# Gaucho Green Tops


Prepared by: Gaucho Green Tops

# Gaucho Green Tops

## Team members

**Katy Carter**
**Robert Lee**
**Theodore Napoli**
**Noemma Olagaray**
**Amy Zhang**

**Prepared for the Environmental Protection Agency and Dr. Kryder**

**May 03, 2021**

# Table of Contents

Gaucho Green Tops
6767 Pasado Road, Goleta
California, 93117
Phone: (805) 555-2021
Email: gauchogreentops@gmail.com

Katy Carter
Robert Lee
Theodore Napoli
Noemma Olagaray
Amy Zhang

To: Dr. LeeAnne G.Kryder
From: Gaucho Green Tops
Date: 3 March 2021
Subject: Project Proposal Memo

We, the Gaucho Green Tops team, propose that UCSB should install a green roof on the fourth-floor ocean side roof of the library in order to mitigate the effects of climate change. This memo will detail the ways in which we communicated, the decisions we made, the research done, and our writing process.

**Communication**

Through this entire process of creating our proposal we have been commuting almost daily on the messenger app GroupMe. We have been using it to ask questions and clarify all aspects of the proposal.

Since January 28th, our team has been meeting up at least once a week over zoom. We would have our weekly meetings on Thursday at 8:00 pm. Several times we would even have two meetings in a week if we deemed it necessary. In these meetings we would make decisions about how we would complete our proposal.

**Decisions made**

Individually we all spent time thinking about how UCSB could mitigate climate change. At our first meeting we all talked about our ideas. Noemma brought up the idea of installing green roofs as they could help lower pollution rates, help retain polluted water, and help reduce reflected heat from the campus. As a team we decided that green roofs were a great idea and at that first meeting, we decided the installation of green roofs would be our proposed solution.

We spent time thinking about whether we should just do green roofs or if we should implement other things as well, like adding solar panels. In the end we decided to focus just on green roofs because it seemed the most plausible and cost-efficient way to fight climate change. We all decided that the library would be a good place to install the green roof as the library roof has a large surface area and people would be able see the vegetation.

**Individual research**

Throughout the entire project process, we each had to do research about how green roofs work and other logistics. But after we created our outline in week three, we figured out what each member would be researching.

- Katy: budget and cost
- Robert: funding and vegetation
- Theodore: maintenance and timeline
- Noemma: climate change issues and green roof solutions
- Amy: construction and location of the green roof

**Writing**

When we created our outline, we divided the proposal into individual sections. We tried to divvy it up so everyone would have an equal amount of writing and research to do. We then compiled all our individual writings onto one document and as a team we finalized the proposal for a green roof on the UCSB library.

Gaucho Green Tops
6767 Pasado Road, Goleta
California, 93117
Phone: (805) 555-2021
Email: gauchogreentops@gmail.com

Katy Carter
Robert Lee
Theodore Napoli
Noemma Olagaray
Amy Zhang

Gaucho Green Tops
6767 Pasado Road
Goleta, California 93117
3 March 2021

The Office of Grants and Debarment
U.S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, CA 94105

Dear Grant Offering Team:

We are requesting $100,000 to transition the UC Santa Barbara Library rooftop into a green roof. We believe that our project fits under your program guidelines of being for “people, prosperity, and the planet”. Our group, Gaucho Green Tops, aims to “improve the quality of people’s lives, provide economic benefits, and protect the environment” which is directly in line with the grant funding requirements.

Green rooftops are needed for our community for the following reasons:

- UCSB creates a large carbon footprint (60,000 tons of CO2 a year)
- Campus hardscapes contribute to polluted stormwater runoff into our oceans
- There is much reflected heat from campus hardscapes
- Overall need to reduce the effects of climate change

With the grant, the installation of green rooftops will mitigate all the reasons listed above as well as reducing electricity costs, increasing biodiversity, preserving the natural habitat, and providing mental therapy. UC Santa Barbara will be doing more in mitigating climate change and the university students and staff will benefit from cleaner, filtered air from green rooftops. The green roofs will be covered with unique plants that are more efficient in air filtering that remove the following pollutants:

- Benzene
- Ammonia
- Xylene

- Formaldehyde
- Trichloroethylene

We will call to confirm the receival of this letter and to help clear up any questions you may have. We may be reached at any time at (805) 555-2021 should you have any queries.

Sincerely,

Gaucho Green Tops Team

## 1.1 Executive Summary

The Gaucho Green Tops team seeks the installation of green roofs on the UCSB campus to mitigate the effects of climate change within the university.

The project aims to address the reflected heat from campus roofing, the polluted stormwater runoff from campus, and the carbon emissions from the university. The goals of the Gaucho Green Tops team align with UC Santa Barbara's future projections toward a more sustainable campus and a greener university.

Although many different approaches were considered, none of these approaches solved as many issues as green roofs did. Solar panels and rain gardens both combat climate change in their own ways, but green roofs were decided to be the most economical, low-maintenance, and they addressed the most problems of climate change.

The green roofs would be extensive, meaning that they would be no higher than 90mm from the rooftop. They would require no regular maintenance and no irrigation system to be installed. A green roof would provide economic benefits as well as environmental benefits. The cost of installing a green roof would be essentially net-zero over the long term of forty years (Breuning, n.d.). This leaves the university with "free" environmental benefits and essentially a return on their investment.

Adding a green roof would increase the average stormwater retention rate from 24% to 80%. In addition, a green roof would reduce the heating and air conditioning costs of the UCSB Library by creating a cooling area on top of the Library rather than having heat-absorbing cement. The plants on the roof would thirdly act as a carbon sink, further canceling out UCSB's carbon emissions.

Gaucho Green Tops plans to apply for the EPA's P3 Grant to fund the initial parts of the project. This grant would allow up to $100,000 for projects they describe to have goals like those of Gaucho Green Tops.

This proposed addition of a green rooftop to the Library would be another meaningful step towards UCSB's push for sustainability.

## 1.2 Team Biographies

Gaucho Green Tops is a team of five students in the Winter 2021 class of Writing for Environmental Professions (WRIT107EP) with Dr. Kryder.

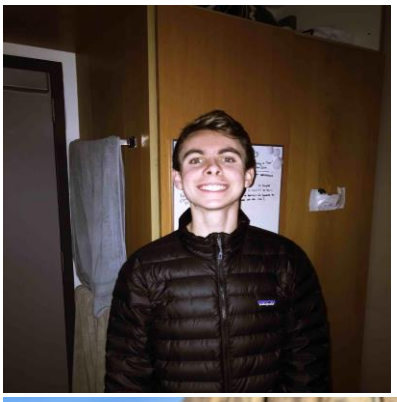
### Katy Carter

A third year student at UCSB pursuing a Bachelor of Arts in Environmental Studies with a concentration in Urban Studies. She is pursuing a career in environmental consulting/planning. She currently works at a Hazardous Waste Facility located on the UCSB campus as a receptionist and is in transition to becoming a technician. In her free time she likes to work out, cook, paint, crochet, and surf.

### Robert Lee

A third year student pursuing a Bachelor's degree in Economics. He hopes to get his MBA after working as a credit rating or financial analyst for several years. In his spare time, Robert enjoys weight lifting, Brazlian Jiu Jitsu, chess, and traveling with friends to national parks.

## Theodore Napoli



A second year student pursuing a Bachelor of Science degree in Environmental Science. He will pursue an environmental law degree and hopes to protect the environment through law. In his spare time he enjoys hanging out with friends, biking, reading books, and playing video games.

## Noemma Olagaray

A third year student pursuing a Bachelor of Science degree in Earth Science with an emphasis in climate and environment. She will pursue a doctoral degree and hopes to eventually conduct research on paleoclimate reconstructions. In her free time, you can find her surfing, rock climbing, hiking, backpacking, or road cycling.

## Amy Zhang

A second year student pursuing a double major in Environmental Studies B.A and Geography B.A. She will pursue a master's degree emphasizing in renewable energy and sustainable green cities. In her spare time, she likes painting, visiting art exhibitions, and traveling around the world.

# 2.0 BODY PART

## 2.1 Introduction to Client's Needs

### 2.1.1 Climate Change

Climate change is a phenomenon that no community is immune to. As a leading research university, UC Santa Barbara has the responsibility to address processes on its own campus that are directly contributing to climate change.

### 2.1.2 Carbon Footprint of UCSB

In the year of 2018 alone, UCSB consumed 84.7 Gigawatt-hours of electricity which translates to roughly 60,000 tons of carbon dioxide released into the atmosphere. This is equivalent to powering 6,910 homes for a year (*Greenhouse Gas Equivalencies Calculator,* 2018).

### 2.1.3 Polluted Runoff

During any large rain event, water that falls on UCSB's campus has the potential to run off into the ocean entirely untreated and unfiltered. This runoff occurs because as the campus turns more open space into concrete, the water simply flows off of the hard surfaces rather than soaking into natural ground. This flowing water can pick up numerous contaminants, which eventually all make it into the oceans at the university's edge. These pollutants can cause toxic algae blooms in the water and lead to unsafe conditions for both humans and marine life.

### 2.1.4 Reflected Heat from Campus Hardscapes

Large swaths of hardscapes on the campus lead to the ever present Santa Barbara sunlight being reflected off the surfaces rather than absorbed by greenery. This reflection of heat creates an urban "heat island" effect and leads to increased energy use, especially during the summer months.

## 2.2 Possible Solutions

### 2.2.1 Solar Panels

Solar panels convert sunlight into electrical energy. Photovoltaic cells are linked together to form panels. Modules can be used together, or several can be connected to form arrays. Then one or more of the arrays is connected to the electrical grid (Solar Photovoltaic Technology Basics, n.d.). When sunlight shines onto the panels, photons from the sun are absorbed into the cell. This creates an electric field across the cell and causes the flow of electricity (Solar photovoltaic technology basics, n.d.). Building a solar roof on top of the library would reduce UCSB's carbon footprint by utilizing electricity, an alternative clean energy ("Going Solar: The Benefits of Solar Panels on Your Roof", n.d.).

### 2.2.2 Rain Gardens

Rain gardens are plants planted around a depressed area in the ground that collects rainwater in urban areas and allows it to be soaked into the ground. Environmentally, rain gardens can be very advantageous as they create cleaner landscapes and habitats. Rain gardens are very effective at filtering water runoffs and removing chemicals and sediments from rainwater runoff. It is very beneficial for the natural surrounding environment as it pulls out any contaminants like oils, bacteria, dirt, fertilizers, and garbage that is collected by the water during precipitation.

### 2.2.3 Green Roofs

Green roofs would be able to help retain polluted runoff through its drainage system. Green roofs would also be able to lower UCSB's carbon footprint by absorbing carbon through photosynthesis and through keeping the building insulated, lowering the need for air conditioning or heating. Green roofs would also help lower the heat reflected from hardscapes as the vegetation would absorb less heat than a normal roof would (National Park Service, n.d). This in turn would help reduce the urban heat island effect.

**Table 2.1:** *Table of possible solutions comparison*

| Issues | Solar Panels | Rain Gardens | Green roofs |
|---|---|---|---|
| Polluted Runoff | ✕ | ✓ | ✓ |
| Carbon Footprint | ✓ | ✓ | ✓ |

| | | | |
|---|---|---|---|
| Reflected heat | ✕ | ✕ | ✓ |

**Note:** Option with ✓ addresses the issue, Option with ✕ does not address the issue

## 2.3 Recommended Approach

### 2.3.1 Suggested Solution

After carefully evaluating different types of roofs, our team concluded that an extensive green roof garden is the best option for a library rooftop rather than an intensive and biodiverse garden.

**Environmental benefits of an extensive green roof** (Tolderlund, 2010, p.8):

- Requires low maintenance and minimal irrigation requirements
- Lightweight, including saturated weight
- Improves air quality
- Increases biodiversity and preserves the natural habitat
- Manages polluted runoff and stormwater runoff

**Economic benefits of an extensive green roof** (Tolderlund, 2010, p.8):

- Saves on electricity and energy costs
- Increases solar panel efficiency
- Improves chance to receive LEED certification

**Community benefits of an extensive green roof** (Tolderlund, 2010, p.8):

- Increases aesthetics and beauty of the rooftop
- Provides mental health therapy
- Provides research opportunities

Implementing a green roof garden is a way to combat climate change and relieve climate change's side-effects. There are three solutions that show how a roof garden can benefit our campus.

**1. Reduce carbon footprint**

Vegetations can absorb the carbon dioxide that is emitted from the UCSB campus through photosynthesis. Modern green roofs mimic the soil structure in the real world which provides a suitable place for vegetation to grow on the roof garden. Moreover, an extensive roof also has 90% to 95% plant cover during the installation process (SIG Design & Technology, n.d).

According to Design Technology's website, a small-scale sedum green roof at Michigan State University absorbed 375 grams of carbon dioxide per square meter. This example verifies that a green roof effectively reduces carbon footprint (SIG Design & Technology, n.d).


**2. Collect and reuse polluted runoff**

Green roofs help to retain the polluted runoff through the drainage system and implements stormwater attenuation. The substrate layer of the green roof collects rainwater run-off, retaining 35% of yearly rainfall, and reuses water for other uses, such as irrigation (SIG Design & Technology, n.d).

Retained water also can be released through natural processes for example, through "photosynthesis, transpiration, evaporation and evapotranspiration" (SIG Design & Technology, n.d).

**3. Reduce the heat reflected from hardscapes**

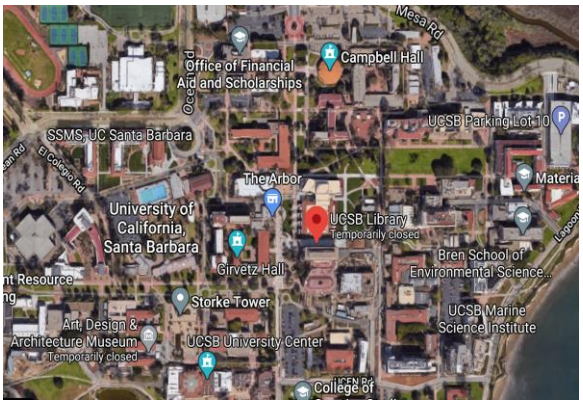
Green roofs have cooling effects to reduce the heat that is reflected from campus hardscapes because vegetation and soils can retain heat and quicken the photosynthesis process.

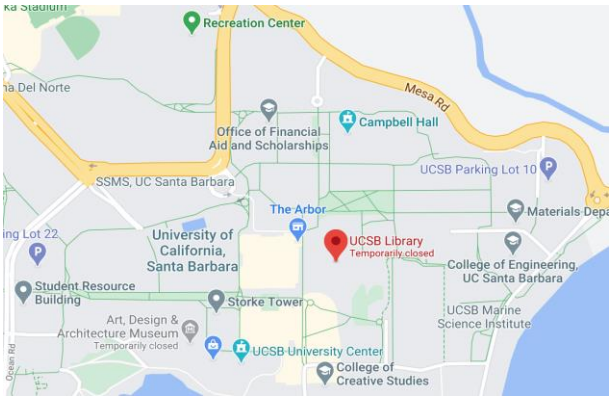
The green roof generally acts as a good insulator. In winter, the green roof will retain heat which provides thermal protection (SIG Design & Technology, n.d).


Gaucho Green Tops

## 2.3.2 Location of Green Roof

The green roof will be implemented on the fourth-floor rooftop of the UCSB library. The library rooftop is pictured below. We chose the library as our first project site because the fourth-floor rooftop has a suitable area and weight capacity to implement an extensive green roof.




***Figures 2.1, 2.2, 2.3*** *(from top to bottom, left to right): Mountain-side Library addition; exact map location of the UCSB Library satellite view; exact map location of the UCSB Library street view.*

Moreover, UCSB Library has become a community hub for decades, supporting students in academic life and providing faculties in intellectual contributions and research (UCSB Library Annual Report, 2020). The library is the most favorable and popular studying space for students. We want to raise students' and faculty members' awareness of green rooftops while working and studying in the library. Our team is also looking forward to having students and faculties to join our research project.

Lastly, implementing a green roof on the library is the best place to solve concerns about climate change. Three solutions of our project are carbon footprint reduction, polluted runoff collection, and energy preservation. Our proposal will build a greener space for the UCSB library and help to reach sustainability and carbon neutrality at UCSB.

**Area and weight capacity:**

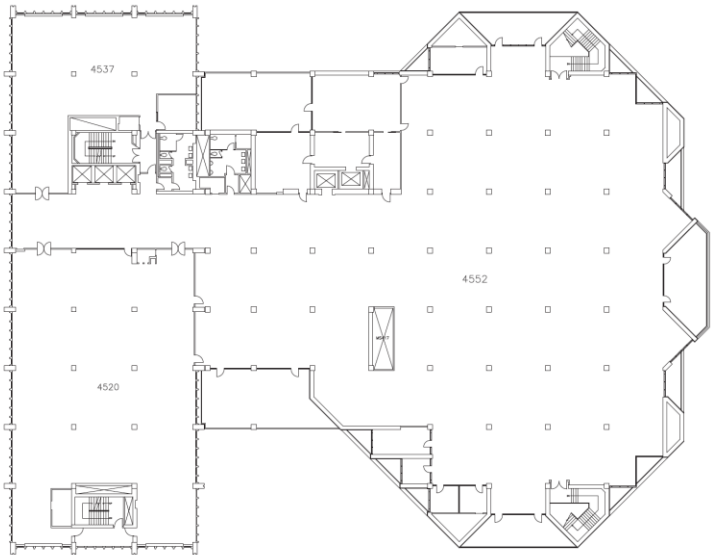
The area of the fourth-floor rooftop is 26,200 square feet which is large enough to implement a green roof garden. Based on the area, the weight capacity also is suitable for an extensive green roof.

Standard parameters of Extensive Green Roof (SIG Design & Technology, n.d):

-Saturated weights: 64.5 kg/m2

-Build-up height: 80-90mm

***Figure 2.4:*** *Roof of UCSB Library, top of fourth floor.*



**Polluted runoff collection:**
Davidson Library implemented stormwater pipes along with the interior of the main campus but the pipelines aren't placed on the top of the rooftops. This makes it so that water flows off buildings onto existing permeable pavements and underlying gravel basins that don't meet the basic demand and efficiency of the stormwater collection (UCSB Water Action Plan, 2017).

The extensive green roof can solve the Library's drainage problem by implementing efficient drainage and waterproof layers between the roof and the plants.

**Energy preservation:**
The extensive green roof has a cooling and thermal effect, so it helps to preserve energy and relieve the heat island effect.

By 2017, the overall yearly electricity consumption reached 7,688,755 kWh and cost $1,269,560.15 (University of California Energy CAP, 2017). Even though the UCSB Library received the LEED Gold certification, it only applies to water-efficient landscaping, water use reduction, recycling of construction waste, a white roof and green building material. Some parts of infrastructure don't meet the Gold requirements, such as the "Optimize Energy Performance" requirement and "Green Power" requirement (LEED Certification Review Report, 2011).

These existing problems underlie the reasons why the UCSB Library is the chosen project location.

## 2.4 Project Specifics

### 2.4.1 Construction of Roof

Green Roof construction is a set of complex engineering processes, including measurements of rooftop weight capacity and area.

The extensive roof is the ideal roof type for UCSB's fourth-floor rooftop because the weight is lighter than intensive and biodiverse rooftops. The table below shows build-up height, saturated weight, irrigation system and maintenance about different rooftops. The arable vegetation on the extensive rooftop ranges from sedums to small grasses, herbs, and flowering herbaceous plants. These plants don't require long-term maintenance and irrigation (Green Roof Technology, n.d).

**Table 2.2:** *Comparison of green roof types.*

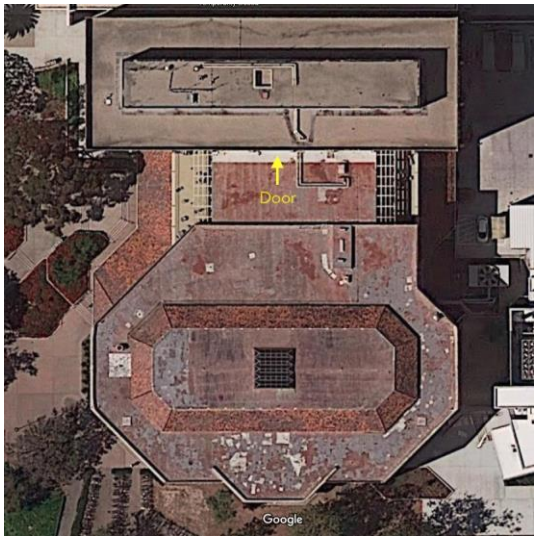
| | **Intensive** | **Extensive** | **Biodiverse** | **Steep Green Roofs up to 35 degree** |
|---|---|---|---|---|
| **Build-up height** | 300 mm + plants | 80-90 mm | 90-225 kg/$m^2$ | 120 mm |
| **Saturated weight** | ⩾200kg/$m^2$ | 64.5 kg/$m^2$ | 90-225 kg/$m^2$ | 155kg/$m^2$ |
| **Irrigation** | Regular | No | No | Regular |
| **Maintenance** | Regular | Minimal | Minimal | Regular |
| | Too heavy | Best Option ✓ | Too heavy | High maintenance |

*Data:California Green Roof Project, SIG Design & Technology, 2017*

To construct the green roof atop the UCSB Library, these steps will serve as a general outline:

Step 1: Contact a green roof company to design a construction plan and choose the type of roof gardens for the library rooftop.

- Our group chose California Green Roof Project. It is a nonprofit organization that helps implement green rooftops in a fast, cost-efficient, and sustainable way. They have expertise in the implementation of landscaped roofs, biodiverse green roofs, and green roof sedum carpet (California Green Roof Project, 2019).



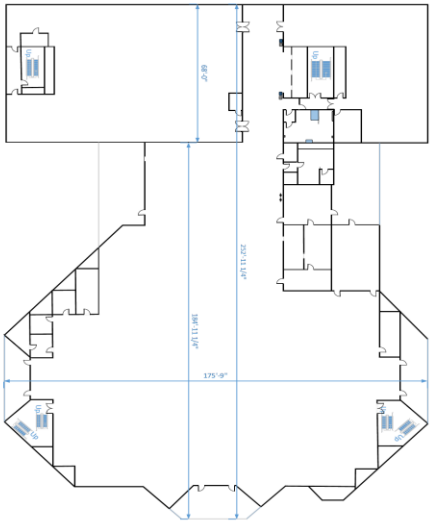



***Figure 2.5, 2.6*** *(left to right): aerial view of UCSB Library fourth floor roof; dimensions and layout blueprint of UCSB Library fourth floor roof.*

Step 2: Measure the area of the green roof garden and sidewalks.

- Total roof area: 26,200 square feet (See Figure 2.6)
- Green roof garden: 20,960 square feet
- Sidewalks area for maintenance: 5,240 square feet

Step 3: Submit completed construction documents to the Fire Department and the Santa Barbara Building and Safety Division for approval.

- Green roof garden design criteria in California states that the original rooftop should have the capability to support vegetation load and saturated roof system (Department of Energy & Environment, n.d).
- A standard green roof system includes several functional layers. The original rooftop should have a weight capacity to support functional layers. A large weight capacity can

increase the life expectancy of a green roof garden and doesn't require regular maintenance.

- Figure 2.7 (right) shows the layer structure of the green roof from top to bottom (Department of Energy & Environment, n.d).
    1. Plant cover
    2. Growing media
    3. Filter fabric
    4. Drainage layer
    5. Root barrier
    6. Insulation layer
    7. Waterproof layer
    8. Deck layer

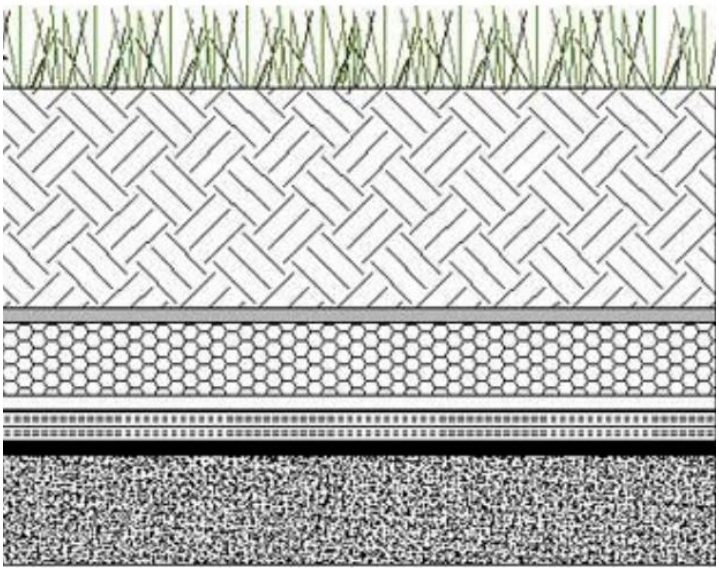


***Figure 2.7:*** *Layer structure of proposed extensive green roof.*

Step 4: Begin construction with the California Green Roof Garden team.

## 2.4.2 Types of Vegetation

**What types of plants?**

According to a green roof maintenance guide, the following plants are the most common in green roofs: (Sood, 2019)

- Sedums
- Perennials
- Ornamental Grasses
- Agave
- Aloe
- Cistanthe

**Why these plants? (Sood, 2019)**

- Hardy
- Survive in tough environments (roof tops)
- Lower maintenance (like watering)
- Not susceptible to pests or diseases
- Removes harmful pollutants

**What do they remove from the air? (Sood, 2019)**

- Benzene
- Ammonia
- Xylene
- Formaldehyde
- Trichloroethylene

## 2.4.3 Operational Maintenance

Once the green roof is installed there will be a little maintenance needed. There are three factors, according to Green Grid Roofs' 2017 Green Roof Maintenance Guide, that will need to be accounted for when the extensive green roof is installed: watering, weeding, and plant care.

**Watering**

As our group has proposed an extensive green roof there will be no need for an irrigation system. But, since Goleta is often warm and dry it will need to be watered regularly for the first two to three weeks after being installed (Semper Green, n.d). After those first few weeks the plants should be able to sustain life without being watered directly. But "if natural precipitation is < 0.5-inch in a 10-15 day period during the growing season, watering may be needed or plants may become dormant or fail''(Green Grid Roofs, 2017). As Goleta can be a dry place, during the growing season the plants may have to be manually watered. This will take two or three UCSB gardeners going on to the roof and watering during these dry periods.

**Weeding**

Also, since there will be a fair amount of vegetation on the roof and Goleta can get strong winds, the green roof will need to have weeds periodically removed. Winds can bring seeds of invasive plant species. To avoid these invasive species, the green roof should be weeded every two to four weeks during the growing season (Green Grid Roofs, 2017). So the same gardeners who are watering the plants during the growing season, may also do some weeding as well.

**Plant Care**

The last aspect that needs to be considered for maintenance is plant care. There are a few things that need to be done in order to maintain the vegetation's health. The first being fertilization of vegetation. According to the Green Grid Roofs, during the first three to five years after extensive green roof installation, fertilization will be needed annually in the spring (Green Grid Roofs, 2017).

The green roof's vegetation will also need to be soil tested to ensure that it is healthy. The tests are recommended annually or bi-annually (Green Grid Roofs, 2017).

Finally the green roof will need to be trimmed. In order to encourage new plant development and avoid overgrowth, it should be cut "every two to three years" (Green Grid Roofs, 2017). With every plant care aspect only being once a year or once every several years, the green roof plant care is a substantial amount less maintenance than a regular garden. Below is Green Grid Roofs' recommended care chart to follow throughout the year:

**Table 2.3: Maintenance Schedule:**

| Plant Type | Spring | Summer | Fall |
|---|---|---|---|
| Sedums | Fertilize (April)<br>Weed (May)<br>Trim (optional – May) | Weed (every 2-4 weeks)<br>Watering (during droughts) | Weed (October) |
| Perennials | Trim(March-Apr)<br>Fertilizer (April)<br>Replant (if necessary) | Weed (every 2 weeks)<br>Activate irrigation system* | Weed (October)<br>Replant (if necessary)<br>Winterize irrigation* |
| Ornamental Grasses | Trim (March-April)<br>Fertilizer (April)<br>Replant (if necessary) | Weed (every 2 weeks)<br>Set Watering Schedule (or use irrigation system) | Weed (October)<br>Replant (if necessary)<br>Winterize irrigation |

*Source: (Green Grid Roofs, 2017)*

*While the chart states the need to use irrigation systems, instead watering schedules can be set when necessary.

## 2.4.4 Timetable

Over the past three months our team has been conducting weekly meetings, doing research, and creating this project proposal. It will take quite some time to receive funding, develop a construction plan, and get it approved. But once it is approved the construction process will only take several weeks (Installation and Maintenance, 2018). Once the construction is finished, maintenance will be established to maintain the vegetation. Within several years we hope to see green roofs installed on other campus buildings. We also wish to see solar panels and areas for studying implemented within these green roofs in order to maximize the efficiency of land usage. Below is our estimated timeline of our proposal.

**Table 2.4:** *Timetable for project implementation.*

| | |
|---|---|
| **January-March 2021** | ● Weekly meetings<br>● Research green roofs<br>● Research Funding<br>● Create Project Proposal |
| **Fall 2022** | ● Secure funding<br>● Contact California Green Roof Project<br>● Create maintenance and construction plan |
| **Within six months of Fall 2022** | ● Get plan approved by Fire Department and Building and Safety<br>● Began construction |
| **Within in 7 months** | ● Finish construction<br>● Implement maintenance |
| **Within 3 years** | ● Implement green roofs to other campus buildings<br>● Implement solar panels and study areas within green roofs |

## 2.4.5 Budget

The following Table 2.5 presents the total estimated cost of the construction of the proposed Gaucho Green Roof. The cost considerations of construction were taken from the organization Growing Green Guide and altered to represent our project's acreage (n.d.). When the Going Green Guide gave a range for an estimated cost, the median of that cost was utilized to calculate our budget (n.d.).

The Operational Cost consists of the upkeep and the plants' watering during a drought, as discussed earlier. The cost of watering the plants would be zero dollars over the long term because the plants would ultimately be watered with collected rainwater. The calculations of labor costs were built off of the following assumptions:

- Maintaining the green roof will require three gardeners who would make approximately $15.19 an hour, based on the Santa Barbara median pay for gardeners.
- Trimming the plants in March will take approximately 2 hours per species of plant.
- Fertilizing all the plants in April will take approximately 4 hours total.
- Weeding the plants will approximately take 2 hours per species of plant.
- During the summer, all the plants will be weeded every 2 weeks.
- The cost of replanting plants is incorporated into the operational contingency cost of 5 percent.

Watering during the summer months will be necessary because the daily chance of precipitation will be less than 0.5 percent from early June to mid-September, according to WeatherSpark (n.d.). Therefore, it is reasonable to expect that the plants will need to be occasionally watered during this time. The workers maintaining the garden can do this at the same time as when they are trimming or weeding. Watering the plants manually would take approximately 2 hours and they would need to be watered approximately four times throughout the summer months.

**Table 2.5:** *Budget table for the total expenses of implementing the Green Roof project.*

| **Estimated Costs of Individual Construction Components** | |
|---|---|
| **Construction Components Considerations** | **Estimated Cost** |
| Water proofing | $195,096.38 |

| | |
|---|---|
| Drainage and protection layers | $48,774.095 |
| Growing substrate, plants, irrigation | $585,289.14 |
| Edge restraints | $8,833.945 |
| Paving, decking, flooring | $585,289.14 |
| Construction equipment | $25,000 |
| **Total cost of individual components** | **$898,782.70** |
| Contingencies and other fees | |
| Design contingency of ten percent | $89,878.27 |
| Cost escalation of three percent | $26,963.481 |
| Construction contingency of five percent | $44,939.135 |
| Consultant fees of ten percent | $89,878.27 |
| **Total Estimated Cost of construction** | **$1,150,441.86** |
| **Estimated Cost of Operations from March to October** | |
| Operational Maintenance | Cost |
| Water | $0 |
| Labor (gardeners) | $2,460.76 |
| Construction contingency of 10 percent | 246.076 |
| Total Estimated Cost of Operations | $2,706.836 |

| | |
|---|---|
| **Total Cost of Construction and Operations** | **$1,153,148.70** |

The estimated costs are subject to change as the planning of this project continues. We will meet with California Green Roof Project and a Green Roof Contractor to further develop our plan and readjust our budget accordingly.

## 2.4.6 Funding Sources

**United States Environmental Protection Agency P3 Grant (Primary Chosen Grant)**
This grant provides up to $100,000 for college students to use to design and implement environmental solutions that "move us toward a more sustainable future". Students in any United States University are eligible to apply. The grant starts accepting applications in the fall of each year. "Proposed projects must embody the P3 approach, which is that they have the intention and capability to simultaneously improve the quality of people's lives, provide economic benefits and protect the environment" (EPA, 2020). The grant encourages groups to "innovate" and "implement" sustainable ideas which is what Gaucho Green Tops aims to do (EPA, n.d.). There are two phases to this grant. "Phase 1 serves as a 'proof of concept,' where teams are awarded a one-year grant of up to $25,000 to develop their idea and showcase their research in the spring of EPA's National Student Design Expo. These teams are then eligible to compete for a phase II grant of up to $100,000 to implement their design in a real world setting." This grant is very broad in describing what projects are eligible. The list includes:

1. Improve Air Quality
2. Provide for Clean and Safe Water
3. Sustainable and Healthy Communities
4. Chemical Safety

**State of California Natural Resources Agency Green Infrastructure Program Grant**
The minimum award is $50,000 and the maximum award is $3,000,000. Projects that could be awarded a grant need to be acquiring, creating, enhancing or expanding community parks and green spaces, using natural systems, or creating systems that mimic natural systems to achieve multiple benefits to create sustainable communities. The grant funding aims to decrease greenhouse gas emissions through incorporating green infrastructure.

**Quadratic Cares Energize the Environment Grant Program**
The grant gives $3,500 to a group that creates an "initiative designed to benefit our environment" (2020). Building green roofs would count as sustainable land management, as adding a green roof to a building helps make said building more sustainable. Gaucho Green Tops meets all of the minimum requirements for this grant.

**California Natural Resources Agency Urban Greening Grant**
This is a decent funding source for the Gaucho Green Tops project because it would be transforming the existing infrastructure of one of the library roofs into a green roof utilizing

native vegetation. To qualify for this grant, a project must have at least one of the major requirements, the most relevant of which is to “sequester and store carbon by planting trees”. Gaucho Green Tops may be able to argue the stance that the green roofs would also act as a carbon sink even though there are no trees being planted.

**University of California - Santa Barbara Sustainability TGIF Grant**

This grant is a university funded program in which they offer grants to groups that wish to help with environmental issues. Because it is school funded, we may have a much better chance of getting the grant. Eligible projects include enhancement of the environment which is what our project is aiming to do through lowering carbon emissions via the use of green roofs which remove air particulates, produce oxygen, etc.

## 2.4.7 Assessment

We will be measuring the success of this project in three ways: Does the green roof successfully help limit polluted runoff from reaching campus, does the green roof help lower carbon footprint, and does the green roof help decrease reflected heat from hardscape surfaces?

**Polluted runoff**

We can measure the success of limited polluted runoff by measuring how much rainwater is captured by green roofs versus how much rain is captured by roofs without green roof installations. A similar test was done by Penn State University comparing water retention for three green roofs and three standard roofs. When the study was done, they found that the standard roofs retained 24% of rainwater while green roofs retained 80% as seen in Table 2.6 (Acks et al., 2006, p. V). So in theory, if the green roof was successful, it would have retained a substantial amount more water than the standard campus roofs. We can measure this success by using the same methodology of modeling that Penn State used in their study.

***Table 2.6:*** *Comparison of stormwater retention rates between standard and green roofs.*

| Rainfall Retained (%) | Standard roof | Green roof |
|---|---|---|
| Average Retention | 24% | 80% |
| Retention at peak runoff | 26% | 74% |

*Data:* (*Acks et al., 2006, p. V*) .

**Carbon footprint**

To measure the success of the green roof lowering UCSB's carbon footprint, we would focus on energy usage. According to the National Park Service "a green roof reduces the temperature of the roof and, therefore, the building itself" (National Park Service, n.d). If the building is cooler, the building will use less air conditioning and in turn use less energy. We can measure the amount of energy the library uses when the green roof is installed compared to a previous year where there was no green roof. It will be successful if there is a significant decrease in energy used by the library.

We could also measure how much carbon is being absorbed by the vegetation on the green roof. In a study conducted by Michigan State University they were able to measure how much carbon their green roof absorbed by using "a Carlo Erba NA1500 Series 2 N/C/S analyzer" (Getter et al., 2009, p. 7565). If UCSB also used this technology we could see how much carbon the green roof was specifically absorbing.

**Reflected heat**

Finally, to assess the success of the green roof we will measure how well the green roof decreases the urban heat island effect. The urban heat island effect is when temperatures in a city are higher than surrounding areas due to paved areas absorbing sunlight and reflecting it as heat (National Park Service, n.d). While UCSB is not a city it is still an area with a large amount of heat reflecting hardscape surfaces like the sidewalks, bike paths, and campus rooftops. With green roofs this amount of reflected heat can be decreased through the vegetation.

We can measure the success of the green roof decreasing the urban heat island effect by comparing its temperature to roofs without a green roof. In the study conducted by Penn State, they used satellite thermal imagery to compare temperatures of roofs (Acks et al., 2006, p. 16). We could use a similar method to measure temperatures. If the green roof has a lower temperature than other buildings on campus, then it will have successfully helped decrease the urban heat island effect.

## 2.4.8 Conclusion

To address UCSB's need to reduce the effects of climate change, we investigated solar panels, rain gardens, and green roofs. We ultimately decided that constructing a green roof on top of the UCSB library would be the best option to mitigate the effects of climate change. Unlike the other options, green roofs would address polluted runoff, UCSB's carbon footprint, and reflective heat. Building an extensive green roof would lower UCSB's carbon footprint by having plants that absolve carbon dioxide. Pollution caused by water runoff would be decreased because of the green roof's substrate layer's water retention properties. Green roofs also have cooling effects thereby reducing the carbon emissions from heating and air conditioning.

We decided that the construction of the green roof should be done on the Ocean Side of the library's fourth floor rooftop because it fits the requirements for the construction of a green roof and allows for maximum awareness about the project. The library roof is flat and can handle the additional weight of the garden. The area outside of the library is often a social and informational space, where students hang out and groups' organize tables. This location allows students to see what the green roof looks like and how it can further be incorporated onto other roofs.

For the planning and construction of the project, we will be working with California Green Project, a nonprofit organization that helps implement green roofs. We will also complete and submit all required Construction documents to the Fire Station and Santa Barbara Building Safety division. After approval, we will begin construction with the California Green Roof Garden Team. After the Green Roof is constructed, the watering, weeding, and plant care will be required for operational maintenance.

Our estimated budget for this project is $1,153,148.70. To estimate the cost, we utilized information provided by the organization Green Roof Guide. We also made some assumptions regarding the time required for managing the plants within the green roof.

We will measure the success of our project based on if the project:

1) Limits polluted runoff

2) Lowers UCSB's carbon footprint

3) Decreases the urban heat island effect

We can measure how much rainwater is captured by green roofs versus standard roofs to see if green roofs will limit polluted runoff. Data taken from the National Park Services shows that green roofs retain more water. To measure the success of lowering carbon footprint, we will analyze energy usage. To measure the green roof's effect on the urban heat effect, we will compare the insulation efficiency of green roofs and those with standard roofing by seeing the amount of hours needed to heat and cool the buildings.

**Looking forward**

With this project, we hope that it will act as a template for future projects to be expanded upon. The more green roofs there are on the campus, the more cumulative beneficial impacts they will generate. The construction of more green roofs opens a variety of opportunities for additional open space utilization. Academic and recreational uses could also be incorporated in future green roofs. Green roofs can incorporate places for the UCSB community to study, meet for group projects, and socialize. Future green roofs could also include solar panels and or edible gardens where the community can grow food. Various options can be incorporated within the development of green roofs for future development.

# 3.0 Supplementary Part

## 3.1 Appendices

Appendix A) Resumes

# Katy Carter

6066 Trigo Rd
Goleta, Ca 93117
(510) 962-1297
katycart3r@gmail.com

---

## EDUCATION

**University of California Santa Barbara**- *A Research based University ranked in top 10 public schools in the country (2018-2022)*

- Currently pursuing a Bachelors of Arts degree in Environmental Studies with a concentration in urban studies

## EXPERIENCE

### UCSB Hazardous Waste Facility- *Receptionist*

February 2020 - Present

- Greet visitors that drop off waste, take down their information and inform them about our procedures
- Answer phone calls
- Answer questions about the facility and provide public with information

### Alameda Arts- *Daycare worker assistant*

2015 - August 2019

- Assist in creating art projects for elementary students and implementing them
- Monitored the classroom and outside area
- Helped solve problems that arose throughout the day

### Bay Island Gymnastics- *Camp Counselor*

June 2018 - August 2019

- Works with kids to provide a safe and fun environment to learn gymnastics by organizing circuits, games and other activities
- Sets up and implements art projects

### Oakland Zoo- *Teen Wild Guide*

June 2016 - June 2018

- Engages with visitors and kids in games and activities
- Informs and educates visitors about exhibits
- Contributes to animal behavioral enrichment

# Robert Lee

3605 Elker Road, Corona, CA 92882 | University of California, Santa Barbara
949-351-6403 | Robertlee@ucsb.edu | Expected Graduation: June 2021

## Education

*University of California, Santa Barbara*

*Santa Barbara, CA*

Credentials — September 2018 - Current

- B.A. Economics
- GPA: 3.4
    - 2nd half of university classes GPA: 3.7

Relevant Coursework

- Microeconomics, Macroeconomics, Labor Economics, Personnel Economics, Statistics

## Work and Relevant Experience

*MediPines, Medical Device Company* — *Yorba Linda, CA*

Business Intern — June 2019 - September 2019

- Developed financial models to justify the financial impact of the medical device to hospital customers
- Created a visual financial model to translate complex concepts into digestible ideas for potential clients
- Identified comparison model of new technology to old methods in respiratory data
- Gathered data from experiments with medical devices to provide feedback for device reliability
- Conducted research on California hospitals to identify potential clients

*University of California, Santa Barbara*

*Santa Barbara, CA*

*Delta Sigma Pi - Professional Business Fraternity*

Finance & Fundraising Chair

June 2020 - Current

- Managed, recorded, and tracked finances of 14 different divisions of the fraternity
- Organized and ran fundraising events to raise $6,000 to cover fraternity financial expenditures
- Created a budget tracking system in Excel to collect data on each divisions' spending

Pledge Educator — October 2020 - December 2020

- Helped integrate new members of the fraternity on the ins and outs of fraternity undertakings
- Accommodated freshmen into college life and educated them in transitioning to a new environment
- Aided members in college coursework and advised them in courses
- Created a four-year college schedule for the pledges that shared the same major and career path

*Korean American Student Association*

Treasurer — April 2020 - January 2021

- Oversaw the incoming and outgoing cash flow for over 10 fundraising, social, alumni events
- Assisted other staff members in planning future events to control costs
- Reimbursed staff for community events that demand communication softwares and event incentives

## Volunteer Experience

*Med Supply Drive* — *Santa Barbara, CA*

Regional Coordinator: Santa Barbara/Riverside/San Fernando Valley — August 2020 - February 2021

- Contacted Volunteers and hospitals for donations of PPE (Personal Protective Equipment)
- Organized pickups/drop-offs of PPE in my region using excel to keep track of drivers transferring units
- Created schedules and assigned drivers to complete the movement of PPE

## Skills and Interests

*Technical skills*

- Excel, Financial Analysis, Powerpoint, Visual Basic Application (VBA), Word

*Soft Skills*

- Presentation skills, Public Speaking, Time management

# Theodore Napoli

Address: 6575 Cordoba Rd Goleta Apt. 4, CA 93117
Cell Phone Number: (805)-236-1706
Email: tnapoli@ucsb.edu

---

## Objective

An internship position utilizing my skills in environmental research, report writing, and communication, all the while contributing to improved performance of WildEarth Guardians.

## Education

**University of California, Santa Barbara** Expected Graduation Date: June 2023

*Bachelor of Science: Environmental Studies* G.P.A: 3.52

Relevant Coursework

- Environmental Studies
- Writing for Environmental Professions

## Community Experience

*Former member of Students for Bernie* Jan 2020 - March 2020

- Advocate for Bernie Sanders to win Democratic Primary
- Speak/Canvas to community about why they should vote
- Help organize rallies and marches in support of Sanders

*Participating member of YDSA* Oct 2020 - Present

- Discuss issues that are relevant to students
- Create and implement solutions to said issues

*Founding member of Gaucho Green Tops* Jan 2021 - Present

- Class project: proposing campus green roof initiative
- Research and proposal writing

## About me

I am a hard worker who thrives in group work with an aptitude for leadership. I am passionate about environmental preservation as well as environmental policy. Anything I lack in experience I will make up with perseverance and determination.

## Special Skills

Proficient in:

- Environmental Research
- Report Writing

- Microsoft word, Google Docs, Microsoft Powerpoint, Google Slides, Microsoft Excel, and Google Sheets

# NOEMMA OLAGARAY

NYOLAGARAY@UCSB.EDU . (209) 331-3823 . 6767 PASADO ROAD APT 4, GOLETA, CA

## OBJECTIVE:

A lab position in a Paleoclimate and Stable Isotope Lab that accepts undergraduates with a desire to learn more about data collection surrounding isotopes in marine sediments and ice cores.

## PROFESSIONAL EXPERIENCE:

INTERN

CHEADLE CENTER FOR BIODIVERSITY AND ECOLOGICAL RESTORATION - SANTA BARBARA, CA

*SEPTEMBER 2018 - JANUARY 2019*

• Assisted in the restoration of plots on UCSB campus.

• Taught local elementary school children about plants and their environment

INTERN

SPALETTA LAW PC - LODI, CA

*APRIL 2020 TO OCTOBER 2020*

• Wrote federal grant applications for irrigation districts

• Researched chains of title to prove riparian water rights • Prepared documents for trial

## SPECIAL SKILLS

• Proficient at graphic in Microsoft Excel

• Basic coding in C in Linux/Unix systems

• Proficient at writing state and federal grant proposals

## EDUCATION

BACHELOR OF SCIENCE, EARTH SCIENCE, CLIMATE AND ENVIRONMENT

UNIVERSITY OF CALIFORNIA, SANTA BARBARA - *EXPECTED GRADUATION DATE: JUNE 2022*

## Relevant Coursework

• Physical Geology

• Earth's Climate

• Biogeochemical Isotopes

• Field Studies in Geological Sciences

# Amy Zhang

## Personal Information

Address: 6689 El Colegio, Goleta, 93117, United States

Phone: 8057082657

Email: yuan_zhang@ucsb.edu

## Education

Bachelor of Arts, University of California, Santa Barbara OCTOBER 2 0 1 9 — JUNE 2 0 2 3

Major: Environmental Studies and Geography

Overall GPA: 3.74 Major GPA: 3.80

Course: Waste Management; Writing for Environmental Professions; Sustainable Infrastructure

## Extracurricular activities

Club leader, Environmental Protection Club, Shanghai, China SEPTEMBER 2 0 1 6 — JUNE 2 0 1 9

- Organize campus events to raise awareness of environmental protection and sustainability
- Build a school gardening to reduce carbon dioxide on campus
- Plant saplings in the western regions of China for four years
- Receive "The Best Club" in high school for three years

Activity planner, Student Union, Santa Barbara, California OCTOBER 2 0 1 9 — PRESENT

- Organize on-campus activities for international students
- Write activities' articles on social platforms
- Gain teamwork ability and communication skills

## Internship

Marketing internship, Dream Share Company, Shanghai, China OCTOBER 2 0 2 0 — NOVEMBER 2 0 2 0

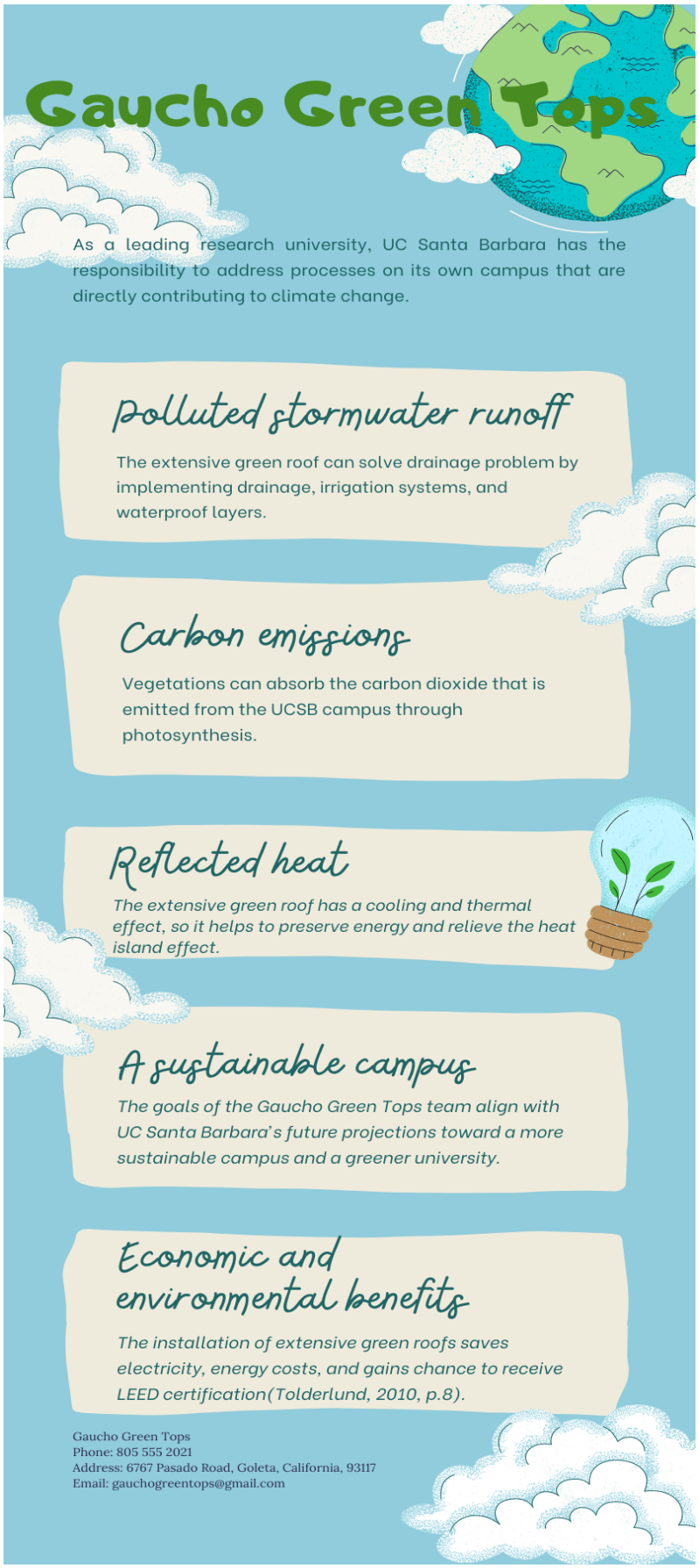
- Market and publicize the company’s profile on different social platforms
- Design posters and company's advertisements
- Summarize daily meeting documents

100% Renewable Energy Campaign, Calpirg, Santa Barbara, California JANUARY 2 0 2 1 — PRESENT

- Engage with campus departments and organize different events to raise awareness of renewable energy on campus
- Write news responses to the journalists to implement 100% renewable energy

goal in California

Appendix B) Brochure



## Appendix C) Glossary

The following definitions are defined by the United States National Park Service and the United States Department of Agriculture.

**Extensive Green Roof**: A green roof with a shallow growing medium with limited plant diversity and minimal watering requirements (United States National Park Service)

**Intensive Green Roof**: A green roof with a deep growing medium that has more soil, which can support more diverse vegetation selection including small trees (United States National Park Service)

**Invasive Species:** A non-native species whose introduction to an ecosystem is likely to cause harm to it (United States Department of Agriculture)

## 3.2 References

Appendix D) References

# References


Acks, K., Beattie, D., Berghage, R., Braman, D., Cox, J., Gaffin, S., Hillel, D., Hodges, S., Mankiewicz, P., Montalto, F., O'Keeffe, G., Ostrof, G., Parshall, L., Rosenthal, J., Rosenzweig, C., Rothstein, K., Solecki, W., Tillinger, D., & Towers, J. (2006). Green Roofs in the New York Metropolitan Region.

*Average weather in Goleta, California, United States, year round*. (n.d.). The Typical Weather Anywhere on Earth - Weather Spark. https://weatherspark.com/y/1430/Average-Weather-in-Goleta-California-United-States-Year-Round#Sections-Precipitation

Benefits of Green Roofs – California Roof. (2019). California Roof – The California Green Roof Project. https://calgreenroofs.org/benefits-of-green-roofs/

Breuning, J. (2021). *The Economics of Green Roofs from the Perspective of the Commercial Client*. Green Roof Technology Form and Function. http://www.greenrooftechnology.com/case-studies

Bruck, T., & Hammond, E. (2020, March 1). *Ohio University receives grants for green roof project*. WOUB Public Media. https://woub.org/2020/03/01/ohio-university-receives-grants-for-green-roof-projec/

California Natural Resources Agency. (2020). Urban Greening Program. https://resources.ca.gov/-/media/CNRA-Website/Files/grants/Urban-Greening-Program-Guidelines--Round-FourRevised-6182020.pdf?la=en&hash=BE61C1F7870166F141B247F69930F905AC876683

Cohen, A., Jasso, J., & Kessling, K. (2017). *Feasibility of Combining Solar Panels and Green Roofs on the Activities and Recreation Center*, 22.

Denworth, L. (2018, February 9). *The benefits of learning outdoors*. Psychology Today. https://www.psychologytoday.com/us/blog/brain-waves/201802/the-benefits-learning-outdoors

Department of Energy & Environment. (n.d.). *Green Roof*.

https://doee.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Section%203.2%20%20Green%20Roofs.pdf

Eldredge, B. (2016, September 27). *Case study: How to install a green roof on a private home*. Curbed. https://archive.curbed.com/2016/9/27/12830392/green-roof-installation-design-private-home

Emery, M. (2017, November 9). Solar-powered outdoor classroom unveiled in Alief. University of Houston. https://uh.edu/news-events/stories/2012/november/1109RibbonCutting.php

Environmental Protection Agency. (2020, August 12). *Greenhouse gas equivalencies calculator*. US EPA. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Environmental Protection Agency. (2021, February 10). *P3 student design competition*. US EPA. https://www.epa.gov/P3

Fineschi & Loreto. (2020, March 24). *A survey of multiple interactions between plants and the urban environment*. Frontiers. https://www.frontiersin.org/articles/10.3389/ffgc.2020.00030/full

Fusco, M. (n.d.). *Green Roofs: Dry in the Sky.* Pacific Horticulture Society. https://www.pacifichorticulture.org/articles/green-roofs-dry-in-the-sky/

Getter, K. L., Rowe, D. B., Robertson, G. P., Cregg, B. M., & Andresen, J. A. (2009). Carbon Sequestration Potential of Extensive Green Roofs. *Environmental Science & Technology*, *43*(19), 7564–7570.

Green Grid Roofs. (2017). *Green Roof Maintenance Guide*. GreenGrid Roofs. https://www.greengridroofs.com/wp-content/uploads/2017/11/GreenGrid_Maintenance_Guide.pd

Green Roof Plan. (2012, April 11). *Intensive vs. Extensive Green Roofs: What's the Difference?* https://www.greenroofplan.com/intensive-vs-extensive-green-roofs/

Green Roof Shelters. (2021). Green roofed outdoor classrooms. https://greenroofshelters.co.uk/green-roofed-outdoor-classrooms/

Green Roof Systems. (n.d.). Green Roof Technology | Green Roof Service LLC. https://www.greenrooftechnology.com/greenroof-system

Green Roof Types Weight Comparison Table. (2013, August). SIG Design & Technology.

https://www.singleply.co.uk/wp-content/uploads/2013/08/Green-Roof-Types-Weight-Comparison-Table-SIG.pdf

Going Green Guide. (n.d.). *Cost considerations*. Growing Green Guide | The Growing Green Guide for Melbourne project is investigating the potential to transform Melbourne's roofs, walls and facades into vegetated, leafy habitats. https://www.growinggreenguide.org/technical-guide/design-and-planning/cost/

*Installation & maintenance | NYC | United States | Green roofs NYC*. (2018). greenroofsnyc.com. https://www.greenroofsnyc.com/installation-maintenance

*Going solar: The benefits of solar panels on your roof*. (n.d.). Solar Metric. https://solarmetric.com/learn/going-solar-the-benefits-of-solar-panels-on-your-roof/

Kuronuma, T., Watanabe, H., Ishihara, T., Kou, D., Toushima, K., Ando, M., & Shindo, S. (2018). CO2 payoff of extensive green roofs with different vegetation species. *Sustainability*, *10*(7), 2256. https://doi.org/10.3390/su10072256

Kris Walker. (2020, October 14). *Environmental benefits of a roof garden*. AZoCleantech.com. https://www.azocleantech.com/article.aspx?ArticleID=341

LEED Certification Review Report. (2011, May 9). *UCSB Davidson Library Addition Renewal*. UC Santa Barbara Library. https://www.library.ucsb.edu/sites/default/files/attachments/about-library/green-features-new-library/LEEDscorecard.pdf

National Park Service. (n.d.). *Green roof benefits—Technical preservation services, National Park Service*. NPS.gov (U.S. National Park Service). https://www.nps.gov/tps/sustainability/new-technology/green-roofs/benefits.htm

NY Daily News. (2013, March 8). Big town Going Green. MBB Architects. https://www.mbbarch.com/wp-content/uploads/2019/09/daily-news-full10.pdf

Propel Studio. (n.d.). Vernon elementary school — Propel studio architecture | Portland, Oregon. https://www.propelstudio.com/project/vernon-elementary-school-outdoor-classroom/

SAMAD, M. A. (2020, November 9). Egypt: Green roof classrooms improve the education experience. World Bank Blogs. https://blogs.worldbank.org/arabvoices/egypt-green-roof-classrooms--improve-education-experience

Scape studio. (2021, February 3). Greenpoint library and environmental education center. SCAPE. https://www.scapestudio.com/projects/brooklyn-public-library-greenpoint-branch-environmental-education-center/

Semper Green. (n.d.). *Maintaining a green roof*. Sempergreen - Marktleider in oplossingen voor groendak & groene gevel - Sempergreen. https://www.sempergreen.com/us/solutions/green-roofs/maintaining#:~:text=An%20extensive%20green%20roof%20is,them%20when%20conducting%20this%20maintenance

Shin, E., & Kim, H. (2019). Benefit–cost analysis of green roof initiative projects: The case of Jung-gu, Seoul. *Sustainability*, *11*(12), 3319. https://doi.org/10.3390/su11123319

SIG Design & Technology. (2017). *Green Roof Systems Overview*. https://www.singleply.co.uk/wp-content/uploads/2017/01/2017-Green-Roof-systems-overview.pdf

SIG Design & Technology. (n.d.). *Benefits of Green Roofing*. https://www.singleply.co.uk/green-roofs/benefits-of-green-roofing/

Soil science of america. (n.d.). Green roofs. Soil | Soil Science Society of America. https://www.soils.org/about-soils/green-roofs/

Sood. (2019, August 10). Article top 9 plants that provide oxygen. Ferns N Petals. https://m.fnp.com/article/top-9-plants-that-provide-oxygen

*Solar photovoltaic technology basics*. (n.d.). Energy.gov. https://www.energy.gov/eere/solar/solar-photovoltaic-technology-basics

Sustainable Technologies Evaluation Program (STEP). (2013, March 13). *Evaluation of an extensive green roof - York University, Toronto, Ontario - Sustainable technologies evaluation program (STEP)*. https://sustainabletechnologies.ca/home/urban-runoff-green-infrastructure/low-impact-development/green-roofs/york-university/

Syracuse University. (2020, November 13). *Green roof*. SyracuseCoE. https://syracusecoe.syr.edu/what-we-offer/research-facilities/green-roof/

Tamlin, E. (2020, August 11). COVID19 and the rise of green roof top classrooms? — Living
architecture monitor. Living Architecture Monitor.
https://livingarchitecturemonitor.com/news/2020/8/11/covid19-and-the-rise-of-green-roof-top-classrooms

Tolderlund, L. (2010, October 10). *Design Guidelines and Maintenance Manual for Green Roofs In the Semi-Arid and Arid West*. Environmental Protection Agency.
https://www.epa.gov/sites/production/files/documents/GreenRoofsSemiAridAridWest.pdf

UC Santa Barbara Sustainability. (2017). *UCSB Draft Water Action Plan*.
https://sustainability.ucsb.edu/plans-reports

UCSB. (2018). *UC Santa Barbara utility and energy Services annual energy report*.

UCSB Library Impact Report 2018-2020. (2020). UC Santa Barbara library.
https://www.library.ucsb.edu/sites/default/files/ucsb_library_impactreport2020.pdf

United States Department of Agriculture. (n.d.). Home | US Forest Service.
https://www.fs.fed.us/wildflowers/invasives/index.shtml#:~:text=What%20is%20an%20Invasive%20Plant%20Species%3F&text=Non%2Dnative%20(or%20alien),(Executive%20Order%2013112).

University of California Energy CAP. (2017). *Executive Summary by Commodity*. University of California, Santa Barbara. https://www.ucop.edu/energy-services/_files/BL12_-_Executive_Summary_by_Commodity-UCOP1.pdf

What is a green building? (n.d.). World Green Building Council.
https://www.worldgbc.org/what-green-building

ZinCo Green Roof Systems. (n.d.). *ZinCo Systems for Extensive and Intensive Landscaped Roofs*. https://zinco-greenroof.com/green-roof-systems

- **This page has intentionally been left blank -**