A Rooftop Solar Development Plan for the Energy Coordinating Agency of Philadelphia

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ABSTRACT

A rapid transition from carbon-intensive energy production methods to clean and renewable energy technologies is imperative in the fight against climate change. During a political moment in which the public sphere is recalibrating this transition, the role of private development is increasingly critical. The present study examines a specific rooftop solar energy development plan for the Energy Coordinating Agency (ECA) of Philadelphia, seeking to answer the question of what the most viable and effective plan for installing rooftop solar on the ECA building is, and what quantity of carbon emissions would be avoided as a result of this system. Through careful research and analysis, this study determines that the C-PACE (Commercial Property Assessed Clean Energy) Finance Program is the most viable financing option for this project. Additionally, based on the calculated number of panels that the ECA can install, data provided by the ECA, and the anticipated costs associated with the investment, this study predicts that the ECA will see a 25% present return on their investment into rooftop solar PV. The main driver of this return will be the cost savings determined by the PV system’s average annual electricity production and the forecasted increase of the electricity retail price. Over the PV system’s projected 22-year lifetime, this study estimates that almost 2.5 million pounds of CO2 emissions could be prevented, the equivalent of taking 245 average passenger vehicles off the road in a year. From these findings, this paper demonstrates the immense impact that private actors can have in mitigating the anthropogenic role in climate change as well as the potential to increase the affordability and efficiency of clean energy technologies so that they become viable alternatives to fossil fuels.

BACKGROUND

- CO2 emissions account for 80% of contributions to climate change from current greenhouse gas emissions.
- In the US, the electric power sector CO2 emissions totaled 7,561 MMT in 2017, the second most polluting economic sector.2
- Recent drastic cost reductions in production of PVs are paving the way for solar energy to be competitive with fossil fuel systems.3
- In Philadelphia, NREL estimates that there are over 35,000 suitable buildings for rooftop PV.
- Despite the worldwide expansion of solar, global demand is driven by government incentives and regulations. By early 2017, almost all new large-scale projects were due to voluntary utility and corporate sourcing.4
- The role of private development in the transition to clean energy is imperative, and adding solar PV to the power mix can reduce costs associated with the generation of electricity.5

METHODS

- Analyzed financing options
- Calculated the number of panels
- Calculated return on investment
- Projected annually prevented CO2 emissions

RESULTS

1. C-PACE (Commercial Property Assessed Clean Energy) Finance Program

- The C-PACE Finance Program is the most viable financing option. The DOE ACE Program is not a viable option because the maximum grant/loan combination provided covered less than 30% of the total project cost, so the ECA would have to fund approximately $1.74 million on their own.
- By leveraging the C-PACE Finance Program, it is projected that the ECA would see a 25% present return on their investment into rooftop solar PV. The main driver of this return will be the cost savings determined by the PV system’s average annual electricity production and the forecasted increase of the electricity retail price. Over the PV system’s projected 22-year lifetime, this study estimates that almost 2.5 million pounds of CO2 emissions could be prevented, the equivalent of taking 245 average passenger vehicles off the road in a year. From these findings, this paper demonstrates the immense impact that private actors can have in mitigating the anthropogenic role in climate change as well as the potential to increase the affordability and efficiency of clean energy technologies so that they become viable alternatives to fossil fuels.

CONCLUSION

- The ECA is a nonprofit organization, and they would not be able to afford the investment in a utility-scale PV without the help of C-PACE. Therefore, it is imperative that the capital investment in solar be reduced, but until that is technologically feasible, more accessible financing options are needed. Moreover, the quantity of CO2 emissions that can be prevented with rooftop PV is extremely significant, demonstrating the immense impact private actors can have.

ACKNOWLEDGEMENTS

I am incredibly grateful for the guidance and support received from my mentor, Dr. Andrew Huemmler, as well as Dr. Jane Dinovitch, Dr. David Goldsby, and the Class of 2020. I am especially thankful to Steve Braden and Dave Hufnagle at the ECA for their help and interest in the project.

REFERENCES

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Experiences of Urban Oil Refining In South Philadelphia
Alexandre Imbot
Thesis Mentor: Dr. Bethany Wiggin
University of Pennsylvania, Earth and Environmental Science Department, 2020

Abstract
America's oldest crude oil refinery has for over a century contaminated the soil of its foundation, the waters of its perimeter, the air it Fraser in its processes, and the noticed of its neighbors for which is supposed to share the right to exist. As the facility dumped its waste and flooded the sides of Philadelphia with hazardous levels of toxic pollution, its emissions and human damages were largely unmonitored, unmeasured, and unregulated over the course of its history. This paper draws attention to the human consequences of urban crude oil refining when local "non-expert" knowledge is left out of the risk assessment discussion.

Through an exploration of the Penn Program for Environmental Humanities Futures Beyond Refining experiment, a community-based participatory research project, this paper highlights the development of a new set of ethnographic data collected alongside a group of experts often overlooked: longtime refinery neighbors, and suggests how making meaningful space for local knowledge to contribute to the assessment of large polluting facilities as crucial for decision makers to better address environmental justice challenges. Where private industry and compliant government officials permit disastrous aggressions against local community, it is in the voices and invaluable primary knowledge held by residents that the needs for future demands and justifications for other operations will emerge.

Background: The Phila. Refinery
America's oldest crude oil refinery sits on 1.250 acres located entirely within the City of Philadelphia. It processed over 700,000 barrels/day, making it the largest refinery on the east coast.

Single largest emitter of toxins air pollution in Philadelphia. There is no accurate public historic databases for facility air emissions and air-quality readings.

The refinery exploded, shut down, and filed for bankruptcy in 2019. An official inquiry stated on its fate was ongoing.

Over 100,000 residents live within a quarter mile of the refinery. 98% of refinery neighbors are not white. Their median house hold income is $46,000.

There is a public health crisis, including asthma-related asthma rates and cancer rates for those living on refinery fence line.

Surrounding communities have long been shut out of the risk assessment and decision making process regarding refinery action.

Feature Question
How can treating primary knowledge held by those considered “non-experts” influence discourse around the consequences of heavy polluting industry beyond traditional risk assessment methodologies?

Methods
Co-creating, documenting, and evaluating the Penn Program for Environmental Humanities Futures Beyond Refining experiment.

Results
The outlined model for the FBR project facilitates the co-creation of a very successful experiment. From Penn co-creating and co-creation, the FBR signature group's Perry and refinery tour had lead dozens of students, activists, community members, and parade students through a journey from childhood through decades centered around being, belonging, and believing in the refinery.

Discussion
The conception, design, execution, and evolution of the FBR experiment help to ask and answer these essential questions:

- What is required to meaningfully involve the Academy and the community?
- How do we create knowledge and who do we consider experts?
- What types of expertise is needed to bring communal discourse forward?
- How are new knowledge communities created? What do they look like?
- How must a project be documented to assure mutually beneficial outcomes?
- With criteria manifesting at different speeds, how should the design of a CBPR project facilitate adaptation and organic evolutions?
- What is the role of trust in building relationships, and how does this conversation extend to the incorporation of lived experience and primary knowledge in the official decision-making processes i.e. Cost benefit analysis and risk assessment?

References

Figure 1: The Futures Beyond Refining experiment kids.

Figure 3: A recap of the tour. Mr. Charles Brown, a co-creator, remembering the memories of the refinery. A photo of Mr. Larry Brown, father of the tour guide, as the tour guide drives along the refinery's perimeter. The tour guide leading the tour of the refinery neighborhood, along with its five stops.

Figure 2: Primary method for project rapid design process, articulated for our topic and usefulness of the community members and Penn students.
Addressing Food Waste in Philadelphia: The Role of Food Policy Councils
Colleen Kutschora; Readers: Michael Kulik, Jane Dmochowski
University of Pennsylvania, Philadelphia, PA

ABSTRACT
This study seeks to understand how the Philadelphia Food Policy Advisory Council (FPAC) addresses food waste issues in Philadelphia. Responses from semi-structured interviews with FPAC members highlight the council's relationship with community members, local businesses, restaurants and start-ups. As a result of this network, they are able to craft well-researched policy recommendations. FPAC's process is a model for collaborative, bottom-up solutions to FLW that may be useful in the creation of similar councils in communities where such an organization does not already exist, or to provide a point of comparison for existing food policy councils (FPC) who are tackling similar issues.

BACKGROUND, CONT.
- Food Policy Councils (FPC) are local initiatives focused on addressing food issues like FLW (2). Each FCP chooses its functions and focuses based on the interests of the community it serves (3).
- Here, we seek to understand how FPAC addresses the unique issues that the Philadelphia community faces:
  1. High Rates of Poverty
  2. Dependence on Emergency Food Sources
  3. SNAP Participation Rates
  4. Land Access
  5. Diet Related Health Indicators
  6. Low Produce Consumption
  7. Status of Food Workers
  8. Senior Food Insecurity
  9. School Cooking Facilities
  10. Loss of Farmland

METHODS
Semi-structured phone interviews were conducted, recorded, and transcribed. Key responses were organized by theme: roles, goals, network, successes, obstacles, and lessons.

RESULTS
GOALS: The reduction of food waste through food recovery.
PARTNERS: Major food recovery and distribution organizations, local businesses such as restaurants and grocery stores and players in local government.
STRATEGIES: Collaboration, networking, educating and facilitating.
SUCCESSES: Creating local jobs and pathways to connect hungry people to food (P1); negotiating schedules and finding a time to brainstorm with everyone (P2); Collaboration and the resulting policy and program implementation (P3).
BARRIERS: Logistical difficulties involved in recovering and transporting food (P1); lack of experience due to FLW being a relatively new field of study (P2); negotiating schedules (P3).

<table>
<thead>
<tr>
<th>ROLES</th>
<th>LESSONS</th>
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| P1    | "The council’s job is to bridge the needs of the community with policy."
| P2    | "[Design]ing the deep dive into the research of the how [...], and giving them the tools and best practices that they can then take and make it into reality."
| P3    | "[Creating]ing recommendations that can be pushed, whether it’s through the city of Philadelphia or through collaboration of businesses in Philadelphia."

"It's not just about [...] nonprofit actors or individuals or communities. (We) need a bringing together of all these pieces to make the solutions work.”

"The biggest lesson is that nothing is too big, nothing is stupid to ask, nothing is stupid to say.”

"The more you can just break it down to a human level, an emotion level, and realize that [...] the people that you're proposing these policies to are all people—and they're emotional people.”

ACKNOWLEDGEMENTS
Special thanks to every FPAC member past and present who helped me along the way. Thank you to my mentor, Professor Michael Kulik, to my instructors, Dr. Jane Dmochowski and Dr. David Goldsby, to my classmates in ENVS 405-001, and to my friends and family.

REFERENCES


DISCUSSION & CONCLUSION
- Major Takeaways: community outreach and the importance of securing the support of government through effective policies.
- FPAC’s research serves as the foundation for the policy solutions which address the issues of FLW, hunger and food insecurity.
- Further Research Potential: FPCs, the processes they must follow to achieve their goals and the potential for expansion to other topics would greatly benefit the field.
Modeling Host Phenology and Multi-Host Parasitic Infection Using E. Coli and Bacteriophage λ
Bonnie Mendelson1, Hannelore MacDonald1, Kayleigh O'Keefe1, Dustin Brisson1
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Abstract
Parasite fitness is partially dependent on a parasite's ability to be transmitted to new hosts. Phenology, a property of species that control their organism's life history, can impact rates of parasitic infection of a parasite's host and is important in multi-host parasitic infection. This work aims to experimentally validate a mathematical model using E. coli and bacteriophage lambda. Using two strains of E. coli, phage was isolated from both bacteria and will be used to infect specific strains of E. coli with different exposure times to the phage “parasite” over the course of multiple seasons. We expect that the closer in time these two hosts are infected relative to each other, the higher the rate of infection.

Introduction
- Multi-host parasite systems are challenging to study including the study of impacts of seasonality on these systems contain multiple organisms with different life history strategies, yielding different activities depending on the season and environment.
- Understanding the impact of seasonality on multi-host parasite systems is especially important due to climate change, predicting the spread of various diseases among humans, and studying patterns of biodiversity in various ecosystems.
- To study impact of host phenology on parasite transmission we are developing an experimental system using bacteriophage lambda and E. coli. We use an experimental system to determine the impacts of various phenological fluctuations on multi-host parasite systems.
- Using E. coli and phage that have short life spans, we are able to control, and are replicable allows for the production of an effective system to study effects of phenology on multi-host systems.
- A phage that alternates between two host types, OmnaF and Lambda, will be isolated and used for experimental analysis.

Methods and Materials
- Proof of Concept: develop lambda-e.coli where lambda receives host recognition protein (H protein) from a phage, lambda E. coli (λFC33). This strain 1
- Knockout the J gene (encodes protein necessary to recognize the receptor on the host to initiate phage infection) of E. coli bacteria and insert a different J gene that encodes for a different phage tail to ensure that model can be carried out experimentally.
- Linear DNA phage was inserted into WT lambda bacteria via electroporation and insertion of the phage DNA packaged to anomalous knock in of P220 fragments
- Insertion was confirmed via PCR and electrophoresis sequencing
- Plage from JKO + new J fragment was isolated and crossed with bacteria from non-cloacogenic bacteria to confirm the knock in
- Construction of two strains of bacteria to create obligate two-host pathogens, constructing two strains, OmnaF and Lambda, forcing the phage to either host
- Two phenotypes were designed to be inserted into two non-cloacogenic bacterial strains with two different tail receptors, OmnaF and Lambda
- Plasmid insertions were completed using electroporation.

Future Steps: Testing Model and Expected Results

Discussion
- This study has the potential to inform understanding of the timing of disease transmission and influence seasonality of causing disease.
- Phenology drives ecological introductions; understanding its involvement in parasite transmission is crucial to understanding disease transmission.

Future Directions
- The system will be used to test different aspects of phenology that can impact multi-host parasite systems by manipulating timing, host concentrations, and parasite concentrations.
- This system (Fig. 1) will be applied to other multi-host parasite systems to understand patterns of disease transmission in humans, the impact of changes in seasonality or multi-host parasite systems that can affect biodiversity, and how climate change will influence disease dynamics in the future.

Acknowledgements
Thank you to the Davis Laboratory for providing bacterial strains used for experimentation. Thank you to members of the Brisson lab.
### Abstract

Water in Western Puerto Rico: Determining Vulnerabilities in a Changing Climate

#### Background & Objective
- Public Water Systems and Service Authority (PWSA) data was used in the study.
- The dataset includes 71 PWSA with 52% of the residents served.
- This project was to determine the vulnerabilities of the water system in the study area and the implications of these within a changing climate.

#### Study Area

![Study Area Map]

### Methods
- Conducted a statistical analysis of vulnerabilities in the system.
- GIS and spatial analysis.
- Use of PWSA data and Service Authority (PWSA) information.
- Analysis of climate change impacts on water systems.

### Results & Discussion

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<thead>
<tr>
<th>Vulnerability</th>
<th>Vulnerable Sites</th>
<th>Effects</th>
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<tbody>
<tr>
<td>Aging infrastructure</td>
<td>High vulnerability</td>
<td>Poor water service, reduced water quality, water system failures</td>
</tr>
<tr>
<td>Communication</td>
<td>Medium vulnerability</td>
<td>Water service degradation, increased water losses</td>
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<tr>
<td>Water supply</td>
<td>Low vulnerability</td>
<td>Water service issues, water system inefficiencies</td>
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<tr>
<td>Disaster management</td>
<td>High vulnerability</td>
<td>Poor water service, increased water losses</td>
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### Conclusions
- There is a need to improve water system in Western Puerto Rico and address vulnerabilities.
- The result of the study will be used to improve the water system and address vulnerabilities.
- The study recommends future work including enhanced data collection and increased monitoring of water systems.

### Acknowledgements

The project was funded by the Water Center at Penn and the Department of Earth and Environmental Sciences, University of Pennsylvania, Philadelphia, PA.
Quantifying Organic Functional Group Composition of Aerosol Particles from Pismo Beach

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Abstract
Higher concentrations of particulates were documented in San Luis Obispo (SLO) county as compared to other coastal regions in California. Organic aerosols at Pismo Beach, located in SLO, likely derive from multiple sources considering the beach’s unique location. To investigate the contributions of the organic functional groups affecting the aerosol composition at Pismo Beach, submicron particles were sampled during May 2019 near the beach during using 1 micron and 2.5 micron filter pumps and analyzed using Fourier transform infrared (FTIR) spectroscopy and machine learning algorithms in R. Results indicated highest proportions of aldehydes and ketones, with overall greatest total organic functional groups concentration found on May 20. This is likely due to marine bubble bursting events, photosynthetic oxidation reactions, and land-sea breeze fluctuations. This work can inform on the climato-ecological properties of the seasonal groups present and potentially guide future air pollution mitigation efforts at Pismo Beach.

Introduction
- Organic aerosols can be created by biomass burning and fossil fuel combustion processes (Gao et al., 2019).
- Pismo Beach, located on the Guadalupe-Sierra Pennies, is near residential areas, agricultural fields, a petroleum refinery, and light industry (Cahill et al., 2011).

Methods
- Air samples were collected during the morning, afternoon, and night at San Luis Obispo County Fire Station 22 using 1 micron and 2.5 micron filter pumps.
- Samples were analyzed in a lab using Fourier transform infrared (FTIR) spectroscopy.
- An automated algorithm in R developed by Martin et al., which includes peak-finding, quantified functional group masses.
- FTIR Imaging was used to visualize monsoon and monthly aerosol optical depth in SLO.
- Wind directions were obtained from Weather Underground.

Fourier Transform Infrared Spectroscopy Results

Discussion
- Greater total organic functional group concentration was obtained on May 20 at approximately 6 am.
- Large proportions of aldehydes (43%) for PM2.5 filter pump and 78% for PM1 pump may be due to elevated organic aerosols caused by photosynthetic oxidation (Rao et al., 2021).
- Large proportions of aldehydes can be attributed to chemical reactions involving cloud nucleation (Russell et al., 2011).
- During the day, wind will blow from the hilly terrain over the ocean to lower pressures over the land causing the sea breeze (marine influence from bubble bursting and sea spray).
- Primary limitations include a small sample size and use of algorithm with an uncertainty of ±20%.
- Future work should include positive matrix factorization to confirm the sources of the organic aerosols.
- With a larger sample size, the Markov chain Monte Carlo simulation technique might be used to account for missing data (example: Google Earth image).

Conclusion
- The location of Pismo Beach provides a unique influence on the beach’s aerosol composition.
- Research recognizes that variations in the land-sea breeze heavily affect the distribution of aerosols over the beach.
- Study can be referred to in evaluating the sources of aerosols and potential implications of greater air pollution mitigation efforts near Pismo Beach.

References

Acknowledgements
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The Impact of Small Dam Removals on Property Values and a Case Study in Lexington, Virginia

Kirk Waller

Abstract
This project used past sales data as well as price estimates and attribute data to find the impact that the removal of the Jordan’s Point Dam in Lexington, Virginia had on nearby properties. Dam removal projects have become increasingly common in the past few decades, since many dams in the United States are aging and losing their functionality. Moreover, past dam removals have shown that the natural riparian ecosystem restores itself quickly. However, a major concern in the discourse surrounding dam removal projects is that lower water levels will adversely affect property values. But this data showed that house value increased more over time in the area near the dam than control groups further away from the dam, and that proximity to the dam’s location supported houses’ prices more after removal. These conclusions support future dam removal projects, since they add another case to the list of successful dam removals, and provide insight into how people put monetary value on ecosystem services.

Main Points
As dams age, they deteriorate and become backed up with sediment. The floods that they were built to control become damaging again and they run the catastrophic risk of breaching. With the licenses of tens of thousands of dams across the United States expiring in the near future, decisions have to be made—should they be repaired or removed?

Reasons for Removal
- Dams disrupt the natural temperature and flow of the river
- Rivers revert quickly to their natural state after a dam is removed
- Aging dams are expensive to fix and cost even more to maintain regularly
- Damsafety.org cites 16 public safety hazards around dams, which include swift currents, rapid changes in water levels, seepage and seepage, and hydraulic rollers

Methods
Data Collection (Sources: Zillow, ReMax)
- Physical attributes of 180 houses across three neighborhoods—see Figure 2
- Pricing data across 4 time periods—Before the decision to remove the dam (T1), date of removal (T2), present day (T3), 1 year future estimate (T4)

Holes in the data
- Raw property with no price point for a given time T was eliminated from the data and calculations for that time
- Imputation—prices were imputed using the results of regressions on existing prices and attributes

Results
Raw Method
- Small but persistent shift toward higher prices over time in Area 1 curves, where the dam was—see Figure 3
- Control areas show less of a clear trend and T4 curves are fragmented—see Figures 4 and 5

Imputation Method—
- The purpose of this was to make sure data wasn’t skewed because of absence of data
- Little deviation from raw data, but the curves didn’t break down—see Figures 6, 7, and 8

Conclusions
- The dam removal had a neutral to slightly positive impact on nearby property values relative to other comparable houses
- Significance and impact of having waterfront went up within Area 1 after the dam was removed
- Area 1 had the highest percent change in average price across the time periods with the lowest standard deviation
- If areas are taken as an aggregate, every additional meter closer to the dam added about $8 to the property’s value, but taken as individual that variable is insignificant
- Potential reasons for these impacts on prices after the dam was removed
- Safety—hydraulic roller eliminated
- Reduced flooding due to lower water level and riparian buffer—yards and even houses upstream on the bank used to flood during heavy rains
- Value in the aesthetic of a natural riparian ecosystem

Areas of Improvement
There were only so many homes that were bought and sold in these specific areas over this roughly four-year period. Therefore much of the price data is based off of estimates from Zillow and ReMax or an imputation that I did myself. Data from the T4 period was particularly unreliable—Zillow future estimates tend to be optimistic, and there were only 23 homes from Areas 2 and 3 that were either for sale or had a 1-year future estimate, resulting in many gaps. If I were to continue this study, collecting good quality data would be the main focus of my efforts, by using the Multiple Listing Service instead of public websites to get clear and consistent appraisal data.
Studying the Effects of Upstream Dam Sediment Capacity On Seagrass in the Upper Chesapeake Bay through Coupled Remote Sensing and In-Situ Data

Abstract

Seagrass beds, one of the most productive ecosystems in the Chesapeake Bay, are vulnerable to environmental stressors like turbidity. Conowingo Dam, located 10 miles upstream of the Bay, has reduced sediment retention capacity, placing it in a dynamic equilibrium state. The goal of this study is to determine the extent to which sediments from Conowingo impact the density of seagrass in the Susquehanna Flats bed in the upper Chesapeake Bay. Field measurements of discharge and seagrass density were compared with parallel analysis of MODIS images. MODIS analysis assessed how remote sensing can be used to indirectly determine turbidity and therefore determine the effect on seagrass. Work completed in this study provides important understanding of the potential long-term ecological impacts associated with hydrologic modifications on valuable downstream ecosystems.

Introduction

- The Chesapeake Bay is the largest estuary in the US.
- Seagrasses are ecosystem engineers, modifying the benthic landscape to form dense meadows that foster high productivity and biodiversity.
- Seagrass beds are vulnerable to excess sediments because they prevent light needed for photosynthesis from penetrating the water column, causing seagrass loss.
- The Conowingo Dam has lost most of its ability to retain sediments and prevent sediments from flowing downstream into the Bay.

Methodology

- Discharge (m³/s) values at Conowingo were imported into R, using the USGS USGкры library, and averaged annually.
- Submerged aquatic vegetation (SAV) density values, quantified on a scale from 0-4, were collected and averaged annually.
- MODIS images were imported into Google Earth Engine for processing. Images were filtered spatially and temporally, cloud masked, and enhanced to 11B.
- Supervised and unsupervised classifications were performed to group pixels into three classes: clear water, turbid water, and land.
- Percent turbidity of the water in the region of interest was calculated by dividing the number of turbid pixels by the sum of clear and turbid pixels.
- Correlation coefficients were calculated using two methods: Kendall and Spearman. Outlier data from 2011 was removed and they were calculated again.

Results

- Discharge and turbidity show a negative correlation (-0.5 to -0.2).
- Turbidity and density show a positive correlation (0.6 to 0.83).
- Discharge and density show a negative correlation (-0.69 to -0.44).
- The inclusion of data from 2011 does not appear to have a major impact on the correlation values.

Discussion

- Isolating a single system in nature is near impossible. External influences may account for the lack of statistical significance in the correlations between variables.
- Ground truthing is necessary in order to improve MODIS classification accuracy.
- Finding more cloud-free images may increase classification accuracy.
- Direct measurements of suspended sediment values may be more significant than discharge values.

Conclusion

- The unexpected negative relationship between discharge and turbidity may indicate that the MODIS analysis is not completely accurate.
- The negative relationship between discharge and density indicates that there may be a negative impact of discharge and sediment from Conowingo on seagrass downstream.
- Considerations need to be had regarding the future of Conowingo Dam, specifically strategies for mitigation of downstream ecological effects.

References

5. Anderson, J. (2003). Certain species are still found in remote areas, but they cannot be accurately assessed using remote sensing techniques.

Acknowledgments

The author acknowledges the assistance of the Department of Natural Resources and the University of Pennsylvania for their continued support and encouragement. Special thanks to J. J. LaPolla for his invaluable contributions throughout the process.
Statistical Modeling of Coral Reefs
Ecological Modeling and Time Series Forecasts for Key Species

Abstract
Most research on reef-dwelling organisms has involved small-scale investigations limited to a specific reef or region. In this study, we leveraged the 10,000-dive Reef Check (RC) dataset to develop global assessments of four species of fishes, two species of invertebrates, and four categories of corals and algae. First, random forest and zero-inflated Poisson models were developed to describe the relationships between these key organisms and a variety of anthropogenic and biological variables. In short, sedentary organisms were more affected by anthropogenic stressors and soft coral appears to handle anthropogenic stress better than hard coral. Second, we developed auto ARIMA and linear regression models to predict these key species' counts in the Caribbean. The models exhibited high training accuracy but low testing accuracy. However, they showed that in the past 22 years, Snapper (Lutjanidae) and Butterfly Fish (Chaetodontidae) have decreased by 64.78% and 74.02% respectively. We plan to build on both these ecological and forecasting models in the coming months.

Background
Reef Check (RC) is a reef conservation nonprofit that trains amateur divers to collect data (RC manual 2006). Data collection involves conducting 100m transects [figure A] as well as providing site descriptors such as anthropogenic stressors and location.

RC Transect Diagram

Methods
First, we cleaned and reshaped the data so that each row represented a unique dive for a given day on a given reef. From this reshaped dataset, we developed two datasets for explanatory modeling and a third for forecasting.

- **Original**: the original reshaped and cleaned dataset without missing data imputation.
- **MICE**: the original dataset above but with anthropogenic data imputed using Multiple Imputation by Chained Equations (MICE).
- **Time Series**: a bivariate timeseries developed from the the original dataset. These were aggregated quarterly and were limited to reefs in the Caribbean.

Using the first two datasets, we developed explanatory models, namely Zero-Inflated Poisson and Random Forest models. Both models used three sets of independent variables (anthropogenic, organism, both) to model 10 dependent variables [figure E].

Dependent Variables

Using the third dataset we developed forecasts of the above 10 variables using Linear Regression and Auto ARIMA.

Results
Explanatory modeling yielded interesting results; however, further investigation is required to draw conclusions. Here are the key findings for global explanatory modeling:

- Soft Coral is Replacing Dead Hard Coral
As demonstrated in the Partial Dependence plots in [figure C], hard coral (HC) decreased with increased levels of stress. However, soft coral (SC), which should have similar responses to these stressors, showed a positive relationship. The best explanation for SC increasing with elevated anthropogenic stress is that HC mortality allows SC to grow.

Sedentary Organisms are More Sensitive to Anthropogenic Stressors
Finally, as demonstrated in [figure E], organisms were modeled best with other organisms whereas corals and algae were modeled best with anthropogenic stressors.

Testing Accuracy for ZIP

PD Plots for Hard and Soft Coral

Reefs are Below Carrying Capacity
As demonstrated in [figure D], there was a steady increase in Butterfly Fish (Chaetodontidae) as their predators also increased. If an ecosystem is at carrying capacity, we would expect to see an inverse relationship; therefore, reefs globally must not be at carrying capacity.

PD Plots for Butterfly Fish

Conclusion
In summary, these ecological findings were promising, however further investigation is required. Likewise with the TS forecasts, further iteration is required to develop meaningful results. The team plans on continuing this research in the coming months.

References

Michael Berk '20
The Potential for California to Implement Utility-Scale Floating Photovoltaics on its Reservoirs

Grace Boroughs

University of Pennsylvania, Department of Earth and Environmental Science 2020

Thesis Advisor: Dr. Andrew E. Huenemoller • Thesis Instructors: Dr. Jane E. Dimochowski and Dr. David Goldsby

ABSTRACT

Floating solar photovoltaic (FSPV) is a new form of renewable energy generation with unexploited potential. Though only eleven FSPV projects currently exist—and only two of them utility scale (≥1 MW) the technology has the potential to produce 10% of US energy needs. A unique advantage of this technology is the cooling impact of locating the panels on the water. The shading of the panels decreases evaporation from the water body while the cooling effect of the water increases panel’s efficiency. Another benefit of FSPV is that it conserves land, taking up previously underutilized surface area. California (CA) is the leading state in FSPV and in solar energy in general. But CA’s total potential for utility scale FSPV has not been analyzed comprehensively. Using the National Inventory of Dams data to determine suitable water bodies, I calculated a theoretical maximum energy potential of 74 gigawatts for CA, assuming 30% of FSPV surface coverage. Capturing the largest projects at 15 GW, I determined a more conservative estimate of 1.6 GW for the state. To identify the reservoirs with the greatest potential for FSPV, I used the National Solar Radiation Database (NSRDB) to rank mean irradiance for each county. This, combined with Google Earth displayed four ideal water bodies for development.

BACKGROUND

- FSPV PV panels coated in anti-corrosion material, mounted onto floating plastic pontoons on the water surface.
- 2007: first FSPV project was implemented in Napa, CA
- Aichi Project array by National Institute of Advanced Science in Japan was the first to test the efficiency of the technology.
- Most of the FSPV growth has been in Asia.
- FSPV decreases reservoir evaporation because panels shade water, temperature and solar irradiance.*
- FSPV decreases evaporation by 90% compared to uncovered water surfaces in India and Chile.*
- Largest FSPV installation: 70 MW capacity in Anhui, China.*

Figure 1: Illustrated FSPV Generation Cycle

Figure 2-5: Google Earth consists of Most Ideal Reservoirs. Source: Google Earth

SOLAR & EVAPORATION EQUATIONS

1. System Capacity [kW] = (Surface Area [acres] x 0.201 acres) x (300 kWh/acre)
2. Annual Electricity Output [kWh] = Output per unit power (kw/hkwp) x System capacity [kW]
3. Value of Electricity Output = Annual Electricity output [kWh] x Average value of electricity [$/kWh]
5. Value of Water Saved [($/yr)] = Water Saved [(acre-ft)] x Average value of water saved/sold [$/acre-ft]

METHODS

1. Sort National Inventory of Dams Database to exclude reservoirs unfit for FSPV development.
2. Filter out recreational use reservoirs.
3. Remove water bodies within 50 ft. of land.
4. Eliminate reservoirs with a surface area of <50 acres.

1. Use the National Solar Radiation Database’s (NSRDB) Multi-Year PSM Normal Irradiance to rank the counties
2. Identify reservoirs in counties with irradiance >5
3. Google Earth assess the ideal surface area and irradiance to idealize 4.
4. Ideal reservoirs for development

RESULTS

- 807 reservoirs appropriate for FSPV
- 1560 kWh/hkwp: output per unit power for an average solar irradiance of 6.9.
- 1675 kWh/hkwp: output per unit power for highest irradiance counties in CA.

- 4 counties were identified to have over 8 kW/h/acre/m/day

WORKS CITED

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Figure 3: Single California 2019 State Source: CA.gov
Figure 4: (right) California In-State Electricity Capacity (GWh) with Conservative FSPV Capacity Replacing High Carbon Capacity.
- Future Work: assessment of the distance from reservoirs to transmission lines. Additionally, sensitivity of reservoirs and fluctuating water levels need to be included in this study to improve accuracy.
- 1.5 GW, conservative is most likely capacity for CA
- Best reservoirs for FSPV development in CA would produce 117 GWh per year.
- CA could save $30,000 acre-feet of water per year by implementing FSPV on all appropriate reservoirs—equivalent to 1% of all the city and industrial use in CA.
- The estimated value of water saved in the theoretical case is $8 million per year.
Reducing the environmental impact of Phila.'s bus networks through Bus Stop Consolidation... 
... whilst keeping in mind accessibility, mobility, and equity

Abstract
Bus stop consolidation is just one approach to work towards making getting around by transit easier and more sustainable. Fewer stops reduces a rider's time spent traveling overall, reduces the transit agency's operating costs, and reduces emissions of the bus itself as well as surrounding traffic. This thesis studies the local SEPTA Route 14 and Direct Bus, which has consolidated stops. The investigation consists of on-board bus surveys and also PM2.5 measurements in conjunction with car counts. Riders did not always take their bus for its advantage (either time savings or proximity to origins and destinations). The Direct Bus was made up of a younger and wealthier population that was more black. Further, the air monitoring research concluded that only the count of vehicles stopping and starting has a correlation to PM2.5 measurements. The air monitoring data serves to enhance the argument for bus stop consolidation. Survey results indicate that bus stop consolidation is welcomed in most cases though care should be given to where these stops are placed to serve older and poorer populations.

Introduction and Background
The issues:
- Transportation is the most polluting sector as of 2018; its pollution disproportionately affects already disadvantaged populations as measured by race, income, and age [1,2].
- Cities' populations are growing exponentially driving higher demand for efficient transit.

Bus stop consolidation:
- Attracts riders by reducing travel times
- Pros: relatively inexpensive and flexible, reduces operational costs of the transit agency, can reduce emissions
- A vehicle emits the most pollutants as it accelerates from a stopped position; these emissions are compounded when vehicles around a stopped bus also need to break then accelerate [3].

Conclusions:
- In cases of riders' progress, the possibility of being inequitable based on stop placement
- Though, researchers in Portland, Oregon found that passenger activity did not significantly change after a bus stop consolidation project which improved running times by nearly 6% [4].

The study area:
- SEPTA Route 14 and the new (2017) Direct Bus
- Fig. 1: they run from Frankford Transportation Center to the Neshaminy Mall mostly along Roosevelt Boulevard
- 67 versus 8 stops (13 min. time savings)
- Direct Bus retains all 20 bus connections [5]

Method
- MetOne Instruments' 831 Aerosol Mass Monitor
- PM2.5 measurements were taken at three locations (fig. 1) every three minutes for an hour (repeated 8 times)
- Car counts taken concurrently: (1) total car count, (2) heavy duty car count, (3) count of cars that stopped and started on the monitoring sensor
- On-board bus surveys of both Route 14 and Direct Bus riders to ask them (1) about their origins and destinations (OD), (2) about their opinions about traveling on this bus, and in general, (3) about their demographics
- 50 responses collected at each bus at varying points throughout the day

Findings
- PM2.5 correlated to stop, start cars at the monitoring location, positively
- Modeled PM2.5 into the future, extreme residuals and coefficients (fig. 3)
- The on-board surveys indicated that Direct bus riders mostly took their bus because it came first value time, consider the environmental impacts of transportation, are younger, are majorly black, and have a lower rate of response to this survey

Discussion

Conclusions
- Confirms that emissions can be reduced by consolidating bus stops
- Only some people are using their respective buses to their advantages
- SEPTA should create multiple Direct Buses, explain advantages more explicitly

Future Recommendations
- Collect more data to strengthen the model
- Attach air monitor to bus tailpipes
- Conduct larger scale emission testing and modeling to determine the environmental impact of emissions
- More accurate origin and destination data should be collected to model time savings of real riders
- Work with SEPTA
Knowledge of Lead's Health Risks and its Possible Effects on Health in Neighborhoods in Philadelphia, PA and Lancaster, PA
Emma Johnson1, Richard Pepino2

Abstract

There are many neighborhoods in and around Philadelphia that are historically low-income and have had high percentages of minority population. Additionally, because of the city’s age, it has a higher than average risk for elevated blood lead levels. Philadelphia ranks third nationally for percent of children with elevated blood lead levels, at 3.9%. This project was designed to evaluate what people know about the risks of lead poisoning and how this knowledge may be affected by demographic factors that accompany gentrification. This was done by conducting group interviews with targeted questions to assess the participants’ knowledge of lead poisoning. The interviews include a demographic questionnaire and a follow-up to determine what the cause of variation in depth of knowledge was. It was immediately evident that there was a divide in knowledge, with some participants explicitly asking questions regarding the risks of lead to their health and others with extensive knowledge due to a family member having been affected or correlated to an increased socioeconomic status.

Introduction

No level of lead in the blood is safe and it causes lasting physical and mental effects. Children are the most vulnerable because their nervous systems are rapidly developing in early life. The CDC states that a person has lead poisoning when they have 20 micrograms of lead per deciliter (µg/dL) of blood. According to the CDC, children living at or below the poverty level who live in older homes face the greatest risk for lead poisoning. Because Philadelphia is a historical city, many homes were built before lead poisoning was outlawed in 1978. It is also noted that Philadelphia is the poorest big city in the US. The combination of its aging infrastructure and the lack of resources for many of its residents would place many neighborhoods at risk for having chipping lead-based paint. Figure 1 displays data on the number of children with elevated blood lead levels. In Philadelphia, in order to prevent children from facing the consequences of lead poisoning, parents must have resources and education about prevention and remediation efforts.

Results and Discussion

As illustrated in the chart to the left, it was found that lead is often not a concern in Philadelphia, many of the homes were built before 1978, when lead paint was outlawed, and most of the people involved reside in such units. There was also a concern of lack of familiarity with the resources and preventative measures available. Those who were interviewed who had extensive knowledge on the subject fell into two groups: those who had been personally affected by lead poisoning and those who had more social power (have more education, wealth, or possessed a similar advantage). The stem and leaf plot made evident some interviewees in particular, who spoke to a young mother who had completed a master’s degree, with a strong focus on lead in soil. She explained the depth of her knowledge and the preventative measures she had taken in her home and in her community environment as a result of her education. People like her have educational advantages, which are emphasized when considering environmental health issues and furthered when making the complications of personal action happen in these communities.

Conclusion and Future Work

My findings indicate that there is a problem in the dissemination of information regarding the dangers of lead to the health of children and the prevalence of lifelong risk that the community faces. Additionally, a social justice view may be taken, and from this perspective, the impact of lead poisoning falls more heavily on people who are disadvantaged, probably due to lack of information, safety precautions, and ultimately empowerment. While many participants cited physicians as educating for preventative measures, it was after their children had displayed elevated blood lead levels and therefore, the damage had been done. The goal is to share information about lead poisoning’s effects on children before a child is affected by lead poisoning. This would entail an informational session in the setting of a neighborhood meeting at a community center, with access to resources such as contacts for remediation corporation, healthcare centers, and information regarding lead Court. A follow-up study should be utilized to determine the efficacy in producing the desired results: reducing the number of children with elevated blood lead levels.

References

1. CDC. "https://www.cdc.gov/nceh/lead/blood_lead_levels/leading_levels.html"

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Abstract

Densification from snow to ice, generally at near-surface depths of glaciers and ice sheets, gradually constricts pores of atmospheric gas. Rates of “firm” densification are influenced by the material properties of ice, including its grain size and impurity content, as well as environmental variables, such as temperature and accumulation rate. Between an intermediate range of densities ($p = 0.73 - 0.83$ g/cm$^3$), scientists have previously considered two possible modes of densification: dilatational creep and diffusional flow. A more recently discovered mechanism, dislocation accommodation grain boundary sliding, may also operate in terrestrial firm densification. To identify densification mechanisms in firn, we conducted ice compression experiments, wherein a constant pressure was applied to powdered ice samples of different average particle size. The measured densification rates were analyzed using a power-law relation between the rate, stress, and grain diameter. For smaller grain sizes and lower stresses, rates of compaction were directly dependent on the sample’s average grain size, indicating the role of dislocation accommodation grain boundary sliding during densification. This creep mechanism is predicted as rate-limiting for the grain sizes and differential stresses characteristic of many regions within terrestrial and solar ice masses.

Flow Law Densification Model

Figure 2: Flow laws for firm creep during intermediate densification at temperature and grain size conditions ($T = 223$, $r = 1$ mm) approximately matching those along the Antarctic ice divide (Vostok). Boundaries between dislocation and GBS creep for both models occur within the stress range characteristic of the near-surface behavior of terrestrial ice sheets, glaciers, ice domes, and planetary cryospheres. The total contribution of GBS creep to natural densification rates steadily evolves with strain and time, competing with dislocation creep. Further research is required to understand the discrepancy between experimental and natural densification rates to accurately employ our flow law model firn densification, with the flow law models overpredicting the natural densification rates.

Image References and Descriptions

(a) Aerial view of Antarctic "Blue Marble" (left) with InSAR site pinned along the central divide, and Meridional Ice Cap (right), ACIS.
(b) Compression sample (left) and diagrams of ice (right).
(c) SEM of sample 21 (green series in Figure 1). Singh Center for Nanotechnology.
(d) Ice core from WAG, preserving bubble climate records. NSIC Ice Core Lab.