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A CELEBRATION OF GRADUATE STUDENT RESEARCH

2020

Cities + Mobility + Built Environment

Environmental Justice Tools of the 21st Century

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ADVISOR: Dr. Paul Mohai

LOCATION: Michigan, USA

CLIENT: Michigan Environmental Justice Coalition (MEJC)

As local environmental justice (EJ) issues have become increasingly prevalent in tandem with our growing global climate crisis, the Michigan Environmental Justice Coalition (MEJC) seeks to advance the use of online EJ screening tools and establish EJ policies for the state of Michigan. This research study sought to address the question, "What are the lessons that Michigan can learn regarding EJ screening tools?" There are two objectives of our research: a) to identify states that use state-specific EJ screening tools and understand how these tools are used in state-level decision-making; and b) to utilize data from our informational interviews to roadmap best practices of development and implementation to serve communities in Michigan. Following initial review of reports within their respective agencies, we conducted a series of semi-structured interviews with EJ advocates, activists, university academics, and others from the states of Washington, New York, New Jersey, Michigan, Minnesota, Maryland, and California. The data acquired from these interviews were examined using the qualitative analysis software NVIVO 12 Plus. From our analysis, we derived several themes concerning EJ screening tools that were common between states, including: understanding of EJ, current and future use of screening tools, limitations, resistance, and measures of success. The results of this research will inform the most efficient and inclusive processes of developing EJ screening tools in Michigan.

Building Energy Democracy into City Commitments to 100% Renewable Energy

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ADVISOR: Dr. Tony Reames

LOCATIONS: USA

CLIENT: Institute for Local Self-Reliance

There are a number of U.S. cities making and implementing ambitious commitments to transition to 100% renewable energy; however, many of them are unsure of how to meet their commitments. This research aims to understand the mechanisms cities are using to achieve their goals while implementing and maintaining energy democracy. In this practice, energy democracy implies an energy system in which decisions are made by the users of energy. This concept is explored at the intersection of eight mechanisms identified as potentially significant levers in the success of achieving municipal energy goals. A national survey was created to assess the relevance and functionality of each mechanism alongside energy democracy within city plans and actions. Three case studies were completed to supplement the survey data and gain in-depth insight into goals, efforts, and progress, and elicit advice from cities with formal commitments.

Early results found that key drivers for the 100% renewable energy commitments are concern for climate change, concern for the local environment, and potential for financial savings. The top barriers to achieving these goals were identified as a lack of funding, support from the utility, and expertise. To engage the community in energy policy-making, cities use a variety of methods, such as meeting with representatives from the community, elected officials, workshops, and social media. Ultimately, this research aims to provide tangible and practical guidance to cities with established commitments, or those seeking to make one, while incorporating and maintaining an equitable and accessible energy transition.

Life cycle greenhouse gas impacts of a connected and automated SUV and van

PRESENTERS: Nick Kemp, MS (SusSys)

ADVISOR: Dr. Greg Keoleian

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Argonne National Laboratory

As technological advancements progress, the automotive industry is getting closer to producing Level 4 connected and automated vehicles (CAVs). Market trends show personal vehicle sales moving towards sport utility vehicles (SUVs) and increasing use of ridesharing services. We conducted a life cycle assessment (LCA) of Level 4 CAV subsystem components integrated into battery electric vehicle (BEV SUV) and internal combustion engine vehicle (ICEV van) platforms to understand the impact of the components and automation on greenhouse gas (GHG) and primary energy use. Vehicle lifetime was modeled based on deployment as an automated taxi, incorporating a standby mode to account for continuous connectivity. This study explores impacts of weight, drag, and subsystem electricity demand relative to benefits of eco-driving, platooning, and intersection connectivity at the vehicle system level. A CAV BEV coupled with a low carbon intensity grid (0.08 kg CO2e/kWh) could see a 31% decrease in life cycle GHG emissions while a CAV BEV with high computing power requirements (4000 W) could see an increase in GHG emissions of 34% compared with the base case. The net result for the base case (500 W computer power, 14% operational efficiency improvement, 45% highway driving) CAV shows an increase in primary energy use and GHG emissions (2.7%, 2.7% for BEV; 1.3%, 1.1% for ICEV) compared with non-CAV platforms.

Public Acceptance and Adoption of Ride-Hailing Pooling Service to Reduce Greenhouse Gas Emissions in the Transportation Sector

PRESENTERS: Kimberly Lippke, MS (EPP, BEC); Christian Noyce, MS (EJ)

ADVISOR: Dr. Michael R. Moore

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Dana Jackman, Economist, Office of Transportation and Air Quality, U.S. Environmental Protection Agency

Transportation now generates more carbon dioxide emissions than any other United States economic sector, and, at the same time, new mobility options are rapidly changing transportation. On-demand ride-hailing companies like Uber and Lyft now provide mobility services that both complement and compete with public transit, personal vehicle and non-motorized options. Within a relatively short period of time, these Transportation Network Companies (TNCs) have expanded across the United States and have introduced new options to riders, such as shared ride services. A growing body of literature indicates that ride-sharing can provide numerous transportation, infrastructure, environmental, and societal benefits. However, regardless of these benefits, the U.S. population has not embraced ride-sharing. Motivated by the important role ride-sharing may play in reducing costs, vehicle miles traveled, road congestion, emissions and the limited use of ride-sharing services in the U.S., this study seeks to provide a deeper understanding of the social and behavioral considerations associated with travelers' acceptance of shared rides and how those considerations factor into individuals' willingness to pay for shared services. The team conducted research using a variety of methods, including a literature review, a web-based consumer survey, and focus group discussions. This combination of methods provides an in-depth understanding of whether and under what conditions people are willing to accept and pay for shared-rides. Results can be used to 1) inform policymakers and TNC executives on what influences the likelihood of an individual to choose a shared-ride over a solo-ride; 2) help TNC decision-makers competitively price their shared services to increase adoption and decrease transit pollution per capita; and, 3) provide insight into complementary services, such as conversation options, that may increase the adoption rates.

Environmental Peacebuilding and the Expansion of EcoPeace Middle East's Strategy

PRESENTER: Andrew Light, MS (EPP)

ADVISOR: Dr. Julia Wondolleck

LOCATION: Kathmandu, Nepal

CLIENT: EcoPeace Middle East

Environmental peacebuilding is a theory of conflict management used by EcoPeace Middle East in the Jordan River Valley. The theory posits that despite a seemingly intractable conflict, communities that come together for the protection of the natural resources can simultaneously build a foundation for peace while also helping the environment. The purpose of this study is to identify the factors that could enable or constrain EcoPeace Middle East's ability to transfer their model of environmental peacebuilding to the Hindu Kush Himalayas by helping the International Centre for Integrated Mountain Development (ICIMOD) apply the model. To identify the relevant factors, in-person interviews were conducted with nine interviewees in Kathamandu, Nepal at the ICIMOD headquarters. A semi-structured interview guide was used to better understand staff perceptions of organizational, contextual, and strategic factors that influence the work being done. Additionally, publicly available information was collected to understand how those three categories of factors influence the work being done at EcoPeace Middle East. The findings of the analysis of the collected data suggest that environmental peacebuilding would not work for ICIMOD in the same way it does for EcoPeace due to limiting factors like the genesis of the organizations, the geography and scope of the conflict being operated within, the existing international policies, and the broader strategies pursued. That being said, there are enabling factors that could serve as points of entry for EcoPeace to begin sharing lessons with ICIMOD to implement particular aspects of their model – EcoPeace's "bottom-up" approach, for example.

Vacant Land Adaptation Strategies in Detroit's G7 Neighborhoods

PRESENTERS: Chuyi Yin, MLA, MS (CE); Yiran Shen, MLA; Alison Rauss, MLA; Sarah Peterson, MLA, MS (CE)

ADVISOR: Dr. Mark Lindquist

LOCATION: Detroit, Michigan, USA

CLIENT: City of Detroit: Planning and Development Department

In partnership with the City of Detroit's Department of Planning and Development, this project identifies, proposes, and communicates land-based strategies and design typologies for the adaptation of vacant land within the Gratiot and 7 Mile (G7) Planning Area in northeast Detroit, Michigan. Vacant land has traditionally been viewed as a 'problem' that inherently leads to blight, crime and illegal dumping but there is a movement Detroit and other de-industrializing cities are taking toward embracing abundant open space as a resource. Through an iterative process of context and site analysis, mapping, community engagement, ideation and design, we investigate the challenges and opportunities presented by vacant land throughout the planning area. From this work emerge pathways toward a multi-functional open space framework, particularly through the lenses of public health and wellbeing, livability, environmental justice and sustainability. Landscape typologies are illustrated and analyzed for their social and environmental benefits, to inform continued planning and design by the City of Detroit and G7 Planning Team. It is hoped that this project will serve as inspiration and guidance for vacant land adaptation in other shrinking, post-industrial cities.

Modeling Circular Urban Metabolism in Santiago, Chile

PRESENTERS: Bianca Dragone, MBA, MS (SusSys); Emily Pfleiderer, MS (EPP), MPP; Leigh Mitchell, MS (SusSys, EPP)

ADVISOR: Dr. Shelie Miller

LOCATION: Santiago, Chile

CLIENT: Universidad Adolfo Ibañez

Cities account for over 70% of greenhouse gas emissions and consume over two-thirds of the world's energy. With the continued rise of urbanization, 68% by 2050 as projected by the UN, cities must be redesigned to ensure emissions, and the associated negative impacts of climate change, do not also increase proportionately. One framework through which a city's sustainability can be analyzed is through the lens of urban metabolism; the inflows, use, and outflows of a city's resources are viewed as analogous to the functions and processes of an organism.

To truly become sustainable, city metabolisms must become "circular," with high quality resources being recirculated and reused throughout the system, thus diminishing the rate of resource exploitation. Through better understanding of a city's urban metabolism, governments can implement policies targeting the points of the system with the biggest impact and increase their city's environmental resilience. Our research focus is on Santiago de Chile and the new Ley de Responsibilidad Extendida del Productor (REP). This extended producer liability law shifts responsibility of a products' end-of-life phase from the consumer to the producer and is a critical area of interest for the Chilean Ministry of the Environment. We analyze the flows of tires, one of the six products covered by REP; highlight potential ways in which to reduce the generation of waste and encourage its reuse; and how recycling and recovery of tires can be implemented through different stages of the product's lifecycle.

Our team conducted a baseline material flow analysis (MFA) of tires in Santiago. Using our model we test out policy interventions that can be utilized in the city to increase its circularity; we were able to then test out more circular policy interventions that may be utilized in Santiago de Chile.

Climate & Energy

Biomass Residue Fueled Microgrid for a Rural Community in Puerto Rico

PRESENTERS: Muzna Raheel, MS (SusSys); Stephen Barr, MS (SusSys)

ADVISOR: Dr. Jose Alfaro

LOCATION: Adjuntas, Puerto Rico

CLIENT: Sustainability Without Borders, Casa Pueblo

To increase the energy resilience of Adjuntas after Hurricane Maria, different scenarios of solar grid expansion were modeled, along with the addition of biogasifiers. The optimal configuration of a microgrid that can supply electricity for the new commercial load was identified in addition with the lowest cost.

To achieve our goal, we developed a commercialized electricity load of Adjuntas, expanded the potential solar generation, developed a distributed generation scenario in the Adjuntas business district, characterized biomass and gas resources, estimated potential electricity production from a gasifier/generator system, and used HOMER Modeling for optimized microgrid scenarios using estimates and assumptions, to determine feasibility and cost of grid expansion.

The expanded grid was optimal with the addition of one more full-sized generator, and the electricity cost around 8 cents/kWh.

Improving Climate Resilience in Seychelles: Evaluating the impacts of sea level rise and storm surge on Seychelles' critical infrastructure

PRESENTERS: Lisa Maillard, MS (BEC); Tonya Summerlin, MS (EPP); Annalisa Wilder, MS (EPP, EJ), MPP (International Economic Development)

ADVISOR: Dr. Avik Basu

LOCATION: Victoria, Seychelles

CLIENT: United Nations Framework Convention on Climate Change (UNFCCC)

In response to greenhouse gas emissions and global warming, oceans are projected to experience climate feedbacks, unavoidable changes spanning decades and millennia, and thresholds of abrupt change. Small islands and communities closely connected to coastal environments are particularly exposed to ocean changes, such as sea level rise and storm surges. The Republic of Seychelles, an archipelago of 115 islands in the Indian Ocean, is facing unprecedented threats to its livelihood and development as a result of climate change. This research aims to incorporate Seychelles' physical and socioeconomic vulnerabilities with climate scenarios to determine the potential impacts of climate change on Seychelles' critical infrastructure, ultimately providing end users with information to enhance adaptation decision-making. Researchers conducted stakeholder interviews to characterize critical infrastructure in the local context, created GIS maps to illustrate vulnerabilities, and developed climate scenarios to understand plausible climate impacts in Seychelles. An iterative dialogue with stakeholders in Seychelles determined the format of the deliverables, including GIS maps, a memo for policymakers, a climate scenario-building toolkit, and a final research report. The researchers found Seychelles' utilities, transportation, fisheries, and tourism industries to be at high risk. Suggestions for mitigating risk and adapting these sectors were provided by the researchers. The geographic location at greatest risk is the coastal plain lining the main island of Mahé, including the capital city of Victoria. Accompanying sea level rise and storm surges, flooding, coral bleaching, and droughts are driving climate risk in Seychelles. With this information, end users can prioritize adaptation action and enhance resilient development in Seychelles by anticipating particular climate changes and the associated impacts.

Designing an Internal Carbon Fee for the City of Ann Arbor

PRESENTERS: Rosanna Ren, MS (EPP), MURP; Adam Freed, MS (SusSys); Lauren Jones, MS (EPP); Eileen Lo, MS (EPP)

ADVISOR: Dr. Sam Stolper

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Office of Sustainability and Innovations, City of Ann Arbor

It is widely known that carbon emissions are harmful to the environment and societal well-being. One policy response is a carbon fee that will price in the negative externalities of emissions. Our master's project designed and modeled the impact of a $5/ton carbon fee on municipal operations in the City of Ann Arbor. For methods of analysis, we conducted interviews, reviewed case studies, and analyzed the City's current greenhouse gas inventory data. We constructed an Excel-based model to show that a carbon fee can generate significant cost and energy savings for city departments over the next ten years. Furthermore, a carbon fee drives multiple other benefits, like the ability to incentivize energy-conserving behavior among City employees and finance energy efficiency upgrades in municipal buildings. The program is currently being proposed by the Office of Sustainability to City Council for adoption in the FY2021 budgeting process.

Sustainability Assessment and Design Recommendations for Meijer Store of Tomorrow

PRESENTERS: Elizabeth Ballor, MS (SusSys); Xinxin Cao, MS (SusSys), MLA; Lisa Dinon, MS (EPP, SusSys); Gautham Karthikeyan, MS (SusSys); Haowen Zhou, MS (SusSys)

ADVISOR: Dr. Greg Keoleian

LOCATION: Grand Rapids, Michigan, USA

CLIENT: Meijer

This project focused on identifying carbon emission abatement strategies for Meijer, specifically addressing lighting, space cooling and heating, and refrigeration, which constitute Meijer's largest demand sectors. Additionally, the project evaluated strategies to reduce water consumption, waste generation and promote customer education of sustainable practices. The project was organized into three phases. In phase I, a comprehensive assessment of sustainable design and technology elements was conducted, which included a review of sustainability initiatives by other retail competitors. During Phase II, solutions were synthesized and reviewed in consultation with Meijer sustainability and design experts. Technological solutions were categorized into five store systems: energy, water and plumbing, sustainable sites, materials and resources, and customer experience elements. A rubric was then created to systematically evaluate strategies for the Market Format and Supercenter Meijer retail stores. Phase III included a detailed environmental and design analysis using the scoring rubric and supporting literature to identify the set of strategies that best reflect Meijer's priorities. This report details the findings of this research and the portfolio of strategies that would help Meijer create the net zero energy, zero waste, and water efficient Store of Tomorrow prototype.

Consumer Hygiene Products and the Circular Economy

PRESENTERS: Madeline Somers, MS (SusSys, Public Health)

ADVISORS: Dr. Jose Alfaro; Dr. Geoff Lewis

LOCATION: Ann Arbor, Michigan, USA

The idea of a circular economy, a system where linear production to disposal is shifted instead towards re-use and regeneration, has placed focus on single-use consumer products. In particular, single-use consumer products like absorbent hygiene products (AHPs), which include baby diapers, feminine protection pads, and adult incontinence pads, pose unique challenges to municipal solid waste systems and consume considerable resources. These products, which typically contain combinations of polypropylene, polyethylene, elastics, cellulose, and superabsorbent polymers (SAPs), emit more greenhouse gases than 1.5 million EU households combined each year. The SAPs in these products are of particular importance as they have been reported to make up over one third of the total mass of AHPs and contribute substantially to the environmental impacts. Partial recycling of AHPs like baby diapers has been achieved with mixed success by a handful of companies. However, these recycling technologies typically aim to reduce ends-of-life impacts, thus neglecting the biggest impacts in the life cycle. Therefore, I aim to shed light on how we might lessen the impacts at the beginning of the life cycle by focusing on theoretical SAP recovery. My research analyzes the environmental and social trade-offs associated with AHP waste under the following three scenarios: 1) current standard diaper disposal via landfill or incineration in a standardized European context, 2) diaper recycling without recovery of the SAP and 3) recycling with theoretical recovery of the SAP. Environmental impacts of these scenarios were modeled in the LCA software SimaPro and social impacts were modeled in the open source software OpenLCA using the Product Social Impact LCA (PSILCA) database and supported by literature. Results show that theoretical SAP recovery decreases life cycle emissions significantly compared to standard landfilling and incineration and moderately when compared to current recycling technologies. Theoretical SAP recovery also demonstrates large potential offsets of energy and water burdens involved in SAP manufacturing. By assessing these environmental impacts and integrating the social analysis, I clarify the point at which AHP disposal demonstrates potential for circular economy.

Developing a Product & Service Strategy aimed at strengthening the Climate Resilience of Zurich Insurance's commercial clients

PRESENTERS: Keely Bosn, MBA, MS (BEC); Katherine Cunningham, MBA, MS (SusSys); Amelia Brinkerhoff, MBA, MS (SusSys); Shirui Li, MS (EI)

ADVISOR: Dr. Andrew Hoffman

LOCATION: Ann Arbor, Michigan, USA & Zurich, Switzerland

CLIENT: Zurich Insurance

With climate change impacts increasing in frequency and severity, along with the pressures from stakeholders on organizations to provide transparency and information to stakeholders, the potential impact of climate change on organizations continues to gain visibility by company risk managers and financial managers as each attempt to quantify and manage their risk profiles. In turn, many commercial organizations are relying on their insurers for support. Insurance companies are realizing that they have a crucial role to play in helping society effectively adapt to and mitigate climate change. Our team's objective is to help Zurich Insurance better understand what other organizations are doing as best practices to overcome these challenges and to develop effective climate risk management strategies by analyzing the climate risk value chain in order to provide possible product and service offerings. Our methods will include conducting a thorough literature review of climate risk management strategies and performing stakeholder/subject matter expert interviews across Zurich Insurance and the wider climate risk management landscape. These insights will provide Zurich Insurance with an opportunity to achieve a strategic competitive advantage in the area of climate risk strategy and a go-to-market strategy approach to new products and services to assist their commercial clients.

Regional-level analysis for the material flows and process energy demands of aluminum and steel in the American automotive industry

PRESENTER: Nate Hua, MS (SusSys)

ADVISORS: Dr. Jarod C. Kelly; Dr. Gregory A. Keoleian; Dr. Geoffrey M. Lewis

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Argonne National Lab

Aluminum and steel represent the two most dominant metals in light duty vehicles (LDVs), yet the flows of these materials into the American automotive industry have not been closely evaluated. This study proposes and implements a method for analyzing the flows of these metals into the automotive industry. We create a framework for performing regionally linked, sector specific material flow analyses (MFA) and apply it to the material flows of wrought aluminum and steel into the American automotive industry. We then regionalize the process energy demands associated with these flows. We show that automotive aluminum sheet and extrusions are sourced primarily from the NPCC (23%), SERC (20%), MRO (18%), and RFC (13%) NERC regions and a spatially unresolved Local region within the U.S. and Canada (18%). We determine that primary aluminum is largely from Canada (70%), primarily Quebec (69%). Further upstream, alumina and bauxite are mostly supplied by Brazil, Australia, and Jamaica. We also show that finished automotive steel is sourced primarily from the RFC (63%) and SERC (20%) regions. The crude steel supply is similarly dominated by the RFC (69%) and SERC (7%) regions. Most upstream raw materials including coke, coking coal, iron ore, lime, and steel scrap are primarily sourced from the U.S.—only direct reduced iron (DRI) and pig iron are exceptions. Regional distributions of process energy demands for these metals largely coincide with their material flows. Overall, we hope this study helps inform the sustainability of the American automotive, aluminum, and steel industries.

Evaluating GLISA's Adaptive Boundary Chain Model for Climate Adaptation

PRESENTER: Owen Watson, MS (EJ)

ADVISOR: Dr. Maria Carmen Lemos

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Great Lakes Integrated Sciences and Assessments

Since 2011, the Great Lakes Integrated Sciences and Assessments (GLISA) has offered small grants to a network of boundary organizations as part of a larger mission to address the risks of climate variability and change in the Great Lakes region. As part of this program, GLISA tests an experimental funding model, the Adaptive Boundary Chain Model, which seeks to link several boundary organizations to co-create usable climate science with users. To evaluate this experimental model and individual project outcomes, 16 organizations were interviewed following the completion of projects for the years spanning 2011-2014 – exploring what worked, as well as what could be improved in future iterations of the small grants project. A second round of interviews were carried out in the summer of 2019 to further understand longer term impacts associated with the projects. Results of the evaluation show that the intensity and amount of interaction between GLISA-boundary organizations and/or boundary organizations-users strongly correlated to positive co-production outcomes, relationship-building, and long-term impacts; that the model is likely least effective in research-based projects that rely on temporary funding as part of a longer-term undertaking rather than a dedicated co-production process; and the subject of resources is most in need of further research, as the complexities/difficulties inherent in analyzing/measuring an organization's capacities and capital make isolating correlations to outcomes challenging.

Cradle-to-Gate Life Cycle Assessment of Multi-Jet Fusion 3D Printing

PRESENTER: Michael London, MBA, MS (SusSys)

ADVISORS: Dr. Geoffrey Lewis; Dr. Gregory Keoleian

LOCATION: Ann Arbor, Michigan, USA

The rapid pace of growth in additive manufacturing has left significant knowledge gaps in life cycle assessment (LCA) literature, limiting inclusion of sustainability considerations in manufacturing and supply chain decisions. The recent introduction of HP's Multi-Jet Fusion (MJF) 3D printing technology shows promise as an alternative to other additive and conventional manufacturing methods on the market; however, scarce environmental assessments of MJF exist in publicly available literature. This study fills the gap in current additive manufacturing LCAs to improve decision-making in plastic part manufacturing. This assessment investigated the cradle-to-gate life cycle energy consumption and greenhouse gas (GHG) emissions of HP's MJF 3D printing technology in comparison to injection molding across production quantities ranging from 100 to 100,000 parts for a plastic product. This analysis leveraged secondary data from various sources, including MJF technical documents, communications with HP representatives, published LCA literature, the ecoinvent 3.5 database, and Argonne National Laboratory's Greenhouse Gases, Regulation Emissions, and Energy Use in Transportation (GREET) 2019 model. Results of the analysis indicate that MJF 3D printing technology emits less GHG emissions than injection molding with aluminum or steel tooling at quantities up to about 450 and 800 parts, which is 5 to 8 prints jobs for the studied design. 3D printing electricity consumption and material yield are the major factors contributing to MJF's GHG emissions. Varying the manufacturing facility electricity generation source, post processing time, raw material production life cycle inventory data, and printing speed can substantially alter the GHG emissions breakeven point between MJF and injection molding. Optimum conditions of these variables for MJF could shift the GHG emissions breakeven with injection molding to a point between 5,000 to 10,000 parts. MJF's lower material yield and requirement for fusing and detailing agent ultimately limit the GHG emissions breakeven quantity with injection molding. Consequently, MJF's GHG emissions breakeven quantity with injection molding remains one to two orders of magnitude lower than HP's advertised economic breakeven quantity of 110,000 parts. This study also shows that MJF is slightly more energy efficient and more resource efficient than Selective Laser Sintering, MJF's peer additive manufacturing process.

Linehaul Trucking Systems Analysis

PRESENTERS: Claire Dodinval, MS (SusSys), MSE (Mechanical Engineering)

ADVISOR: Dr. Gregory Keoleian

LOCATIONS: Ann Arbor, Michigan, USA & Seattle, Washington, USA

CLIENT: Amazon

Amazon WW Sustainability proposed a suite of carbon reduction goals in anticipation of the public release of Amazon's carbon footprint in the fall of 2019. Shipment Zero was Amazon's initial public goal to make 50% of all shipments net-zero carbon by 2030. Later, informed by its carbon footprint assessment, Amazon announced its goal to reach net-zero carbon across all of Amazon by 2040. According to the U.S. Department of Transportation, trucking is the largest contributor to national freight-related air pollution and its greenhouse gas emissions have increased five times faster than passenger travel emissions since 1990. Carbon reductions can be achieved by reducing the well-to-wheel emissions of vehicle operations, while zero-emissions targets specifically require vehicles with zero tailpipe emissions. This research evaluated the potential of renewable natural gas, hydrogen fuel cell electric, and battery electric vehicles to reduce the carbon footprint of heavy-duty diesel linehaul trucking. Research insight was based on an extensive literature review, the Argonne National Laboratory's transportation emissions and economic modeling tools, academic and fuel-vendor interviews, and a summer internship on Amazon's Transportation Sustainability team. Five criteria were determined to influence the fit of alternative powertrains for linehaul trucking: greenhouse gas reduction potential, vehicle availability, vehicle functionality, cost, and scalability. No one technology is a perfect decarbonization solution, and all powertrains require a facilitative market and policy environment. The resultant report makes contingent recommendations for decarbonizing linehaul trucking activities in order to contribute to Shipment Zero and other net-zero carbon goals.

Training and Research under a Sustainable Roof: Developing a Net-Zero Biological Field Station at the Taboga Forest Reserve, Costa Rica

PRESENTERS: Andrew Harrison, MS (SusSys), MSE (Chemical Engineering); Jacob Picardat, MS (CE); Tom Hayek, MS (CE)

ADVISOR: Dr. Jose Alfaro

LOCATION: Taboga Forest Reserve, Guanacaste, Costa Rica; San Jose, Costa Rica; Ann Arbor, Michigan, USA

CLIENT: University of Michigan

This project laid the groundwork for establishing a net-zero biological field station at the Taboga Forest Reserve in Costa Rica. This field station will serve as a school for U.S., Costa Rican, and international students to learn about sustainable energy systems, ecology, and agriculture, in addition to hosting a full-time research project investigating behavior and cognition in wild white-faced capuchins. The site will serve as a model site for sustainable energy, water, and waste management solutions.

This team focused on a strategic energy plan to provide reliable and sustainable energy to an expanding facility. The team investigated a combination of solar, hydrokinetic, biomass, and battery storage resources to meet the site's current needs, in addition to supporting two additional houses and a forecasted 16-bedroom dormitory.

Microgrid architectures were modeled using HOMER optimization software, balancing renewable resources and their associated costs with projected electricity demand. A proof-of-concept rooftop solar array was installed on the laboratory to provide energy security and inform solar performance for future microgrid expansions. Optimization results were presented to stakeholders at Universidad Técnica Nacional and Tecnológico de Costa Rica, who are partnering with the project to install a biomass gasification system that will supplement electricity generation from local sugarcane and rice agricultural residues.

Conservation + Restoration

Rapid Identification of Beech Bark-Diseased Trees Using High Resolution NAIP Imagery

PRESENTER: Jared Barnett, MS (EI, CE)

ADVISOR: Dr. Kathleen Bergen

LOCATION: Pellston, Michigan, USA

Non-native diseases and insects can have a significant impact on forest health. Locating outbreaks and patterns of spread is important in order to mitigate spread (where possible) or plan for forest-species change. Beech Bark Disease (BBD) is a two-step disease involving a beech scale insect, Cryptococcus fagisuga, and a fungi of the genus Nectria. BBD is actively affecting northeastern U.S. forests, including those of northern Lower Michigan, the location of this study. Remote sensing technologies have the potential advantage of being able to monitor for forest health events over broad landscapes and to track change over time. The goal of my study was to use publicly available imagery and open-source software to develop a remote sensing-based BBD mapping approach that can be replicated by other land managers at the landscape scale. My study site was the ~4200-ha University of Michigan Biological Station (UMBS) landscape in northern Lower Michigan. I used the National Agriculture Imagery Program (NAIP) imagery and R software. My specific objectives were: 1) develop field data characterizing BBD infestation over the study site landscapes and forest cover types; 2) collect training and testing data of BBD-affected plus declining aspen tree crowns for remote sensing classification, 3) assess remote sensing characteristics of BBD-affected image pixels and their spectral separability from those of healthy beech trees and declining aspen, 4) use the above field data combined with multi-year NAIP imagery to map BBD-affected tree crowns and track BBD outbreaks over several years.

ITC Trailhead Park Master Plan

PRESENTERS: Terra Weiland, MLA; Xian Jia, MLA; Zibo Zhu, MLA

ADVISOR: Stanton Jones

LOCATION: Novi, Michigan, USA

CLIENT: Novi Parks, Recreation & Cultural Services

The goal of this project is to develop a Master Plan for a practical trailhead park from three adjoining parcels recently acquired from the Michigan Natural Resources Trust Fund and a private donation. This park will provide a naturalistic experience to nearby residents without compromising the habitat and natural systems within the parcels. Our team will base our design and programming recommendations on an analysis of ecological conditions and information gathered about the residents' needs and desires for the park based on surveys and focus groups. We will conduct a literature review for best practices for survey and focus group development to get meaningful information to inform our design decisions.

Our Masterplan may ultimately include trails, habitat restoration, invasive species removal, interpretative signage, etc. We will draft a realistic budget for the development of the park in phases that could be used for seeking grants.

InvestEGGator Pilot Study: Policy Analysis, Recommendations, and Feasibility for Costa Rica

PRESENTERS: Araceli Morales-Santos, MS (CE); Zoe Fullem, MS (EI, CE); Jared Hocking, MS (EPP, CE)

ADVISOR: Dr. Inés Ibáñez

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Paso Pacífico

Despite their protected status, a major threat to sea turtles is egg poaching for local consumption and commercial trade. In Costa Rica alone, as many as 100% of eggs are poached in some beaches (Fonseca et al, 2015). To help address this problem, our team partnered with Paso Pacífico who created the InvestEGGator – an artificial 3D printed egg containing a GPS tracker which resembles a real sea turtle egg.

The primary component of the project involved initiating a pilot study of the InvestEGGator. We aimed to understand whether conservation nonprofits could utilize this device to track poaching routes. Through semi-structured interviews we discovered that NGOs followed different monitoring protocols; different sea turtle species overlapped at some nesting grounds; cell tower signal strength and availability were limited; and poaching activity varied across five NGO locations. These site differences affected deployment of the InvestEGGators. NGOs successfully deployed 21 devices between October and December 2019 and only two were poached. We were unable to retrieve positional data for the stolen decoy eggs. Our findings show that the InvestEGGators are capable of deceiving poachers based on appearance but require improving their internal hardware to render them reliable for future deployment.

Second, we sought to understand the socioeconomic drivers of sea turtle egg poaching in Latin America, and what policy interventions might help address the issue. We identified five primary reasons for high rates of continued poaching, including a strong cultural tradition of consuming sea turtle eggs and lack of economic alternatives to poaching. Our investigation found that more governmental assistance is needed to ensure successful conservation outcomes.

The Impact of Mycorrhizal Networks on quercus rubra Seedlings Recruitment

PRESENTER: Sam Schaffer-Morrison

ADVISORS: Dr. Inés Ibáñez; Dr. Don Zak

LOCATION: Ann Arbor, Michigan, USA

Introduction: Mycorrhizal fungi are ubiquitous plant mutualists and can form mycorrhizal networks (MNs), consisting of fungal hyphae that connect plants of the same and different species. The degree to which the MNs of adult trees facilitate or inhibit other plants, specifically seedlings, is unclear.

Research Objective: This study examines how the MNs associated with different species of adult trees affect mycorrhizal colonization, growth, survival, and root fungal community of Quercus rubra seedlings, an ectomycorrhizal (EM) tree species.

Methods: Seedlings were planted under four adult tree species: Q. rubra, Q. velutina, Acer saccharum, and Carya glabra. Two thirds of the seedlings were grown in micromesh bags. Seedlings were separated into treatment groups: no bag control (C), bagged control (BC), and disturbed (D). C and BC groups were grown undisturbed. Seedlings in the D group had their connection to the MNs consistently disrupted. Seedlings were collected at the end of the growing season. A subset of the seedlings was examined for EM colonization, and all colonized tips were collected. Collected tips had fungal DNA sequenced to determine the EM community.

Results: Seedling survival in the D treatment group was negatively impacted by mycorrhizal colonization, while survival in the control groups, BC and C, was unaffected. D seedlings were colonized by a different suite of EM taxa than control seedlings. Our data indicate that that MNs have a positive impact on Q. rubra seedling recruitment regardless of the species of adult tree a seedling is grown under. This work represents an important additional step in advancing our understanding of the role that mycorrhizal MNs play in how temperate forest communities assemble.

Creating a Vision for SEAS Properties

PRESENTERS: Cyrus Van Haistma, MS (CE); Lara O'Brien, MS (EI, CE); Maxwell Deyoung, MS (CE); Peter Siciliano, MS (BEC, CE), MA (Educational Studies); Zhengyu Li, MS (EI); Zimeng Ding, MS (EI)

ADVISORS: Bob Grese; Shannon Brines; Dean Jonathan Overpeck

LOCATIONS: Scio Township, Argentine Township, Webster Township, St. Charles, Hamburg Township, Dexter Township, Michigan, USA

CLIENT: SEAS

The University of Michigan's School for Environment and Sustainability (SEAS) currently owns 1761 acres across six individual properties in Southeastern Michigan, including Saginaw Forest, Stinchfield Woods, Newcomb Tract, St. Pierre Wetland, Ringwood Forest, and Harper Preserve. These natural areas accompany various other satellite properties owned by other university departments, existing as part of a broad patchwork of preserved property across northern, central, and southern Michigan. The diverse array of habitats across the sites and vast networks of local and regional stakeholders present a unique opportunity to reexamine the goals and management plans for these properties, and to further demonstrate the university's commitment to land preservation, sustainable stewardship, and carbon neutrality. With these goals in mind, our team operationalized several interdisciplinary research methods during the course of this project, largely consisting of carbon sequestration and storage analyses, remote sensing, and social research considerations. Over the past year, these approaches were used to arrive at holistic, concrete recommendations for both current and future property uses and considerations, which will lay groundwork for forthcoming masters projects at each specific property. Our results point towards a wealth of new management and utilization objectives, including carbon neutrality and pricing, stewardship program initiatives, joint management models with land conservancies, and expanded curriculum opportunities within SEAS program offerings.

Enabling a Stewardship Economy in Rural Communities in the American West

PRESENTERS: Emily Blackmer, MS (EPP); Logan Christian, MS (EPP, BEC); Rebecca Conway, MS (EPP), JD

ADVISORS: Dr. Julia Wondolleck; Dr. Steve Yaffee

LOCATION: Western USA

CLIENT: Wallowa Resources

Over the last three decades, many rural, isolated communities in the western United States have contended with four intersecting challenges: a downturn in natural resource-based economies; environmental degradation resulting from fire suppression, resource extraction, and intensive uses; a desire for new economic opportunities beyond tourism and recreation; and the need to build resilience in the face of a changing climate. Our research identified and studied rural western communities, in a variety of ecosystems, that have responded to these challenges by fostering community-based efforts that prioritize environmental stewardship as an economic and community development strategy. Some of these efforts include building socially- and economically-viable landscape-scale forest, watershed, and rangeland restoration projects; employing work crews to carry out these projects; helping ranchers and farmers maintain their livelihoods while investing in the health of land and water resources; and seeking to realize market and non-market value from natural resource stewardship. We conducted research in 13 communities to better understand what constitutes a "stewardship economy," assess what stewardship economy activities are taking place, and identify what has enabled and constrained these activities' success. Using this research, we developed recommendations for communities, government agencies, policy-makers, and foundations interested in advancing ecological, economic, and community well-being in the rural western United States.

The Future of Michigan Forests: Neighborhood and Climate Interactions

PRESENTER: Kirk Acharya, MS (CE)

ADVISOR: Dr. Inés Ibáñez

LOCATION: Ann Arbor, Michigan, USA

Temperate forests are integral to landscape scale processes and human services. The impacts of climate change and the benefit of biodiversity for forests are both well studied, but the interaction between the biotic and abiotic factors is still not completely agreed upon. This study described how individual species will interact with each other to influence yearly growth under a changing climate. We used a combination of spatial analysis, dendrochronology, and predictive modeling to answer our research questions. We found differences in impacts on tree species common to Southeast Michigan. The purpose of this study was to describe the interaction between climate and biodiversity and also aid forest managers interested in adaptively preparing their stands for a future climate.

The Comparison of Effects of Environmental Changes on the Growth Rate of Tree Species at Different Latitudes

PRESENTER: Xiaomao Wang, MS (CE)

ADVISOR: Dr. Inés Ibáñez

LOCATION: Ann Arbor, Michigan, USA

In order to make reliable forecasts which allow people to predict the future forest dynamics globally under the climate change scenarios, the aim of this study is to identify and quantify the effects of environmental changes at various latitudes on the growth rate of diverse tree species. This multi-site demographic study incorporates a dendrochronological study, observational data and climate data to analyze the differences in tree response to environmental changes. The primary objectives of this project are: To assess how a particular tree species responds to the environmental changes at two latitudes differently and how these differences might influence the composition of forests at different latitudes in the future. For the field data, tree cores of two target species, red maple and sugar maple, were collected in several sites at UMBS and Ann Arbor. After getting the annual growth data of individual trees, a model was used to determine the main factors affecting the tree growth and how strong these factors are at these two latitudes. The results of this study would help with better prediction of future forest dynamic changes with finer resolution.

Tillage classification with random forest algorithm using high-resolution satellite data

PRESENTERS: Haoyu Wang, MS (CE, EI)

ADVISOR: Dr. Meha Jain

LOCATION: Ann Arbor, Michigan, USA

To minimize soil disturbance and improve yields, transition from the measures of intensive tillage to reduced or zero tillage is becoming prevalent throughout the world. Zero-tillage (ZT) practices have become popular among farmers in different countries and regions. Many recent studies focused on the tillage detection utilizing various techniques, such as satellite remote sensing, yet most of them were not focusing on separating ZT and conventional tillage (CT) in a large spatial scale. In this study, we analyzed the classification performance of Sentinel-1, Sentinel-2, and Landsat satellites using random forest algorithm for the large-scale tillage practices at Guanajuato, Mexico in 2017. The research aims to 1) accurately classify agricultural fields with zero tillage measures in Guanajuato; 2) find out classification accuracies among different composite methods for different sensors individually, and for sensor combinations to evaluate the improvement of classification accuracies; 3) analyze the phenology features of the study area, and compare the performance across different composites and sensors; and 4) figure out important features for random forest classification. We had a classification accuracy up to 86.46% for the multi-month sowing plus peak season composite with full sensor combinations. Furthermore, we found that the classification accuracy (up to 82.27%) when using 30-day composite only in sowing season was still reliable if compared to a multi-month composite. The results illustrate that it is reliable to apply combined high-resolution satellite data with different compositing methods to classify zero-tillage agricultural fields in Guanajuato, Mexico.

An Ecological Assessment for the Creation of the Kiwanis Environmental Education Preserve (KEEP)

PRESENTERS: Sarah Brannon, MS (CE, EI); Katherine Ferran, MS (CE); Joy Yakie, MS (CE, EJ)

ADVISOR: Dr. Allen Burton

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Kiwanis Club of Ann Arbor Foundation Inc.

The Kiwanis Club of Ann Arbor, a 501(c)(3) non-profit corporation known for its thrift store sale and scholarship for high school students, envisioned a preserve to instill an environmental consciousness in young people in the Ann Arbor area. It is to this effect we conducted a thorough ecological evaluation of the selected urban forest situated within the 17-acre property belonging to the Kiwanis Club. Utilizing our skills in field monitoring, geographical information systems, and hydrological modeling, we carried out a number of activities, including an on-site investigation of the KEEP surveying the species of amphibians, mammals, and birds that inhabit the area from early spring through late fall of 2019. The vegetation assessment, which began with identifying plant species and classifying the microhabitats in the area, ended with an overview of the land-cover development from 1960 through 2005 using aerial photographs. The in situ testing of the aquatic condition of the two ponds and drain in the site included pH, oxidation-reduction potential, dissolved oxygen, specific conductance, and temperature. Additional analysis was done by sampling for benthic invertebrates and collecting water samples for in-lab testing. Following the water analysis and hydrological modeling carried out, we propose a possible re-routing of captured rainwater to the ponds to restore the water quality. Our wildlife and vegetation report gives suggestions on the preservation of areas with high species activities and guidance to ensure the biodiversity of plants respectively. Our effort builds a foundation for the actualization of the KEEP.

Trails as Conservation: Road-to-Trail Conversion in the Restoration of Redwood National Park's Lower Prairie Creek Watershed

PRESENTERS: Jack Pritchard, MLA, MS (CE)

ADVISOR: Bob Grese

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Redwood National Park

A history of intensive, clear-cut logging adjacent to the historic boundary of Redwood National & State Parks (RNSP) in California's North Coast has created a post-industrial landscape within much of the present-day park. Overstocked with an unnatural composition of timber species, severely degraded habitat, and crisscrossed with a network of abandoned logging roads sets the scene for the site of the Lower Prairie Creek Restoration Project. Remediation along this network of logging roads, in conjunction with forest thinning efforts, has begun a years-long effort to set this landscape on a trajectory towards a future stable-state condition. However, within the project site, there is limited opportunity for engagement through trails, and even less opportunity to understand how the story of this place, including its restoration, has shaped the land.

Research Objective: How can road-to-trail conversion and a proposed trail network in the Lower Prairie Creek Restoration Project Area at RNSP establish a precedent for documenting previous anthropogenic changes to an ecosystem while raising awareness and/or recording the benefits of ongoing restoration?

A review of both design and redwood ecology literature, coupled with field observations, mapping and trail network development has led to an iterative design process in concert with the development of a trail design theory that can be applied to a general understanding of how trails and restoration can advance conservation in sensitive landscapes.

Reclaiming the Shiawassee Flats: Monitoring During Hydrologic Restoration of the Shiawassee Flats Ecosystem

PRESENTERS: Eliza Lugten, MS (CE); Olivia Mitchinson, MS (CE); Matt Puz, MS (CE); Matthew Sens, MS (CE); Kate Vogel MS (CE)

ADVISORS: Dr. Karen Alofs; Dr. Catherine Riseng; Dr. Paul Seelbach

LOCATIONS: Ann Arbor & Saginaw, Michigan, USA

CLIENT: U.S. Fish and Wildlife Service & U.S. Geological Survey

The Shiawassee National Wildlife Refuge is home to a unique collection of diked wetland units that have been restored from farmland. Our research focuses on three wetland units: Maankiki North (MN) and Maankiki South (MS), both recently restored in 2017, and Pool 1A, which has been connected to the Shiawassee River since the 1950s. Throughout the summer of 2019, Pool 1A was kept open to the river through a water control structure. In contrast, Maankiki North and South were closed after being open for three days in late March. We collected data on fish, vegetation, and macroinvertebrate communities and water quality from May through November 2019. We analyzed how Pool 1A, a long-term system, differs from MN and MS, two closed and recently restored units. Although the age and management of MS and MN are most similar, 1A and MS show more similarities in ecology than MS and MN, as seen by similar IBI scores for fish, vegetation, and macroinvertebrates. Our findings indicate that Maankiki South has the highest diversity of fish, vegetation, and macroinvertebrate communities. We believe that the differences among units can be explained by variations in depth and hydrology, rather than age or length of time a wetland unit has been connected to the Shiawassee River. We are working with the U.S. Fish and Wildlife Service to develop a monitoring plan that incorporates depth and hydrological differences in predicting and understanding biological responses to various water management strategies.

Food

Conservation Biocontrol of the Coffee Berry Borer in Coffee Farms through Ant Predation

PRESENTER: Jannice Newson, MS (CE)

ADVISORS: Dr. Ivette Perfecto; Dr. John Vandermeer

LOCATION: Utuado, Puerto Rico, USA

Pesticide use threatens biodiversity in farms and the matrices where they exist. In the coffee system, conservation biocontrol is a sustainable agriculture practice that has the potential to ameliorate the effects of pesticide by encouraging the presence of natural enemies. The coffee berry borer (CBB) remains the most important insect pest in coffee around the world. Spending the majority of its life cycle within coffee berries, the coffee berry borer evades topical applications of pesticide. Ants have been shown to be important predators of the coffee berry borer in field and laboratory settings. We assessed the ability of Wasmannia auropunctata, the little fire ant, to prey on adult female coffee berry borers in Puerto Rico. Over 20,000 coffee berries were assessed from 220 plants and two farms in Puerto Rico. W. auropunctata activity was determined via tuna fish baits in individual coffee bushes. There were significantly more attacked coffee berries in coffee bushes with W. auropunctata than in those without. However, coffee bushes with W. auropunctata had significantly less adult coffee berry borers inside the bored berries. These results suggest that W. auropunctata may be deterring other predators of the adult beetles before they penetrate the berries, and that W. auropunctata's predation on the coffee berry borer is post-berry penetration, making W. auropunctata an important last line of defense against coffee berry borer infestation. Our results suggest that implementation of sustainable agriculture practices like conservation biocontrol could be important for the effective control of the CBB.

Going Local: Encouraging the Growth of Sustainable Small Grain Economies in Southeast Michigan

PRESENTERS: Sheila Wald, MS (CE, EPP); Nicholas Empey, MS (EI, EPP); Zixuan Jiang, MLA, MS (CE)

ADVISORS: Dr. Jennifer Blesh; Shannon Brines

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Zingerman's Bakehouse and Nature and Nurture Seeds

Current conventional food production has created genetically homogeneous crops that encourage environmentally harmful practices. The large-scale production of commodities like wheat discourages consumer engagement and has led to the efficient production of mass quantities of subpar quality food. Encouraging the growth of local small grain economies and partnerships between farmers and businesses can produce food that is flavorful, nutritious, has fewer harmful environmental impacts, and has greater genetic diversity. This project analyzed local grain economies in Southeast Michigan in order to identify the barriers that exist to their expansion, and facilitated a partnership between Zingerman's Bakehouse and a local organic seed company (Nature and Nurture). The goal of this project is to expand the variety of local grains Zingerman's Bakehouse uses in their products and to help create a market for local sustainably produced small grains. To identify diverse wheat varieties that can grow in this area, a series of grain trials were designed for Nature and Nurture to implement over three years. Surveys were used to identify consumer preferences that drive behavior and the grain attributes that are most meaningful to consumers, and expert interviews were utilized to guide our research and gather first-hand information. Creating relationships between farmers and product markets, and identifying gaps in the local grain economies prior to large-scale production mitigates risks, and outlining this process will be useful for more of these grower-buyer relationships to form in the future.

Navigating Michigan Dining Towards Carbon Neutrality

PRESENTERS: Cameron Clark, MS (BEC); Krysten Dorfman, MS (BEC, CE)

ADVISOR: Joseph Trumpey

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Alex Bryan, Michigan Dining

In Fall 2018, the University of Michigan made a public pledge towards carbon-neutrality. This pledge, along with pressure from concerned citizens at the local and global level, make it essential for Michigan Dining (MDining) to proactively address their greenhouse gas emissions. The goal of this research was to assess the impact of existing MDining initiatives to reduce emissions from purchased food, and to provide recommendations for navigating MDining towards carbon neutrality. The researchers used carbon emission estimates from an existing meta-analysis of food product Life Cycle Assessments (LCAs) and MDining data on food purchases from the 2018-2019 school year to estimate the impact that the "Sustainable Mondays" initiative had on emissions. The results from those estimates showed that the Sustainable Mondays initiative reduced emissions by up to 45% in some dining halls, but that the implementation varied significantly across dining halls. Based on these findings, as well as best practices from the literature on behavior change and marketing, the researchers recommend that MDining: make Sustainable Mondays implementation more consistent across their dining halls; more effectively share food emissions information with students using existing digital tools; investigate student attitudes via specific survey questions; and explore possibilities such as carbon-positive farming and appropriate use of offsets.

Using Policy Interventions to Boost Cover Crop Adoption in the Lake Erie Watershed

PRESENTERS: Erica Blair, MS (EPP)

ADVISORS: Dr. Jennifer Blesh; Dr. Tom Princen

LOCATIONS: River Raisin Watershed (Michigan) and Maumee River Watershed (Ohio), USA

Industrial agriculture presents tremendous environmental challenges – from soil health to water quality to climate change – and more sustainable management practices are needed to reduce negative environmental consequences. Increasing plant diversity in agroecosystems through use of cover crops is a promising solution because they provide a host of ecosystem services and can help mitigate pollution. Despite their benefits, however, adoption of cover crops remains slow. This study seeks to better understand the complex, multiscalar factors that shape farmers' management decisions and identify policy interventions to make cover cropping a more viable practice. This research asks:

1. What factors constrain or support cover crop adoption?
2. What is the role of policy in cover crop adoption currently?
3. How can policy be used as a tool to ameliorate constraining factors and better leverage supporting factors to increase cover crop adoption?

Using the snowball method, I identified cover crop farmers in Michigan and Ohio and conducted 20 semi-structured interviews with farmers of varying sizes and experience. Interviews were then transcribed and analyzed using NVivo.

The results indicate the cost share programs, administered both locally and federally, are critical to increasing adoption of cover crops. A major challenge with the programs, however, is that many farmers discontinue the practice once the cost share program ends and financial assistance stops. Farmers offered a wide range of suggestions to fix these problems, including 1) lengthening cost share contracts to enhance cover crop benefits, 2) changing the payment structure, which would enable distribution of funds to more farmers, and 3) reducing confusion and bureaucracy in the programs to eliminate enrollment barriers.

Transforming Protein, Land Use Implications of Plant-Based Alternative Meat Adoption

PRESENTERS: Greg Phillips, MS (SusSys), MBA; Elizabeth Rees, MS (SusSys); Joe Garcia, MS (SusSys), MBA; Leah Gustafson, MS (SusSys), MBA; Ricky Wozniak, MS (SusSys), MBA

ADVISOR: Dr. Ravi Anupindi

LOCATION: Redwood City, California, USA

CLIENT: Impossible Foods

Animal-based protein is broadly known to have negative environmental impacts resulting from inefficient transformation of plant inputs to edible meat, ecologically damaging land use to grow plant inputs and facilitate animal husbandry, and the greenhouse gas emissions from the animals themselves. Our project examines the land use change implications of market segment expansion of the plant-based alternative meat industry as U.S. consumers shift consumption from animal-based to plant-based alternative meat. To do so, we modeled systemic land use change using Stella software, incorporating prior life cycle analyses for agricultural inputs and potential consumer demand scenarios into an interconnected systems model. Our results have shown that increased consumer demand leads to a reduction in net land use, in large part due to a reduction in animal grazing space. However, we find that plant-based alternative meat can be expected to increase land use in emerging markets, whose land is not similarly utilized for animal-based meat production, in order to support increased demand for oils such as coconut oil. Given these results, we've developed a case study to help Impossible Foods address expected sustainability challenges in key coconut oil-producing markets. These findings provide Impossible Foods with direction on areas of focus for their sustainability strategy as this fast-growing company supplies an increasing volume of plant-based alternative meat to consumers.

Perceived and Actual Environmental Impacts of the U.S.-Mexico Avocado Trade

PRESENTER: Kimin Cho, MS (EJ, EPP)

ADVISORS: Dr. Joshua Newell; Dr. Jennifer Blesh; Dr. Dorceta Taylor; Dr. Benjamin Goldstein

LOCATION: Ann Arbor, Michigan, USA

The growing appetite of the U.S. market made matching its demand for avocados with its domestic supply impossible and about 78% of avocados sold in the United States in 2018 are imported from Mexico. The U.S.-Mexico avocado trade is rapidly growing as a result, but the concern over its environmental impact is getting more attention as well. In this study, we explored the avocado supply chain's environmental impacts perceived by the key actors and actual impacts on the ground. To do so, we first reconstructed the actor-based U.S.-Mexico avocado supply chains based on TRAcking Corporate Actors across Space and Time (TRACAST) framework that uses and combines heterogeneous data. From the reconstructed supply chain, we identified key actors who have ability to address the avocado industry's environmental problem. Then, we interviewed the key actors to see what their perception about the U.S.-Mexico avocado industry's environmental impacts is. Finally, we used remote sensing to capture the land-use change associated with Mexican avocado production to compare with the key players' perception. We found dissonance between the avocado supply chain's environmental impacts perceived by the key actors and actual impacts on the ground. Finally, we suggested several recommendations for more sustainable and responsible U.S.-Mexico avocado supply chains.

Information + Education

Dow Innovation Teacher Fellowship Design

PRESENTERS: Julia Glassman, MS (BEC); Allyson Wiley MS (BEC), MA (Teaching and Learning)

ADVISOR: Dr. Rebecca Hardin

LOCATION: Ann Arbor, Michigan, USA

CLIENT: University of Michigan's Center for Education Design, Evaluation, and Research

Concern for a more sustainable society has become prominent throughout the world with younger populations leading the movement in demanding climate action. Exposure to sustainability education empowers students to recognize environmental injustices, how to cope with them, and how to organize to change the system. While younger populations are demanding action and understanding of sustainability topics, most of our current teaching workforce is not equipped to teach sustainability content due to a lack of exposure to the subject.

As a response to these needs, Dow Chemical developed the Dow Innovation Teacher Fellowship (DITF), which is implemented through the University of Michigan's Center for Education Design, Evaluation, and Research. DITF supports educating teachers in the Saginaw-Bay area about sustainability education methods while providing professional development experience on how to integrate sustainability across school subjects to support the execution of interdisciplinary sustainability learning units in their classroom using project and place-based pedagogical methods.

Our research further supports these efforts by expanding the scope of informing teachers about these topics through a comprehensive narrative of experiences that DITF teachers face throughout the development, refinement, and implementation of their sustainability learning units. Our work takes a narrative research design approach by utilizing extensive qualitative interviews, classroom observations, and field experience to fully capture the participants and their experience throughout this work. The hope and goal of this research are for the combined narratives of DITF teachers to inform future educators, students, and alike as they work towards more influential forms of place-based sustainability education.

Green HRM: How People Strategy Professionals Can Lead Triple-Bottom-Line Sustainability

PRESENTER: Chris Owen, MS (BEC), MBA

ADVISOR: Dr. Victoria Campbell-Arvai

LOCATIONS: Ann Arbor, Michigan & Seattle, Washington, USA

CLIENT: Microsoft

People-strategy professionals are largely underutilized as leaders in driving sustainability initiatives within their organizations. Few people associate human resource managers with sustainability; yet, HR departments hold the keys to culture creation, compensation, recruiting, training and development, DEI, and several other important strategic areas that can drastically influence pro-environmental behavior and triple-bottom-line decision-making.

My research asks, "How can HR help embed triple-bottom-line sustainability within organizations?" Forty-three interviews with people-strategy and sustainability professionals were conducted to identify key obstacles, opportunities, and best practices for people-strategy professionals to lead sustainability in their organizations. These findings were supplemented by data from a survey of global business leaders, and then confirmed during an on-site consultation with people- strategy and sustainability leaders at Microsoft in Seattle, Washington. The result of this research is a "How to Guide" for people-strategy professionals who want to help lead their organizations towards triple-bottom-line sustainability.

Water

Watts Branch Resiliency Masterplan

PRESENTERS: Zane Almquist, MS (CE, EI); Zihao (Howie) Chen, MS (CE, EI); Soyoung Jin, MLA; Neha Srinivasan, MLA; Jingyuan Wu, MLA, MS (CE)

ADVISORS: Dr. Stan Jones; Dr. Andrew Gronewold

LOCATION: Washington, D.C., USA

CLIENT: RAMBOLL

The Watts Branch is a tributary of the Anacostia River and is located in Washington, D.C. and Prince George's County, Maryland. This densely populated urban area is vulnerable to flooding, a risk that is expected to worsen due to the effects of climate change. We have created a masterplan for the Watts Branch watershed to relieve the effects future flooding might have on the area. This masterplan has three goals: decrease flood risk, improve habitat and water quality, and increase local residents' connection to the river and quality of life. First, we generated a map of priority areas in the watershed, along with a list of interventions that might be used to achieve one or more of the three goals. We then created decision trees to assist in the process of assigning interventions to specific areas. These decision trees can also aid the community through future decision-making processes. Lastly, we chose three sites within the Watts Branch watershed to conceptually implement a set of these interventions. These pilot projects demonstrate the variety of options made possible by this masterplan.

Capital Market – Based Corporate Water Risk Assessment: Improved Application of waterBeta® on Japanese Corporations

PRESENTERS: Muhan Chen, MS (SusSys)

ADVISORS: Dr. Peter Adriaens; Dr. Anthony Arnold

LOCATION: Ann Arbor, Michigan, USA

As a resource that is often scarce in many regions, water has been identified as a key risk factor in corporate development. Generic financial indicators – such as stock price and financial beta – are not able to show idiosyncratic risks caused by water-related issues. Thus, failure to consider water risks and relative indicators may lead to investment loss. The existing waterBeta® index was developed by Equarius Risk Analytics to assess and price idiosyncratic corporate water risk. It takes capital market indicators, corporate financials and water data into account.

This study will focus on ten selected Japanese corporations and calculate their waterBeta®. Improvement in calculation includes usage of company-specific water data instead of industry average, as well as more insight into huge corporations with multiple lines of business. Correlation between month-specific water risk and price/sale performance was also observed to assess the robustness of waterBeta®.

Data are collected through Bloomberg, Factset, D&B Hoovers and public corporation financial and sustainability reports. Data verification and processing are needed before applying waterBeta® formula. Calculation was done by collaborative effort. Interpretations and suggestions were derived after calculation.

Exploring Innovative Techniques for Continuous, Real-time Monitoring of Fecal Contamination in the Clinton River Area of Concern

PRESENTER: Christine Brown, MS (CE)

ADVISORS: Dr. Paul Seelbach; Dr. Andrew Gronewold

LOCATION: Macomb and Oakland County, Michigan, USA

CLIENT: Michigan Department of Environment, Great Lakes, and Energy

Fecal contamination is a wide-spread impairment to riverine and near-shore environments across the state of Michigan. Where fecal contamination is present, harmful human pathogens are likely to exist, potentially resulting in infectious diseases. Fecal contamination may also carry with it contaminants such as nutrients, pharmaceuticals, endocrine disruptors, and other toxic compounds that cause adverse disruptions to aquatic ecosystems. While Escherichia coli (E. coli) water quality standards have laid the groundwork for monitoring fecal contamination, they are limited by the poor timeliness between E. coli sampling and lab analysis results. Additionally, wet-weather monitoring of E. coli requires substantial personnel availability and poses safety risks for those sampling. However, emergent technologies present a potential solution to these restrictions. Particularly, optical signals such as tryptophan-like-fluorescence and optical brighteners have been shown to correlate with sewage contamination in previous studies. These parameters can be monitored more easily than E. coli, and in a continuous fashion, to provide high volumes of data. In this study, the authors conducted a three-month pilot study to evaluate the prediction ability of these parameters under various hydrologic conditions in the Clinton River Watershed. This presentation will cover deployment methodologies, preliminary findings from the data, and lessons learned about the logistical and technical challenges of using optical signals for water quality monitoring. The results of this study will provide site-specific recommendations for using optical signatures as an indicator of fecal contamination to guide future monitoring campaigns.

Assessment of Ecosystem Management Strategies and Stakeholder Needs for Harmful Algal Blooms in the Great Lakes

PRESENTERS: Adam Oest, MS (CE); Charlie Ramsey, MS (CE); Hanqing Wu, MS, (CE, EI); Seamus Harrison, MS (CE, EI)

ADVISORS: Dr. Casey Godwin; Dr. Tom Johengen

LOCATION: Ann Arbor, Michigan, USA

CLIENT: Cooperative Institute for Great Lakes Research (CIGLR), University of Michigan

Harmful algal blooms (HABs) have increasingly become a problem in Lake Erie and the Saginaw Bay of Lake Huron since the 1990s. While problematic within the Great Lakes, algal blooms also occur in streams, rivers, and coastal regions around the globe. These blooms occur when the cyanobacterium Microcystis reaches a high density and begins producing a toxin known as microcystin. When ingested, this toxin imposes a risk to human health and thus, to coastal communities reliant on the lakes as their primary water source.

The ultimate goal of our project is to improve the reliability of the HAB forecasting model of NOAA and CIGLR within Lake Erie and Saginaw Bay and to enhance system usability among water utility managers. To achieve this overarching goal, we will address four related objectives:

1. How much nutrient reduction is required to control growth of harmful algae, and which forms of nutrients are responsible for triggering the onset of severe blooms?
2. Do invasive mussels exacerbate HABs by recycling nutrients that favor growth of harmful algae or by selectively consuming competitor species of phytoplankton?
3. Do harmful algae regulate their buoyancy in response to the ecological conditions of Saginaw Bay?
4. What information do public water systems need about harmful algal bloom toxicity to support continued delivery of high-quality drinking water during a bloom?

This research project will inform existing modeling efforts at CIGLR and GLERL by addressing key gaps in our understanding and improving their effectiveness in meeting the needs of their relative communities. It will provide early comparisons of the algal blooms of Saginaw Bay and Lake Erie which may be useful in making predictions and may also help inform future research and management efforts.

Evaluation of Two Volunteer Programs in Organizations Dedicated to Urban River Protection in the U.S. and China: The Huron River Watershed Council and The Protect Environment Together Association

PRESENTER: Jiangyun Li, MS (CE)

ADVISORS: Dr. Sara Adlerstein Gonzalez; Dr. Julia M. Wondolleck

LOCATION: Ann Arbor, Michigan, USA & Beijing, China

This study is to analyze and evaluate volunteer programs of two environmental non-profit organizations that focus on the environmental protection of local urban rivers. The project is to propose suggestions for improvements on data quality, educational achievements, and volunteer engagement. The two organizations that we will work with are The Huron River Watershed Council in Ann Arbor and The Protect the Environment Together Association in Beijing. The Huron River Watershed Council (HRWC) is southeast Michigan's oldest environmental organization dedicated to river protection. It is a coalition of residents, businesses, and local governments. The volunteers in HRWC help with monitoring environmental conditions in the Huron River and its tributaries, with restoration projects, and provide and engage in public education. The Protect Environment Together Association is a non-governmental organization which just got established in 2014. It collaborates with the Changping District Science and Technology Commission of Beijing, and the volunteer activities mainly include monitoring the river ecosystem health of the Chaobai and Yongding Rivers and their tributaries in Beijing and conducting educational programs in schools to drive more people towards environmental stewardship. By comparing these two volunteer programs which are inserted in different cultures and that are in different stages of development, we seek to provide suggestions to improve data quality, educational achievements, and volunteer engagement of their projects.

Long-Run Risk Management of Michigan's Contaminated Aquifers: An analysis of the State of Michigan's current regulatory framework for managing groundwater contamination

PRESENTERS: Morgan Beeler, MS (EPP) MPP; Iqra Nasir, MS (EPP) MPP; Matthew Willig, MS (CE)

ADVISORS: Dr. Paul Seelbach; Dr. Allen Burton

LOCATION: Michigan, USA

CLIENT: Michigan Department of Environment, Great Lakes, and Energy (EGLE) - Office of the Great Lakes (OGL)

Restrictive management actions have been used across the State of Michigan to address groundwater contamination; however, the long-term impacts of these management choices have not been fully assessed. The 2016 Michigan Water Strategy recommended developing a comprehensive groundwater management strategy in order to better protect Michigan's valuable water resources, but the lack of understanding regarding long-term impacts of restrictive management actions is a major barrier to developing an effective management strategy. The project team took a deep dive into the State of Michigan's use of restrictive management actions, commonly referred to as institutional controls, conducting a multistep analysis of: 1) the legal framework and history of institutional controls used to manage contaminated groundwater, 2) how other states manage contaminated aquifers, and 3) whether the use of institutional controls can adequately manage Michigan's groundwater contamination into the future. Further, the project team conducted an analysis of current institutional controls using GIS as well as considered appropriate groundwater models for projecting groundwater flow and movement of contaminants. Lastly, the project team developed recommendations based on in-person interviews with EGLE and DHHS staff as well as best practices from other states to provide feedback on how to improve management and coordination on groundwater contamination.

Hydroperiod and Water Level Effects on Greenhouse Gas Exchanges in Great Lakes Coastal Wetlands

PRESENTER: Ye Yuan, MS (CE,EI)

ADVISOR: Dr. Bill Currie

LOCATION: Ann Arbor, Michigan, USA

Carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) are key radiatively active greenhouse gases (hereafter GHGs) with variable global warming potential. Wetlands play a vital role in regulating global GHG emission through plant assimilation and soil sequestration of CO2 as well as microbial production of CH4 and N2O. These gas dynamics are greatly affected by seasonal water-level fluctuations that modulate plant productivity and dictate the location and extent of oxic and anoxic zones, which regulate soil microbial processes including denitrification and mineralization of organic carbon in detritus. Modeling results suggest that high water level lowers net CO2 emissions by promoting C storage while seasonally fluctuating water levels increased N2O production. High N-loading and high residence time of water consistently lowered net CO2 emissions but increased N2O production.

Thank You, Clients!

Our sincere thanks to the project client organizations (listed below). You provide SEAS students with key opportunities for research and the development of professional skills. We greatly value your partnership.

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University of Michigan

One of the nation's top public universities, the University of Michigan has been a leader in research, learning and teaching for more than 200 years. U-M's alumni body is one of the largest in the world and includes a U.S. president, scientists, actors, astronauts and inventors. The university, which also boasts a world-renowned intercollegiate athletics program, has been the site of many important events in U.S. history, including JFK's announcement of the Peace Corps, LBJ's "Great Society" speech, and the clinical trials of the Salk polio vaccine. The main campus in Ann Arbor comprises 19 schools and colleges; there are also regional campuses in Dearborn and Flint, and a nationally ranked health system, Michigan Medicine. In 2017, U-M celebrated its bicentennial, marking 200 years since its founding in the city of Detroit.

School for Environment and Sustainability (SEAS)

The School for Environment and Sustainability's overarching objective is to contribute to the protection of the Earth's resources and the achievement of a sustainable society. Through research, teaching and outreach, faculty, staff and students are devoted to generating knowledge and developing policies, techniques and skills to help practitioners manage and conserve natural and environmental resources to meet the full range of human needs on a sustainable basis.

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