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Sunday, April 14, 2017
Welcome to the 2017 Spring Master’s Project Symposium. All presenters are students in the Master of Environmental Management (MEM) and/or Master of Forestry (MF) or the Duke Environmental Leadership (DEL-MEM) professional degree programs at the Nicholas School of the Environment, Duke University. Presentations are a culmination of theoretical and analytical training acquired by the students to natural resource or environmental problems during their two years of study. The final master’s project is the capstone piece for MEM and MF students.

The master’s project could take the form of a management plan, handbook and/or educational curriculum. The project is intended to represent the student’s major academic focus, and demonstrates the student’s competence in that area as well as integrating course work, seminars, independent projects, internships, and other experiences in an in-depth study that culminates in a professional quality report and a formal presentation. All students must make a public presentation of their master’s project in their final semester of enrollment. Thank you for taking the time to join our students as they present their master’s projects to the community as well as their families and friends.

Nicholas School of the Environment Professional Degrees and Program Areas of Study

**Master of Environmental Management**
- Business and Environment (BE)
- Coastal Environmental Management (CEM)
- Ecosystem Science and Conservation (ESC)
- Ecotoxicology and Environmental Health (EEH)
- Energy and Environment (EE)
- Environmental Economics and Policy (EEP)
- Global Environmental Change (GEC)
- Water Resources Management (WRM)
- Duke Environmental Leadership (DEL)

**Master of Forestry**

**Concurrent/Joint Degrees:**
- Master of Environmental Management (MEM) and Master of Forestry (MF)
- Master of Business Administration (MBA)
- Juris Doctor in Environmental Law (JD)
- Master of Science in Computer Science (MS-CPS)
- Master of Divinity (DIVN)

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**ABSTRACTS**

*(In Order by Last Name)*

**Alexandra Aines: MEM**  Advised by: Drs. Andre Boustany and Pat Halpin

Feeding Habits of the Tiger Shark, *Galeocerdo cuvier*, in the Northwest Atlantic Ocean and Gulf of Mexico

Sharks are hypothesized to be apex predators that structure marine communities through predation. Despite a large number of studies in other areas, there are no quantitative data on the diet of tiger sharks, *Galeocerdo cuvier*, in the northwest Atlantic Ocean and Gulf of Mexico. Diet was assessed from 169 tiger sharks by life stage, area, and environmental factors. Fifteen prey groups were identified, with teleosts, molluscs, birds, cephalopods, and reptiles being the predominant prey categories. There was an ontogenetic shift in diet, prey size and diversity with an increase in shark size. Molluscs were most common in smaller sharks, while teleosts and reptiles became more important in the diet of larger sharks. Dietary overlap was significant by area (Gulf of Mexico vs Atlantic Ocean) and among all life stages except for young-of-the-year and adult tiger sharks. Overall, tiger sharks in the northwest Atlantic and Gulf of Mexico had diverse diets and exhibited ontogenetic shifts, similar to Pacific tiger sharks. Juvenile tiger sharks also demonstrated selective feeding by targeting gastropod foot over ingesting the entire animal. The results of this study will contribute to developing ecosystem models for tiger sharks in an area where their diet has been studied very little.
Spatial Assessment of Southern Ocean Krill in the Palmer Long-Term Ecological Research (LTER) Study Site

Antarctic krill are a keystone species in the Southern Ocean ecosystem, and provide food to higher trophic level predators such as marine mammals. Regional warming due to climate change may affect the quantity and distribution of krill along the Western Antarctic Peninsula. Surveys from December through February within the Palmer Long Term Ecological Research (LTER) study site have collected acoustic Doppler current profiler (ADCP) density data for the past twenty years. Signal processing scripts were developed to integrate and aggregate acoustic data on a variety of spatial scales. These tools allowed for qualitative comparisons of krill patch size, location, and depth dependent patterns. High-density patches were found onshore and in the upper 150 meters of the water column. These results supplement our understanding of the spatiotemporal variability of Antarctic krill during the austral summer, which is critical to interpreting changes within the ecosystem and the foraging dynamics of their predators.

Achieving Better Outcomes in Local Government Stormwater Programs through Pay for Performance

Pay for performance links payment to delivery of specified outcomes or objectives that relate to environmental performance. Pay for performance differs from traditional approaches that pay for delivery of a defined scope of work or set of actions without a meaningful portion of payment being linked to environmental performance. In the Chesapeake Bay region, the ambitious goals set forth by the Chesapeake Bay Total Maximum Daily Load have sparked innovation in local government stormwater programs. I analyze four stormwater programs in Chesapeake Bay region that are utilizing innovative delivery models that leverage green infrastructure as a cost-effective approach to stormwater pollution mitigation. Since green infrastructure is a nascent technology, pay for performance serves a useful role in testing its effectiveness and mitigating the risk of public funds being used on projects that do not deliver intended results. Each program analyzed is structured differently and offers unique advantages, such as shifting performance risk to the private sector, providing latitude in project selection, and placing more responsibilities on the private sector for the design, build, operations and maintenance phases of the construction process.

Drivers and Challenges for the Expansion of Renewable Resource Feedstocks: The Sustainable Apparel Sector

Companies are increasingly exploring renewable resource feedstocks (RRFs) as inputs into consumer goods; to shift away from non-renewable resources and support sustainability efforts. A significant gap exists in understanding the opportunities and barriers for RFF expansion, specifically in the apparel sector. In this study, a global survey was administered to textile professionals to explore value chain perceptions of RRFs and outline the RRF landscape. The greatest drivers in RRF utilization were demand from brands and retailers, industry trends, and sourcing availability. Cost of inputs was rated as the greatest barrier to RRF utilization, followed by availability of inputs, performance, and associated technology requirements. Information gaps in RRF environmental impact and RRF procurement were also identified as barriers. While RRF was the terminology used for this study, the results indicated a lack of homogeneity in the term RRF and with what materials are considered “sustainable.”
Optimal Economic Use of Small Pelagic Fish: Case Study of the Sardine Fishery in the Gulf of California

From a management perspective, what is the best use of forage fish? Global landings of forage fish comprise approximately 37% of global wild marine fish catch. Forage fish provide livelihoods and a protein source for millions of people worldwide. Also, forage fish are a critical food source in transferring energy from plankton to higher trophic levels in marine ecosystems. Knowing their significance, should forage fish be made into fish meal and used in agriculture, canned for domestic human consumption, frozen fresh as feed for blue fin tuna mariculture, or left in the ocean to serve ecological functions? Recognizing that this is a complex topic, this project aims to analyze the sardine Mexican fishery solely from an economic standpoint and identify externalities or relationships in the market that, if managed differently, could have significant effects on economic incentives for the use of sardines. This economic analysis of the use of the sardine resource in Mexico can consequently be complemented by social, environmental, or other tailored analyses.

Kenyan Market Analysis: An Evaluation for Emerging Food Technology Companies

The reduction of waste along the food production chain will help increase sustainability of the agricultural sector and help improve the quality of the environment overall. The use of active packaging technology (AP) has been found to reduce waste and help more products successfully reach the market by increasing shelf life of fresh produce. Businesses are now turning to developing countries for expansion opportunities where AP technology would have a significant impact. The following analyses should help determine whether Kenya is one such country. Although Kenya has a variety of laws in place that should protect foreign investors and intellectual property rights, it is unclear whether governmental organizations have the capacity to truly enforce these regulations. Furthermore, concerns exist over the physical state of infrastructure and political stability that could negatively impact the success of a new business. However, Kenya is a country whose population, particularly women in rural communities, is deeply reliant on the success of agriculture. Additionally, the Kenyan economy has grown tremendously in recent years and shows few signs of stopping, having already attracted a wide variety of investors. Therefore, Kenya presents a strong case for investment. Although issues persist at the federal and infrastructural level, investment in this case could not only mean profit, but could also have positive social and environmental benefits that would help not only Kenyans, but the global community as well.

Governance and Management in a Complex Landscape: Learning from the Yasuni National Park

The Amazon biome houses one of the most extensive intact tropical forests in the world and, as a result of conservation efforts, more than 60% is under formal protection and recognized indigenous territories. The prominent conservation approach in the Amazon biome for the last 20 years has been protected area creation and ensuring their effective management. Yet, despite concrete results, conservation practitioners constantly debate over what is the most effective conservation approach to secure the Amazon’s long-term protection. By applying a mixed-method study, I analyze protected area governance and management conditions in a complex socio-economic landscape such as the Yasuni National Park in Ecuador. Based on a 14-year forest cover assessment, the low deforestation rates inside the park compared to the forest loss trends outside its limits validates studies in other tropical regions that protected areas deter deforestation. However, the management effectiveness results and the local reality in Yasuni provides insights into other governance factors that should be considered. Given the multiple threats to the park and the variety of stakeholder interests, the study recommends governance approaches to take into account the social, environmental, and political reality on the ground.
Feasibility Study of Energy Recovery by Incineration - A case study of Triangle Wastewater Treatment Plant

This study evaluates the energy recovery potential of wastewater by means of incineration for a small wastewater treatment plant. An analysis was conducted taking a local sewage treatment plant as a case in point, the challenge being the relatively small size of the treatment plant. This study investigates the future financial impact of unchanged sludge disposal method and the potential benefits and drawbacks of a sludge incineration plant. Wastewater flow data was collected and the digested waste analyzed to find its calorific value. An appropriate sewage incineration plant design was identified. Projection of wastewater flow growth and parameters of the incineration plant were used to identify the energy recovery potential and financial feasibility of such a project. The selected incineration plant, when sized in accordance with the wastewater treatment plant in question, was self-sufficient in terms of its own energy needs but the net generation was small. It is recommended that a detailed technical, legal, resource and operational feasibility study be performed before any definite decision is made.

Business Models for Extracting More Useful Life from Lithium Ion Battery Systems

Demand for new lithium-ion battery (LIB) systems is forecast to double between 2015 and 2020. However, current battery disposal practices mean that by 2020, tens of GWhs of still-useful lithium ion storage capacity could be directed towards landfills. While automotive companies are actively engaged in “second life” concepts for their electric vehicle batteries, it is not apparent that non-automotive batteries have similar applications. Non-automotive batteries have many different chemistries and form factors, and suffer from weak economics in the recycling process. This project explores the entrepreneurial viability of finding a “second-life” for non-automotive LIB systems. Specifically, we explore (1) capturing this low cost “waste” stream from primary users of batteries, (2) diagnosing and refurbishing used LIB systems, and (3) selling these systems to secondary users. Environmental benefits are quantified via (1) mineral conservation and (2) avoided emissions attributable to further unlocked levels of renewable energy supported by increased storage levels on the power grid.

Integrated Water Finance Solutions to Drought in the Yakima Basin, Washington

Located in south-Central Washington, the Yakima Basin is one of the most affluent agricultural hubs in the nation, contributing over $3 billion to the state economy annually. Junior water users in the Basin, namely Roza Irrigation District (Roza), have already experienced the negative financial impacts of drought. To ensure water supply stability in preparation for future droughts, Roza has partnered with the Department of the Interior’s Natural Resource Investment Center (NRIC) in developing the financial strategy for the Yakima Drought Relief Pumping Plant (YDRPP), an infrastructure project that will provide 200,000 AF of additional water during drought years. As student consultants for the NRIC, we conducted hydrological, ecological, and financial analyses exploring the potential benefits of the YDRPP for the Yakima Basin. Our results revealed that junior water users are vulnerable to shortage during drought years due to an increased reliance on reservoir storage during non-drought years. In addition to sustaining the agricultural economy in Roza, water generated by the YDRPP could supplement instream flows in 92 miles of critical fish habitat throughout tributaries in the upstream Kittitas Reclamation District. Ecological benefits of the station may be leveraged to create unique finance options for Roza such as environmental impact bonds and green impact investing. We also analyzed and compared other alternative financing strategies, including traditional capital bonds, public-private partnership contracts, and climate-risk bonds. Our findings indicate that overall project costs for Roza are highly dependent on the amount of financial risk that the district is willing to retain in the construction, operation, and maintenance of the YDRPP.
Assessing Land Availability for Utility-Scale Solar in North Carolina Using GIS

The use of utility-scale solar photovoltaic (PV) systems to generate electricity has been increasing substantially in the U.S., and North Carolina is a leading state in its installation. Optimally siting utility PV projects can maximize power generation and reduce projects’ costs, environmental impacts, and social opposition. Our analysis develops a GIS method to optimize siting these projects and assess how suitability factors affect land availability over large areas. We first identify criteria important for siting utility PV projects, such as land-cover, slope, and proximity to electrical substations. We then assess how the addition of these criteria, from most to least stringent, reduces the availability of suitable land across North Carolina. As the use of utility solar grows in North Carolina, our analysis provides an assessment of siting constraints, identifies prime locations, and quantifies the state’s theoretical potential for this power source.

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Mountaintop Mining’s Impact on Watershed and Regional Scale Nitrogen Export

Mountaintop removal coal mining with valley fills (MTM) is the most prevalent form of land use change in the coal mining region of Central Appalachia. MTM creates dramatic changes to mined landscapes and has been linked to a number of water quality and hydrologic concerns. Land use change is commonly associated with both increased nitrogen inputs and alterations to how landscape process and export nitrogen into streams. To understand, MTM-VF’s impact on nitrogen export, here I report on stream sampling and continuous hydrologic data from the Mud River basin in West Virginia (WV). I quantify the extent MTM-VF and valley fills of various ages increase the flux and alter timing of nitrogen export in headwater catchments. I further compare historic and current datasets to explore how stream nitrate concentrations are changing over time. To better understand sources of elevated nitrogen, I combine an analysis of nitrate isotopes with the development of a nitrogen budget for a mined watershed. Finally, to assess regional implications, I analyze relationships between regional mining trends and thirty years of nitrate concentrations in WV river.
John Burrows: MEM (ESC)/MF

Group Members: Harley Burton and Tim Hipp

Advised by: Dr. Sari Palmroth

Inventory Modeling and Scenario Analysis of Timber Resources in the Duke Forest

Since it was founded in 1931, the Duke Forest has shown a commitment to sustainable timber management practices and forestry education. However, in recent years, a misalignment between revenue expectations and the timber management paradigm have resulted in an uneven age class distribution favoring younger age classes of pine. The purpose of this project is help the Duke Forest address this management challenge by reassessing its inventory and yield projections from its 2010 inventory to understand how the Forest might be able to improve its estimation of sustainable harvest by more accurately accounting for volume growth. Additional analyses were also conducted to model different harvest rotation lengths using the US Forest Service’s Forest Vegetation Simulator (FVS) to understand how more intensive management practices, such as shortening the pine rotation length and planting genetically improved stock, could help balance the Forest’s age class distribution in other divisions while keeping the forest profitable.

Harley Burton: MF

Group Members: John Burrows and Tim Hipp

Advised by: Dr. Sari Palmroth

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Tripp Burwell: MEM (ESC)/MBA

Advised by: Dr. Jesko von Windheim

Financial Analysis of Sustainability Initiatives in the Luxury Cashmere Supply Chain

Many corporations have begun to make sustainability investments, and those investments typically have relied on reducing costs, for example, though reduced energy, water, and material usage. However, an expanded focus on where sustainability can increase revenue and reduce risk will likely drive future corporate investment. The number one risk that supply chain purchasers have identified is raw material price fluctuation. Working with a large European luxury goods manufacturer, the coefficient of variation (standard deviation/mean) is used to analyze price volatility in the cashmere supply chain, both for the Client and the market as a whole. Since implementing direct purchasing, among other sustainability initiatives, the Client has reduced their raw material price volatility. However, the analysis includes no causal assessment. Future work should incorporate more data to look at the causal relationship between sustainability initiatives and reduced price volatility.
Diego Calderon-Arrieta MEM (ESC) Advised by: Dr. Nicolette Cagle

Evaluating Current Attitudes towards Snakes in the NSOE Environmental Master’s Student Community

The ecosystem services that snakes yield can become overshadowed by the negative attitudes that humans direct towards them. My master’s project seeks to evaluate current attitudes towards snakes among the Nicholas School of the Environment student community and to discover what new methods can be used to decrease the unpleasantness of snakes. This unique community will be evaluated, because these students will play an important role in addressing environmental ethics and human-wildlife conflicts. Using an online survey and ordered logistic regression models, I demonstrated that – compared to natural science-focused students – social science-focused students are less likely to indicate higher levels of positive attitudes towards snakes. The survey also indicates that there is high demand for seminars like learning how to handle snakes safely or general knowledge about them. Future researchers will have to measure these methods’ respective efficacies in reducing negative views.

Samuel Benton Cantey: MEM (DEL) Advised by: Dr. Jonas Monast

The Effectiveness of Wildlife Trafficking Enforcement in the United States

Wildlife trafficking is the fifth most profitable illicit trade in the world. While it’s impossible to ascertain the true extent and value of the illegal trade, UNEP estimates range from US$7.6 to $10 billion globally per year. Wildlife trafficking occurs within and across U.S. borders. Not only is the United States among the world’s major markets for wildlife and wildlife products -- both legal and illegal -- but it also serves as a transit point for trafficked wildlife moving from “source” (or “range”) countries to destination markets around the globe, as well as a source for illegally taken wildlife. The U.S. Government recognizes wildlife trafficking is a serious crime and it appears to be committed to ensuring domestic enforcement efforts adequately protect wildlife resources. Effective enforcement depends on robust legal authorities to disrupt wildlife trafficking networks, apprehend and prosecute traffickers, seize and forfeit proceeds of crimes and apply penalties that deter and prevent others from committing such crimes. As wildlife crimes are often similar to drug trafficking and other smuggling schemes, investigators employ techniques similar to those used in narcotics enforcement such as controlled deliveries of contraband wildlife and anticipatory warrants. However, is it true that historic and current enforcement efforts are effective in ensuring adequate protection of U.S. Wildlife resources?

Xiaoyu Cen: MEM (ESC) Advised by: Dr. James Clark

Spatial Variation in Forest Growth After Disturbances in a Northern Hardwood Ecosystem and its Relationship with Underlying Environmental Factors

Disturbances can influence the structure and function of forest stands. But under the same disturbances, spatial variation in forest growth can still arise from inter-specific differences and spatially varying environmental factors. In this study, I analyzed the spatial variation in the growth of two forest stands in Hubbard Brook Experimental Forest. Either a calcium addition or a clear-cut disturbance was introduced to the forest stands. To focus on the influence of environmental factors, I isolated the inter-specific differences and created a “Forest Change Index” to indicate the forest growth condition. Comparing the inter-plot difference in forest growth before and after the disturbances, I found the spatial variation patterns were highly persistent. Even after a high magnitude disturbance like a clear-cut, the original spatial variation pattern recovered with the recovery of the forest stand. Furthermore, a linear regression analysis on the environmental prove their significant influence on the spatial variation in the forest growth. But a generalized joint attributes model analysis show that the influence of different environmental variables varies for different species, which implies the imperfectly matched species with environmental variables may be the main cause of the spatial variation in forest growth.
Policy Analysis and Implementation Guidance for Addressing Invasive Wild Boar in the State of São Paulo

The introduction of invasive wild boar (sus scrofa) through intentional and accidental releases in the 1990’s has caused significant harm to the native ecology, economy, and social impacts of Brazil’s wealthiest and most populated state, São Paulo. This report draws upon the experiences and management approaches taken at the state and federal level in the United States to provide the Secretariat of the Environment of São Paulo: (1) a review of policies and methods in the United States for managing wild boar, (2) a policy analysis of four wild boar population management policy alternatives, (3) a geospatial analysis of suitable wild boar habitat in São Paulo to aid in planning, and (4) implementation recommendations. This report ultimately recommends that the Secretariat of the Environment adopt policy alternative 4, Government Implemented Wild Boar Control, and create a state-wide wild boar management plan implemented by state and local wildlife agencies with minimal private wild boar management efforts. The Secretariat of the Environment’s Wildlife Department should implement an adaptive management plan that maximizes removal effectiveness by (1) utilizing modern removal methods in an effective sequence and (2) prioritizing removal efforts to protect critical natural resources in areas susceptible to wild boar damage and invasion before resilient populations can be established.

Patrick (Genghua) Chen: MEM (EE)
Advised by: Dr. Elizabeth Albright
Group Members: Kerri Metz, Jesse Way, Shaina S. Nanavati and Jingqi Yang

A Roadmap to the New Rural Electric Cooperative Business Model

In North Carolina today, 26 rural electric cooperatives provide electricity to 26% of the state’s population. This project aims to assess the services that rural electric cooperatives in North Carolina should offer their members in order to improve their business model. We interviewed ten organizations that were chosen using sampling by convenience, using a semi-structured format. In doing so, we learned about the benefits, challenges, and priorities of the cooperatives relative to offering clean energy and energy efficiency services to their customers. Using NVIVO to analyze our data, we identified the priorities of affordability, reliability, and customer satisfaction that cooperatives should use to assess the menu of service options we have outlined. While each cooperative in North Carolina is unique, we have recommended services they should offer based on their individual priorities.

Benjamin Cheney: MEM (EE)
Advised by: Dr. Jesko A. von Windheim
Group Members: Katherine Hurrell and Rui Shan

Waste Heat Recovery in Bicycle Manufacturing Process for Specialized Bicycle Components

Cooperating with Specialized Bicycle Component, we conducted a waste heat analysis on two heating processes for its aluminum bicycle frame. We found that the waste heat from these processes is 451.60 MWh/year worth 22,174.97 $/year estimated with the local fuel price and the heat absorbed by the frame holder could be the most practical start point to reduce the waste heat. At the same time, by consulting professionals and literature review, we found that some commonly used waste heat recovery strategies could not be implemented in our context. Furthermore, we gave two detailed recommendations, switching the fuel and changing the material of frame holders, to reduce the economic cost and environmental impact of this process. Switching fuel from LPG to natural gas would save 9528 $/year and reduce 18.96 ton CO2/year. Changing the frame holder from steel to carbon composite would save 209 $/month and the investment will be paid back in 17 months. The possibility of process optimization was also discussed.
Natural gas has gained increasing attention as a clean and efficient fuel. Reflecting upon the low percentage of natural gas usage in China, motivation related to natural gas production and usage from a macroeconomic view is worth discussing. Although carbon tax can be used as an effective policy tool to promote carbon emission reduction, the implementation of levying a carbon tax has a negative impact on natural gas and other clean energy industries. Based upon this, with the employment of CGE theory, this paper applies the GAMS advanced modeling system to construct a CGE model that targets natural gas tax exemption using Beijing as an example to simulate and analyze the impact of gas tax exemption policy on carbon emissions, economic systems, and social welfare. The paper reveals that the exemption of natural gas might be a possible choice to control CO2 emissions in Beijing to a certain extent. At the same time, it has a positive impact on the macroeconomic variables and social welfare of the residents of Beijing. Therefore, we suggest that in the early stages of the design and implementation of a carbon tax, the protection of natural gas industry should be considered.

Optimizing Conservation Benefits of Pelagic Marine Protected Areas: Alternative Timing of the Charleston Bump Time-Area Closure

The three-month Charleston Bump Time-Area Closure was implemented in 2001 with the primary goal of reducing bycatch of juvenile swordfish in the U.S. Atlantic pelagic longline fishery. Due to this closure and other management measures, this swordfish stock has since rebuilt, and the fishery is currently underutilized; swordfish landings are below the recommended quota. To meet consumer demand in the United States, swordfish are imported from foreign fleets, many of which are less strictly regulated and are not held to the same bycatch reduction standards as U.S. fisheries. By analyzing the composition and species abundance of pre and post-closure catch data, as well as interpolating catch per unit effort during the closure, this project investigates potential temporal alternatives for the closure which would increase domestic catch of swordfish while limiting interactions with protected and frequently discarded species of sharks, finfish, and sea turtles.

Economic Potential of Offshore Wind Development in South Carolina

While the global offshore wind capacity has grown significantly in the past few years, it has been largely driven by Europe and China. The United States is only now starting to develop the significant supplies of wind available off its coasts. With the first wind farm beginning operations and more offshore leases being secured, momentum is building to bring an offshore wind supply chain to the Atlantic coast. The supply chain will provide jobs and significant economic benefits to the states where it develops. In order to take advantage of these benefits states will need to adopt policies supporting offshore wind and its associated industries. Our report focuses on South Carolina as an area with significant offshore resources as well as great potential for supply chain development. We examined the potential impacts of offshore wind development on the state by determining a viable installed capacity of offshore wind, and used wind farm models to project electricity cost, energy outputs and economic impacts. These results are accompanied with an assessment of current and potential policy factors as well as likely areas of supply chain growth.
Demonstrating Air Emissions Reductions through Energy Efficiency Retrofits on Maersk G-Class

From 2015-2016, Maersk Line invested $125 million to retrofit their G-class vessels. This Radical Retrofit (RR) program is a part of Maersk’s commitment to reduce global fuel consumption and related CO2 and other air pollutants by 60% per container. In 2015, Maersk received a grant from the San Pedro Bay Ports Clean Air Action Plan to develop a methodology for quantifying the benefits from these efficiency improvements from both an emissions inventory and validation standpoint. We present the results through a series of linear regressions used to compare the Manual Ship Performance System (MSPS) data from before and after RR. Through graphical visualization and t-tests, the report also compares MSPS data against automated Control, Alarm, and Monitoring System (CAMS) data. These results are intended to guide Maersk as it develops a methodology for calculating emissions. The report makes recommendations on how Maersk can design its Performance Platform to incentivize additional emissions reductions.

Produced Water Spills Related to Unconventional Oil and Gas Development in North Dakota

Beginning in 2007 unconventional oil production increased dramatically in the region of North Dakota overlying the Bakken shale formation. Since, the North Dakota Department of Health has reported more than 4,000 accidental spills of produced water. Our study seeks to follow up on a 2016 study by Nancy Lauer et al., which characterized the major and trace element chemistry of 29 surface waters in areas impacted by oil and gas wastewater spills. Comparing to background levels, we characterized 33 surface water and 4 associated groundwater impacted sites, including 12 sites sampled the year before. Soil and sediment collected from the sites analyzed for total radium activities (228Ra & 226Ra) showed an accumulation at some sites. One of the most heavily affected sites, an 11 million gallon spill near Blacktail Creek, studied the year before experienced recent remediation and displayed much lower levels of contaminants. However, this site was an anomaly; other sites continue to display persistent inorganic contamination up to 5 years after the initial spill.

Quantifying Ecologically Significant Feeding Areas for Marine Mammals and Seabirds in the Arctic

The Arctic marine ecosystem is highly dynamic and sensitive to environmental change, experiencing the impacts of climate change at a rate at least twice as fast as other areas of the world. Arctic organisms are adapted to the strong seasonality of the Arctic marine ecosystem, making them sensitive to changes in phenology. While it has already been shown that phenological shifts are occurring with relation to sea ice and primary production in this region, it is necessary to further quantify what species and key ecological zones will be most impacted. In an effort to assess changes to these key ecological areas, I analyze satellite remote sensing data for sea ice concentration and chlorophyll a concentration in ecologically significant feeding areas for cetaceans, pinnipeds, and seabirds in the Arctic. This provides for a clearer view of what species stand to gain or lose the most as the Arctic transitions to a more temperate marine environment.
Breanna L. Crowell: MEM (WRM)  
Advised by: Drs. Curt Richardson and Neal Flanagan  
Group Members: Jerrett Fowler, Jennifer Lenart, and Auston Smith

Streambed Texture and Hydraulic Connectivity Analysis of Restored, Degraded, and Natural Reference Streams in Durham, NC

In the face of growing concerns about how water quality is affected at the watershed level due to land use change, six sites in the same watershed near Durham, North Carolina were selected for an analysis of streambed sediment texture and hydraulic conductivity. The primary problem of interest is to investigate whether select Priority 1 stream restorations in Durham differ from degraded and natural streams in connectivity and exchange between the stream and subsurface. The main concern with Priority 1 restoration is that it requires burying the original stream channel and creating a new channel in the adjacent floodplain. If a floodplain differs significantly enough from the natural streambed and little is done to correct this in the restoration, there could be impacts on overall stream function. The results of our research will aim to inform future restoration practices pertaining to streambed sediments in newly created Priority 1 streams.

Maria Cuglievan Weise: MEM (GEC)  
Advised by: Dr. Jay Golden  
Group Members: Erin M. Leon

Sustainable consumption in the U.S.: A Consumer-Facing Analysis of Strategies and Business Models in the Retail Industry

The RILA (Retail Industry Leaders Association) Department of Sustainability tasked the Duke team with exploring and defining sustainable consumption and production in the next generation of the U.S. retail market. The Duke team focused on identifying the opportunities for retailers to monetize, adopt and leverage these newly developing business models in a circular economy space. The team worked closely with nine leading RILA brands (Coca-Cola, The Home Depot, Ikea, REI, Target, Unilever, VF Corp, Walgreens, Whole Foods) to 1) conduct research to develop a framework for consumer-facing, sustainable consumption initiatives and 2) create a set of criteria and industry best practices to identify gaps and barriers for strategy implementation opportunities. Next, the Duke team examined the feasible of a collaborative materials marketplace at the regional level (NC Research Triangle) and executed a materials process analysis to examine specific material flows and feedstock dynamics.

Laura Marie Davis: MEM (ESC)  
Advised by: Dr. Pam George  
Group Member: Tianshu Sun

Durham County Food System: A Qualitative Analysis of Actors, Missions, and Challenges

In the context of a national movement around local food, our clients, the Duke Campus Farm and World Food Policy Center want to know what they can do to best engage with and support the local food system (LFS) in their community of Durham County, North Carolina. We conducted an exploratory case study to characterize the current network of actors within the Durham LFS and the challenges they face, in order to provide recommendations to our two Duke clients. Qualitative analysis of interview data resulted in a network sociogram showing two main clusters of actors, generally separated by sector and mission. The primary challenges facing these actors include financial barriers, lack of communication, and issues related to food policy. We recommend that our clients 1) facilitate communication between network actors 2) assist with collecting baseline data for evaluation, and 3) provide relevant policy analysis.
Sarah DeLand: MEM (CEM) Advised by: Drs. Pat Halpin and Kelly Stewart

Quantifying Injury Rates on Nesting Leatherback Turtles (*Dermochelys coriacea*) at Sandy Point National Wildlife Refuge, St Croix

Sandy Point National Wildlife Refuge (SPNWR) in St. Croix is one of three critical US nesting locations for leatherback sea turtles. Many female leatherbacks nesting at SPNWR have been observed with injuries, but these injuries have not yet been incorporated in the long term research study at this site. My research focused on collecting photographs of the injuries on nesting females during the 2016 nesting season, March through June. These photographs were used to identify trends in the timing of injuries, the rate of healing, possible cause of injuries, and the common injury locations on leatherbacks. Results show that female leatherbacks are sustaining injuries all throughout the nesting season and that these are likely due to interactions with sharks. This research will help identify threats to this population and guide future research.

Maurita J. Denley: MEM (BE) Advised by: Dr. Jay Golden

Group Members: Shuvya Arakali and Amanda Hoster

Drivers and Challenges for the Expansion of Renewable Resource Feedstocks: The Sustainable Apparel Sector

Companies are increasingly exploring renewable resource feedstocks (RRFs) as inputs into consumer goods; to shift away from non-renewable resources and support sustainability efforts. A significant gap exists in understanding the opportunities and barriers for RRF expansion, specifically in the apparel sector. In this study, a global survey was administered to textile professionals to explore value chain perceptions of RRFs and outline the RRF landscape. The greatest drivers in RRF utilization were demand from brands and retailers, industry trends, and sourcing availability. Cost of inputs was rated as the greatest barrier to RRF utilization, followed by availability of inputs, performance, and associated technology requirements. Information gaps in RRF environmental impact and RRF procurement were also identified as barriers. While RRF was the terminology used for this study, the results indicated a lack of homogeneity in the term RRF and with what materials are considered “sustainable.”

Pablo Diaz: MEM (EE)/MBA Advised by: Dr. Dalia Patino Echeverri

Distributed Electricity Generation from Solar Photovoltaics in Chile: Economic Assessment for an Industrial Site in Santiago

With some of the best solar resources of the world, Chile is positioned to vastly reduce its consumption of fossil fuels and ramp-up the share of renewables for electricity generation. Distributed generation facilities appear particularly attractive as a way to reduce the needs for power transmission capacity. This paper evaluates the technical and economic feasibility of installing a roof-top solar photovoltaic (PV) system on the facilities of a major shipping company in the city of Santiago. A computer based-model estimates hourly electricity generation during the life-time of the solar panels, as well as the expected electricity consumption, and corresponding injections/withdrawals of electricity to/from the main grid, to assess economic benefits. The model is composed of 3 modules: 1) A solar generation model; 2) an Electricity Demand module; and 3) an Economic Assessment model that estimates the costs and benefits associated to the installation of PV solar. Results indicate that under the baseline conditions, the Net Present Value of the project is negative, mainly due to the absence of subsidies to solar installations and to the low electricity prices offered to consumers under the Net Metering policy. However, when lower solar system installation costs, or the costs the company incurs to reduce its carbon emissions are considered, the Net present value becomes positive.
The Use of Descending Devices in Fisheries Management to Reduce Discard Mortality: Regional Experiences and Considerations

The South Atlantic red snapper fishery is overfished and continues to experience overfishing without an open fishing season. Red snapper are caught incidentally when anglers target other species in the snapper grouper complex. Ascending a red snapper to the surface from depth can cause barotrauma, a pressure-induced condition, which often results in mortality. Anglers can use descending devices, which reduce symptoms of barotrauma, to increase the survivability of discarded fish by returning fish to their original capture depth. This practice can lower discard mortality rates and potentially prevent overfishing. Through interviews and document analysis, this study analyzed the challenges and opportunities of using descending devices in the South Atlantic red snapper fishery by investigating the process of successful descending device utilization in the Pacific groundfish fishery.

A Climate and Operational Vulnerability Assessment of the Water Company in Salamanca, Chile

The present master’s project is an analysis of the future vulnerability of the water company (Aguas del Valle) in Salamanca, Chile to potential changes in population, per capita water use, leakage, and climate. Scenario modelling and sensitivity analysis was carried out in Excel and Stella. We find that under a business as usual scenario, the water company will reach maximum production capacity according to its current water rights in the year 2027. In the most pessimistic scenario, the company will reach maximum capacity in year 2022 and need to produce around 16 million m3 in 2050, while in the most optimistic scenario, it will not reach maximum capacity before the year 2050, and will only need to produce around 1.54 thousand m3 yearly. A detailed sensitivity and Monte Carlo analysis revealed that per capita water use was the principal driver of water production for the future of the water utility. We recommend that the company reduce leakage, which has averaged 30% over the past 10 years. Lastly, we recommend increasing resilience of the system in case of a drought emergency by investing in water storage.

Analyzing the Role of Sound in the Endangered Species Act: A Petition for Sperm Whale (*Physeter macrocephalus*) Critical Habitat

A key feature of the Endangered Species Act (ESA) is the designation of critical habitat for threatened and endangered species. It is challenging to design critical habitat for marine species, however, due to knowledge gaps and the lack of spatial separation between key life functions (i.e. breeding, feeding). The acoustic component of habitat is particularly important for cetaceans, which rely on sound for communication and other essential life functions. Incorporating an acoustic factor into the critical habitat designations of threatened and endangered cetaceans has only occurred once to date. Thus, this project aims to suggest a way to incorporate sound into the ESA framework by drafting a citizen petition to the National Marine Fisheries Service to designate critical habitat for sperm whales (*Physeter macrocephalus*) in the Gulf of Mexico, largely based on the importance of acoustic habitat to their basic behavior.
HanesBrands Renewable Energy Prioritization

HanesBrands Inc. (HBI), a world-wide leading apparel manufacturer, has established the sustainability goals of reducing its energy intensity, carbon emission intensity, and increasing their renewable energy use. Duke Team has focused on HBI’s commitment of increasing company-wide renewable energy use to 40% by 2020 through prioritizing renewable energy investment options in their global portfolio. Based on the energy use breakdown & electricity costs of facilities, the Duke Team identified 10 facilities for a deeper dive. In order to better target facilities for the scalable Solar Photovoltaic (PV) & Solar PV + Battery technologies, a utility compilation database with electricity invoices detailing demand, consumption and administrative charges was created. Interval data was used to support the utility database by analyzing the energy consumption profiles of qualifying facilities with the best compatibility. Renewable energy investment options were explored in National Renewable Energy Laboratory’s (NREL) System Advisor Model (SAM) model, with the support of thorough geo-market research. Ultimately, technical & financial feasibility analyses were the basis for recommendations in the areas of Solar PV & Solar PV+Storage, (Synthetic) Power Purchase Agreements (sPPAs), and RECs that could facilitate HBI’s goal regarding renewables.

Assessing Children’s Exposure to Organophosphate Flame Retardants in the Home Environment

Flame retardants are chemical additives used to suppress combustion in various consumer products, such as furniture. Increasing use of organophosphorus flame retardants (OPFRs) raises concerns about exposure in the home, particularly for vulnerable populations such as children. Here we conducted statistical analyses to determine if OPFR exposures in toddlers (n=181) was associated with demographic variables, or indoor air concentrations. A second objective investigated associations with exposure and children’s growth. Statistically significant differences in urinary metabolite concentrations were found between children whose mothers had a college degree compared to those that did not. The urinary metabolites DPP and tbutylDPP also were significantly correlated with OPFR compounds measured in indoor air. One urinary metabolite, ipDPP, was found to have a statistically significant relationship with BMI percentiles in the toddlers, suggesting exposures might be affecting growth.
Streambed Texture and Hydraulic Connectivity Analysis of Restored, Degraded, and Natural Reference Streams in Durham, NC

In the face of growing concerns about how water quality is affected at the watershed level due to land use change, six sites in the same watershed near Durham, North Carolina were selected for an analysis of streambed sediment texture and hydraulic conductivity. The primary problem of interest is to investigate whether select Priority 1 stream restorations in Durham differ from degraded and natural streams in connectivity and exchange between the stream and subsurface. The main concern with Priority 1 restoration is that it requires burying the original stream channel and creating a new channel in the adjacent floodplain. If a floodplain differs significantly enough from the natural streambed and little is done to correct this in the restoration, there could be impacts on overall stream function. The results of our research will aim to inform future restoration practices pertaining to streambed sediments in newly created Priority 1 streams.

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Improving Water Quality in China: Developing a Platform to Help Industrial with Water Issues

Agricultural water pollution in China coupled with new governmental policies provide opportunities for collaboration between industries and environmental service providers (ESPs). Last year, SinoAltas, a platform was established providing information and opportunities for stakeholders to meet and cooperate. This year, the objective is to identify a target agricultural industry, identify its water pollution challenges, conduct technology to promote cooperation between industries and ESPs. After conducting literature reviews, qualitative interviews of pollution experts and new governmental policies for water pollution, we identified pig farms as our target industry. We researched current waste treatment techniques in China and created equations to calculate the cost benefit of each technique. We also developed an online Search System to provide ESPs information, which enables farmers to select ESPs based on their geographical location and waste water treatment choice. Once search system and treatment models are posted online, our client can market SinoAltas to increase platform popularity and user engagement by developing social media communication and attending industrial conferences.
Hannah Girardeau: MEM (EE) Advised by: Dr. Subhrendu Pattanayak

Household Solar Adoption: A Systematic Review

The astounding scope of the global energy poverty challenge has motivated many organizations to provide solar energy solutions to lighting, heating, and cooking needs in off-grid settings. However, poorly designed or executed projects have the potential to cause unnecessary harm in communities lacking access to reliable energy. This review aims to identify and analyze the enabling environment factors that drive or block the diffusion, dissemination, and adoption of solar home systems, solar lanterns, solar hot water heaters, and solar cooking products in low-income countries. To address this question, I have conducted a systematic review to examine which factors support or complicate household solar adoption. I identified 49 studies in 26 countries that describe an environment including financial controls, market development, program mechanisms, and regulatory standards. Common drivers and barriers include the cost of the product, availability of local banking and financial institutions, the quality of after-sales support and maintenance, user training programs, and mandatory product testing. Although there are a number of studies that fit the scope of this review, more research is needed to examine missing countries, correct imbalances in the technologies studied, and address themes missing in the selected papers.

Pedro Gochicoa: MEM (WRM) Advised by: Dr. Martin Doyle

Group Member: Lucas Eastman

A Climate and Operational Vulnerability Assessment of the Water Company in Salamanca, Chile

The present master’s project is an analysis of the future vulnerability of the water company (Aguas del Valle) in Salamanca, Chile to potential changes in population, per capita water use, leakage, and climate. Scenario modelling and sensitivity analysis was carried out in Excel and Stella. We find that under a business as usual scenario, the water company will reach maximum production capacity according to its current water rights in the year 2027. In the most pessimistic scenario, the company will reach maximum capacity in year 2022 and need to produce around 16 million m³ in 2050, while in the most optimistic scenario, it will not reach maximum capacity before the year 2050, and will only need to produce 154 thousand m³ yearly. A detailed sensitivity and Monte Carlo analysis revealed that per capita water use was the principal driver of water production for the future of the water utility. We recommend that the company reduce leakage, which has averaged 30% over the past 10 years. Lastly, we recommend increasing resilience of the system in case of a drought emergency by investing in water storage.

Ashley M. Gordon: MEM (CEM) Advised by: Dr. Patrick Halpin

Expanding and Evaluating the Biological Content of the Marine Cadastre Ocean Reporting Tool

The Marine Cadastre Ocean Reporting Tool is an online spatial planning tool designed to provide summary statistics for areas of interest in the Atlantic Ocean, spanning from Virginia to Florida. To expand the biological content of the tool, geospatial analysis techniques were applied to develop infographic designs summarizing marine mammals and seabirds predictive abundance models for pre-defined report areas. The proposed designs were shared with potential tool users, including professionals from non-profit organizations and federal and state agencies. A qualitative analysis of interview responses informed modifications to the initial infographic designs. The final infographic designs provide recommendations for future inclusion of marine mammals and seabird spatial data in the tool. The information presented is intended to support various marine spatial planning efforts in the southeastern United States.
Initiating Orvis’ Sustainability Strategy: Identifying Strategic Priorities and Sustainability Champions Within the Business

Orvis is America’s oldest mail-order outfitter and longest continually-operating fly-fishing business with more than $340 million in sales, offering a wide assortment of fly-fishing, hunting, and sporting goods. The company dedicates itself to personal responsibility and strives to restore, enhance and protect wild places; however, Orvis does not currently have an overarching sustainability strategy. In order to fill this gap, our research strives to capture an understanding of the perceptions, attitudes, and priorities of Orvis associates, managers, and executives with regard to sustainability initiatives. Insights gathered through the creation and distribution of employee engagement surveys, along with industry best practice research and an analysis of Orvis’ Higg Index results, will be used to develop key components of a long-term Corporate Social Responsibility strategy.

Forest Preferences and Urbanization: Perspective from Four Sacred Groves in India’s National Capital Region

The sacred grove, a forest abode of a deity or deities, exists in contemporary myths and landscapes. This study analyzes sacred groves as complex socio-ecological systems and approaches the plight of four extant sacred groves amidst the urbanization in India’s National Capital Region as a collective action problem. Utilizing demographic and ecological variation in Willingness to Pay (WTP) – by revealed and stated preference measures – for visits to sacred forest, non-sacred forest, and worship sites outside of sacred forests, I analyze shifts in demand in this socio-ecological system. This data provides nuance to the hypothesis that Sanskritization – transition from local, folk to global, Hindu deity worship – results in degradation of the sacred grove institution. While increased urban and Sanskritization characteristics correspond with a trade-off of sacred forest for temple preference, these characteristics also correspond with increased perception of non-sacred forests as useful for ecosystem services. These results suggest attention to nonlinear dynamics in collective action settings sensitive to cultural evolution.

Effects of Stand Attributes in Evaluating Even-Aged Loblolly Pine Volume with LiDAR

The purpose of this project is to determine the practicality of using LiDAR technology in the field as a primary tool for forest inventory. Specifically, this project uses variables generated from Quality Level 2 (QL2) LiDAR data obtained from the state of North Carolina Floodplain Mapping Program to investigate the overall goodness of fit of loblolly pine volume. Seven stands in the Piedmont and coastal regions in North Carolina were used in this study. Volume was calculated using pre-harvest cruise data and was regressed against the LiDAR generated predictors of height and canopy cover. The analysis was conducted on both plot level and at a mid-sized management level, of theoretical harvest units (THUs). These LiDAR derived variables were able to moderately explain loblolly pine volume at the plot level (R^2 = 0.45) while at the THU level, model fit improved markedly (R^2 = 0.70). This suggests that LiDAR is a good predictor volume when examined at a larger unit – such as at the stand level.
Coastal climates have distinctive effects on the growth, quality, and quantity produced of wine grapes. A changing coastal climate could alter these interactions and impact regional wine style and variety. There is a need to understand how growers and wine makers are perceiving and responding to climate change to inform future adaptation strategies. To explore this topic, viticulturists on the Eastern End of Long Island, NY were interviewed regarding their perception of 1) how the maritime climate affects viticulture, 2) how that interaction has changed/may change in the future, and 3) how they will adapt. The maritime climate has the perceived effects of moderating land temperature, inducing humidity, and featuring unpredictable weather such as hurricanes and coastal storms. Most respondents believe that the maritime climate has changed over time, allowing for higher quality wine but also greater environmental risk. Industry professionals don’t see extensive adaptation methods as necessary yet, but do seek to utilize sustainable and vigilant vineyard practices to enhance resilience in times of greater risk and uncertainty.

In the western United States, prior appropriation is the dominant form of water rights. In times of scarcity, the most senior water rights are given priority. Water right transfers can increase economic efficiency by moving water toward higher value uses, but the parties involved must prove that transfers do not reduce water availability for third-party users. In this study, the Upper Gunnison River Basin in Colorado is used as a test case to study the effects of network structure on third-party injury in water right transfers. Results show that in some cases, multi-party transfer agreements can be used to avoid injury to third-parties or to increase instream flows in vulnerable reaches. Additionally, a new web-based tool is described, which allows users to explore potential water right transfers within the basin and to estimate the effects on third-party water availability and instream flows.

Local communities play an integral role in biodiversity conservation, however local values are often not considered in regional environmental decision making. This study provides a first look at developing management strategies that are compatible with rural livelihoods in northeast Gabon where extractive industry and national parks have the potential of impacting forest-dependent communities by limiting forest access. Community mapping exercises, surveys, and interviews were conducted in 10 villages to assess local values and perceived threats to natural resources, and potential solutions to address local concerns of resource availability. My findings suggest that croplands are the most highly valued resource, elephant crop raiding and logging are the main local concerns, and communities nearest the national park have the most negative perceptions of forest access. I suggest steps forward for mitigating human-elephant conflict and facilitating the establishment of community forests in order to achieve long-term conservation outcomes.
Kayla A. Hartigan: MEM (ESC) Advised by: Dr. Douglas Nowacek

Using Soundscape Ecology Techniques to Determine Changes in Biodiversity off the Coast of Cape Hatteras, NC

Long-term habitat monitoring is an essential but often difficult and time-consuming task that has increasingly been accomplished using passive acoustic data to assess properties of the environmental soundscape. Soundscape properties and bioacoustic indices can provide information about ecosystem processes and biodiversity, an important environmental health indicator, though little is known about how soundscapes vary with depth. This project used acoustic data collected from 2013 to 2015 off the coast of Cape Hatteras, NC, using an array of hydrophones deployed at five different depths to examine various properties of the soundscape, and calculated two acoustic indices shown to determine biodiversity in marine environments. Through this analysis, diel patterns were observed at all depths, peak times throughout each month and season were identified for biological activity (e.g. fish sounds) and anthropogenic activity (e.g. vessel noise), and changes in biodiversity were determined and compared across depths.

Janesha Hassaram: MEM (EEP) Advised by: Dr. Timothy Johnson

Group Members: Hoel Wiesner, Yifu Wang and Eric Brawner

Assessing Land Availability for Utility-Scale Solar in North Carolina Using GIS

The use of utility-scale solar photovoltaic (PV) systems to generate electricity has been increasing substantially in the U.S., and North Carolina is a leading state in its installation. Optimally siting utility PV projects can maximize power generation and reduce projects’ costs, environmental impacts, and social opposition. Our analysis develops a GIS method to optimize siting these projects and assess how suitability factors affect land availability over large areas. We first identify criteria important for siting utility PV projects, such as land-cover, slope, and proximity to electrical substations. We then assess how the addition of these criteria, from most to least stringent, reduces the availability of suitable land across North Carolina. As the use of utility solar grows in North Carolina, our analysis provides an assessment of siting constraints, identifies prime locations, and quantifies the state’s theoretical potential for this power source.

Virginia R. Henson: MEM (ESC) Advised by: Dr. Elizabeth Shapiro

Group Members: Elissa Tikalsky, Sofia Tenorio Fenton

Understanding Pathways to Contaminant Exposure in North Carolina Community Gardens

Community gardens are a valuable resource for empowering communities and keeping individuals healthy. Unfortunately, the geographic and social context of these gardens increases the likelihood that contaminants, such as heavy metals and other toxic chemicals, will be present in garden soils. However, informed and responsible choices by garden managers and participants can often maintain the positive benefits of these gardens while safeguarding participants from these risks. To begin to address this problem, we conducted i) six case studies at North Carolina community gardens, involving interviews, focus groups, observations, and material culture analysis, and ii) a statewide web-based survey of community gardeners. Our findings suggest that many gardeners are concerned about contamination, but often lack the knowledge, resources, and social support necessary to adopt safe practices. We therefore offer recommendations for tailoring effective outreach materials to encourage practices that reduce the risk of gardeners’ exposure to contaminants.
Business Models for Extracting More Useful Life from Lithium Ion Battery Systems

Demand for new lithium-ion battery (LIB) systems is forecast to double between 2015 and 2020. However, current battery disposal practices mean that by 2020, tens of GWhs of still-useful lithium ion storage capacity could be directed towards landfills. While automotive companies are actively engaged in “second life” concepts for their electric vehicle batteries, it is not apparent that non-automotive batteries have similar applications. Non-automotive batteries have many different chemistries and form factors, and suffer from weak economics in the recycling process. This project explores the entrepreneurial viability of finding a “second-life” for non-automotive LIB systems. Specifically, we explore (1) capturing this low cost “waste” stream from primary users of batteries, (2) diagnosing and refurbishing used LIB systems, and (3) selling these systems to secondary users. Environmental benefits are quantified via (1) mineral conservation and (2) avoided emissions attributable to further unlocked levels of renewable energy supported by increased storage levels on the power grid.

Inventory Modeling and Scenario Analysis of Timber Resources in the Duke Forest

Since it was founded in 1931, the Duke Forest has shown a commitment to sustainable timber management practices and forestry education. However, in recent years, a misalignment between revenue expectations and the timber management paradigm have resulted in an uneven age class distribution favoring younger age classes of pine. The purpose of this project is help the Duke Forest address this management challenge by reassessing its inventory and yield projections from its 2010 inventory to understand how the Forest might be able to improve its estimation of sustainable harvest by more accurately accounting for volume growth. Additional analyses were also conducted to model different harvest rotation lengths using the US Forest Service’s Forest Vegetation Simulator (FVS) to understand how more intensive management practices, such as shortening the pine rotation length and planting genetically improved stock, could help balance the Forest’s age class distribution in other divisions while keeping the forest profitable.

Achieving Sustainable Development Goal 12: An exploratory study on sustainable consumption in Lima, Peru

In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development; a global action plan for people, planet, and prosperity. Sustainable Development Goal 12 (SDG12) aims to ensure sustainable consumption and production patterns. This research explored the attainability of SDG 12 in Lima-Peru through the lens of market-based, purpose-driven organizations. First, semi-structured in-depth interviews were held with founders of market-based, purpose-driven organizations in order to analyze their perspectives on the current state of sustainable consumption in Lima, Peru. Second, a comparative knowledge, attitude, and behavior survey was implemented to a group of followers of one of the market-based, purpose-driven organizations and a control group of non-followers of environmental organizations. Interview results show that the founders believe that they are actively contributing to achieving SDG12, but that even though sustainable consumption patterns are beginning to emerge in Lima, Peru, targets will unlikely be reached by 2030. Survey results showed minimal differences between the two study groups, with followers of the market-based, purpose-drive organizations scoring slightly higher on sustainable consumption behavior.
A Bottom-Up Model of Residential Electricity Demand in North and South Carolina

Given the growth in energy efficient appliances, lighting, and building materials and construction, a shift in residential electricity demand is likely. In this paper, we construct a bottom-up engineering model of electricity consumption in the residential housing stock of North and South Carolina. We build a set of archetypes representative of the residential housing stock based on the EIA's 2009 Residential Energy Consumption Survey (RECS). Energy use for these archetypes is modeled using DOE’s EnergyPlus with the BEopt shell. These results are then scaled by archetypes’ proportion of the housing stock to calculate regional electricity consumption. Using expected residential growth rates, we extrapolate to 2015 and use residential electricity demand in that year as a measure of the model’s forecasting viability.

Drivers and Challenges for the Expansion of Renewable Resource Feedstocks: The Sustainable Apparel Sector

Companies are increasingly exploring renewable resource feedstocks (RRFs) as inputs into consumer goods; to shift away from non-renewable resources and support sustainability efforts. A significant gap exists in understanding the opportunities and barriers for RFF expansion, specifically in the apparel sector. In this study, a global survey was administered to textile professionals to explore value chain perceptions of RRFs and outline the RRF landscape. The greatest drivers in RRF utilization were demand from brands and retailers, industry trends, and sourcing availability. Cost of inputs was rated as the greatest barrier to RRF utilization, followed by availability of inputs, performance, and associated technology requirements. Information gaps in RRF environmental impact and RRF procurement were also identified as barriers. While RRF was the terminology used for this study, the results indicated a lack of homogeneity in the term RRF and with what materials are considered “sustainable.”


The Regional Greenhouse Gas Initiative (RGGI) is a cap-and-trade program in the Northeast and Mid-Atlantic covering power sector carbon dioxide emissions. Many expect policies aimed at reducing carbon dioxide emissions, like RGGI, to cause coal-fired power plant closures as a way of complying with emissions reduction requirements, given the relatively higher carbon intensity of coal plants (as opposed to other fuel types) and the limited availability of carbon dioxide pollution control technology. This analysis qualitatively and quantitatively evaluates coal closures within the RGGI states between 2005 and 2015 to identify the extent to which RGGI caused these closures. A qualitative analysis of media reports and press releases surrounding the closures indicates that RGGI did not play a role in any of the closures; however, regression analysis suggests that RGGI did have a statistically significant impact in causing closures. The RGGI closures are compared to closures in the non-RGGI states as well as closures occurring before the policy was announced.
Waste Heat Recovery in Bicycle Manufacturing Process for Specialized Bicycle Components

Cooperating with Specialized Bicycle Component, we conducted a waste heat analysis on two heating processes for its aluminum bicycle frame. We found that the waste heat from these processes is 451.60 MWh/year worth 22,174.97 $/year estimated with the local fuel price and the heat absorbed by the frame holder could be the most practical start point to reduce the waste heat. At the same time, by consulting professionals and literature review, we found that some commonly used waste heat recovery strategies could not be implemented in our context. Furthermore, we gave two detailed recommendations, switching the fuel and changing the material of frame holders, to reduce the economic cost and environmental impact of this process. Switching fuel from LPG to natural gas would save 9528 $/year and reduce 18.96 ton CO2/year. Changing the frame holder from steel to carbon composite would save 209 $/month and the investment will be paid back in 17 months. The possibility of process optimization was also discussed.

Initiating Orvis’ Sustainability Strategy: Identifying Strategic Priorities and Sustainability Champions Within the Business

Orvis is America’s oldest mail-order outfitter and longest continually-operating fly-fishing business with more than $340 million in sales, offering a wide assortment of fly-fishing, hunting, and sporting goods. The company dedicates itself to personal responsibility and strives to restore, enhance and protect wild places; however, Orvis does not currently have an overarching sustainability strategy. In order to fill this gap, our research strives to capture an understanding of the perceptions, attitudes, and priorities of Orvis associates, managers, and executives with regard to sustainability initiatives. Insights gathered through the creation and distribution of employee engagement surveys, along with industry best practice research and an analysis of Orvis’ Higg Index results, will be used to develop key components of a long-term Corporate Social Responsibility strategy.

New Insights Into the Primary Drivers of Gray Whale (*Eschrichtius robustus*) Foraging Off the Coast of Port Orford, Oregon

Little is known about the drivers and mechanisms of gray whale foraging. The population of Gray whales that forage seasonally on hyperbenthic mysid along the coast of Port Orford, Oregon, offer an opportunity to explore the important yet understudied dynamics of these animals and their prey at a local scale. During the 2016 foraging season, GoPro video footage of the water column was used to measure prey distribution and abundance while individual gray whales were tracked using a novel, non-invasive method. In addition, environmental parameters were measured including water depth, distance to kelp, and habitat type. An analysis of these data determined that distance to kelp and depth were highly significant drivers of gray whale foraging effort. These results provide new insight into understanding the complexity of gray whale foraging.
Habitat Restoration Incentives for Major Infrastructure Projects

Major infrastructure projects constitute the undertaking by an agency or organization to develop large-scale projects that provide integral public services. As proponents of major infrastructure projects contemplate future efforts, they should consider habitat restoration at the onset of the project. Three case study projects located in Washington State are used to explore the incentives for including habitat restoration as part of major infrastructure projects: the Elliott Bay Seawall Project, the State Route 520 Bridge Replacement and High-occupancy Vehicle Program, and the Yakima River Basin Integrated Water Resource Management Plan. Review of these case study projects shows that the habitat restoration component of these projects was instrumental in increasing public support, streamlining regulatory review, saving money, and providing opportunities for innovation.

Feasibility Study of Energy Recovery by Incineration - A Case Study of Triangle Wastewater Treatment Plant

This study evaluates the energy recovery potential of wastewater by means of incineration for a small wastewater treatment plant. An analysis was conducted taking a local sewage treatment plant as a case in point, the challenge being the relatively small size of the treatment plant. This study investigates the future financial impact of unchanged sludge disposal method and the potential benefits and drawbacks of a sludge incineration plant. Wastewater flow data was collected and the digested waste analyzed to find its calorific value. An appropriate sewage incineration plant design was identified. Projection of wastewater flow growth and parameters of the incineration plant were used to identify the energy recovery potential and financial feasibility of such a project. The selected incineration plant, when sized in accordance with the wastewater treatment plant in question, was self-sufficient in terms of its own energy needs but the net generation was small. It is recommended that a detailed technical, legal, resource and operational feasibility study be performed before any definite decision is made.


A YieldCo is a publicly traded investment vehicle that owns operating energy assets, the majority of which are typically renewable, and whose stated purpose is to distribute the majority of its available cash to shareholders while minimizing corporate taxes. After three successful years in the market, multiple events during the summer of 2015 led investors to question the fundamental nature of the YieldCo structure. This project seeks to understand if the uncertainty surrounding the long-term viability of the YieldCo as a financing vehicle for renewable energy is well founded. Our analysis uses market data, firm disclosures, and equity research reporting to evaluate the macroeconomic, firm-specific, and intrinsic risks of the YieldCo structure. We explore several explanations for the sector’s turbulence since 2015 and propose recommendations to align YieldCo, sponsor, and shareholder incentives. This assessment of the YieldCo financing vehicle can be used to inform future action in the sector, as well as renewable energy financing more broadly.
San Francisco’s 2030 District: Performance and Implications for Urban Energy Efficiency

Buildings are responsible for 40% of the United States’ total energy consumption and a proportionate amount of greenhouse gas emissions. Transportation activities are responsible for another 30%, of which a significant amount is linked to workers’ daily commutes by car. Individual investments in home energy retrofits are helpful in the fight against climate change, but the greatest opportunities in the built environment lie with commercial properties in urban cores. As one of 15 cities subscribed to the 2030 Challenge, San Francisco has organized 40+ downtown properties to reduce their aggregate energy consumption and commuter-based emissions by 50-100% by 2030. This master’s project analyzes energy consumption by District properties against a city-established baseline and reduction target. It also calculates a commuter emissions baseline for the San Francisco 2030 District (SF2030D), and compares it to the District’s current performance as measured by a custom survey. The results show that SF2030D has outperformed its peers and reached its 2030 energy target within its first reportable year (2016). These findings have significant implications for the 2030 Challenge’s design, and may position SF2030D as a leader in the pursuit of energy efficiency innovations at the district scale.

Phthalate Exposure Among Children in a North Carolina Cohort

Phthalates, chemicals found in plastics and personal care products, are a ubiquitous class of chemical compounds that have been associated with adverse health effects. Mothers and their toddlers were recruited from a pregnancy cohort and completed a questionnaire which included demographic information and reports of children’s product use habits. Pooled urine samples (3 over 48 hours) were collected from 180 toddlers and analyzed for five major phthalate metabolites: mEHP, mEP2, mBP, miBO, and mBzP2. Statistical analysis compared the urinary metabolite concentrations with the children’s demographic information and average product use. Maternal education was inversely associated with urinary concentrations of all metabolites. After controlling for confounding by demographic variables, lotion and nail polish use were significant predictors of urinary mEP2 levels. This study suggests personal care product use in toddlers influences phthalate exposure.

Business Models for Extracting More Useful Life from Lithium Ion Battery Systems

Demand for new lithium-ion battery (LIB) systems is forecast to double between 2015 and 2020. However, current battery disposal practices mean that by 2020, tens of GWhs of still-useful lithium ion storage capacity could be directed towards landfills. While automotive companies are actively engaged in “second life” concepts for their electric vehicle batteries, it is not apparent that non-automotive batteries have similar applications. Non-automotive batteries have many different chemistries and form factors, and suffer from weak economics in the recycling process. This project explores the entrepreneurial viability of finding a “second-life” for non-automotive LIB systems. Specifically, we explore (1) capturing this low cost “waste” stream from primary users of batteries, (2) diagnosing and refurbishing used LIB systems, and (3) selling these systems to secondary users. Environmental benefits are quantified via (1) mineral conservation and (2) avoided emissions attributable to further unlocked levels of renewable energy supported by increased storage levels on the power grid.
**Bug Ideas: Assessing the Market Potential and Regulation of Insects as a Feed Source in the United States**

Insects can be grown at industrial scale using low energy, low water and high waste inputs. They have the correct nutritional makeup of protein, fat and omega-3s to supplement fishmeal when fed to fish, pigs and chickens. Furthermore, the ability to control the insect rearing conditions means the cost and output of insect meal can be more stable than fishmeal, which has dramatic price fluctuations. This leaves opportunity for a new feedstock to capitalize upon the increased demand for feed. This presentation will provide clarity and guidance in the emerging insect-based feedstock market. The two areas of focus are regulatory status and market potential. The primary geographical scope of this project will be the United States of America. However, given the global nature of feed, relevant tangential international implications will be presented as well.

**Protecting Health From Rising Air**

Air pollution is a major public health threat in cities across the world, especially in India. Ahmedabad, India has some of the worst air pollution in the world. To protect local communities from rising air pollution levels, the Ahmedabad Municipal Corporation (AMC) is developing an Air Quality Index (AQI). The AQI is a tool that serves as a communication bridge and summarizes complex air quality information to members of the public. To support the Ahmedabad AQI, the Natural Resources Defense Council (NRDC) and other institutions are working with the AMC on information, education, and communication strategies. This includes displaying the information and forecast, early warnings, media campaigns, and distributing informational pamphlets. Proper communication and outreach strategies are essential to protect the publics’ health from rising air pollution.

**Effects of Different Land-Use Strategies on Rural Livelihoods and Perceptions Towards Conservation in Gabon**

The government of Gabon has made efforts in recent years to develop sustainably by coupling development and conservation goals. This is particularly important for rural areas, where forests of high conservation value exist adjacent to villages that have some of the highest poverty rates in the country. In these areas, the primary development opportunities include logging and industrial agriculture, while conservation efforts are focused on the creation of national parks. To determine the impact of these activities on these rural, forest dependent communities, we conducted a household level livelihood and perception survey in 136 households in 15 villages in Gabon. Self-reported information on livelihood indicators and attitudes toward forests, wildlife, and conservation were recorded. Results show that national parks have more of a negative effect on livelihoods than either logging or industrial agriculture, demonstrating a need for improved integration of conservation and development.
Developing an Alternative Approach to Wildlife Management in the Duke Forest

Wildlife management is not currently a major priority of the Duke Forest, but staff have expressed an interest in making it a more significant aspect in future forest management decisions. We here used a multi-criteria decision analysis framework to explore a variety of wildlife management and monitoring alternatives with the aim of providing Duke Forest staff an adaptive tool for making well-informed wildlife management decisions. We identified potential management strategies by looking at forest management plans in use by peer institutions and then conducting a meta-analysis to determine the effect each of the potential strategies had on taxa of interest to Forest staff. We also looked at the possibility of using a community-based monitoring approach to supplement limited Forest staff resources through the use of expert interviews and a formal review of the literature, and assessed the importance of multiple components in ensuring quality data monitoring. We used the results of both of these analyses to construct a decision framework Duke Forest can use to identify wildlife management and monitoring schemes.

Integrated Water Finance Solutions to Drought in the Yakima Basin, Washington

Located in south-Central Washington, the Yakima Basin is one of the most affluent agricultural hubs in the nation, contributing over $3 billion to the state economy annually. Junior water users in the Basin, namely Roza Irrigation District (Roza), have already experienced the negative financial impacts of drought. To ensure water supply stability in preparation for future droughts, Roza has partnered with the Department of the Interior’s Natural Resource Investment Center (NRIC) in developing the financial strategy for the Yakima Drought Relief Pumping Plant (YDRPP), an infrastructure project that will provide 200,000 AF of additional water during drought years. As student consultants for the NRIC, we conducted hydrological, ecological, and financial analyses exploring the potential benefits of the YDRPP for the Yakima Basin. Our results revealed that junior water users are vulnerable to shortage during drought years due to an increased reliance on reservoir storage during non-drought years. In addition to sustaining the agricultural economy in Roza, water generated by the YDRPP could supplement instream flows in 92 miles of critical fish habitat throughout tributaries in the upstream Kittitas Reclamation District. Ecological benefits of the station may be leveraged to create unique finance options for Roza such as environmental impact bonds and green impact investing. We also analyzed and compared other alternative financing strategies, including traditional capital bonds, public-private partnership contracts, and climate-risk bonds. Our findings indicate that overall project costs for Roza are highly dependent on the amount of financial risk that the district is willing to retain in the construction, operation, and maintenance of the YDRPP.
Jennifer Lamy: MEM (EEP)

Agricultural Drivers of Nutritional Outcomes in Mvomero, Tanzania

My research question is: What land use and agricultural practices most significantly influence nutritional and food security outcomes? In particular, are there specific crop growing, selling, or irrigation practices that, when performed by a household, help to reduce the risk that children under five years old in that household are stunted or anemic. What is the impact on perceived food security by the household head? I use data collected in 2011 and 2013 in the Mvomero district of Tanzania in order to answer these questions. Using a combination of data at the household level on land use practices and on the individual level of health measures, I perform logit and ordered logit regressions in order to identify significant associations between the two groups. My results are varied: some agricultural practices tend to influence stunting or anemia, while others have a greater influence on measures of food security. Household size is negatively associated with both food security measures, implying that households in the region have difficulty keeping up with food demands of larger households. My findings point to the fact that there is no silver bullet in the quest to improve childhood nutrition and food security in Mvomero, Tanzania.

Janet L. Larsen: MEM (DEL)

Agriculture and Land Use Change in Paraguay

In recent years Paraguay has become one of the five countries with the fastest accelerating deforestation rates in the world. Land clearing for cattle pastures and for soybean farms are the two main drivers of forest loss. Paraguay now ranks as the world’s fourth leading exporter of soybeans and the fifth leading exporter of beef. This study uses governmental statistics and remotely sensed data to analyze Paraguay’s changing land use patterns. It projects the land area available for future agricultural expansion and examines the policies and voluntary agreements that affect deforestation. Results indicate that expanding soybean farms in Paraguay’s Eastern Region are displacing cattle ranches into the Western Region. Growing demand for both beef and soybeans on international markets are likely to increase deforestation pressures on Paraguay’s remaining forests.

Jennifer Lenart: MEM (WRM)

Streambed Texture and Hydraulic Connectivity Analysis of Restored, Degraded, and Natural Reference Streams in Durham, NC

In the face of growing concerns about how water quality is affected at the watershed level due to land use change, six sites in the same watershed near Durham, North Carolina were selected for an analysis of streambed sediment texture and hydraulic conductivity. The primary problem of interest is to investigate whether select Priority 1 stream restorations in Durham differ from degraded and natural streams in connectivity and exchange between the stream and subsurface. The main concern with Priority 1 restoration is that it requires burying the original stream channel and creating a new channel in the adjacent floodplain. If a floodplain differs significantly enough from the natural streambed and little is done to correct this in the restoration, there could be impacts on overall stream function. The results of our research will aim to inform future restoration practices pertaining to streambed sediments in newly created Priority 1 streams.
Sustainable consumption in the U.S.: A Consumer-Facing Analysis of Strategies and Business Models in the Retail Industry

The RILA (Retail Industry Leaders Association) Department of Sustainability tasked the Duke team with exploring and defining sustainable consumption and production in the next generation of the U.S. retail market. The Duke team focused on identifying the opportunities for retailers to monetize, adopt and leverage these newly developing business models in a circular economy space. The team worked closely with nine leading RILA brands (Coca-Cola, The Home Depot, Ikea, REI, Target, Unilever, VF Corp, Walgreens, Whole Foods) to 1) conduct research to develop a framework for consumer-facing, sustainable consumption initiatives and 2) create a set of criteria and industry best practices to identify gaps and barriers for strategy implementation opportunities. Next, the Duke team examined the feasibility of a collaborative materials marketplace at the regional level (NC Research Triangle) and executed a materials process analysis to examine specific material flows and feedstock dynamics.

Demonstrating Air Emissions Reductions through Energy Efficiency Retrofits on Maersk G-Class

From 2015-2016, Maersk Line invested $125 million to retrofit their G-class vessels. This Radical Retrofit (RR) program is a part of Maersk’s commitment to reduce global fuel consumption and related CO2 and other air pollutants by 60% per container. In 2015, Maersk received a grant from the San Pedro Bay Ports Clean Air Action Plan to develop a methodology for quantifying the benefits from these efficiency improvements from both an emissions inventory and validation standpoint. We present the results through a series of linear regressions used to compare the Manual Ship Performance System (MSPS) data from before and after RR. Through graphical visualization and t-tests, the report also compares MSPS data against automated Control, Alarm, and Monitoring System (CAMS) data. These results are intended to guide Maersk as it develops a methodology for calculating emissions. The report makes recommendations on how Maersk can design its Performance Platform to incentivize additional emissions reductions.

Generating Homeowner Demand for Energy Efficiency Retrofits: Recommendations for the NCBPA

With rising concern aimed at energy consumption and its environmental impacts, efforts are being made to conserve energy across the United States. Nearly half of all domestic energy use is dedicated to homes and buildings. Despite significant strides by the building industry to design new energy efficient structures, a significant portion of the current housing stock includes inefficient, poor-performing homes. The North Carolina Building Performance Association (NCBPA) tasked us with identifying the barriers preventing homeowners from investing in home energy retrofits and offering pertinent recommendations to address these roadblocks. Through an exhaustive review of current literature and key insight from industry leaders, we distilled the many barriers into four areas: consumer education, home valuation, financing, and marketing. Our recommendations include building-out the NCBPA consumer education website, hiring of a full-time data manager to create an inventory focused on capturing metrics surrounding home valuation, developing a conjoint marketing plan to target specific audiences, and continuing to push for commercial PACE and on-bill financing in North Carolina.
The Impact of Rural Electrification in the Kingdom of Bhutan

Since the 1990s, the Kingdom of Bhutan has made significant investments to achieve universal rural electrification (RE), with goals to improve education, health and employment outcomes and reduce fuelwood consumption. While planners expect that improved energy access generally enhances well-being, previous assessments of RE programs find highly varied, context-dependent impacts. To assess the impact of RE in Bhutan, I rely on survey data from three rounds of the Bhutan Living Standards Survey. Applying linear and non-linear regression methods as well as propensity score matching, I find that the RE program led to improvements in education and reduced fuelwood consumption. I find inconclusive evidence of the effects of RE on non-agricultural employment and find no effect on health. I conduct a cost-benefit analysis (CBA) to compare program costs, at both the government and household levels, against estimated benefits. I test the sensitivity of the CBA result to variation in the magnitude of estimated impacts and other key parameters.

Comparing Estimates of SO\textsubscript{2} and NO\textsubscript{x} Emissions Inventories for the U.S. and China: Exploring the Reasons for Discrepancies between EDGAR and ECLIPSE

EDGAR (Emissions Database for Global Atmospheric Research) and ECLIPSE contain estimates of past, current, and future emissions of greenhouse gases and other air pollutants, at the global, regional and country scales. These datasets are each a direct output of two models; the Integrated Model to Assess the Global Environment (IMAGE) model, and the Greenhouse Gas and Air Pollution Interactions and Synergies GAINS Model.

This project compares the estimates of Nitrogen oxides (NO\textsubscript{x}) and sulfur dioxide (SO\textsubscript{2}) for years 2000, 2005 and 2010 reported by ECLIPSE for the U.S. and China, with the same estimates from EDGAR, and examines the underlying assumptions and modeling structures to understand the sources of differences. Results show that while global estimates from the two datasets are similar there are noticeable discrepancies at the national levels. This highlights the uncertain nature of the quantity of emissions associated to each sector. In particular, it is found that the transportation sector is the driver of significant differences in estimates of both global and national NO\textsubscript{x} emissions.

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Handi Ma: MEM (EEP)
Group Member: Helena S. Rhim
Advised by: Dr. Prasad Kasibhatla

Recommendations on Campus Sustainability Development for Duke Kunshan University

As the Sustainable Duke Office at Duke University determines the next steps on how best to integrate a satellite campus such as Duke Kunshan University (DKU) into its Climate Action Plan, it is important for both DKU and Duke to gain an in-depth understanding of campus sustainability at other higher education institutions. Through a review of literature and a case study of campus sustainability at Hong Kong University of Science & Technology (HKUST), this project seeks to provide a baseline for further studies on sustainable development at DKU by (1) identifying the types of sustainability initiatives currently taking place at HKUST, (2) understanding the specific challenges of implementing such initiatives, and (3) providing recommendations for DKU on how best to incorporate sustainability as it continues to expand its physical campus and academic programs.

Peter J. Magner: MEM (EE)
Group Members: Christopher Sanders and Isa Li
Advised by: Dr. Timothy Johnson

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Conor B. Makepeace: MEM (ESC)
Advised by: Drs. Nicolette Cagle and Dean Urban

Assessment of Avifauna in North Carolina Piedmont Prairies

The historic Piedmont Prairie is often considered a haven for many threatened avifauna. This study uses a paired sample technique and point counts to compare the species composition of prairie and non-prairie sites to determine if these prairies contain a significantly different species composition. The study also analyses environmental variables relevant to species composition to determine the drivers of any species differences. Mantel tests showed no significant relation between the prairie designation and the composition of bird species at these sites. Wilcox tests and ANOVAs revealed no significant difference in the total number of species, mean number of species, or species richness (Simpson index) of prairie / non-prairie areas. Species accumulation curves revealed that prairie sites showed less variation and saturated less rapidly than their non-prairie counterparts, leaving the door open for further studies of longer time scales.
Conserving forests and increasing energy efficiency are two key ways that developing regions can contribute to climate change mitigation. I examine whether and how initiatives to reduce emissions from deforestation and forest degradation (REDD+) affect household choice of cooking technology. I draw evidence from household surveys in and around pilot REDD+ initiatives across the tropics, including two in Tanzania that promoted improved cookstoves as a way to reduce forest degradation. After controlling for confounding variables through propensity score matching and endogenous treatment-regression models, I find that the interventions in Tanzania did increase adoption of improved cookstoves, although the vast majority of households still cook on traditional three-stone fires. Across the tropics, I find that interventions to reduce deforestation and forest degradation that are implemented in the context of REDD+ are more effective at encouraging adoption of improved cookstoves than adoption of LPG.

Elizabeth C. Mason: MEM (CEM)  Advised by: Dr. Dave Johnston

An Evaluation of the Accuracy of Photogrammetric Measurements from Unmanned Aircraft Systems

Photogrammetric research on marine mammals seeking to estimate size and body condition requires careful assessment and correction of distortion in imagery. This is especially true for consumer cameras not designed for quantitative photogrammetry. The present study quantifies the distortion for three different cameras, a GoPro Hero 4, Olympus E-PM2 and Sony a5100, and assesses the accuracy of photogrammetric measurements from each system. Using Adobe Photoshop, the amount of both barrel and pincushion distortion found in imagery was assessed and corrected. Images were taken of a reference targets on the ground with varying distances from the object (10m, 20m, 30m, 40m, 50m), and the difference between actual size and photogrammetric measurements were quantified. We then used the same three cameras on multirotor drones to further assess the accuracy of photogrammetric measurements in field deployments. The outcomes of these assessments were then applied to images of humpback whales (*Megaptera novaeangliae*) that were measured to look at total length of individuals in the Antarctic.

Sam Matias: MEM (EE)/MBA  Advised by: Dr. John Buley

Group Members: Elise Johnson, Danny Suits and Heather Wiggins


A YieldCo is a publicly traded investment vehicle that owns operating energy assets, the majority of which are typically renewable, and whose stated purpose is to distribute the majority of its available cash to shareholders while minimizing corporate taxes. After three successful years in the market, multiple events during the summer of 2015 led investors to question the fundamental nature of the YieldCo structure. This project seeks to understand if the uncertainty surrounding the long-term viability of the YieldCo as a financing vehicle for renewable energy is well founded. Our analysis uses market data, firm disclosures, and equity research reporting to evaluate the macroeconomic, firm-specific, and intrinsic risks of the YieldCo structure. We explore several explanations for the sector’s turbulence since 2015 and propose recommendations to align YieldCo, sponsor, and shareholder incentives. This assessment of the YieldCo financing vehicle can be used to inform future action in the sector, as well as renewable energy financing more broadly.
Were the Post-Sandy Staten Island Buyouts Successful in Reducing National Vulnerability?

An increasingly common post-disaster mitigation approach, home buyout programs are generally intended to reduce vulnerability to future disasters. However, to date, there has been no quantitative evaluation of whether or not coastal buyout programs are successful in reducing vulnerability. Through a change in vulnerability analysis, this study quantifies the success of the Staten Island buyout program in reducing the national vulnerability of people and property to coastal flood hazards. Results show an increase in overall vulnerability, which includes exposure and social vulnerability, for 99% of the buyout participants studied. Buyout participants tend to relocate within five miles of their origin address, move to areas with higher levels of poverty, higher population density and greater percentages of individuals over 65. Given these results, it remains unclear whether the program met its objective of reducing the vulnerability of people and property to coastal flood hazards.

Practical Guidance for Environmental NGOs on Cost-effectively Integrating the Use of Unmanned Aerial Systems

Environmental non-governmental organizations (NGOs) must collect immense amounts of data on a range of critical topics from breeding habits and coastline change to achieve their missions. UAS technology, commonly known as drones, offers an opportunity to collect environmental data more frequently and efficiently than traditional aerial methods — at a fraction of the cost. However, there is still a great deal of uncertainty within many organizations on how to outline a path toward integrating the use of drones into their work. This MP will utilize traditional strategic frameworks to suggest a cost-effective approach for the North Carolina Coastal Federation (NCCF) to integrate the use of UAS. This effort will ultimately assist the NCCF, and other NGOs, with the incorporation of drone technology into environmental applications.

Three Decades, Three Stories? A 29-Year Separate Account Case Study and the Evolution of Timberland Investment

Portfolio-level return series can be used to assess the pros and cons of investing in timberland. This study employs multiple performance measurement techniques to analyze returns from a southern softwood portfolio managed by Forest Investment Associates. The portfolio grew at 8.04% annually for 29 years, beating most U.S. stock market indices and publicly-traded forest products companies. The portfolio exhibited low correlations with financial assets, inflation-hedging attributes, strong returns from cash, and positive alpha. Ten year returns decreased from 14% to 2% between 1987 and 2016, but the portfolio maintained low exposure to systematic risk and positive diversification attributes. Shrinking returns coincided with an increase in competition among TIMOs, suggesting that investors who bought into timberland in the 1980s and 1990s have seen greater gains than those who bought in later.

A Roadmap to the New Rural Electric Cooperative Business Model

In North Carolina today, 26 rural electric cooperatives provide electricity to 26% of the state’s population. This project aims to assess the services that rural electric cooperatives in North Carolina should offer their members in order to improve their business model. We interviewed ten organizations that were chosen using sampling by convenience, using a semi-structured format. In doing so, we learned about the benefits, challenges, and priorities of the cooperatives relative to offering clean energy and energy efficiency services to their customers. Using NVIVO to analyze our data, we identified the priorities of affordability, reliability, and customer satisfaction that cooperatives should use to assess the menu of service options we have outlined. While each cooperative in North Carolina is unique, we have recommended services they should offer based on their individual priorities.
Forest Elephant Movements and Habitat Use in a Tropical Forest-Savanna Mosaic

Poaching of forest elephants for ivory has decreased their populations in Central Africa by approximately 62% from 2002 to 2011. To protect this ecosystem engineer, conservation managers need to know how forest elephants interact with their landscape. Numerous studies on savanna elephants have successfully implemented global positioning system (GPS) technology to track elephant movements. However, much less is currently known about the movement behavior and ecology of forest elephants. This study aims to address this research gap by investigating the movements of GPS-collared forest elephants in the tropical forest-savanna mosaic of Wonga Wongué Presidential Reserve in Gabon. Results show that selective use of savanna and total home range area vary across season and sex. Vegetation and distance to villages are significant drivers of forest elephant movements, providing management implications for minimizing human-elephant conflict along the boundaries of the reserve.

Joseph "Joby" Moss: MEM (EE)

Group Members: Will Yang, Liam Regan, Serkan Erdem and Xiaonan Feng

HanesBrands Renewable Energy Prioritization

HanesBrands Inc. (HBI), a world-wide leading apparel manufacturer, has established the sustainability goals of reducing its energy intensity, carbon emission intensity, and increasing their renewable energy use. Duke Team has focused on HBI’s commitment of increasing company-wide renewable energy use to 40% by 2020 through prioritizing renewable energy investment options in their global portfolio. Based on the energy use breakdown & electricity costs of facilities, the Duke Team identified 10 facilities for a deeper dive. In order to better target facilities for the scalable Solar Photovoltaic (PV) & Solar PV + Battery technologies, a utility compilation database with electricity invoices detailing demand, consumption and administrative charges was created. Interval data was used to support the utility database by analyzing the energy consumption profiles of qualifying facilities with the best compatibility. Renewable energy investment options were explored in National Renewable Energy Laboratory’s (NREL) System Advisor Model (SAM) model, with the support of thorough geo-market research. Ultimately, technical & financial feasibility analyses were the basis for recommendations in the areas of Solar PV & Solar PV+Storage, (Synthetic) Power Purchase Agreements (sPPAs), and RECs that could facilitate HBI’s goal regarding renewables.

Kristin Murphy: MEM (EEP)

Analysis of Commercial Use Management Policies in the National Park Service

Private companies, or commercial services, provide goods and services within national parks including lodging, food, transportation, and guided activities. One way for commercial services to operate within a national park is by applying for a commercial use authorization (CUA), which is a short-term permit that authorizes small-scale commercial activity. Due to the NPS Centennial celebration and record-breaking visitation, Arches National Park and Canyonlands National Park have experienced an overwhelming increase in CUA applications over the last few years. This paper uses a literature review of NPS policies and semi-structured interviews conducted with NPS employees to analyze how CUA programs operate at 10 other parks. Findings from this study will provide guidance and recommendations to Arches and Canyonlands on long-term strategies to improve the management of their CUA program.
Kathleen Myers: MEM (ESC)

Prioritization Model for the Treatment of Invasive Arundo donax in the Pedernales Watershed in Central Texas

Arundo donax, commonly known as Giant Reed, is an invasive species of growing concern in the Central Texas Hill Country ecoregion. A. donax is an aggressive invader of riparian zones; it crowds out native streambank vegetation, disrupts floodplain function, and causes excessive evapotranspiration. In an effort to control the spread of A. donax, the Texas Parks and Wildlife Department (TPWD) has collaborated with nonprofit organizations to create the Healthy Creeks Initiative (HCI), which is currently active in the Pedernales and Blanco watersheds. Through HCI, TPWD and its partners enroll private landowners into a voluntary program that provides free herbicidal treatment for A. donax. This analysis provides a framework for prioritizing the treatment process based on A. donax biology and treatment efficiency. I applied several different weighting schemes to the prioritization model and used it to analyze both enrolled parcels and parcels that intersect with the overall distribution of A. donax. These analyses resulted in different distributions of treatment priority. The end product is a flexible model that can be used as HCI efforts continue in the Pedernales watershed and beyond.

Michelle S. Myers: MEM (DEL)

Policy Analysis of Sea Level Rise Adaptation Planning and the Use of Natural Flooding Mitigation Measures in SF, NOLA, and NYC

Sea level rise (SLR) and severe weather events have already exposed the vulnerability of coastal cities to flood events. Regional planning bodies are developing comprehensive plans to build resiliency utilizing both hardened and natural flood mitigation measures. While the plans use living shorelines and wetland restoration to buffer coastal regions, land managers have uncertainty to the level of protection these measures provide and a bias to maintain hardened shorelines and levee infrastructure. In addition, there are barriers to implementation of SLR adaptation plans in permitting, funding and land tenure. Research methods for the project include a literature review of resiliency planning documents and related articles, as well as interviews with resiliency planning staff in the case study areas of New York, San Francisco, and New Orleans. Policy recommendations are made that include: standardizing economic valuation and performance matrices of natural flood barriers, simplifying agency approvals, developing managed retreat practices and project migration zones, and increasing federal funding while identifying local resources for adaptation projects.

Shaina S. Nanavati: MEM (ESC)

A Roadmap to the New Rural Electric Cooperative Business Model

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Managing Anthropogenic Noise in the Alaskan Arctic

For the Inupiat and Inuit people on the North Slope of Alaska, globalization brings with it many threats to traditional way of life as subsistence whalers. After thousands of years of living off the land, climate change, rapidly melting sea ice, warming ocean temperatures, resource extraction operations, and the general increase of global interest and presence in the Arctic are all new obstacles indigenous communities face in trying to maintain their traditional way of life. One of the many, and perhaps less obvious, challenges these indigenous whalers are beginning to face is the increase in ocean noise. This increase of anthropogenic noise in the Arctic due to increased shipping, offshore oil exploration and various other factors left unregulated could result in negative implications for the indigenous inhabitants of the North Slope Borough as increased noise may disrupt whales in hunting areas and may impact migration patterns. This project investigates the potential to limit anthropogenic Arctic Ocean noise by 1) using species occurrence data to map likely future anthropogenic noise threats as a planning tool to inform policy on the way anthropogenic noise is regulated and 2) analyzing options for anthropogenic noise policies and regulations on the North Slope.

Eunji Oh: MEM (EE)
Advised by: Drs. Emily Klein, Megan Mullin, and Martin Doyle
Group Members: Mavis Zhou and Vanessa Waller

Standardizing Sustainability for Private Water Companies: Existing Standards and Future Opportunities

Water companies, like all other businesses, are faced with the question of how much time and resources to put toward environmental concerns. However, private water companies must work creatively within the confines of regulations as well as stakeholder and shareholder expectations.

In most businesses, this question is addressed by operationalizing the concept of “sustainability.” Sustainability standards have played a key role in allowing businesses to measure and market their progress. Some of these documents specifically address sustainability for water utilities. Our task was to evaluate these questions and develop recommendations for an improved sustainability standard for private water companies. We accomplished this goal through phone interviews with utility managers and company executives, as well as literature review.

Hannah Palmer-Dwore: MEM (ESC)
Advised by: Dr. Nicki Cagle
Group Members: Renee Kramer and Peter Satin

Developing an Alternative Approach to Wildlife Management in the Duke Forest

Wildlife management is not currently a major priority of the Duke Forest, but staff have expressed an interest in making it a more significant aspect in future forest management decisions. We here used a multi-criteria decision analysis framework to explore a variety of wildlife management and monitoring alternatives with the aim of providing Duke Forest staff an adaptive tool for making well-informed wildlife management decisions. We identified potential management strategies by looking at forest management plans in use by peer institutions and then conducting a meta-analysis to determine the effect each of the potential strategies had on taxa of interest to Forest staff. We also looked at the possibility of using a community-based monitoring approach to supplement limited Forest staff resources through the use of expert interviews and a formal review of the literature, and assessed the importance of multiple components in ensuring quality data monitoring. We used the results of both of these analyses to construct a decision framework Duke Forest can use to identify wildlife management and monitoring schemes.
Feasibility Study of Energy Recovery by Incineration - A Case Study of Triangle Wastewater Treatment Plant

This study evaluates the energy recovery potential of wastewater by means of incineration for a small wastewater treatment plant. An analysis was conducted taking a local sewage treatment plant as a case in point, the challenge being the relatively small size of the treatment plant. This study investigates the future financial impact of unchanged sludge disposal method and the potential benefits and drawbacks of a sludge incineration plant. Wastewater flow data was collected and the digested waste analyzed to find its calorific value. An appropriate sewage incineration plant design was identified. Projection of wastewater flow growth and parameters of the incineration plant were used to identify the energy recovery potential and financial feasibility of such a project. The selected incineration plant, when sized in accordance with the wastewater treatment plant in question, was self-sufficient in terms of its own energy needs but the net generation was small. It is recommended that a detailed technical, legal, resource and operational feasibility study be performed before any definite decision is made.

Evaluating the Visualization of Fisheries Data on the Northeast Ocean Data Portal

Last fall, the Northeast Regional Planning Body (NEPRB) released the nation’s first regional ocean plan. The NEPRB identified the Northeast Ocean Data Portal as a resource that supports their goal of moving towards ecosystem-based regulatory decisions. In an effort improve the fish data on the portal this study compares fish biomass data collected between 2007-2014 from two scientific trawls. The Northeast Fisheries Science Center conducts trawls in federal waters off of the Northeastern United States, and the Northeast Area Monitoring and Assessment Program uses similar trawl methodology in the adjacent state waters. Seven species were selected due to their similar distribution and abundance in each dataset. Then, the species were compared using geospatial and statistical analysis. Although results varied between species, there is no indication of high correlation between datasets. These results shine a light on potential ways to improve trawl methodologies to make the surveys more comparable. Also, understanding the differences between these datasets should urge the NEPRB to reconsider single-species data maps for more user-friendly, habitat-based, maps on the portal.

The Impact of Disease in Shrimp Aquaculture on Prices in the U.S. Market

Shrimp is one of the most traded seafood commodities in the world, and aquaculture now contributes greater volumes to global shrimp production than capture fishing. Since the 1970s, the shrimp culture industry has been simultaneously characterized by rapid growth due to falling production costs as well as severe losses from disease outbreaks like White Spot Syndrome and Early Mortality Syndrome. I seek to determine if both cultured and wild-caught shrimp prices reflect output declines attributed to acute disease epidemics in farmed shrimp. Analysis relies on U.S. farmed shrimp import data between 1990 and 2016 from three major producers: Ecuador, Thailand and Indonesia. Also included are data from the U.S. Gulf of Mexico capture shrimp fishery. After testing country-level price indices for cointegration, I use structural break tests to determine if significant price changes coincide with anecdotal disease crises. I attempt to further characterize the shrimp market using impulse response functions to estimate the time required for shocked prices to return to long-run trends and weak exogeneity tests to identify a price leader.
Lili Pita: MEM (EEP)
Group Members: Barbara A. Gore and Dan Hutter

Initiating Orvis’ Sustainability Strategy: Identifying Strategic Priorities and Sustainability Champions Within the Business

Orvis is America’s oldest mail-order outfitter and longest continually-operating fly-fishing business with more than $340 million in sales, offering a wide assortment of fly-fishing, hunting, and sporting goods. The company dedicates itself to personal responsibility and strives to restore, enhance and protect wild places; however, Orvis does not currently have an overarching sustainability strategy. In order to fill this gap, our research strives to capture an understanding of the perceptions, attitudes, and priorities of Orvis associates, managers, and executives with regard to sustainability initiatives. Insights gathered through the creation and distribution of employee engagement surveys, along with industry best practice research and an analysis of Orvis’ Higg Index results, will be used to develop key components of a long-term Corporate Social Responsibility strategy.

Tian Qiao: MEM (EE)
Group Members: Bojia Zhang

Use Cases of Demand Response and Application to China

China’s economy has been changing and developing rapidly, and these changes have put pressure on China’s electricity system. Electricity markets have been slow to change and are not effectively addressing pressing problems created by industrialization, pollution, and renewables. China desperately needs a more flexible electricity system to meet these challenges and to enable critical, market-based reforms. Demand response, which could provide immediate solutions, is massively under-developed in the country, although policy developments are on-going. This paper, through a number of case studies, aims to offer a basic blueprint for China on what’s needed to transform its early demand response pilots into effective programs that can address its current and future challenges.

Priya Ranganathan: MEM (ESC)

The Effects of Land Use Change on Sympatric Carnivore Use of Wildlife Dispersal Routes in Ranthambhore Tiger Reserve, India

The Royal Bengal tiger (Panthera tigris tigris) and other large carnivore populations in northern India are increasingly threatened by habitat fragmentation. Exemplifying this issue, a rare sub-population of arid-zone tigers is at risk due to land use changes that affect wildlife dispersal corridors that are conduits of gene flow between increasingly-isolated forest patches within and around Ranthambhore Tiger Reserve (RTR). Using both field surveys and geospatial analysis, I designed a project to: (1) quantify land use and land cover change between 2011 and 2016 in RTR; (2) assess the effects of this change on the two major dispersal corridors; and (3) understand how this change affects corridor use by tigers. Field surveys documented land cover use by tigers and other large carnivores, as well as their prey. Analysis revealed that major threats to corridors are expansion of agricultural land, sand mining, livestock grazing in protected forests, and urban expansion. Results suggest the need for conservation education and stricter land use regulation in areas surrounding wildlife corridors.
Flooding Outside the Floodplains: An Evaluation of Pluvial Flooding Practices and Application to the Ellerbe Creek Watershed

Flood-related policies and programs have historically focused on riverine and coastal flooding, overlooking the potential impact of pluvial flooding. Pluvial flooding occurs when the rainfall rate exceeds the capacity of the ground to absorb water and/or drainage systems’ ability to carry away water. This process is exacerbated in our increasingly urban landscapes where impervious surfaces preclude infiltration of rainfall into the ground. This project aims to encourage stakeholders to invest in studying and managing pluvial flooding through three objectives: 1) providing a review of current pluvial flood management practices and modeling resources, 2) identifying areas prone to pluvial flooding in the Ellerbe Creek Watershed using EPA’s Stormwater Management Model (SWMM), and 3) integrating the pluvial flood map into the ongoing watershed protection projects of our client, the Ellerbe Creek Watershed Association (ECWA), by building an interactive GIS tool for land prioritization. This work reflects ECWA’s mission statement to move Durham to be an example for proactive urban stormwater management.

HanesBrands Renewable Energy Prioritization

HanesBrands Inc. (HBI), a world-wide leading apparel manufacturer, has established the sustainability goals of reducing its energy intensity, carbon emission intensity, and increasing their renewable energy use. Duke Team has focused on HBI’s commitment of increasing company-wide renewable energy use to 40% by 2020 through prioritizing renewable energy investment options in their global portfolio. Based on the energy use breakdown & electricity costs of facilities, the Duke Team identified 10 facilities for a deeper dive. In order to better target facilities for the scalable Solar Photovoltaic (PV) & Solar PV + Battery technologies, a utility compilation database with electricity invoices detailing demand, consumption and administrative charges was created. Interval data was used to support the utility database by analyzing the energy consumption profiles of qualifying facilities with the best compatibility. Renewable energy investment options were explored in National Renewable Energy Laboratory’s (NREL) System Advisor Model (SAM) model, with the support of thorough geo-market research. Ultimately, technical & financial feasibility analyses were the basis for recommendations in the areas of Solar PV & Solar PV+Storage, (Synthetic) Power Purchase Agreements (sPPAs), and RECs that could facilitate HBI’s goal regarding renewables.

Examining Perceptions & Experiences Surrounding Whale Ecotourism & Conservation in Husavik, Iceland

The whale watching industry is rapidly expanding throughout the world. Researchers have found that the experience of whale watching holds value within the context of ecological education and fosters a sensitivity towards environmental issues. Meanwhile, others researchers are concerned that the industry will do more harm than good to vulnerable populations of whales. This research explores these concerns in Husavik, a town in northern Iceland that largely owes its success to the diversity of its whale ecotourism opportunities. Through semi-structured interviews with individuals whose careers depend on this business in Husavik, data was collected on current perceptions of the industry and the larger issues surrounding whale conservation. Within these topics, barriers were explored that exist within the local environment that threaten both the industry and the ecological health of the marine environment it relies on, as well as the over-arching narrative of those working within the industry. Why did these individuals develop a career in Husavik and what are their motivations and hopes as part of a community so largely impacted by whale ecotourism?
Recommendations on Campus Sustainability Development for Duke Kunshan University

As the Sustainable Duke Office at Duke University determines the next steps on how best to integrate a satellite campus such as Duke Kunshan University (DKU) into its Climate Action Plan, it is important for both DKU and Duke to gain an in-depth understanding of campus sustainability at other higher education institutions. Through a review of literature and a case study of campus sustainability at Hong Kong University of Science & Technology (HKUST), this project seeks to provide a baseline for further studies on sustainable development at DKU by (1) identifying the types of sustainability initiatives currently taking place at HKUST, (2) understanding the specific challenges of implementing such initiatives, and (3) providing recommendations for DKU on how best to incorporate sustainability as it continues to expand its physical campus and academic programs.

Jared Rist: MEM (EE) Advised by: Dr. Timothy Johnson
Group Members: Elena Clemenceon-Charles and Qier Xue

Economic Potential of Offshore Wind Development in South Carolina

While the global offshore wind capacity has grown significantly in the past few years, it has been largely driven by Europe and China. The United States is only now starting to develop the significant supplies of wind available off its coasts. With the first wind farm beginning operations and more offshore leases being secured, momentum is building to bring an offshore wind supply chain to the Atlantic coast. The supply chain will provide jobs and significant economic benefits to the states where it develops. In order to take advantage of these benefits states will need to adopt policies supporting offshore wind and its associated industries. Our report focuses on South Carolina as an area with significant offshore resources as well as great potential for supply chain development. We examined the potential impacts of offshore wind development on the state by determining a viable installed capacity of offshore wind, and used wind farm models to project electricity cost, energy outputs and economic impacts. These results are accompanied with an assessment of current and potential policy factors as well as likely areas of supply chain growth.

Sarah M. Roberts: MEM (CEM) Advised by: Drs. Patrick Halpin and Andre Boustany

Projecting the Impacts of Climate Change on Mid-Atlantic Fish Species

As anthropogenic climate change increases the temperatures of the world’s oceans, the survival rates, spatial distribution, and phenology of marine species are adversely impacted. This study evaluates the potential effects of anthropogenic climate change on seven commercially regulated fish species along the Mid-Atlantic Bight. Coupling Random forest models with the output from an ensemble of climate models, this study projects the future distribution of species using bottom temperature, salinity, substrate type and AMO and NAO indices. Results indicate that species distribution shifts vary depending on the season, the species preferred temperature range, and the relative importance of habitat and salinity for the species. For moderate species, climate change may shrink the appropriate saline habitat while increase the preferred thermal habitat to include northern waters. Overall, a northward and offshore shift was observed for temperature-dependent species while species with a large thermal window experienced minimal future distribution shifts.
Anthropogenic and natural stressors have long been a source of concern as they relate to water quality and marine ecosystem health, particularly in the United States Virgin Islands (USVI). Although many studies have been conducted in the USVI on factors influencing near-shore ecosystems, most are concentrated on just one or two inputs leaving data gaps. By conducting a meta-analysis of available long-term data produced by different organizations in ArcGIS, correlations between the following factors were observed: 1) land use 2) development 3) water quality and 4) coral health. Increased development is significantly correlated ($p < 0.01$) with increased turbidity and lower live coral cover at corresponding time scales. The results indicate the importance of linking multiple parameters to overall ecosystem health in order to develop focused management strategies to protect fragile near-shore environments.

Eric Russman: MEM (EEH)
Advised by: Dr. Avner Vengosh

Coal Combustion Residuals and the Occurrence of Hexavalent Chromium

Each year in the U.S., coal-fired power plants generate millions of tons of coal combustion residuals (CCRs). Notable CCR spills in Tennessee and North Carolina drew attention to the hazards of CCR storage in surface impoundments, which are known to contribute pollutants to groundwater and vicinal surface waters. A particular public concern about hexavalent chromium (CrVI) contamination of water resources exists because CCRs contain elevated chromium (Cr) levels and most of the toxicity associated with Cr is attributed to exposures to CrVI compounds, which are respiratory carcinogens in humans. The common assumption that CrVI is associated only with anthropogenic activities and the detection of CrVI in drinking water wells located near coal ash ponds perpetuates this public concern.

To examine the occurrence of CrVI associated with CCRs produced across the U.S., this work used modified Leaching Environmental Assessment Framework (LEAF) methods to provide an analysis of CrVI levels and Cr speciation in leachates of CCRs obtained from coal-fired power plants sourcing coal from the Appalachian, Illinois, and Powder River Basins. The results indicate how varying environmental conditions influence the presence of CrVI in CCR leachates and may provide useful insights for exposure scenarios, CCR management, future regulatory standards, and human and ecological health concerns regarding CCR disposal or releases into the environment.

Christopher Sanders: MEM (EE)
Advised by: Dr. Timothy Johnson

Generating Homeowner Demand for Energy Efficiency Retrofits: Recommendations for the NCBPA

With rising concern aimed at energy consumption and its environmental impacts, efforts are being made to conserve energy across the United States. Nearly half of all domestic energy use is dedicated to homes and buildings. Despite significant strides by the building industry to design new energy efficient structures, a significant portion of the current housing stock includes inefficient, poor-performing homes. The North Carolina Building Performance Association (NCBPA) tasked us with identifying the barriers preventing homeowners from investing in home energy retrofits and offering pertinent recommendations to address these roadblocks. Through an exhaustive review of current literature and key insight from industry leaders, we distilled the many barriers into four areas: consumer education, home valuation, financing, and marketing. Our recommendations include building-out the NCBPA consumer education website, hiring of a full-time data manager to create an inventory focused on capturing metrics surrounding home valuation, developing a conjoint marketing plan to target specific audiences, and continuing to push for commercial PACE and on-bill financing in North Carolina.
Peter Satin: MEM (ESC)  Advised by: Dr. Nicki Cagle

Group Members: Renee Kramer and Hannah Palmer-Dwore

Developing an Alternative Approach to Wildlife Management in the Duke Forest

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Alexis D. Schwartz: MEM (EEP)  Advised by: Dr. Lori Bennear

Forestry Carbon Offsets under California AB 32: Examining Business Practices and Externalities

The primary objective of this study was to conduct an encompassing analysis of current forestry carbon offset business practices under California A.B. 32. This study goes beyond the critiques of the forestry carbon offset approach and highlights current business practices, examines fringe benefits, and hypothesizes the viability for small and large landowners moving forward. ARB faces an issue when it comes to large and small landowners: to require immense reporting deters TIMOs and large landowner companies, while having such high transaction costs deters small landowners from engaging in climate change mitigation tactics, but the asset proves itself to be a worthy investment going beyond climate change mitigation tactics and entering a realm of biodiversity conservation and improving community economic development. Thanks to an industry wide survey, the business practices of this newly developed asset are becoming clear and showcases future business strategy plays.

Andrew Seelaus: MEM (EE)  Advised by: Drs. Tim Profeta and Tim Johnson


In the past five years, large advances have been made in providing energy access to base of the pyramid African consumers. Mobile money-based financing has unleashed tremendous growth in companies offering Pay-As-You-Go (PAYG) solar home systems (SHS). However, the energy services provided by SHS products are generally limited to lighting, phone charging, and televisions. This study investigates efforts to provide productive power, or electricity access enabling meaningful economic development at the community level. Through literature review, field observation, and industry interviews, the author identifies key factors that limit scaling of renewable microgrids, one of the most popular solutions to the productive power question. The study then proposes a novel business model for microgrids that incorporates recent advances in smart metering devices and blockchain technology. The result of the new approach are trading-enabled, ad-hoc microgrids that address several of the key limitations identified in current microgrid efforts.
Waste Heat Recovery in Bicycle Manufacturing Process for Specialized Bicycle Components

Cooperating with Specialized Bicycle Component, we conducted a waste heat analysis on two heating processes for its aluminum bicycle frame. We found that the waste heat from these processes is 451.60 MWh/year worth 22,174.97 $/year estimated with the local fuel price and the heat absorbed by the frame holder could be the most practical start point to reduce the waste heat. At the same time, by consulting professionals and literature review, we found that some commonly used waste heat recovery strategies could not be implemented in our context. Furthermore, we gave two detailed recommendations, switching the fuel and changing the material of frame holders, to reduce the economic cost and environmental impact of this process. Switching fuel from LPG to natural gas would save 9528 $/year and reduce 18.96 ton CO2/year. Changing the frame holder from steel to carbon composite would save 209 $/month and the investment will be paid back in 17 months. The possibility of process optimization was also discussed.

Analyzing the Current and Future Status of Aquatic and Hydrologic Ecosystem Services in the French Broad River Basin

Ecosystem services are the benefits that people receive from nature, and are an increasingly important component of conservation planning. Many of these ecosystem services are threatened, however, by land use change and development, climate change, and pollution. This project assesses the current state of several water-related ecosystem services in western North Carolina’s French Broad River Basin, which includes the city of Asheville, and compares this to a potential future state given predicted changes in development patterns and climate. We identify where sources of water-related ecosystem services are located within the watershed, how many people they serve, where threats to ecosystem services are located, and how ecosystem services and aquatic biodiversity may be affected by future climate and land use changes. Our findings show that climate change and development will have significant implications for the future provisioning and regulation of ecosystem services and the habitat of aquatic biodiversity in western North Carolina.

Improving Water Quality in China: Developing a Platform to Help Industrial with Water Issues

Agricultural water pollution in China coupled with new governmental policies provide opportunities for collaboration between industries and environmental service providers (ESPs). Last year, SinoAltas, a platform was established providing information and opportunities for stakeholders to meet and cooperate. This year, the objective is to identify a target agricultural industry, identify its water pollution challenges, conduct technology to promote cooperation between industries and ESPs. After conducting literature reviews, qualitative interviews of pollution experts and new governmental policies for water pollution, we identified pig farms as our target industry. We researched current waste treatment techniques in China and created equations to calculate the cost benefit of each technique. We also developed an online Search System to provide ESPs information, which enables farmers to select ESPs based on their geographical location and waste water treatment choice. Once search system and treatment models are posted online, our client can market SinoAtlas to increase platform popularity and user engagement by developing social media communication and attending industrial conferences.
An Analysis Comparing Mangrove Status under Different Management Scenarios in Southeast Asia

Mangroves serve a variety of crucial ecosystem services such as stabilizing the shoreline, promoting aquaculture, and buffering coastal communities. However, they are threatened by anthropogenic factors such as pollution and development in recent decades. Existing literature on mangrove forests indicates that mangroves were declining at an alarming rate at many sites globally. Mangrove loss in Southeast Asia is especially concerning due to the expansion of urban lands, aquaculture, and plantation. The project aims to look at how distribution and status of mangrove forests have changed over time and how mangrove health has changed at two sites. The first site is in Phang Nga Bay, Thailand. This site has experienced little management and is located mainly in a national park setting. The second site is mainly in Matang Forest Preserve, Malaysia. The site is intensely managed. This project examines Landsat images from 2000 to 2010 to detect the changes in the mangrove forests at the two sites.

Environmental Features Relevant to Deep-Sea Mining along the Rio Grande Rise for the Implementation of Protected Areas

Interest in the extraction of mineral resources from the deep-sea has increased rapidly in recent years due to technological advancements. Since 2001, the International Seabed Authority has granted over 25 exploration leases for deep-sea mining in oceanic areas beyond national jurisdiction. These areas are often poorly studied and thus it is currently a challenge to develop effective regulations before mining activities commence. This study attempts to address this issue by exploring the environmental characteristics found in an emergent area of deep-sea mining exploration, the Rio Grande Rise (RGR) off the Southeastern coast of Brazil. This is accomplished through the compilation and mapping of environmental datasets for the RGR region as well as a biogeographic classification of the RGR seafloor based on several datasets that are known to influence deep-sea biodiversity. The goal of this study is to identify areas and features within this region that are important for regulators to consider as mining regulations and protected areas are developed in the near future.

Streambed Texture and Hydraulic Connectivity Analysis of Restored, Degraded, and Natural Reference Streams in Durham, NC

In the face of growing concerns about how water quality is affected at the watershed level due to land use change, six sites in the same watershed near Durham, North Carolina were selected for an analysis of streambed sediment texture and hydraulic conductivity. The primary problem of interest is to investigate whether select Priority 1 stream restorations in Durham differ from degraded and natural streams in connectivity and exchange between the stream and subsurface. The main concern with Priority 1 restoration is that it requires burying the original stream channel and creating a new channel in the adjacent floodplain. If a floodplain differs significantly enough from the natural streambed and little is done to correct this in the restoration, there could be impacts on overall stream function. The results of our research will aim to inform future restoration practices pertaining to streambed sediments in newly created Priority 1 streams.
Comparing Estimates of SO$_2$ and NOx Emissions Inventories for the U.S. and China: Exploring the Reasons for Discrepancies between EDGAR and ECLIPSE

EDGAR (Emissions Database for Global Atmospheric Research) and ECLIPSE contain estimates of past, current, and future emissions of greenhouse gases and other air pollutants, at the global, regional and country scales. These datasets are each a direct output of two models; the Integrated Model to Assess the Global Environment (IMAGE) model, and the Greenhouse Gas and Air Pollution Interactions and Synergies GAINS Model.

This project compares the estimates of Nitrogen oxides (NOx) and sulfur dioxide (SO$_2$) for years 2000, 2005 and 2010 reported by ECLIPSE for the U.S. and China, with the same estimates from EDGAR, and examines the underlying assumptions and modeling structures to understand the sources of differences. Results show that while global estimates from the two datasets are similar there are noticeable discrepancies at the national levels. This highlights the uncertain nature of the quantity of emissions associated to each sector. In particular, it is found that the transportation sector is the driver of significant differences in estimates of both global and national NOx emissions.

Comparing Social-Ecological Trends in Three Marine Protected Areas in the Gulf of California

Marine protected areas (MPAs) have become an increasingly common conservation tool in marine environments, yet few studies have focused on impacts to fisheries and communities in addition to ecological impacts. In this study, I draw on multiple data sources including interviews with MPA managers, ecological monitoring data, and fisheries landing reports, in a more holistic approach to understanding how MPAs interact with social-ecological systems. Using qualitative and quantitative analyses, I aim to illuminate social, ecological and fishery trends surrounding Cabo Pulmo National Park, Bahia de Loreto National Park, and Espíritu Santo Archipelago National Park in the southern Gulf of California, Mexico. Findings from this study show that trends reflected in different data sets can vary widely for a single MPA, and future research should focus on disentangling the connections between social, ecological and fisheries data in MPA evaluations.


A YieldCo is a publicly traded investment vehicle that owns operating energy assets, the majority of which are typically renewable, and whose stated purpose is to distribute the majority of its available cash to shareholders while minimizing corporate taxes. After three successful years in the market, multiple events during the summer of 2015 led investors to question the fundamental nature of the YieldCo structure. This project seeks to understand if the uncertainty surrounding the long-term viability of the YieldCo as a financing vehicle for renewable energy is well founded. Our analysis uses market data, firm disclosures, and equity research reporting to evaluate the macroeconomic, firm-specific, and intrinsic risks of the YieldCo structure. We explore several explanations for the sector’s turbulence since 2015 and propose recommendations to align YieldCo, sponsor, and shareholder incentives. This assessment of the YieldCo financing vehicle can be used to inform future action in the sector, as well as renewable energy financing more broadly.
Durham County Food System: A Qualitative Analysis of Actors, Missions, and Challenges

In the context of a national movement around local food, our clients, the Duke Campus Farm and World Food Policy Center want to know what they can do to best engage with and support the local food system (LFS) in their community of Durham County, North Carolina. We conducted an exploratory case study to characterize the current network of actors within the Durham LFS and the challenges they face, in order to provide recommendations to our two Duke clients. Qualitative analysis of interview data resulted in a network sociogram showing two main clusters of actors, generally separated by sector and mission. The primary challenges facing these actors include financial barriers, lack of communication, and issues related to food policy. We recommend that our clients 1) facilitate communication between network actors 2) assist with collecting baseline data for evaluation, and 3) provide relevant policy analysis.

Developing Competitive Sustainable Manufacturing in The Indonesian Textile Industry

The Government of Indonesia through its Ministry of Industry launched a voluntary sustainability standard for textile industry called “Standar Industri Hijau (SIH)” or the Green Industrial Standard (GIS) in December 2015 in response to the increasing global consumers demand to produce environmentally and socially conscious products, and to improve the Indonesia textile industry’s competitiveness in global markets. This study compares and evaluates GIS which is limited to dyeing, printing and finishing processes, with four globally-established textile sustainability standards namely, STeP by OEKO-TEX®, EU Ecolabel, Adidas, and the Higg Index as benchmarks. Then uses both a quantitative survey and qualitative interviews of stakeholders in the Indonesian textile and apparel industry to uncover the deeper issues involved in implementing sustainable manufacturing practices from various perspectives.

Understanding Pathways to Contaminant Exposure in North Carolina Community Gardens

Community gardens are a valuable resource for empowering communities and keeping individuals healthy. Unfortunately, the geographic and social context of these gardens increases the likelihood that contaminants, such as heavy metals and other toxic chemicals, will be present in garden soils. However, informed and responsible choices by garden managers and participants can often maintain the positive benefits of these gardens while safeguarding participants from these risks. To begin to address this problem, we conducted i) six case studies at North Carolina community gardens, involving interviews, focus groups, observations, and material culture analysis, and ii) a statewide web-based survey of community gardeners. Our findings suggest that many gardeners are concerned about contamination, but often lack the knowledge, resources, and social support necessary to adopt safe practices. We therefore offer recommendations for tailoring effective outreach materials to encourage practices that reduce the risk of gardeners’ exposure to contaminants.
Analyzing the Current and Future Status of Aquatic and Hydrologic Ecosystem Services in the French Broad River Basin

Ecosystem services are the benefits that people receive from nature, and are an increasingly important component of conservation planning. Many of these ecosystem services are threatened, however, by land use change and development, climate change, and pollution. This project assesses the current state of several water-related ecosystem services in western North Carolina’s French Broad River Basin, which includes the city of Asheville, and compares this to a potential future state given predicted changes in development patterns and climate. We identify where sources of water-related ecosystem services are located within the watershed, how many people they serve, where threats to ecosystem services are located, and how ecosystem services and aquatic biodiversity may be affected by future climate and land use changes. Our findings show that climate change and development will have significant implications for the future provisioning and regulation of ecosystem services and the habitat of aquatic biodiversity in western North Carolina.

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Strategic Reforestation as a Climate Change Risk Mitigation Tactic: A Case-study for the Mining Industry

Mining companies that operate in economically, politically, socially, and environmentally sensitive environments are particularly susceptible to climate change risk, as their social impacts can adversely affect corporate reputation and financing. In response to stakeholder concern, mining companies are increasingly developing climate change risk mitigation strategies, including net greenhouse gas (GHG) emission reduction. Strategic reforestation provides an opportunity for mining companies to reduce the social damages of operational GHG emissions while providing environmental and reputational co-benefits. This case study demonstrates use of a model framework to estimate the carbon sequestration value and social benefit of multiple reforestation alternatives, and the extent to which they reduce operational damages. This framework is intended as a tool to supplement a broader climate change risk mitigation strategy.
Improved Connectivity Analysis Using Multiple Low-cost Paths to Evaluate Habitat for the Endangered San Martin Titi monkey (*Callicebus oenanthe*) in North-Central Peru

Graph theoretic evaluations of habitat connectivity often rely upon least cost path analyses to determine the connectedness of any two habitat patches, based on an underlying cost surface. I present two improvements upon these commonly used methods. First, rather than using a single least-cost path, I use multiple low cost paths. This allows me to differentiate between habitat patches that are connected only through a single narrow corridor, and habitat patches that are connected through a wide swath of traversable lands. The ability to identify habitat patches with greater numbers of possible routes to other patches is of interest for resiliency planning and prioritization in the face of continued habitat loss and climate change. The second improvement I present is that instead of relying upon a single cost surface to evaluate connectivity, I iteratively generate landscapes with spatially varying costs. By testing a variety of alternative cost surfaces, I can better account for spatial uncertainty in my input data. As a case study to test these methods, I am evaluating habitat connectivity for the endangered San Martin titi monkey (*Callicebus oenanthe*) in north-central Peru.

Standardizing Sustainability for Private Water Companies: Existing Standards and Future Opportunities

Water companies, like all other businesses, are faced with the question of how much time and resources to put toward environmental concerns. However, private water companies must work creatively within the confines of regulations as well as stakeholder and shareholder expectations. In most businesses, this question is addressed by operationalizing the concept of “sustainability.” Sustainability standards have played a key role in allowing businesses to measure and market their progress. Some of these documents specifically address sustainability for water utilities. Our task was to evaluate these questions and develop recommendations for an improved sustainability standard for private water companies. We accomplished this goal through phone interviews with utility managers and company executives, as well as literature review.

Assessing Land Availability for Utility-Scale Solar in North Carolina Using GIS

The use of utility-scale solar photovoltaic (PV) systems to generate electricity has been increasing substantially in the U.S., and North Carolina is a leading state in its installation. Optimally siting utility PV projects can maximize power generation and reduce projects’ costs, environmental impacts, and social opposition. Our analysis develops a GIS method to optimize siting these projects and assess how suitability factors affect land availability over large areas. We first identify criteria important for siting utility PV projects, such as land-cover, slope, and proximity to electrical substations. We then assess how the addition of these criteria, from most to least stringent, reduces the availability of suitable land across North Carolina. As the use of utility solar grows in North Carolina, our analysis provides an assessment of siting constraints, identifies prime locations, and quantifies the state’s theoretical potential for this power source.
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A Roadmap to the New Rural Electric Cooperative Business Model

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Flooding Outside the Floodplains: An Evaluation of Pluvial Flooding Practices and Application to the Ellerbe Creek Watershed

Flood-related policies and programs have historically focused on riverine and coastal flooding, overlooking the potential impact of pluvial flooding. Pluvial flooding occurs when the rainfall rate exceeds the capacity of the ground to absorb water and/or drainage systems’ ability to carry away water. This process is exacerbated in our increasingly urban landscapes where impervious surfaces preclude infiltration of rainfall into the ground. This project aims to encourage stakeholders to invest in studying and managing pluvial flooding through three objectives: 1) providing a review of current pluvial flood management practices and modeling resources, 2) identifying areas prone to pluvial flooding in the Ellerbe Creek Watershed using EPA’s Stormwater Management Model (SWMM), and 3) integrating the pluvial flood map into the ongoing watershed protection projects of our client, the Ellerbe Creek Watershed Association (ECWA), by building an interactive GIS tool for land prioritization. This work reflects ECWA’s mission statement to move Durham to be an example for proactive urban stormwater management.
Katrina Wert: MEM (CEM) Advised by: Dr. Xavier Basurto

Tagging Red Drum in North Carolina: Estimating Exploitation, Mortality, Tag Retention, and Tag Reporting Rates

Red drum (*Sciaenops ocellatus*) is the largest inshore game fish in North Carolina, making it highly valuable to the state’s economy. In the 1980’s red drum were overfished due to the lack of regulations, causing stock assessments and fishery management plans to be implemented. In 2015, the Atlantic State Marine Fisheries Commission stated a need for more research to be conducted in the form of a tagging study to better determine mortality rates and fill in gaps in models due to data limitations. This study estimated rates for red drum tagged and released in 2014 by NC Division of Marine Fisheries. Tag reporting and tag retention rates were calculated by hand, while mortality rates were calculated using the Hoenig model (Age-Independent Instantaneous Rates Model of Jiang et al. (2007) Incorporating Catch and Release Tag Returns) in the fishmethods package in R. This project serves as the model for how tagging data for other species at NCDMF will be analyzed.

Melissa L. Whaling: MEM (CEM) Advised by: Dr. Lisa Campbell

How Tos For Turtle Tourism: A Review of Sea Turtle Tourism, Its Impacts, and Guidelines to Inform Stakeholders in Martinique

The Caribbean island of Martinique is a classic resort destination, attracting thousands of tourists to its beautiful beaches and diverse landscapes each year. Yet the recently declining tourism industry has prompted the country to begin developing a new tourism segment known as sea turtle tourism (STT) in order to reinvent its offerings. Little is known about the state of these nascent STT developments, and what threats they might pose to sea turtles and the community. As a result, stakeholders in Martinique are interested in developing a set of informed best practices to manage STT as it grows. This report will serve as a useful resource for stakeholders, by synthesizing the available literature regarding: 1) the scope of STT in and beyond the region; 2) the environmental impacts of STT; and 3) how STT is managed in practice. Finally, preliminary recommendations are provided, to encourage discussions of sustainable STT within Martinique’s boundaries.

Rachel K. Whitson: MEM (EEH) Advised by: Dr. William Pan

Impact of El Niño on Environmental Mercury in Madre de Dios, Peru

Studies show that concentrations of methylmercury in sediment and fish increase in association with flooding. El Niño is a systematic weather phenomenon, occurring every 2-7 years, bringing heavier precipitation and flooding than typical to Peru. Additionally, the southeastern Amazonian region of Peru, Madre de Dios (MDD), is seeing increased development of artisanal and small-scale gold mining (ASGM) and use of mercury to extract the gold. Mercury used in ASGM is released into the environment and methylated by anaerobic bacteria into the more toxic species, methylmercury (MeHg). MeHg biomagnifies in aquatic food chains, and consumption of mercury-contaminated fish can lead to adverse cognitive and kidney effects and cause lasting neurological damage during developmental stages. Our hypothesis is that due to increased flooding in MDD from El Niño, there will be greater amounts of bacterial activity in sediment that will lead to increased bio-methylation of mercury. This means biomagnification of MeHg in fish downstream of ASGM activity will be higher during and just after El Niño when compared to previous concentrations. This study will address a public health issue if higher levels of methylmercury are entering aquatic food chains, increasing methylmercury exposure to communities dependent on fish from the river.
Assessing Land Availability for Utility-Scale Solar in North Carolina Using GIS

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Innovative Ideas for Overcoming the Challenges that Fishermen Face Selling Their Catch from Boat-to-Fork

One rapidly growing approach to support both healthy fisheries and fishing communities is through the promotion of local seafood via direct marketing arrangements such as community supported fisheries, in which fishermen sell their catch directly to consumers. In this study, previously identified challenges impeding the growth and long-term economic sustainability of these systems are ranked through pairwise ranking of discrete choices by members of the LocalCatch.org network. The top 5 challenges identified are: (1) gaining access to processing, storage, and/or markets; (2) setting prices for the catch that are fair to both fishermen and customers; (3) balancing the extra time and energy for marketing with the need to leave flexibility for good fishing days or doing other things; (4) creating the most value for product after accounting for the costs of distribution, processing, and coordination; and (5) selling catch to institutions such as hospitals, schools, etc. This study aims to facilitate innovative problem solving to top challenges by soliciting solution pitches from a variety of disciplines, to be unconstrained by the experiences, histories and understanding of those presently immersed in fisheries. Pitches are presented to the LocalCatch.org network as a first step in moving past these barriers to growth.
Analyzing the Potential Capacity and Associated Impacts of Widespread Commercial Solar Build Out in North Carolina

This study uses regional commercial building stock survey data and simulated year-long generation data to determine both the potential capacity and expected grid impact of varying levels of commercial solar PV penetration in the Duke Energy’s DEP and DEC service territories. It estimates the potential utility cost savings and broader economic impact to the commercial sector and provides a data-driven perspective on the benefits and costs of commercial-scale solar in North Carolina to customers and the utility. The results indicate that positive post-financing NPV project are available for all but two identified commercial sectors, suggest innovative financing strategies can broaden adoption to less creditworthy customers and discuss the implications for future grid management and optimization efforts.

Identifying Metrics for Health and Outdoor Initiatives: A Toolkit for Community Evaluators

Rising rates of urbanization and resource exploitation have reduced opportunities for human interaction with nature and motivated an expansion of interest in research and development of initiatives to connect human health benefits and contact with nature. Despite a growing base of evidence linking health outcomes to experience with the outdoors, there is little information informing interventions at the community level. To better assist communities in developing effective health and outdoor initiatives, I conducted a comprehensive review of metrics used by national community outdoor initiatives to evaluate health outcomes. I compared community metrics to measures supported by scientific research and consolidated the results into a guideline for evaluators of community health and outdoor programs.

Examining the Local Impacts of California Community Choice Aggregation: A Case Study of Marin Clean Energy

As federal support for renewable energy development sits tenuously, many state and local governments have taken greater roles to drive more aggressive clean energy adoption. In California, Community Choice Aggregation (CCA) in particular has gained strong momentum in recent years. CCA, permitted by state law, is an energy supply model that allows local governments and special joint districts to procure and develop power generation while the existing utility continues to manage power delivery, grid maintenance, billing and customer services. CCAs promise customers a higher clean energy mix at rate parity to the local utility as well as local renewable energy and related job development. However, it’s not transparent how much local economic benefits and new renewable generation CCAs have actually spurred. This study examines Marin Clean Energy, California’s first CCA launched in 2010, as a case study of power purchase agreements and developments that it has undertaken and indications for upcoming of other CCAs.
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While the global offshore wind capacity has grown significantly in the past few years, it has been largely driven by Europe and China. The United States is only now starting to develop the significant supplies of wind available off its coasts. With the first wind farm beginning operations and more offshore leases being secured, momentum is building to bring an offshore wind supply chain to the Atlantic coast. The supply chain will provide jobs and significant economic benefits to the states where it develops. In order to take advantage of these benefits states will need to adopt policies supporting offshore wind and its associated industries. Our report focuses on South Carolina as an area with significant offshore resources as well as great potential for supply chain development. We examined the potential impacts of offshore wind development on the state by determining a viable installed capacity of offshore wind, and used wind farm models to project electricity cost, energy outputs and economic impacts. These results are accompanied with an assessment of current and potential policy factors as well as likely areas of supply chain growth.

HanesBrands Inc. (HBI), a world-wide leading apparel manufacturer, has established the sustainability goals of reducing its energy intensity, carbon emission intensity, and increasing their renewable energy use. Duke Team has focused on HBI’s commitment of increasing company-wide renewable energy use to 40% by 2020 through prioritizing renewable energy investment options in their global portfolio. Based on the energy use breakdown & electricity costs of facilities, the Duke Team identified 10 facilities for a deeper dive. In order to better target facilities for the scalable Solar Photovoltaic (PV) & Solar PV + Battery technologies, a utility compilation database with electricity invoices detailing demand, consumption and administrative charges was created. Interval data was used to support the utility database by analyzing the energy consumption profiles of qualifying facilities with the best compatibility. Renewable energy investment options were explored in National Renewable Energy Laboratory’s (NREL) System Advisor Model (SAM) model, with the support of thorough geo-market research. Ultimately, technical & financial feasibility analyses were the basis for recommendations in the areas of Solar PV & Solar PV+Storage, (Synthetic) Power Purchase Agreements (sPPAs), and RECs that could facilitate HBI’s goal regarding renewables.
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