Oct. 2012.
Web. 28 Oct. 2012.
<a href="http://www.nyserda.ny.gov/Saratoga-Technology-and-Energy-Park/STEP-News/STEP-Announcements/2010-Announcements/TEC-Announcements/2010-Announcements/TEC-Announcements/2010-Announcements/TEC-4

4 Ynts/kT B]
TS(SiAstron Strategy) x 2s 4 (think / 411 (testilation 2 B)] (19) (2ade) Ts2 strategy) x 2s 4 (think / 411 (testilation 2 B)] (19) (2ade) Ts2 strategy) x 2s 4 (think / 411 (testilation 2 B)] (19) (2ade) Ts2 strategy) x 2s 4 (think / 411 (testilation 2 B)] (19) (2ade) Ts2 strategy) x 2s 4 (think / 411 (testilation 2 B)] (19) (2ade) Ts2 strategy) x 2s 4 (think / 411 (testilation 2 B)] (19) (2ade) Ts2 strategy) x 2s 4 (think / 411 (testilation 2 B)] (19) (testilation 2 B) (19) (testilation 2 B) (18) (testilation 2 B) (testilation

"The Weather Station." *WeatherShack.com*, 2013. Web. 17 Apr. 2013. http://www.weathershack.com/static/ed-the-weather-station.html.