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Quantifying Sustainability in Puerto Rico: A Scientific Discussion

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Proceedings of Quantifying Sustainability in Puerto Rico: A Scientific Discussion

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Quantifying Sustainability in Puerto Rico: A Scientific Discussion

Puerto Rico Convention Center
Meeting Room 104A
100 Convention Boulevard
San Juan, PR

June 5 – 7, 2012

EXECUTIVE SUMMARY

The purpose of the U.S. Environmental Protection Agency's Office of Research and Development's symposium/workshop entitled, "Quantifying Sustainability in Puerto Rico: A Scientific Discussion," was to establish a dialogue between researchers and decision-makers and facilitate research to be used in policy and decision-making. The symposium was designed to discuss sustainability; present ongoing research/work related to the identified issues; discuss what researchers think policy-makers could do to move Puerto Rico toward sustainability, relative to their research; and discuss what was necessary to implement their research island-wide (e.g., data description [spatial and temporal resolution], policy relevance). The subsequent workshop provided participants an opportunity to present what they learned from the talks, how they could use the information, and what was necessary to implement the research into decisions (i.e., what research is needed to fill gaps). Participants included representatives from federal agencies, the Commonwealth of Puerto Rico, academic researchers, and nongovernmental organizations; participants provided expertise from several disciplines.

The event provided a new perspective for sustainability researchers. Participants learned that scientists have different visions of sustainability, and a cohesive collaborative effort in the sustainability community is lacking. The symposium created a missing forum for scientific discussion and was a first step rather than the final answer. A number of recommendations were put forth; the primary recommendation was the establishment of a task force with broad representation and whose primary responsibility is sustainability of Puerto Rico. The suggested purpose of the task force is to establish a vision for Puerto Rico with a number of associated goals. The task force must determine the current state of sustainability in Puerto Rico and decide the future path. It is important that all stakeholders are represented on the task force and sustainability must be addressed with short-, medium-, and long-term goals. In addition, the research community must convert from discipline-based thinking to issue-based thinking.

Everyone agreed that it was important there be an incentive for decision-makers and that representatives from the business sector are present at future symposia. Moreover, there was an obvious need for this event and the effort to establish a sustainability vision for Puerto Rico. The symposium/workshop was a good first step, and the goal was to involve the appropriate individuals to further the effort, regardless of government support.

MEETING SUMMARY

INTRODUCTION AND OVERVIEW

The U.S. Environmental Protection Agency's (EPA) Office of Research and Development's (ORD) symposium/workshop entitled, "Quantifying Sustainability in Puerto Rico: A Scientific Discussion," was held in San Juan, Puerto Rico, from June 5–7, 2012. The symposium/workshop brought together approximately 60 researchers from academia, nonprofit organizations, industry, and government to discuss ongoing research to quantify sustainability in Puerto Rico (Appendix A includes the participants list). Specifically, the objectives of the symposium were to share research and identify how the research could be used to aid *municipio* and island decision-making. The workshop objectives were to learn from decision-makers what information they need and how the researchers' information can be made useful to them to make better-informed decisions.

The meeting served as a stimulus to discuss issues pertinent to sustainability in Puerto Rico, learn about current sustainability research projects in Puerto Rico and how the research could help decision-makers, determine how EPA's ORD can collaborate with researchers, and plan a coordinated research agenda and activities to increase sustainability in Puerto Rico. Notes from the meeting follow.

JUNE 5, 2012

Welcome/Perspectives
José Font, EPA, Region 2, Director, Caribbean Environmental Protection Division; Matt Hopton, EPA, ORD, National Risk Management Research Laboratory (NRMRL); Ernesto Diaz, Departamento de Recursos Naturales y Ambientales (Department of Natural Resources and the Environment)

Dr. Hopton called the meeting to order at 9:27 a.m. and welcomed the participants to the meeting and to Puerto Rico. The purpose of the symposium was to determine how current knowledge and science could be integrated into policies and decision-making to increase sustainability in Puerto Rico. After describing some logistical aspects of the meeting, he explained the presentations would be available on the website after they have been made Section 508 compliant. He thanked the Puerto Rico Environmental Quality Board (EQB) for its sponsorship of portions of the event.

Mr. Font welcomed the participants to Puerto Rico and thanked ORD and the local entities that took the initiative to develop the symposium/workshop. He also thanked the academicians and environmental groups that helped to ensure the event came to fruition, as sustainability is an important topic. He noted the impressive amount of knowledge among the participants, which he said would be significant as they worked together to increase sustainability in Puerto Rico. Sustainability is based on a simple principle: Everything that is needed for survival depends on the natural environment. Sustainability creates and maintains the conditions under which humans and nature can co-exist in productive harmony. Sustainability is important to ensure that humanity continues to have the resources to protect human health and the environment. It is important to discuss this topic and disseminate the knowledge to be able to have and enjoy a better future. Although some believe that balancing a healthy environment and a healthy economy is a "zero-sum game" (i.e., both cannot be attained), this is false. It is possible to maintain a sustainable environment while developing a strong economy. To do so, it is necessary to support the best ideas and technologies until they become common practice.

It is best to begin with simple, local projects that help the environment in multiple ways. For example, recycling is important because it saves energy, conserves raw materials, reduces the amount of waste sent to landfills, and decreases pollution. The waste disposal situation in Puerto Rico is dismal; all 29 waste

disposal facilities are out of compliance with environmental regulations. The recycling rate in Puerto Rico is estimated to be between 8 and 12 percent, which is lower than in the mainland United States. EPA helped to launch the Puerto Rico recycling initiative 2 years prior. The concept is that people will reduce, recycle, and compost. The small amount of solid waste that is generated will be sent to a lined, environmentally compliant landfill. This cost-effective initiative created scores of new jobs. Another method to increase sustainability is to increase use of public transportation. Puerto Rico has one of the highest car ownership rates in the world, and has the highest asthma rate among U.S. states and territories. Issues such as storm water management and urban sprawl would be mitigated if more people used public transport. It is necessary to develop sources of clean, renewable energy, which will reduce the cost of health care, reduce the amount of resources used, and increase jobs. Many more jobs are created by renewable energy as compared to coal-fired power plants. The future lies in green energy; there is a market for energy that is sustainable and does not increase the burden on society.

Puerto Rico is working with the U.S. Department of Energy to evaluate the feasibility of developing renewable energy production at landfills and Superfund and Brownfield sites. The project brings together many experts from a variety of sectors to explore the unique opportunity to generate renewable energy at landfills. The project has received a commitment from four *municipios* to install photovoltaic cells to generate and distribute energy. Sites are authorized to transfer 5 megawatts of energy to nearby facilities in need of energy. If the photovoltaic cells can be manufactured in Puerto Rico, this will bring additional jobs to the island. Training personnel on the island to install and maintain the cells also will create jobs. Recently, $1 million was provided to a cooperative formed by four *municipios* on the southern coast that is determining how to make the best use of that area. By training and working together, this group was selected to move forward with the initiative. Many *municipios* rely on more than 300 small, private water systems that have many issues (e.g., bacteriological, compliance). Another pilot project focuses on use of portable technology to address these problems. Although the challenge is enormous, solutions are available, and science and technology will provide additional solutions. It is necessary to increase awareness of the importance of sustainability; focusing on small projects will help in this effort.

Dr. Hopton explained that he and Dr. Matt Heberling were co-leading the research on sustainability metrics in Puerto Rico and that sustainability has become a focus of ORD research. The objectives of the meeting were to: (1) discuss issues pertinent to sustainability in Puerto Rico (e.g., biodiversity, water quantity and quality, habitat loss); (2) discover what researchers in many disciplines currently are studying in Puerto Rico related to sustainability and how that research can affect or help decision-makers; (3) learn how EPA's ORD research goals can be enhanced and applied in collaboration with the research described above; and (4) plan a coordinated research program and implementation of integrated activities to move Puerto Rico toward a more sustainable future.

ORD is a scientific research organization that focuses on addressing research questions with basic and applied research, which may aid decisions or regulations. The office provides the science and information to help inform credible decisions for its customers, which include EPA regions and program offices and the American public. The sustainability research group within ORD has focused on multidisciplinary, integrated research for years. In recent years, EPA moved toward this trend until ORD Assistant Administrator Paul Anastas determined in 2010 that it was necessary to take this a step further and established the goal of sustainability as the "true north" for ORD. All problems are addressed in terms of sustainability, and the solutions are examined for unforeseen consequences in a systematic approach. To be truly sustainable, it is necessary to look far into the future. The first EPA Administrator also spoke of sustainability without a name when he noted that EPA's mission transcends dealing with the usual mix of social problems.

To meet the goal of sustainability, ORD has realigned its research into six programs that have sustainability research at their core. Each program has research projects, which are further divided into tasks. Within the Sustainable and Healthy Communities Research Program (SHCRP), EPA researchers, their partners, and

stakeholders are working together to form a deeper understanding of the balance between the three pillars of sustainability—environment, society, and economy—so that individual needs are met. This transdisciplinary work will provide the decision tools and data that communities need to make proactive, strategic decisions aimed at a prosperous, more environmentally sustainable future. SHCRP research focuses on developing comprehensive approaches to help communities become more sustainable; developing decision-support tools, models and metrics that can be used to improve sustainable community practices; and meeting EPA's regulatory requirements. The SHCRP research in Puerto Rico began in 2009 and includes coral reef management in the Guánica Bay Watershed and sustainability metrics research. The goals of the metrics research are to develop decision-support tools and data for examining system sustainability and to identify trends in moving toward or away from sustainability. Dr. Hopton's PowerPoint presentation can be found in Appendix B.

Mr. Diaz said that he would place into context what sustainability means to Puerto Rico. The world is facing many challenges in mapping a course toward sustainability. All current crises (e.g., energy, global recession, and climate) are interconnected, and the only manner by which to address them effectively is to implement integrated solutions. Puerto Rico can be compared to small island nations, and the vulnerability of its ecosystems arises from the interplay of several factors (e.g., size, geographic dispersion, limited resilience, unique biodiversity). Small island nations pay high costs for energy, infrastructure, transport, and communications.

Agriculture and food security are important for Puerto Rico. The food crisis has highlighted the increasing importance of agriculture to develop a safe and sustainable food supply. Less than 10 percent of the food consumed on Puerto Rico is produced on the island, implying that the island's food supply is not secure. It is necessary to address development and natural system needs through integrated water resources planning and management. Use of water has increased six-fold during the last decade, and pressure on water resources will increase as the population increases. Although Puerto Rico has had a slight decline in population, water supply and sanitary infrastructure issues remain. In terms of biodiversity, most of Puerto Rico and its outlying islands are covered by tropical forests; approximately 9 percent of the land has been designated as federally protected, whereas 25 percent of the island's water environments have received this designation. Natural disasters are a factor because more than 10 percent of the population lives in flood-prone areas. Mr. Diaz's organization has been working with 140 scientists, planners, economists, architects and communicators for the past 2 years to gather the best knowledge regarding climate change in Puerto Rico. Working groups have identified information and use the information to reduce and/or eliminate potential effects and impacts. The results of this effort will be presented at the end of June 2012, and the report is expected to be released in the fall of 2012. Future climate change adaptation priorities also have been identified.

Mr. Diaz's goal for the symposium was to discuss the shared vision of what sustainability means to Puerto Rico. He characterized the agenda as interesting and informative. Another goal was to promote partnerships between stakeholder initiatives aimed at fostering and implementing sustainability development initiatives to complement governmental action. He noted that new indicators of health and well-being need to be developed, and a challenge in carrying forward a sustainability strategy in Puerto Rico would be to establish a shared vision, coordinate partnerships among various agencies and organizations, and translate the developed framework into coordinated action.

Discussion

A participant asked what interaction EPA has had with communities in Puerto Rico. Many communities are active in sustainability, and local students need to be educated. Dr. Hopton agreed. ORD would like to establish collaborations with academia, as local researchers have a great deal of expertise from which EPA researchers would benefit. The problem with working with individual researchers prior to this event is the perception they have an advantage. Everyone is invited to share in this dialogue, and Dr. Hopton is hopeful

that this will be the beginning of a rich partnership. The participant noted that transparency in dialogue is a tenet of sustainability and must be accomplished if true sustainability is to be achieved. Dr. Hopton agreed and reiterated that he was hopeful that this symposium would result in a partnership between EPA and its stakeholders in Puerto Rico. A participant added that ORD has been sponsoring workshops, and academia has been invited to participate. EPA researchers in Cincinnati, Ohio, are working with the Puerto Rico Aqueduct and Sewer Authority. Dr. Hopton reiterated that a dialogue has been initiated, and researchers should contact ORD to continue the dialogue.

A participant noted that ORD is examining trends, but sustainability needs goals, which in turn depend on visions; different stakeholders have different visions. In examining trends, how will ORD go about determining the consensus of the goals and involve the stakeholders when determining whether Puerto Rico is moving from or toward sustainability? Dr. Hopton said that ORD has spoken with key people in agencies and academia in Puerto Rico and developed a framework for sustainability, but other tools may be necessary. Recently, ORD has initiated place-based studies. In addition to government and academia, community members are being approached for their input via community outreach.

A participant suggested that ORD should expand the academic disciplines with which it is consulting; many fields are involved in sustainability research. For example, she is a sociologist performing sustainability research, but she only heard about this conference from an engineering colleague. Dr. Hopton said that ORD identified academic members based on those who had published in the literature about sustainability within the past 5 to 7 years. Unforeseen circumstances shortened the planning time for this event; ideally, the organizers would have had more time to research potential participants. He asked the participants to disseminate information to their colleagues; the goal is to be as inclusive, integrative, and collaborative as possible.

A participant remarked that sustainability has become a buzzword and expressed hope that the effort toward it would be serious. Will this collaboration deal with real issues? Will government decision-makers take into account any metrics identified during the symposium? Dr. Hopton said that this was the goal of the workshop.

A participant noted that policy analysts and decision-makers needed to be present at the workshop. Decisions are made by values and visions rather than empirical data. Dr. Hopton responded that goal was to connect with sustainability researchers, determine what ongoing research is being conducted, and then begin a dialogue with the decision-makers to determine how this research can be effective in decision-making. Decision-makers can explain to the researchers what they need, and the researchers can explain why their information should be important to decision-makers. Once researchers understand what information is needed, they can incorporate this into their research to provide useful information that will inform decision-making. This event is a starting point.

Another participant commented on the importance of considering Puerto Rico as an island nation; U.S. federal regulations are not always applicable to the island. A participant noted there are three main principles that guide the achievement of sustainability in Puerto Rico: guidance for public and private development in coastal areas, support for active management of coastal marine resources, and active research that fosters public participation. Social, political, and economic issues have an impact on the decision-making process. It is necessary to deal with reality and consider the sustainability one is trying to achieve. Several overlapping processes are ongoing (e.g., climate change, fish, and wildlife), and it is necessary to combine these efforts to find synergies. This is a great opportunity to contribute to an effort that attempts to develop a baseline and then perform future monitoring. The group must collectively draft a vision of sustainability for Puerto Rico.

Dr. Hopton noted that from a research perspective, there are not enough data, which need to be collected and made readily available for researchers to use to quantify sustainability in Puerto Rico.

A participant expressed hope that the interaction between researchers and EPA would not be framed on a basis of mistrust because of the legacy of mistrust. The role of EPA in Puerto Rico needs to be revised and reconceptualized because of the uniqueness of the island and its needs for capacity building. Trust must be built. He does not want the event to become a public hearing. EPA needs to structure meetings so they foster collaboration and reduce suspicions. It is necessary to move toward a collaborative partnership; Dr. Hopton agreed.

Dr. Heberling said that ORD is guided by research questions and moves forward by addressing these questions. Feedback from local researchers and communities is useful in advancing ORD's research in Puerto Rico, because ORD scientists are not the local experts. The scientists, however, are experts on metrics. It is necessary to work together to determine whether the metrics can be applied to decision-making in Puerto Rico.

A participant commented the exchange of information causes a redistribution of power. Information and ideas about paradigms and processes can be shared back and forth; processes and flow of information capture the attention of decision-makers better than data. "Soft" science needs to be intertwined with "hard" science to achieve policy change.

Puerto Rico Sustainability Metrics Project
Matthew Heberling, EPA, ORD, NRMRL

The PowerPoint presentation can be found in Appendix C. Dr. Heberling provided the most often cited definition for sustainability, noting that it includes economic, social, and environmental pillars. The concept of sustainability is very broad, complicated, and challenging, and a collaborative, interdisciplinary approach is needed to quantify it. A single metric or index will not capture all aspects of a system. The federal government must integrate economic, social, and environmental policies to achieve sustainability; therefore, EPA and its partners are developing integrative decision-support tools and supporting analyses that will help decision-makers choose sustainable development. The goal is for local decision-makers to use the developed tools and analyses as part of their future environmental management decisions.

The specific goal of ORD's sustainability metrics project is to produce a straightforward, inexpensive methodology to measure and monitor the prosperity and environmental quality of a regional system. ORD tested the approach in the San Luis Basin (SLB) of Colorado. ORD's definition of sustainability is that economic, social, and supporting environmental systems must work in concert to maintain a desired level of functioning indefinitely; if any single component is not sustainable, the entire system is not sustainable. An indicator measures one characteristic of a system, whereas a metric combines many indicators through aggregation to measure sustainability. The ORD team emphasizes metrics above indicators to capture and quantify system dynamics. Although some metrics can identify a system as sustainable, the team thought that it was more informative to identify where a system is heading because sustainability is a moving target. The multidimensional problem of sustainability requires multiple metrics (e.g., ecological footprint analysis [EFA], green net regional product, emergy analysis [EmA] and Fisher information [FI]).

As a result of the work in the SLB, the ORD team developed eight recommendations that it will apply to future projects. The team learned to involve stakeholders and decision-makers early in the process, and there is no "one-size-fits-all" metric; tools must be tailored to fit the region. For its follow-on project, the team chose a second site that is completely different from the SLB, using the whole island of Puerto Rico. Knowledge gained from the SLB project informs the Puerto Rico project. This scientific symposium was planned as a 2012 outcome with the goal of leveraging the knowledge of local experts. The process for the metric research was formalized based on the Global Environmental Management Initiative's Metrics Navigator™, using four relevant metrics from the SLB project as a starting point. The objectives of the project are to: (1) determine applicability of using existing datasets to estimate metrics on a regional scale,

(2) calculate metrics through time from 1960 to the present, and (3) compare and contrast the results to determine whether the region is moving toward or away from sustainability.

Dr. Heberling described the four metrics being used for the Puerto Rico sustainability project: (1) EFA, which captures the supply and demand of biologically productive land; (2) green net national product, (GNNP), which captures the welfare of the system; (3) EmA, which captures the flow of energy through the system; and (4) FI, which captures the dynamic changes in the condition of a system. EFA and EmA are measures of strong sustainability, and FI and GNNP are measures of weak sustainability. The team also is interested in environmental justice. In December 2009, the team met with stakeholders and decision-makers—including the Office of the Governor, the EQB, the Departamento de Recursos Naturales y Ambientales (Department of Natural and Environmental Resources; DNER), and the Puerto Rico Solid Waste Authority—to identify relevant issues. The stakeholders were asked what issues matter to Puerto Rico and sustainability to supplement the literature search performed by the team, which indicated that some relevant issues appeared to be soil erosion, land and habitat loss and transformation, population growth and density, coral reefs and fisheries, and water quality and quantity. In addition to these issues, the stakeholders further identified invasive species, energy use, air quality, and trash and solid waste as issues. The stakeholders were asked the following questions: Who are the relevant decision-makers for island metrics? What current research activities are planned or ongoing at government agencies or universities related to sustainability metrics or decision support? What are the data needs? Who are the best people with whom to discuss data and availability?

Dr. Heberling discussed the current status of the project, noting that data collection is concluding, but the progress on preliminary calculations depends on the metric. He chose the economic metric of GNNP to highlight the progress, explaining that although gross domestic product measures market transactions, it was never intended to measure welfare and ignores leisure and nature's contribution to welfare. Augmented GNNP, however, captures the welfare of the system. GNNP also can be used as a one-sided test of unsustainability to determine whether a system is moving away from sustainability. Dr. Heberling showed a graph highlighting the preliminary estimate of GNNP, which has risen since 1993. The next steps of the project are to develop: (1) a proceedings from this meeting to identify existing research and potential collaborations, (2) a written protocol for identifying and calculating the metrics in Puerto Rico, (3) a scientifically sound strategy for sustainable environmental management in Puerto Rico, and (4) journal articles presenting the metrics and results.

Discussion

A participant asked Dr. Heberling to define the term "stakeholder." He responded that it is a difficult term to define; the team took a broad view to be as inclusive as possible, but this approach still could be improved because the team members were limited by their personal knowledge. In this case, stakeholders were considered those who deal with, have knowledge of the issues, and could inform the work. A participant noted the public was not considered a stakeholder in this case and asked for confirmation that EPA generally considers the public. Dr. Heberling confirmed that EPA often seeks public comment. Dr. Hopton added that during the SLB project, the local universities obtained public input; this approach could be used in Puerto Rico. The ORD team is working closely with Region 2 and its Caribbean Environmental Protection Division to involve as many people as possible. The goal is to include a broad array of representatives so that everyone's voice is heard.

A participant asked about nature's contribution to welfare and thought that perhaps some other elements were being undervalued. Dr. Heberling agreed there were underestimations because of data availability, and the team has not determined how to include those variables (e.g., coral reefs, fish stocks) in the GNNP in a theoretical manner; recreation is partially included.

A participant was concerned about using FI, which applies a linear approach to a system that behaves nonlinearly. A straightforward approach would be to use Google Maps and examine those activities that are not supposed to be occurring (e.g., building of resorts in banned locations). Changes in regulations (e.g., more flexible zoning and environmental regulations) are straightforward indicators the government of Puerto Rico is moving away from sustainability. These types of indicators should be added to the indicator matrix, which will provide valuable information. Dr. Heberling said that FI has been tested in environmental data to examine known changes in a system but recognized there is concern about using environmental data in FI. It would be interesting to examine past decisions in relationship to the indicators.

A participant stated that inclusion of social sustainability indicators is absolutely necessary. Quantification is needed to ensure transparency in decision-making. In terms of literature searches, the University of Puerto Rico has a particular method of promoting its publications, which must be published in Spanish in Latin American forums. An English literature search likely will miss many peer-reviewed articles about Puerto Rico research. Dr. Hopton explained that this was why the team attempted to be as inclusive as possible because team members recognized they were coming from outside of the culture. For this reason, the team asked the stakeholders in 2009 to identify issues in addition to those the team had found in the literature.

A participant asked what ORD was going to do for Puerto Rico. Dr. Heberling responded that ORD researchers wanted to work together with Puerto Rico researchers and stakeholders to provide tools to allow Puerto Rico to move toward sustainability. The goal is to establish a dialogue with Puerto Rico researchers, decision-makers, and agencies.

A participant asked how scale issues were incorporated into the analysis. Dr. Heberling responded the work was being performed on the island-level. Some data from *municipios* may need to be scaled up, but the analysis focuses on the island.

A participant suggested the ORD team examine the quality of data, determine how the calculations were made, and examine the margin of error. Dr. Hopton said the team would appreciate help with this.

Legacies of Socioeconomic Transitions on the Structure and Function of a Tropical Drainage Basin: Resilience and Sustainability Implications
Carla Restrepo, University of Puerto Rico, Río Piedras

The PowerPoint presentation can be found in Appendix D. Dr. Restrepo showed several photographs that highlighted the common theme of abandoned structures and cars, nonrunning rivers, invasive species cover and overgrown coffee plantations. The Rio Grande de Arecibo Watershed (RGAW) experienced high levels of rainfall from 1899 to 1909, and a 1902 paper details several waterfalls to be used for the development of power. In 1909, the uneven distribution of rainfall on the island was noted; although sugar cane was grown in the south, the north experienced higher levels of rainfall. An irrigation scheme was developed that would remedy the irregular and insufficient rainfall in the south. Dr. Restrepo displayed a timeline that highlighted major events in the development of the water supply in Puerto Rico, including legislation at the U.S. and island levels and the addition of major infrastructure in the watershed. The most recent activity was the development of a super water aqueduct that connects the eastern portion of the island to the watershed. As a result, the majority of the island is connected to the watershed.

Water has multiple uses, is a valuable resource that can be moved via technology and infrastructure development, and is a commodity that connects people across great distances. Infrastructure development occurs in cycles; when one cycle ends, the old infrastructure becomes a nuisance. Can the function of the watershed be maintained with the entire built infrastructure? Stream network and water quality and quantity are used to assess the watershed, and these variables change across time. Eco-hydro-geomorphic and socioeconomic processes can affect the health of the watershed.

Sustainability is about the intersection of social, environmental, and economic factors, and sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Ecological resilience is the amount of disturbance (e.g., water withdrawal, water management) that a system can absorb without changing its state or structure and still function. As such, the researchers developed three questions: What are the relationships between stream and infrastructure networks and patterns of human occupation in the RGAW? How do socioeconomic conditions and water quality indicators vary across the RGAW? Is there a relationship between socioeconomic and water quality variables?

The main towns in the watershed have been established on the river; therefore, there is a relationship between humans and stream network. The researchers chose four variables to determine the variability of the watershed. The researchers examined whether there was an association between water quality and socioeconomic status and determined there was; the lowest water quality is found in the lowest socioeconomic areas. In terms of stream network and socioeconomic indices, headwaters are in areas of high concern. When the researchers added information regarding public infrastructure network and socioeconomic indices, they determined that large infrastructure projects have negative impacts on the citizens of Puerto Rico. Based on their data, the researchers concluded that stream networks are key elements in the organization of human settlements, and public infrastructure networks have impacted human populations. Socioeconomic indices are spatially heterogeneous and may suggest regime shifts; socioeconomic and water quality indices were correlated in one instance. Finally, areas of socioeconomic concern appear to be associated with areas in which public infrastructure projects have been developed.

Discussion

A participant commented the watershed is located in a highly calcified area, which affects water quality, so perhaps this is a contributing factor. Dr. Restrepo responded the water quality data were obtained from the upper portion of the watershed. She noted the need for agricultural water explains why infrastructure was built in unsuitable areas (e.g., those prone to landslides).

A participant thought that data might say more about how society has changed from agricultural to industrial rather than about water use. Dr. Restrepo said there had been competition for water, water is needed for energy production, and mountain agriculture required water, which created large amounts of sediment. Many efforts have been focused on dealing with this sedimentation.

A participant noted that from a political standpoint the historical view is fascinating. The regional level of analysis is important to examine policy regimes regarding the development of infrastructure. There has been no change in regime: the centralized nature of decision-making still exists. Local knowledge is not used in the development of infrastructure. Examining the various layers could provide a better picture of the sustainability (or unsustainability) of an area across time. Dr. Restrepo agreed that it is important to learn from past mistakes to improve the future.

Resident Perception and Valuation of Green Areas and Riverbank Hypothetical Improvements in a Tropical Urban Watershed
Luis E. Santiago, University of Puerto Rico Graduate School of Planning

This PowerPoint presentation can be found in Appendix E. Dr. Santiago described the San Juan Urban Long-Term Research Area (ULTRA) project. The study attempted to increase understanding of the perceptions of residents toward green areas and bodies of water and provide an estimation of the valuation attributed by residents to them. San Juan is located in the Río Piedras Watershed, in which more water flows through potable water and sewer pipes than its rivers and tributaries. The land-use change since the 1930s, which Dr. Santiago illustrated with satellite images, has been dramatic and has led to many changes in ecosystem services. Green infrastructure contributes to the socioecological system in terms of flood

control, temperature regulation, pollution control, soil conservation, aesthetic and recreational value, and planting of fruits and vegetables.

To explore the watershed, the researchers developed the integrated socioecological sampling network to examine houses within defined sampling circles. The researchers conducted 441 20-minute, in-person interviews between January and August 2011 to obtain a representative sample of watershed residents. Housing sales data from 2005 to 2009 were obtained, and property addresses were used to geocode the georeferenced points of these sales. The researchers defined a viewshed representing visible green areas from a property and estimated residential housing distance to public green areas, rivers, streams and shopping malls. The researchers found there has been a progressive isolation from the river because of human intervention (e.g., channelization). Residents who had visited the river were on average older than those who had not. Two-thirds of the residents who knew the location of the river had never visited it. Based on interviews, there appears to be a gap between a stated preference for trees in properties and the reduction in public and private green areas in the watershed.

The hedonic method was used to estimate the value of green areas. The hedonic method is an indirect valuation method that infers consumer values from observable market transactions, in this case the housing market. Factors considered when purchasing a home include its physical characteristics and distance to other amenities. The researchers investigated approximately 1,000 housing sales using linear regression, with housing purchase as the dependent variable versus six independent variables. The preliminary results indicate there is no statistically significant relationship between the purchase price of properties and distance to large public urban green areas within the Río Piedras watershed; however, a positive and statistically significant relationship was found between green area visibility and property purchase price.

Next, a contingent valuation exercise of stream and riparian environmental services was conducted, with the intent of assessing the feasibility of a voluntary contribution (willingness to pay [WTP]) for collaborative management funding. Participants were shown two pictures of two different river scenarios: dirty and clean. None of the variables that explained resident connection to nearest stream were statistically significant. Median WTP was estimated at $155.48 per household per year, and expected median revenue is $4.8 million per year. The next steps are to continue characterizing green areas and bodies of water in the watershed, identify sustainability indicators in consultation with stakeholders, and quantify and value important ecosystem services in the watershed. Further information can be found at the San Juan ULTRA website (http:// www.sanjuanultra.com).

Discussion

A participant asked whether Dr. Santiago thought the housing market crash may have influenced the results. Dr. Santiago replied that this variable would be introduced into the analysis in the next phase.

A participant asked whether river use was dependent on the area of the study. Dr. Santiago responded the area of the study included the six sampling sites, and the researchers analyzed by study area and by individual sampling site. The sampling method may be influenced by age, as the older population tends to be home during sampling. Anecdotal evidence indicated that people are not using the river because obstacles to doing so have been introduced.

A participant asked whether the researchers planned to analyze the difference between condominiums and single-family homes. Dr. Santiago explained that although there were condominiums within one sampling site, the majority of the residences visited were single-family homes. There did not appear to be a significant difference between the two housing types in terms of preferences for green areas.

A participant asked who was considered a stakeholder in the study, and Dr. Santiago replied the community and the local government were considered stakeholders. A participant involved in the research project

added the research questions were developed using stakeholder input from the beginning of the project; scientists, nongovernmental organizations (NGOs), community leaders, and the government guided the research in terms of what was most relevant.

In response to a question from a participant, Dr. Santiago explained the researchers asked community members if they knew the location of the river; most knew but had not visited it.

Green Area Loss in San Juan's Urban Neighborhoods: Estimation Methods, Environmental Consequences, and Preliminary Identification of Precipitating Factors and Processes
Luis Enrique Ramos, University of Puerto Rico Graduate School of Planning

This PowerPoint presentation can be found in Appendix F. Mr. Ramos explained there were several reasons to study suburban green areas. (1) Urban and suburban private and public residential green areas are considered beneficial for the natural environment and societal well-being. (2) They provide significant health, economic and ecological benefits. (3) Their continuous detriment and/or loss are considered problematic. (4) Suburban residential areas constitute the majority of San Juan's metropolitan footprint. (5) Green areas are an intrinsic element of the suburban landscape, and their loss represents the erosion of a utopian vision that sought a healthier and closer relationship between man and nature.

In this research, socioeconomic, physical/spatial and land-use trends, and technological and regulatory characteristics as they evolve in time, are documented and analyzed. The study also attempts to quantify the loss of environmental services and identify the socioeconomic and technological factors and processes that are associated with suburban green area loss. The objectives of the research are to: (1) design and apply methodologies for suburban green area loss/gain estimation; (2) use quantitative and qualitative techniques for socioecological analysis; (3) understand the link between socioeconomic trends, technological conditions and cultural/legal factors that influence green/grey area dynamics in suburban neighborhoods; and (4) expand the discussion on Neighborhood Decline Cycle Theory by incorporating explicit environmental issues. The researchers performed green area loss quantification for three neighborhoods in Río Piedras. Green cover loss quantification via aerial photography was in process at the time of this meeting.

The results indicated the Puerto Nuevo neighborhood had a 209 percent increase in its building footprint between 1948 and 1968, resulting in a green area loss of 25.83 acres. Caparra Terrace experienced a 135 percent increase in its building footprint between 1956 and 2008 with a green area loss of 25.35 acres. University Gardens, the most affluent neighborhood, lost only 14.57 acres of green area, with a 63 percent increase in the building footprint between 1965 and 2008. This green area loss results in a loss of environmental services, including increased storm-water runoff and sedimentation, diminished carbon-absorption capacity, degraded aesthetic qualities, loss of habitat for flora and fauna species, loss of noise-absorption capacity, and loss of spiritual and psychological well-being.

Additionally, socioeconomic and housing data were compiled for each of the three neighborhoods using U.S. Census data from 1960 through 2000. University Gardens residents' median income was considerably higher and the poverty rate lower compared to the other two neighborhoods; the population density of all three was similar, although the housing density of University Gardens was considerably lower. Increases in auto ownership in the Caparra Terrace and Puerto Nuevo neighborhoods resulted in an increased number of carports. Preliminary findings indicate that loss of green areas occurred in each of the three private residential areas, with the exception of most condominium properties. In older working-class neighborhoods, green area loss is significantly larger. Factors associated with green area loss include conversion from residential to commercial land use, increases in automobile ownership, and increases in low-rent housing units and density. The environmental and socioeconomic trends identified by this study in older neighborhoods present an unsustainable process of neighborhood decline, with negative consequences for the local and surrounding socioecological system. These areas need to be addressed by

the government in a proactive and comprehensive manner. The opportunity is present to enable these neighborhoods to evolve into more sustainable human settlements through simultaneous physical redevelopment and socioeconomic revitalization programs in which lost green areas and environmental services are recuperated.

The next steps are to increase the sampling of neighborhoods with diverse socioeconomic and morphological-typological characteristics to conduct statistically significant studies, quantify loss of environmental services resulting from suburban green area loss, and perform statistical regression analyses between socioeconomic variables and green area loss ratios. Finally, Mr. Ramos highlighted a proposal to improve sustainability in via a long-term urban vision for one of the neighborhood units in Puerto Nuevo.

Discussion

A participant suggested collecting data regarding urban flash floods to determine whether the loss of green areas results in increased flash flooding.

A participant noted the relationship of socioeconomic status and the number of trees has been well documented; one explanation is that those in higher socioeconomic classes view nature as recreational, whereas those in lower classes view it as their working environment. This research fits very well into this paradigm. Mr. Ramos said that perhaps the working class values housing over green areas.

A participant commented that more decision processes are being based on consensus rather than individual propensity to invest. Is there a limit to economic tools (e.g., WTP) compared to sociological tools? Mr. Ramos responded that a possible source of error is that WTP measures the response to a hypothetical situation rather than an actual experience.

A participant asked whether the researchers were going to experiment with other methodologies. Mr. Ramos explained the obstacle to achieving sustainability is financial, and many subsidies are needed. The research attempted to define a unit of growth so that sustainability could be achieved block by block. Redevelopment ideally would happen if the residents are owners of the area and establish a land trust. The government's role is to educate and help establish such a trust. Self-collective ownership allows for negotiation of profit sharing, thereby improving the economic situation of the resident owners, creating green areas and establishing a legal framework to protect these areas. Based on the government's past record, a participant warned about including it as a third party.

A participant asked where the residents would live while their housing was being redeveloped. Mr. Ramos responded the current proposal requires 20 to 22 houses; people would be relocated temporarily to the base housing of a nearby-realigned Army base, which as a Base Realignment and Closure Act base can be used under an economic development conveyance. All levels of complexity must be addressed to advance sustainability block by block.

Dr. Hopton expanded the discussion to include questions and comments for Drs. Restrepo and Santiago in addition to Mr. Ramos.

A participant asked the three speakers to comment on the value of quantifying sustainability to achieve target goals. What is an appropriate metric to quantify conditions in the watershed needed to achieve the sustainability goals at the watershed level? Dr. Restrepo responded that a watershed is a producer, so quality can be an indicator for the sustainable management of a watershed. The question is: Sustainable for whom? There are trade-offs between local and regional sustainability. Dr. Santiago added that it is necessary to manage institutional factors before implementing the indicators process. Stakeholder input is important to ensure the selection of the appropriate indicators.

A participant asked Mr. Ramos whether the arterial avenues were considered detrimental to the long-term planning strategy of the urban vision. Mr. Ramos said the neighborhood did not plan for the tertiary sector of the economy, and this lack of planning is a problem because it was not designed for or optimal; it may have occurred because of a lack of governance. Planning provides an opportunity to develop a sustainable community. It is necessary to predict and adapt in a sustainable manner.

A participant asked Dr. Santiago whether it was possible the people in his survey did not visit the river because of water quality. He responded that garbage in the river and safety issues were cited as reasons for not visiting.

Integrated Management as an Essential Component of Sustaining Coral Reefs and Associated Fisheries
Richard S. Appeldoorn, University of Puerto Rico, Mayagüez

This PowerPoint presentation can be found in Appendix G. Dr. Appeldoorn explained that coral reef ecosystems are complex, nonlinear socioeconomic and environmental systems. Impacts to coral and the fish that interact with the coral affect the entire system. Controlling land-based pollution is where humans can have an impact, but whether the system will respond or if it is possible for coral reefs to recover is unknown. Coral cover and overall fish and herbivore abundance decline with turbidity. There has been a steady decline in water transparency since 2000; 40 centimeters of light penetration are lost per year, for a total of 4 meters (m) during the past decade. This is a direct result of the land environment; to manage the marine environment, it is necessary to manage the land environment.

Connectivity across the seascape enhances productivity. Dr. Appeldoorn highlighted this concept by showing graphs of the habitats of early juveniles, juveniles, and adults of several fish species, noting differences and similarities among the habitats. Scientists can use a combination of locations and habitats to determine the essential fish habitat; it is necessary to think at a much larger scale about what is going to maximize or maintain the connectivity that is important to all of the species combined. It is necessary to consider ecosystem function (e.g., settlement, recruitment, nursery habitats, connectivity, spawning sites) and how it affects ecosystem services (e.g., commercial and recreational fisheries, shoreline protection, scientific research, bioactive compounds). It is possible to link subsections of habitats to function; dividing habitats into much finer segments in terms of fish habitats and their functions allows conservation of the most critical areas needed to maintain function. Marxan, software designed to aid conservation planning, was used to identify critical habitat and target areas of high protection. Important criteria in this determination include shoreline-to-shelf edge inclusion, larval connectivity based on a 40-kilometer distance between areas, and replication of targets.

Resilience also requires “first principles” for fisheries management, such as maintenance of ecosystem integrity (i.e., conservation of biodiversity) and function, rigorous protection of habitat and water quality, maintenance of monitoring reference points, and production limits and extraction control. Management tactics include protection of herbivores, predators, spawners, and habitat; establishment of marine reserves to protect spawning stocks and trophic structures; controlled fishing and reduced overfishing; adjustment of water quality standards to match ecosystem needs; and more rigorous coastal construction permitting decisions. The goal is that with integrated watershed approaches, erosion control, marine reserves, and coastal and marine spatial planning, the coral reefs will recover.

Discussion

A participant asked whether the researchers had identified an increase in turbidity. Dr. Appeldoorn responded there was not a straightforward answer to this question, but Dr. Ernesto Weil would address this during his presentation.

A participant asked what is included in the model. Dr. Appeldoorn replied that a map of habitat was used; how habitat is defined impacts the output and whether it is related to ecological function. Marxan was designed to identify areas prioritized for development of a marine protected area; it is a cost-minimization program. Five factors are examined, and a spatial map with various costs is generated.

An Interdisciplinary Erosion Mitigation Approach for Coral Reef Protection—A Case Study From the Eastern Caribbean
Juan Amador-Gutiérrez, Greg L. Morris Engineering-COOP

The PowerPoint presentation can be found in Appendix H. Mr. Amador-Gutiérrez provided background about the location of the project, Culebra, which is an island 19 miles east of Puerto Rico, which supports coral reef ecosystems that are characteristic of northeastern Caribbean marine biodiversity and represent highly valuable sources of fishing, tourism, and recreational activities. Coral reefs near Puerto Rico are among the most highly threatened reefs of the Caribbean as a result of the combined effects of climate change, coral bleaching, increased incidence of disease, overfishing and the delivery of inland pollutants; a reduction of 50 to 80 percent in coral coverage in the Cayo Luis Peña Natural Reserve near Culebra has been observed since 1997.

The objective of the project is to describe an innovative framework by which technical knowledge gathered by marine ecologists, watershed scientists, and civil and environmental engineers can be best employed in the development of an erosion-mitigation strategy that best uses available funds to reduce impacts. To achieve this, the researchers used a multistep approach. The first step included collecting basic information to describe coral reef abundance and condition, estimating watershed-scale sediment loading rates, and evaluating the feasibility of onsite installation of erosion control measures. The second step was to formalize an approach to select the watersheds and associated marine habitats that merit a preferred status for the implementation of erosion-control activities. The third step is to choosing the specific sites (i.e., sediment sources) and methods (i.e., best management practices [BMPs]) to be implemented within the priority areas by invoking a sediment-reduction cost-effectiveness analysis. Mr. Amador-Gutiérrez displayed a flowchart highlighting the general scope of the proposed interdisciplinary erosion mitigation strategy.

The researchers assessed the abundance of coral reef habitats based on aerial coverage and pre-existing benthic habitat maps. Data on structure and condition were obtained at depths of 3 to 7 m and included percent cover of benthic components. The researchers investigated eight watersheds on Culebra, and, in terms of watershed assessment, Culebra's unpaved road network is considered the island's most important anthropogenic source of sediment. Erosion and sediment-yield assessments relied on application of the St. John Erosion Model (STJ-EROS), which estimates erosion rates from natural and anthropogenic sources of sediment based on empirical equations developed from data collected on St. John, U.S. Virgin Islands, an island with a similar physical setting as Culebra. Unpaved roads on Culebra were found to be similar to those from which the STJ-EROS road-erosion algorithms were developed in terms of substrate, road prism geometry, and range of slopes.

Developing BMPs is limited by an existing and thus mostly immovable road network layout, a characteristically rugged topography, and a lack of locally available specialized materials and equipment that significantly increases costs; these limitations reduce the number of BMPs that otherwise would be considered feasible. Three main types of BMPs were evaluated: (1) methods that improve the resistance to erosion processes by preventing the direct contact of rain and runoff with the soil surface, (2) methods that minimize the amount of flow on the unpaved road surface and thus reduce its erosive energy, and (3) methods that attempt to capture as much sediment as possible while runoff is transported through or discharged from the road prism. BMP selection in most cases is site specific, and a combination of individual BMPs usually is the most effective alternative. Therefore, the researchers developed three

general road designs or treatments, each incorporating a different subset of BMPs, resulting in different costs and erosion rates.

Coral reef condition assessments are based on a one-time observation, and erosion analyses explicitly lack the capacity to understand sediment dynamics and effects once delivered to the marine environment. The combined watershed and marine habitat evaluation procedure is based on three criteria: (1) abundance of the marine resource, (2) marine resource condition, and (3) stress level. Each criterion being considered for analyses can be graphically portrayed as one axis of a three-dimensional cube. The cube also serves to map the justification or goal of erosion-control activities being implemented. Implementation of erosion-mitigation strategies for coral reef protection can be justified because of three main motives—preservation, prevention, and remediation. In conducting the coral reef condition assessment, the same analysis was performed for all of the parameters (e.g., percent cover of total algae, macroalgae, algal turf, crustose coralline algae, and cyanobacteria cover; coral-to-macroalgae ratio) relative to sediment loading rates. Results indicated the two watersheds that merit additional analysis are Ensenada Fulladosa and Cayo Dakiti; erosion control in the Ensenada Fulladosa Watershed could be justified based on the argument that marine systems are interconnected through complex ecological functionalities so that benefits to a submersed aquatic vegetation-dominated area could improve conditions in nearby reef areas. The Puerto Del Manglar Watershed was chosen as the target area for conducting cost-effectiveness analyses because of its high sediment yield rates, its relatively extensive unpaved road network, and the poor-to-moderate condition of its adjacent marine resources. The results indicated the BMPs depend on the amount of funding available.

The researchers concluded the strategy serves in part to choose priority target watersheds for erosion control based on the intentions of the mitigation efforts. The cost-effectiveness analyses aid in choosing specific sites and erosion-control methods to maximize the net reductions in sediment loads while minimizing costs (e.g., "the biggest bang for the buck"). Finally, application of this cost-effectiveness analysis to one watershed in Culebra suggests the choice of most effective erosion-control method varies according to the amount of funds available for implementation.

Discussion

Because of time constraints, Dr. Hopton asked the participants to save their questions for Mr. Amador-Gutiérrez until after the final coral reef speaker had presented.

Coral Reef Decline in Puerto Rico: Link to Global Warming, Potential Social Impact and "Sustainability"
Ernesto Weil, University of Puerto Rico, Mayagüez

This PowerPoint presentation can be found in Appendix I. Dr. Weil explained that coral reefs are more than 400 million years old, widely distributed and have survived four major extinction events in Earth's evolutionary history. Their fine tissue layer provides benefits by influencing the chemical balances of the ocean, fixing/absorbing 700 billion kilograms of carbon dioxide per year, protecting coasts, aiding in formation of other important communities, and serving as a reservoir of biodiversity and high productivity. Humans additionally benefit because coral reefs are a source of protein and economic support for millions of families and provide pharmaceuticals, education, recreation, and ecotourism (i.e., source of income). Reports from the last 20 years, however, indicate there has been a significant degradation of coral reefs worldwide, resulting in a loss of live coral cover, productivity, fecundity, biodiversity, and the capacity to absorb carbon dioxide and fix calcium carbonate. The major threat to coral reefs and their sustainability is humans.

Dr. Weil reiterated the three pillars of sustainability (economic, societal, and environmental) always are included in definitions of sustainability. Degradation of coral reefs because of anthropogenic factors, global

climate change, and natural hazards offers no sustainability. Coral reefs can recover from natural hazards, but the synergy of anthropogenic factors, which increase carbon dioxide, hurricanes, and so forth, decreases the coral reefs' capacity to recover and induce mass mortalities, reduce reproduction and calcification, and increase bioerosion.

Dr. Weil described a case study of the village of La Parguera on the southwestern coast of Puerto Rico, which has experienced sustained but not sustainable development since the 1930s. There has been no erosion control, which has increased sediment runoff across the southern coast to the city of Ponce. There has been a significant decline in water transparency in La Parguera over time, which is correlated with the sedimentation. Furthermore, winter mean surface sea water temperatures have been above average for 5 years in a row, which is correlated with a shift from seasonal to chronic infectious diseases in coral reefs. Two major bleaching events correlated with above-average temperatures and were accompanied by increased disease outbreaks with high coral mortality. These bleaching events affected 52 coral species, and the 11 biotic diseases affected 42 coral species; the significant mortalities of corals and other important members of the coral reef community resulted in the loss of habitat and productivity and had epizootic consequences. There was a mean coral cover loss of 53 percent in La Parguera between 1994 and 2010.

Sustainable coastal growth in Puerto Rico is desired, but coastal growth has been unsustainable in practice. It is not possible to reach sustainability until local and global environmental deterioration is controlled, which in itself is not possible unless all stakeholders are involved in the process and human population growth is controlled. Coral reefs are slow growing and take many generations to recover. To foster this recovery, it is necessary to improve environmental conditions, protect genetically diverse populations of the main reef-building species by increasing the number and area of Marine Protected Areas, involve all stakeholders, and reduce human population growth.

Discussion

Dr. Hopton opened the discussion to include questions for the three coral reef speakers: Dr. Appeldoorn, Mr. Amador-Gutiérrez, and Dr. Weil.

A participant asked Mr. Amador-Gutiérrez whether any traffic analysis had been performed. Mr. Amador-Gutiérrez responded that it had not been. The participant asked whether Mr. Amador-Gutiérrez was aware of technology for percolated road surface. Mr. Amador-Gutiérrez replied that he was aware of the technology, but the researchers avoided this approach because of the cost of importing materials and equipment. The focus was on solutions that could be implemented easily on the island, without the need for expensive importation. The goal is to teach the machine operators not just how to retrofit a technology but also how to implement sustainable future planning. In response to a question from the participant, Mr. Amador-Gutiérrez explained the area was a low-traffic area.

A participant asked who pays for the strategies and who had paid for the roads to be built. Mr. Amador-Gutiérrez responded that it was the responsibility of the private landowners or the *municipio*. A regulatory framework is supposed to be in place to control road construction, but it is not enforced. There has been no planning, and those involved are ignorant of BMPs. A participant commented that this indicates the best investment of money is in education of the local residents. Mr. Amador-Gutiérrez agreed and explained the next project is to develop a workshop for local decision-makers and the community to provide education so they have the knowledge of how to make on-the-spot decisions about the proper routing and creation of roads; BMPs regarding how to manage stormwater will be included as well. A participant noted that it was important to educate citizens so they know how to choose leaders who will take the desires of constituents into consideration when making decisions.

A participant noted that Culebrans no longer can afford land on Culebra. Enforcement officers at the local, island and federal levels ignore environmental complaints from residents. Another participant commented

the DNER is not responsible for enforcement. It sought to be deputized, but the EQB refused, citing the additional work that this would cause. In response to a question by this participant, Mr. Amador-Gutiérrez explained the analysis was cost-adjusted for Culebra construction costs.

The participant commented that 80 percent of Puerto Rico's land cover was lost between 1830 and 1950, which increased sedimentation, and asked Dr. Appeldoorn how synergistic effects could be occurring now when there has been a 50 percent increase in land cover. Dr. Appeldoorn responded that approximately one-half of the sediment from the earlier deforestation still is in the river systems; the legacy of deforestation is ongoing. Dr. Weil added the significant increase in rainfall during the previous decade has contributed, as the rainfall pushes more sediment from the rivers. Enrichment of nutrients produces organic particulate as well.

A participant asked whether algae were having any positive effects on the marine environment. Dr. Weil said that if they could be harvested, algae would be an excellent source of biofuel. Black sea urchins are returning, and algae are a food source for this species; this could allow recovery of coral and fish. It is difficult to determine what benefits may be derived from an algae-dominated habitat.

A participant from EPA commented that, in terms of enforcement, Vieques and Culebra are challenges for Region 2. The Agency currently is involved in several enforcement actions on these islands and will continue to be involved as long as EPA maintains jurisdiction. Currently, the Agency only has stormwater jurisdiction on property greater than 1 acre. If EPA has not engaged in enforcement, then it does not have jurisdiction. Mr. Amador-Gutiérrez added the EQB is comprised of political appointees who need to perform their jobs because the locals do not have the technical knowledge to do so. The goal is to educate the local population. A participant noted that to change the current culture it is necessary to educate citizens so they have the power to pursue politicians and hold them accountable. Mr. Amador-Gutiérrez explained the goal of his project is to help residents properly and responsibly develop their properties in favor of the environment.

A participant commented that coral reef environmental sustainability is one area in which there is a great deal of scientific information regarding causes of decline and scientific monitoring. The gap is not lack of scientific data but rather institutional. There are questions about the boundary of the marine-terrestrial zone and who is responsible for what actions, which in turn affects the flow of information. Who is accountable? Someone must take responsibility, and EPA is in a unique position to tell the government what actions need to be taken to build sustainability and improve coral reef condition. Mr. Amador-Gutiérrez thought that it was a matter of consolidating and enforcing the current laws rather than developing new laws. His next planned project has been delayed because officials still are trying to decipher the new permitting laws.

A participant commented the paradox is the major government plan in the 1960s was to develop the coastal areas, which probably resulted in many of the current problems. The shift from a mountain population to a coastal population has had significant impacts. Mr. Amador-Gutiérrez commented the core of the problem could be observed in the room; the decision-makers are not present and they do not consider sustainability when making decisions. It is necessary to educate them so they do consider sustainability. He has been trying to integrate sustainability into the engineering and execution of his projects, but it has been a challenge because of the considerable pushback that he has received. The sustainability message must be disseminated everywhere.

A participant stated that if EPA is searching for metrics, it is necessary to look at the priorities of Puerto Rico. There are "loaded" questions regarding implementation, and policy is key. To move forward, it is necessary to educate decision-makers and communities and re-educate those who were not educated correctly.

A participant commented on the historical importance of what is occurring currently. A cultural transformation began 60 years prior; Puerto Rico has assimilated U.S. consumption patterns, which has led to the current situation. This is a cultural problem and must be contextualized within the social framework in which each decision is made. Another participant agreed that it is necessary to speak to the island's cultural heritage and educate island residents about the effects their actions have on the coral reefs. A participant commented that it is difficult to establish a link between people's actions and ecosystem services; for example, most of the fish consumed by Puerto Ricans is imported. There is an intersection between the environment, society, and economy. Researchers have an idea about impacts in the environmental and economic sectors, but society is limiting sustainability, and that needs to be addressed. Additionally, the current political structure is limiting, but short-term actions can help the long-term situation.

A participant thought the metrics should include the fact the majority of the members of Puerto Rico's government appear overly concerned about their political careers to the exclusion of all else.

A participant commented that land ownership drives decision-making in the absence of clear zoning laws; poor decisions made on a case-by-case basis have built up to the massive problems in existence now. Mr. Amador-Gutiérrez agreed that it is a complex problem, and the goal of his project was to illustrate what could be accomplished with various amounts of funding.

Day 1 Wrap-Up

Dr. Hopton thanked the speakers for generating such engaging discussion. His goal is to continue the dialogue with the participants even after the event has been completed. He hopes that more decision-makers will be present during the remainder of the event. He thanked the participants and recessed the meeting at 5:42 p.m.

JUNE 6, 2012

Welcome
Matt Hopton, EPA, ORD, NRMRL

Dr. Hopton called the meeting to order at 9:32 a.m. He hoped the discussion would be as interesting and as informative as the discussions had been the prior day. After reviewing some logistics for the symposium/workshop, he said that it was necessary for the participants to consider how, as a group, they could present to the decision-makers, ensuring the key points from the discussion are presented to them. The purpose of the symposium/workshop was to share research, identify how the research should be used to aid *municipio* and island decision-making, and learn from decision-makers what information they need and how the researchers' information can be made useful to them.

"Achievability" vs. "Sustainability": Including Community Acceptance Consideration in the Implementation of Renewable Energy Projects in Puerto Rico
Marla Perez-Ortiz, University of Puerto Rico, Mayagüez

This PowerPoint presentation can be found in Appendix J. Dr. Perez-Ortiz explained there had been a paradigm shift when considering renewable energy; the terms "green," renewable" and "sustainable" are used interchangeably, but they are not truly interchangeable. Green indicates that something is less harmful than petroleum-based alternatives. Sustainable processes are renewable but are implemented in a different manner. The term renewable indicates the resources can renew themselves. A key aspect of sustainability is transparency, and if this is not present, then renewable energy projects can be unsustainable. Social acceptance is a set of sociopolitical, community, and market characteristics that determine the social sustainability of renewable energy projects. Achievability does not imply that a plan is acceptable or

sustainable; social acceptance is based on public perception. Empirical research shows that 30 percent of nonfinalized wind farm projects in Europe are stopped by lawsuits and public resistance. Community ownership models have a positive effect on local acceptance, which is not related to knowledge or attitudes toward renewable energy technologies. Siting issues include distrust and environmental justice. Investigations indicate that community acceptance of wind power schemes is not explained by the egotistical motives of local residents (i.e., the "not in my backyard" [NIMBY] syndrome) and indicate locals' commitment to equity issues and fairness of decision-making.

The researchers developed a survey to systematically and randomly sample 409 residents older than age 18 in three communities (Vieques, Cataño, and Camuy) previously targeted for the siting of a wind energy project. The residents of Cataño were surveyed before and after the wind, turbines were constructed. Stakeholders were identified and analyzed; the stakeholders were complex with varying motives and perceptions; there was some conflict when the stakeholders were considering the best course of action. In terms of general knowledge, the most recognized renewable energy sources are wind and solar. There is a positive bias toward solar energy. Survey respondents think the sun is the least expensive, safest, and least polluting energy source. Solar energy is perceived as the most viable for development in Puerto Rico as well in their community.

In terms of procedural justice, the developer is responsible for informing the community via community meetings rather than public hearings. Community participation is very important, particularly at the early stages of project development. The community should be involved in the project's approval and in selecting the project's location. The community needs to have access to independent experts for a neutral perspective on the technology and the project. In terms of distributional justice, the community should be compensated if the project is approved against its will, although most communities tend to sacrifice their well-being for the good of Puerto Rico. Fair compensation schemes include discounts on electric bills, provision of electricity to a local school or hospital, or another activity that brings collective well-being. The communities have issues with trust. The majority of community members voted in the general elections, but this has had little impact on the community's well-being. Community members distrust current decision-making processes and doubt the government and the private sector have the community's interests and needs in mind when proposing new infrastructure projects.

In examining the pre- and post-surveys in the community of Cataño, the researchers found there was a significant increase in community members who thought that wind and natural gas are renewable sources of energy. There was an increase of those community members who thought the community should sacrifice for the good of all of Puerto Rico. Presurveys indicated that 78.5 percent of respondents thought that politicians cared about citizens' opinions, whereas post-surveys indicated that only 20.9 percent thought this way. Successful implementation of renewable energy projects in Puerto Rico will need to consider aspects of social acceptance in addition to technical achievability. The researchers proposed a Community Acceptance Index for Renewable Energy Projects (CAIREP) at the community level to move Puerto Rico toward sustainability. CAIREP will include collection of data on communities near identified renewable energy resources, which will allow integration of social acceptance information with renewable resources availability data into a map that identifies communities that exhibit high achievability and acceptability of renewable energy technologies. Another goal is to develop a policy toolbox for the successful implementation of renewable energy projects in Puerto Rico.

The research questions for the project include: How do communities located where renewable resources can be extracted perceive current decision-making processes? How is the distribution of costs and benefits associated with renewable energy projects perceived? What are the perceived economic, environmental, and aesthetic consequences of a renewable energy project in the targeted community? These three questions address justice, equity, and impact, respectively. There are similar governmental initiatives designed to ascertain community acceptance in countries around the world; the European Union leads in terms of this kind of research. To implement the research on social acceptance in Puerto Rico, it is

necessary to ask the following questions: Can sustainability be truly defined? Can Puerto Rico move toward sustainability? Can researchers speak to the policy relevance of their research? Can researchers say what is necessary to implement their research island-wide that has not been said already? Sustainability is defined in very different ways, and the social dimension of sustainability is based on conflict; these conflicts must be addressed. The key to the achievement of sustainable development is broad public participation in decision-making.

Discussion

Because of time constraints, Dr. Heberling asked that discussion be saved for later in the session.

Renewable Energy Self-Sufficiency Roadmap of Puerto Rico
José Colucci, University of Puerto Rico, Mayagüez

This PowerPoint presentation can be found in Appendix K. Dr. Colucci explained that various studies have shown that Puerto Rico has the resources necessary for energy self-sufficiency, but the question is implementation. In March 2011, the President's Task Force on Puerto Rico's Status released a report indicating that renewable energy was beneficial to Puerto Rico to move toward sustainability. The basic premise of the work is that Puerto Rico has agreed, as a society, to achieve self-sufficiency in producing all of the island's electricity while keeping electricity prices at 2010 levels or lower. The study also assumes that future political will and public policies will be aligned with the goal of energy self-sufficiency. The goal is not to abandon the grid but rather to update it, incorporating renewable and sustainable tenets. Biofuels, preferably produced on the island, will run the grid instead of fossil fuels. The transition will include replacing fossil fuels with variable energy resources. To accomplish this, load reduction and identification of variables sources will be necessary. Once this is complete, the next step will be to explore baseload options, including biomass and nonrecyclable waste gasification, landfill energy, anaerobic digestion, algae oils and ocean-thermal sources. Storage and frequency control will provide stability to the grid.

A net 17 percent reduction in energy load requirements was projected as technically and economically feasible given past experience in commercial, residential, and industrial settings. Air conditioning must be considered; Puerto Rican market acceptance leans toward energy-efficient air conditioners versus other appliances. Offshore wind represents the largest single potential source of renewable energy for Puerto Rico. The proposed effective capacity would be approximately 300 megawatts, which is enough to supply 10 percent of projected Puerto Rico electrical energy demand; this proposed capacity is very conservative, and 10 times the capacity is possible. In terms of strategic crops and biomass, all crops must have multiple uses to be successful. Pumped water storage provides stability to the system by providing energy when the wind does not. This type of technology already is being used and must be brought to Puerto Rico. The various facilities will be placed throughout the island, so it will be important to move past the NIMBY syndrome. The total investment will be billions of dollars, which will need to be a joint investment between the government and the people. Once this investment is complete, the cost will be $1 billion annually, versus the current $2 billion annual investment for petroleum. A constitutional amendment may be needed to accomplish this.

A key benefit of the implementation of this roadmap will be the creation of direct and indirect jobs, which can range from 2,000 and 50,000, depending on the percentage of savings that is used for salaries and cash-flow circulation of the savings. It is important to keep the funds and jobs local. Dr. Colucci highlighted the example of the inclusion of photovoltaic panels for local energy needs in terms of workforce development and expansion of local industries. Additionally, income from biofuels could be as much as $5 million to $1 billion annually. To achieve this, a 15- to 20-year commitment is needed. The government needs to move beyond its comfort zone and examine the areas that are most likely to succeed.

Discussion

A participant commented that a finance scheme via taxes potentially could work, but trust must be included. The taxpayers need to know these funds are being used for their intended purposes and not for political gain. A more transparent government is needed. Dr. Colucci responded that community members would see the results in their houses or communities (e.g., presence of photovoltaic panels). A direct joint investment will cost $1 billion annually, and it is necessary to determine from where these funds will come.

A participant asked whether the analysis included the environmental cost of each strategy. For example, biofuels require intense agriculture. It is necessary to perform a preliminary analysis because this question will be raised by multiple stakeholders. Dr. Colucci said that it was necessary first to agree to eliminate fossil fuels. Once this is accomplished, then the components of the plan can be determined. There is no point in moving forward unless there is an agreement to eliminate fossil fuels.

A participant noted that 50 percent of the roofs on the island could provide 100 percent of Puerto Rico's electricity needs. Dr. Colucci agreed and stated the importance of being self-sufficient but not necessarily independent of the grid.

A participant mentioned that an agreement to switch to natural gas would involve an agreement to a transitional process. Dr. Colucci said that natural gas is at the core of a degrading situation because individuals on both sides of the issue use only their own agendas to drive the discussion and focus on passing blame. Transitioning to natural gas is the best way to move toward renewable energy, although natural gas itself is not a renewable energy.

Large-Scale Spread of Vines and Sustainability
Diana L. Delgado, University of Puerto Rico, Río Piedras

This PowerPoint presentation can be found in Appendix L. Ms. Delgado explained that her research was inspired by her observation of the increasing amount of vine patches over the landscape of Puerto Rico; she was driven to attempt to understand this occurrence. The vine patches are comprised of multiple species, both native and exotic. Vines are a functional group of plants represented in more than 80 families and can be woody or herbaceous. A common characteristic among the species is the need for other structures to support them. They are important for the economy (e.g., agricultural and ornamental uses) and, until recent years, generally had been ignored in the literature. Vine invasions are common in other parts of the world, including the southeastern United States, Australia, and Hawaii.

Many factors favor vine success, including their ability to grow rapidly and make rapid use of available resources; their life strategy allows them to invest less resources on their own support. Vines are able to take advantage of human-built infrastructure (e.g., poles and lines of utility networks); this infrastructure works as corridors that help vines to overcome physical barriers in the landscape. Vine spread alters the landscape configuration, which in turn can alter the function of the landscape and the services that it provides, thereby decreasing sustainability. Additionally, vines increase infrastructure vulnerability. Because this new, vine-invaded state is very resilient, the vine invasion process makes the state of the system vulnerable to a shift toward a vine-invaded landscape.

Examining connectivity on a large scale can be challenging, but networks that model invasions can be used to represent and measure connectivity. Spatially explicit networks provide information about the configuration of the network in the landscape, including the identification of important clusters or groups. Networks are a tool used for management and conservation and provide information about the resilience of the network. Modeling was applied to a central portion of the island along the RGAW. The study area contains a complex mosaic of environmental conditions (e.g., subtropical forest, mountains, dry forest) and diverse land uses (e.g., rural, urban, agricultural). This area once was the center of agriculture on the island,

but the shift of the population to the coast resulted in many abandoned coffee plantations. The researchers used image processing of high-resolution satellite imagery to classify the land, followed by an accuracy assessment. Next, network analysis was performed to determine the probable dispersal of vines among the existing patches. It is possible to detect the importance of certain patches in terms of connectivity. The thought is that perhaps if these patches can be eradicated, it will be easier to eradicate the overall system.

Ms. Delgado described the location and size of the vine patches in the study area and the vine network node degree distribution. Only 16 of 780 found vine patches were highly connected. In terms of infrastructure, 58 percent of poles and 30 percent of lines observed showed vine growth; power company workers continually clean the lines, which may explain the lower percentage. Among the vines found growing on the poles, the dominant species was found to be a native woody vine (*Cissus verticillata*), followed by *Ipomoea* species, some of which are exotic. The average length of these vines was 11 m, but some were measured at 41 m and crossed streets, hills and small rivers. The researchers concluded the landscape is dominated by small vine patches. The majority of vine patches cover crop lands, and these patches are larger than those found in other land uses. In addition, the majority of vine patches have a small number of connections. The few highly connected vine patches as well as the large clusters of vine patches are found within 150 m of the road network of secondary and tertiary roads.

Discussion

A participant asked how many individual vines constitute a patch. Ms. Delgado responded the number of vines is difficult to determine because of the density and tangling. A patch on a satellite image is 100 m2; patches must be dense to be seen on satellite. The participant asked whether the researchers performed ground-truthing. Ms. Delgado explained that this was part of the accuracy assessment.

A participant asked about the connectivity. Ms. Delgado explained that dispersal was considered. The plan is to create several networks to allow for minimum and maximum distribution to observe how the distribution of patches changes.

A participant noted that once invasive species impact local species they become important. There is a disconnect between reality and people's perceptions of exotic species. What can be done to close this gap and move biodiversity conservation forward? Ms. Delgado said that this was a good point and added that most species are noted in the literature after they become a problem. Most people do not understand the connection, so education is one method of closing the gap. It is important to maintain human well-being, and many do not understand that ecosystem services are important to this well-being. People need to be educated to understand this connection.

A participant said that from a policy standpoint, it would be beneficial to examine the different views at the different levels of analysis; different generations have different views. Use of network analysis is excellent, and the researchers should go one step further and use social science regarding political views.

A participant asked about the impacts of the vines on the entire canopy, including coverage of species considered part of sustainability (e.g., fruit). Ms. Delgado responded that part of the problem is that it is very difficult to restore an area that has been totally invaded to its original state because of the investment, time, and labor required. This makes the vine-invaded state very resilient, even on active plantations. Because the vines are extremely fast-growing, intense labor and significant amounts of time are spent clearing the plantations because they are surrounded by an abundance of vines.

Dr. Heberling opened the discussion to include questions for the three speakers: Drs. Perez-Ortiz and Colucci and Ms. Delgado.

In response to a question from a participant, Dr. Colucci said that it might be possible to use the vines as biofuel. A participant noted the vines grew into a problem in response to policy; they were used to decrease erosion. This is an example of an unforeseen circumstance, and it is important to learn from the past.

A participant asked Dr. Perez-Ortiz whether a difference between social acceptance and rejection has been seen historically. Dr. Perez-Ortiz responded that she did not think so. Some land uses have clear-cut opposition in any backyard, but wind farms are not clear cut. People tend to agree about their benefits, but the process can create opposition, and Internet social networks allow for quick organization of opposition. Another participant added that it is necessary to consider environmental justice. There also have been arguments among green groups about projects that supposedly are environmentally friendly; people believe in different levels of environmentalism, which creates a schism. The process of implementation is important for environmentally sound projects to be sustainable. A participant stated that governance is another issue that compounds the problems of process.

A participant noted that agriculture is an important stakeholder that was missing from the discussion; this important sector needs to be included.

In response to a question, Dr. Perez-Ortiz said the perception of the Cataño residents that natural gas was a renewable energy source during the post-survey could have been a result of the massive marketing campaign for the Via Verde natural gas pipeline. This determination was outside the scope of the research. She noted that stakeholders have a certain vocabulary, and it is necessary to understand this vocabulary so the message is not "lost in translation."

Tropical Coastal Sustainability 101: Lessons Learned From the Slippery Road Toward Sustainable Practices in Puerto Rico Under a Climate of Change
Edwin A. Hernández-Delgado, University of Puerto Rico, Río Piedras

This PowerPoint presentation can be found in Appendix M. Before providing his recommendations, Dr. Hernández-Delgado highlighted a series of lessons learned:

Lesson #1: *Caribbean hurricane frequency, and in some areas severity, have increased*. It is necessary to examine sustainability when developing coastal areas, as they are susceptible to sea level rise and flooding from hurricanes.

Lesson #2: *The sea surface temperatures near Puerto Rico and Culebra have increased*. Spring temperatures are behaving like summer temperatures, creating an extended summer; winter temperatures also have increased.

Lesson #3: *There has been a nonsustainable increase in coastal urban development during the previous six decades*. Per each square kilometer of land in Puerto Rico, there are 3 kilometers of road; much of this infrastructure is poorly maintained.

Lesson #4: *The frequency of localized extreme rainfall events has increased*.

Lesson #5: *There are indicators of nonsustainability in the socioeconomic development of Puerto Rico*. These indicators include: decreased public participation in governance; permanent negative done to the environment "for the sake of progress"; continued socioeconomic degradation (e.g., increased crime, decreased quality of life); lax regulations (e.g., zoning, environmental); decision-making processes conducted with significant conflicts of interests and corruption; revenue leakage (i.e., leaves the island); and lack of recognition that climate change impacts constitute a significant threat.

Lesson #6: *Large-scale development along watersheds and the coast have resulted in a chronic, dramatic decline in coastal water quality*. This is highlighted by the fact the Great Northeastern "Reserve" has been abused and is in a permanent state of turbidity.

Lesson #7: *Increasing water turbidity has been accompanied by a significant increase in fecal pollution.*

Lesson #8: *Chronic fecal pollution, turbidity, and eutrophication kill corals*.

Lesson #9: *GIS-based modeling shows impacts at the subwatershed level can significantly influence sewage pollution gradients*.

Lesson #10: *The major coral reef decline during the previous decades has been accelerated by unprecedented massive bleaching and coral mortality*. There has been a significant loss of reef-building coral species, causing a collapse in population as well as community structure phase shifts.

Lesson #11: *The richness of coral species has been declining across the Great Northeastern Reserve*.

Lesson #12: *Coral reefs are on a "road to slime."* There has been an 80 percent loss in coral cover.

Lesson #13: *Increasing Fajardo River flow has been accompanied by a significant long-term decline in* Montastraea annularis *(boulder star coral) growth and calcification rates*.

Lesson #14: *Demographic models of recurrent massive bleaching and mass mortalities in* M. annularis *suggest rapid extinction*.

Lesson #15: *A significant fish biomass decline (i.e., loss of fish) occurred between 1997 and 2007*. Nontarget fish decline following the loss of coral and other fish is important because overall decline across different trophic groups suggests significant nonsustainable impacts across large spatial and temporal scales as a result of fishing impacts and environmental degradation. In addition, large-scale coral mortality has resulted from climate change-related impacts.

Lesson #16: *Coral farming aimed at multispecies reef rehabilitation may be successful*. Community-based rehabilitation is an opportunity to transform behavior in a positive manner.

Dr. Hernández-Delgado next provided his recommendations for a sustainable Puerto Rico:

- Integrate the community into all aspects of the sustainability process, including discussion of problems, planning, decision-making, implementation, adaptation, and revision.
- Acknowledge that scientists have the responsibility to translate technical knowledge into "normal," lay language.
- Foster a sustainable development model in Puerto Rico by immediately adopting adaptation policies to climate change impacts, along with initiatives to reduce the vulnerability of natural and human systems along the coast to expected climate change effects and improve food security through appropriate agricultural and fisheries planning and management.
- Immediately adopt adaptation policies to climate change impacts with initiatives to: improve water quality and availability through appropriate water resources management, improve support of planning and operations in the public health sector, improve disaster risk management, prioritize capacity building, and ensure greater availability of and access to ecosystem services.

- Review and modify existing international policies of institutions (e.g., World Bank, United Nations Environment Programme, and U.S. Agency for International Development) so that Puerto Rico is not in the same category as the United States and, thus, considered a developed nation. This erroneous classification excludes the island from significant funding and resources directed toward capacity building.

- Provide a moratorium on the Puerto Rico government policy of fostering nonsustainable tourism and urban development across the coastal zone until an environmentally and socioeconomically sustainable strategy is implemented through a reviewed, sound land-use plan; a climate change adaptation strategy; the reincorporation of community-based participatory processes; and community-based integration into all aspects of the process, including discussion of problems, planning, decision-making, implementation adaptation and revision.

- Reanalyze all permit applications under consideration by commonwealth and federal government agencies under stricter parameters to ensure long-term sustainability and meaningful community-based participation.

- Eliminate the standard EPA policy of fostering Clean Water Act Section 301(h) waivers to Puerto Rico regional sewage treatment facilities.

- Establish a long-term coastal water quality monitoring program.

- Modify existing coastal water quality microbiological standards in Puerto Rico.

- Establish nitrogen and phosphorus standards.

- Rehabilitate coral reef ecological functions and ecosystem values via community-based coral farming and reef-restoration initiatives. These successful initiatives have resulted in important hands-on educational experiences that have fostered a paramount transformation in behaviors.

- Expand the current scale of community-based reef management efforts by improving funding to foster improved capacity building, training and education, and new projects across different localities in Puerto Rico.

- Capitalize on the existing opportunity to ensure that today's investment in coastal tourism and urban development will not compromise the availability and quality of resources for future generations.

- Use a precautionary approach in investing in coastal development to minimize the risk of and vulnerability to projected climate change-related impacts.

- Transform from the current nonsustainable model to a sustainable alternative.

Discussion

Dr. Heberling held off discussion until after the final speaker of the morning.

Community-Based Efforts for Sustainable Conservation and Management of Coral Reefs at Vega Baja and Manatí, Puerto Rico
Ricardo Laureano, *Vegabajeños Impulsando Desarrollo Ambiental Sustentable* (VIDAS) (*Vegabajeños* Promoting Sustainable Environmental Development)

This PowerPoint presentation can be found in Appendix N. Mr. Laureano stated that Acroporid coral populations have largely declined across the Atlantic during the last four decades as a result of a combination of natural and human factors, including climate change. The north shore reefs of Puerto Rico also have seen this decline. Coral reefs across the high-energy but poorly studied northern coast of Puerto Rico still support impressively large thickets of threatened Elkhorn coral; fringing reefs off Vega Baja and Manatí have very high densities of this species. If the government continues the practice of using the maritime terrestrial zone as a site for permanent structures, the whole archipelago will be destroyed without the protection of the natural coastal barriers and the food source the reefs represent; enforcement also is an issue. Growing the coral reef to stabilize the breakers is the way to manage the water level rise associated with climate change.

Without permits, a private company contracted by the *municipio* of Vega Baja affected the ecosystems. Since 2004, the company has been required to follow an EPA order to minimize impacts within the water bodies. This construction, however, increased chronic turbidity, coral mortality and illegal raw sewage spills. The mayor of Vega Baja has been convicted of sponsoring illegal activities on the shore. In another instance, a private company was hired by the Puerto Rico Highway and Transportation Authority to construct state road 686. The company was informed about the importance of the coral reef and the measures necessary to minimize impacts but ignored them, which resulted in coral mortality. Because the Elkhorn coral is a threatened species, an Endangered Species Act 4(d) rule was put in place in Vega Baja, but the rule has not been enforced. There is a nearby landfill that was supposed to close and whose administrator was involved in the extortion case against the convicted former mayor of Vega Baja, but the leachate from this landfill still is draining into the river, which in turn drains into the sea and affects the coral, local fish population and consumers of these fish. Nutrient levels are very high in the water near Vega Baja, and the water treatment plant does not cover the actual capacity of the *municipio*. A proposed zoning change near Manatí will allow hotel construction in the buffer zone of the Laguna Tortuguero Natural Reserve; VIDAS has publicly testified about the need to protect this area and demanded a signed commitment from the mayor of Manatí to oppose the zoning change. This commitment is important because even in the protected zone, construction disrupted a turtle nesting ground and destroyed many turtle eggs. Despite rules and orders from agencies, there is no enforcement, even in protected zones. To rectify this, it is necessary to combine efforts; VIDAS is working with the scientific community and agency members.

Mr. Laureano described low-tech conservation efforts, including nursery units to develop coral fragments. Cleaning and maintenance of coral nurseries is the main focus of coral farming projects. Direct coral planting is the fastest method of promoting living reef coverage. VIDAS proposes to: (1) develop an ecofriendly runoff management plan that will function as a model for other communities with similar issues, (2) formerly designate the Los Jardines Submarino de Vega Baja-Manatí Natural Reserve and include the communities in the development of the management plan, (3) develop an educational program about sustainable use and respect of nature, and (4) foster communities with ecotourism projects for the cultural benefits of Puerto Rico's coastal villages.

Discussion

Dr. Heberling held off discussion until after the final speaker of the morning.

Fostering Employment-Linked Training Opportunities in Coastal Research and Restoration as a Vehicle for Change Toward Implementing Long-Term Ecologically Sustainable Behaviors: Case Studies From Culebra Island, Puerto Rico
Mary Ann Lucking, CORALations

The PowerPoint presentation can be found in Appendix O. Ms. Lucking explained the mission of CORALations is to conserve, nurture, and educate. In its efforts to conserve, CORALations is a coastal clean water advocate and obtained a court ruling that requires EPA to upgrade Puerto Rico's water quality standards and implement an antidegradation policy. CORALations' "watchdogs" chronic illegal and/or unsustainable coastal development and carries some of these actions through the courts. To nurture, CORALations has been a Reef Ball™ artificial reef systems distributor since 1997 and engages in community coral farming and transplanting with local scientists and the University of Puerto Rico. To educate, the organization has established an ocean studies classroom at Culebra's Eco-School to teach visiting groups via an after-school program and summer camps.

Flamenco Beach on Culebra previously was used by the U.S. military and North Atlantic Treaty Organization for military target practice and is littered with unexploded ordinance. Although cleanup is underway, no bombs have been removed despite the $11 million that has been spent on the effort; this is a result of poor management. The roads on Culebra are constructed with no planning and often are placed in dry river beds. Illegal clearing occurs, and the reporting of such acts often actually fosters them. EPA enforcement frequently is a lengthy process; in one situation, the violation was issued by the Agency 9 months after its initial site visit, which allowed for significant deforestation during the delay. The Costa Bonita Resort was built despite local opposition. Although Culebra enjoys possibly the strictest environmental legal protections in the Caribbean, including protective low-density zoning laws and a civil code criminalizing environmental harm, all Agency oversight depends on citizen reports, and the most meaningful actions by EPA depend on citizen suits. Citizens have been threatened after reporting. Although the perception is that Culebrans are not aware of the importance of environmental conservation, this is not true. The local commercial fishermen's association proposed a no-take reserve in the waters of Puerto Rico in 1981. As a result, the first no-take marine reserve in Puerto Rico was designated as such in 1999.

Current environmental education in Puerto Rico is undertaken apart from researchers and focuses on future stakeholders; however, many individuals leave the island, so the education is lost. In addition, implementing environmentally sustainable behavioral changes requires more than awareness, so a new approach that uses economic incentives to maximize limited resources and facilitate more sustainable behaviors is needed. CORALations has initiated a case study that engages local youth in a coral farming and transplanting project by providing them with their dive certifications in exchange for work. Another case study employs three local youths in a fish health study; these three jobs make a great deal of difference. To educate about erosion control, the National Oceanic and Atmospheric Administration (NOAA) has committed $70,000 for 3 years to train local heavy equipment operators; however, enforcement is needed to ensure the contractors use the BMPs they have learned.

CORALations has developed a list of 14 recommendations:

1. Remove policy gaps to prevent lobbying of nondiscretionary duties of oversight between agencies in terms of land clearing.

2. Restore enforcement and meaningful response time.

3. Maximize limited financial, human, and temporal resources by making local employment a requirement in Requests for Proposals (RFPs).

4. Maximize limited financial, human, and temporal resources by relying on local scientists.

5. Use GIS aerial data to monitor coastal impacts, and provide these resources free to watchdogs.

6. Provide ethics seminars for employees so they understand the amount of money a violator possesses should not influence enforcement actions.

7. Abandon mitigation deals.

8. Appoint a district attorney who is educated in and devoted only to environmental crimes.

9. Abandon complex balanced fishery management legislation and work from the bottom up to create small marine-protected areas within local communities.

10. Abandon top-down approaches (e.g., requiring local organizations to partner with large nongovernmental organization competitors).

11. Implement "connected contractor" oversight so that RFP focus is dictated by science rather than connected contractors.

12. Listen to economists and social scientists to encourage behavioral changes.

13. Reward fishermen when they "step up and do the right thing."

14. Consider management alternatives in unexploded ordinance cleanup for Vieques and Culebra and implement no-anchor zones as a safety measure.

Discussion

Dr. Heberling opened the discussion for questions to all three speakers: Dr. Hernández-Delgado, Mr. Laureano, and Ms. Lucking.

A participant commented that regulatory agencies cannot be expected to perform ministerial duties. Citizens should sue perpetrators who violate environmental acts and laws; these lawsuits hurt the perpetrators financially. Ms. Lucking said that planning must occur; these suits happen after damage already has occurred, so oversight must be a priority. Federal funding for coastal zone management should be used for planning; Culebra has benefited from this approach. A participant added that a doctrine that he learned in graduate school was that only strict oversight can control human behavior until an environmental activist then came along who encouraged everyone to examine institutional arrangements that may curb human behavior and to look at others as collaborators rather than negatively. Top-down "command and control" does not work.

Ms. Lucking said that from a nonregulatory standpoint it is challenging to deal with the government because of the policy structure. Agencies can alter how the money is distributed by modifying RFPs so they require local participation.

A participant asked what actions academicians could take. What is desired of stakeholders? Ms. Lucking replied that multidisciplinary alliances and partnerships are beneficial. Dr. Hernández-Delgado added that working with the people in communities also is desirable. For example, VIDAS educated and trained locals, and now they can act on their own. Sociologists and individuals from other disciplines are needed. Regarding funding, some agencies have serious limitations. NOAA is limited to focusing on specific geographic areas, and those of greater priority are ignored. Short-term vision is preventing the ability to accomplish things.

A participant provided a caution about partnerships, which can romanticize the role of locals who have jobs, families, church, and so forth as priorities. EPA personnel are paid; the locals are not. Ms. Lucking said that a goal was to pay the locals as well (i.e., use funding to engage fisherman rather than print brochures). Another participant said that what the locals accomplish already should not be overlooked. A participant thought the funding issue was part of the command-and-control philosophy. Ms. Lucking noted that matching nonfederal funds could be problematic. Those with funds may not be as effective as the community, which does not have funds. Mr. Laureano said that his group is submitting numerous proposals to obtain funding. Dr. Hernández-Delgado stated there is a conflict of interest in terms of some RFPs in that those administering the grants also are competing for them.

The Automated Remote Biodiversity Monitoring Network (ARBIMON)
T. Mitchell Aide, University of Puerto Rico, Río Piedras

The PowerPoint presentation can be found in Appendix P. Dr. Aide explained the research, management, and conservation communities need better long-term data for fauna. Automated data collection is more advantageous than typical data collection because real-time data can be collected across many sites 24 hours per day, 365 days per year. There is no observer bias, and a permanent, verifiable, open-access record of the data is available. The automated portion of ARBIMON uses wireless Internet technology to collect real-time images and sound. Its remote capability allows solar-powered data collection in areas that are difficult to access. The network provides frequent, long-term information about diverse bird, amphibian, insect, bat, fish, and marine animal species. ARBIMON is user-driven, global and utilizes cloud computing. Images and sounds the microphones and cameras record in the field are accessed in real-time via a website, and machine learning allows for automated species identification. Currently, the website offers more than 1 million recordings.

The current permanent stations are located in El Verde, Puerto Rico; Sabana Seca, Puerto Rico; La Selva, Costa Rica; and Hawaii. The Sabana Seca site was chosen because previously unknown coquí species were identified in the area. Portable, iPod touch-based recorders can be placed in temporary sites and their data uploaded to the laboratory. The heart of the system is the dynamic website that is open to everyone. The system also includes web-based visualization software and tools, and an algorithm is capable of identifying regions of interest. The information is used to create species-specific models for species detection, identification, and monitoring. The researchers also have used the system to analyze the effects of anthropogenic noise on Anuran and bird communities in Puerto Rico, finding that high road noise has a negative effect on bird diversity. In addition, the bird songs were found to overlap with low-frequency traffic noise. Another advantage of the network is the ability to monitor rare species, such as the Costa Rican tink frog and the Puerto Rican crested toad. A traditional census generally produces 26 observations of the tink frog per year, whereas ARBIMON recorded 10,605 observations. This allows researchers to reduce field technician travel expenses by facilitating targeted travel. The goal is to expand ARBIMON to many sites across Puerto Rico.

Discussion

Dr. Hopton observed the equipment must have some bias and asked whether it could be corrected by ground-truthing by field personnel. Dr. Aide stated that field biologists never would be eliminated. Bias is reduced because the data collected by multiple investigators may not be comparable.

A participant asked whether the researchers were concerned about safety issues and the integrity of the equipment. Dr. Aide conceded the permanent stations have solar panels that attract human visitors. The iPod Touches are buried underground to reduce theft; every one that was placed in the field was recovered 1 year later.

A participant asked about equipment cost and the image data. Dr. Aide explained the cameras send images in real-time via the Internet, which allows the information to be more useful. Most of the cost comes from personnel. The portable stations cost approximately $500 to $600, and the permanent stations cost $4,000 to $5,000.

A participant asked whether there were any problems with automated species identification in noise-rich environments. Dr. Aide responded that one site in Brazil was home to more than 300 birds and there were 12 to 15 different calls per minute; this was challenging. The sites in Puerto Rico have not been a challenge. Additionally, the algorithms can be improved to improve species identification.

A participant asked whether call frequency was found to be correlated with species density. Dr. Aide replied that this analysis had not been carried out but could be performed in the future. Currently, the researchers are examining presence and absence data, but they are interested in converting it to abundance data.

The Distribution of Pollution and Environmental Justice in Puerto Rico: A Quantitative Analysis
Shanshan Wu, EPA, ORD, NRMRL

This PowerPoint presentation can be found in Appendix Q. Dr. Wu explained that this study attempted to understand environmental inequalities and health in Puerto Rico, examining two related issues—pollution distribution and environmental justice. To measure pollution distribution, the researchers used an environmental Gini coefficient, which is an inequality measure used mostly for income distribution. According to environmental justice literature, pollution is related to socioeconomic and demographic indicators. Regression analysis was used to investigate the relationship. EPA's Toxic Releases Inventory (TRI) provided data for the study, and the researchers examined releases into all media, particularly air, from 2000 to 2008; this timeframe allowed the use of a stable data set. The *municipio* was the spatial unit; release data are available for 50 *municipios*. The results indicated that releases to all media and to air have significantly decreased over time.

The next step was to investigate distribution of releases to determine whether different *municipios* experience the same amount of releases. An environmental Gini coefficient can quantify the distribution of toxic releases. Gini is bounded within the interval (0, 1); zero indicates perfect equality, and one indicates perfect inequality. The calculation of this coefficient indicated that it increased slightly for air and all media releases and that releases are unequally distributed across *municipios* in Puerto Rico. This unequal distribution of releases implies that people in different *municipios* may be suffering different levels of releases, which contradicts the principle of environmental justice. Therefore, the next step was to investigate environmental justice in Puerto Rico.

According to EPA, environmental justice is achieved when everyone enjoys the same degree of protection from environmental hazards. Based on environmental justice literature, the researchers selected several socioeconomic and demographic indicators (race, population density, poverty, education, housing rental status, age, unemployment, and car ownership) that may be related to releases. A quantile regression approach was used to estimate the regression model, and because this is not commonly applied in environmental economics, ordinary least squares and Tobit approaches also were used. Results indicated the strongest relationship was between indicators and all-media releases in *municipios* with the fewest releases (lowest quintile) and most releases (highest quintile). Poverty level had no strong relationship with releases, and education had strong relationships with releases; *municipios* with a high percentage of poorly educated individuals were more likely to experience releases. An interesting finding that needs more study is the percentage of renter-occupied housing was negatively related to releases in the most polluted *municipios*. In terms of air releases, the relationship between indicators and releases was similar; however, poverty was a significant estimate in the most-released *municipios*. Income variables were used in a

sensitivity analysis, and results indicated that income differentials were not strongly related to releases in Puerto Rico.

Dr. Wu summarized the large estimates of the environmental Gini coefficient imply that toxic releases are unequally distributed in Puerto Rico, but inequality did not increase between 2000 and 2008. Indicators of nonwhite population, population density, education, age, unemployment and car ownership have clear and significant relationships with toxic releases. To policy makers, a focus on education and unemployment is important because both indicators are clearly and strongly related to toxic releases.

Discussion

In response to a question from a participant, Dr. Wu explained that TRI is a data inventory that was developed and has been used by EPA since 1988. Facilities are required to file their release information with the Agency annually. A participant from the EQB added the EQB cooperates with EPA in this regard, requiring all *municipios* to report their release information.

In response to a comment from a participant, Dr. Wu noted the coefficient of determination value was large enough to perform the regression analysis.

A participant asked how releases in Puerto Rico sites compared to U.S. sites per capita. Dr. Wu responded that this comparison had not been performed; comparative analysis is planned for the future.

A participant asked whether the reason for the decrease in releases occurred because of plant closings or because plants were taking environmentally protective measures. Dr. Wu said that TRI data affect the share price of companies on the stock market, so there is a financial incentive to reduce releases. A participant said that in the 1990s, the major polluters were the pharmaceutical companies; now the largest polluter in Puerto Rico is the government. He would be interested in examining individual polluters, including pharmaceutical companies and electricity producers. Another participant noted that different data could be reported over time.

A participant asked about the inclusion of Asian as a race in the study. Dr. Wu responded that she had not completed a summary of Asians living in Puerto Rico.

Comprehensive Disaster Reduction: A Social Vulnerability Index for Puerto Rico
Jenniffer M. Santos-Hernández, University of Delaware

This PowerPoint presentation can be found in Appendix R. Ms. Santos-Hernández explained that Puerto Rico's topography, climate and geographic location make extreme weather events very probable. Changing weather patterns have been observed, and weather events often have led to disasters. Demographic and economic research shows the development policies implemented in Puerto Rico have not or only partially succeeded. The industrial sector has declined, and it is argued that Puerto Rico has transitioned into a service economy. Employment opportunities in the emerging sector are different and often less profitable than previously. To absorb the increasing unemployment, the public sector became the largest employer. Additionally, Puerto Rico has been a laboratory for many social policies, and many benefits and problems have been the result.

Inadequate planning and zoning have led to a large increase in the number of persons living in areas susceptible to storm surge, tsunami, and flooding. Governmental policy also has contributed to increasing physical vulnerability by allowing high-rise construction projects along coastal areas and by locating critical infrastructure in known at-risk areas. It is important to study development because it often leads to vulnerability. Disasters are social processes, and framing vulnerability as an issue of capital accumulation affords an opportunity to understand the differential impact and consequences of disasters. Comprehensive

vulnerability management can be defined as "holistic integrated activities directed toward the reduction of emergencies and disasters by diminishing risk and susceptibility and building of resistance and resilience." The challenge of creating a vulnerability index is that it is a static view of a population and is limited in its ability to monitor changes. It is difficult to determine what is occurring from a social aspect; it is necessary to examine each community to determine the root of the problem.

Ms. Santos-Hernández's graduate work examined social vulnerability to coastal hazards; the accumulation of disadvantage was used to develop a social vulnerability score. Results indicated that although the population residing in exposed areas increased from 1990 to 2000, there has been an observed decline in most vulnerability indicators. This finding may raise questions about the use of demographic indicators only to assess social vulnerability. High vulnerability is characteristic of deindustrialized areas, and there is a need to develop emergency preparedness and response plans that address the needs of a changing population with relatively high levels of vulnerability. It also is necessary to prepare proactively to meet the needs of those with disabilities and an increasingly older population residing in areas exposed to hazards. Despite the decline in vulnerability indicators (e.g., poverty, low education), they remain quite high, particularly in comparison to the United States. The researchers developed a Disaster Decision Support Tool with various layers that are of use to emergency managers, who were trained to use these data in a useful manner.

Ms. Santos-Hernández's current doctoral work focuses on how the governance of disasters and emergencies is shared in Puerto Rico, and she has completed in-depth interviews with emergency managers and National Weather Service personnel. The research highlights important differences in terms of the role of emergency managers, levels of training, access, preferences and use of information sources compared to the organizational features of the *Agencia Estatal Para el Manejo de Emergencias* (State Agency for Emergency and Disaster Management). Preliminary findings indicate that shared conventions, expectations, and cultural concerns are brought to bear when making decisions; the culture of Puerto Rico mediates how the agencies work. Upper-level managers are concerned about job security of their employees because there often is a cycle of increased hiring preceding an election and firing following an election. The researchers are focusing on case studies of the *municipios* of Dorado and Cataño to understand how social vulnerabilities play out in communities, in addition to examining the evolution of risks in Cataño and the role of the *municipio* in Puerto Rico's development. Preliminary findings indicate a variety of themes (e.g., changes in transportation, land use, energy, soil; drugs and violence; community resistance to government intervention), and there are conflicts among community organizations on various issues. The Caribbean Petroleum Corporation explosion in Cataño illustrates the pre-existing vulnerability in the region.

Ms. Santos- Hernández reiterated that her research suggests the need to develop emergency preparedness and response plans that attend the needs of a changing population with relatively high levels of vulnerability. The majority of disaster scholars, however, are not expert in bringing about massive cultural change. It is necessary to prepare to meet the needs of the elderly and those with disabilities and to develop and implement programs that increase awareness and mitigation of hazards that more frequently affect communities. Finally, there is a need to review emergency management and disaster policies to better prepare for such events.

Discussion

Dr. Heberling invited discussion for all three speakers: Drs. Aide and Wu and Ms. Santos-Hernández.

A participant asked Dr. Wu whether EPA considers all communities in Puerto Rico as environmental justice communities. Dr. Wu responded the research was performed across the entire island, and she is unsure how to define an environmental justice community. Dr. Heberling added that this was completely outside the scope of the research and the role of ORD. The Region 2 Environmental Justice Coordinator would be able to answer that question.

A participant asked how a stakeholder could access TRI data (e.g., National Pollutant Discharge Elimination System [NPDES] permitting violations). Dr. Wu explained that TRI data are publicly available on the TRI website. A participant from the EQB explained the EQB did not have jurisdiction over NPDES. A participant asked whether water quality data for Puerto Rico are available online. Dr. Wu said that TRI data on water releases are available.

A participant stated that President Clinton had signed a bill regarding the monitoring of coastal waters with recreational use. The EQB was provided with $300,000 to monitor the coasts, but he has been unable to determine how the funds are being used. The participant from the EQB said that public notice had been given on the matter; 19 beaches are monitored on a continuous basis, and the rest are monitored every 1 to 2 weeks.

Facilitated Session—Feedback From Participants

Dr. Hopton remarked there is a need for the scientific community to determine how to affect decision-making so that decisions are made based on sound science rather than on financial incentives or lobbying. Puerto Rico decision-makers are interested in this type of decision-making, and it is necessary to begin collaboration between researchers and decision-makers to ensure that sustainability research is useful for decision-making and, if it is not, how it can be made useful. He explained that ORD has clients; anyone can contact the office for assistance. Although EPA is regulatory, ORD is not. The sustainability work in the SLB led the Puerto Rico government and Region 2 to contact the research team to discuss its metrics research. The governor's office appointed a contact person so that Puerto Rico agencies remain involved in the research, and the governor of Puerto Rico sent EPA Administrator Lisa Jackson a letter thanking her for EPA research in Puerto Rico. Dr. Hopton reiterated the Puerto Rico government has expressed interest in using sustainability research in its decision-making. Finally, it is necessary to address problems at a smaller scale to effect global change. ORD would like to provide communities with the tools to do so, recognizing there are trade-offs (e.g., Puerto Rico may benefit even if a specific community does not).

A participant noted there is a clear lack of knowledge about what research academicians in Puerto Rico are performing. What has ORD staff learned during the past 2 days? Dr. Hopton thought that a lesson learned was that it is necessary for all stakeholders and researchers to reach out to work with others. Because ORD researchers do not have access to the Spanish literature, utilizing those who do would broaden the available expertise for inclusion in the effort.

A participant asked what information presented during the symposium ORD staff members had found relevant for their research. Dr. Hopton replied that all of the presentations and discussions had been relevant. ORD researchers have expertise with four metrics. These four metrics capture sustainability, but are they useful? Is this information that Puerto Rico cares about? Metrics provide a snapshot of the system. It is beneficial to examine the general system, but issues important to the island must be monitored and quantified. ORD ecologists, lawyers, economists and so forth can focus on Puerto Rico, but they do not have local expertise. The goal is for ORD metrics research in Puerto Rico to be as inclusive as possible and focus on important island issues.

A participant stated there are different methods to achieve sustainability (e.g., habitat, water) and asked whether ORD staff members have a template for sustainability strategies. Dr. Hopton replied they had not developed such a template because Puerto Rico stakeholders must be included in identifying the island's important issues for concern. One single project will not satisfy all of the issues. Dr. Heberling asked the participants whether they had developed a strategy for sustainability. ORD brought metrics and now would like to know what Puerto Rico finds useful and what the Puerto Rico researchers think is a good template. A participant thought there were so many possible frameworks that sustainability might be unobtainable under a strict timeline.

Dr. Hopton commented that sometimes it is necessary to identify just one or a few important issues for a system; as a group, the participants could reach a consensus on these items. Once there is a general idea of where Puerto Rico wants to go, then the researchers can determine how to get there. Sustainability is a moving target as a result of changes in technology, population, demand for resources and so forth; it is necessary to adapt and change with the system.

A participant stated that, according to the literature, energy is a key component of sustainability at all levels. A philosophy for Puerto Rico's sustainable energy future must be developed, and a serious strategy regarding energy and vulnerability must be established.

A participant remarked that pollution is a significant issue, and if the island relies on nonrenewable sources of energy, Puerto Rico never will be a sustainable society. A participant said that recognition that a true shared governance process must exist is needed; another participant strongly agreed. This process must include full accountability, transparency and a genuine desire for true participation. Another participant noted that human behavior must be studied in addition to the natural sciences and technology. If the wrong practices are in place, Puerto Rico never will reach sustainability. Research in all areas is needed to ensure that this does not happen.

Dr. Hopton wondered whether the steps of the process should be completed simultaneously or in an ordered fashion. A participant thought they needed to be concurrent because they feed into each other. Another participant said the process needs a facilitator. Dr. Hopton stated that ORD recognizes this need, and the staff members hoped their Puerto Rico colleagues could provide a facilitator.

A participant stated that sustainability is not decided independently. There is a process that needs to include everyone and possess a good flow of information. Every energy source has environmental impacts; decisions must include knowledge about the choices and the pros and cons of each choice. Although different stakeholders have different interests, it is necessary to reach a consensus. A great deal of information in the natural sciences, particularly marine science, already exists, but the social and political landscape must be included as drivers. Behavior, which is variable and has many effects, must be included in the sustainability indicators. The social component of sustainability must be included.

A participant said that researchers have been compiling information, but what do they want to achieve? Goals and policy must be determined because that will determine the possible scenarios. Is the current plan to replace manufacturing on the island with tourism sustainable? This plan will affect coastal resilience. It is necessary to establish a baseline of current conditions and then monitor changes. A shared vision of future directions is needed, and stakeholders must be included in developing this vision.

A participant remarked that sustainability is a scenario. It is necessary to include multiple disciplines so there is common information and knowledge; each discipline manages different types of information, so compiling all of this information would be beneficial to create a different dynamic. It would be helpful to determine how trends (e.g., oil imports, murder, deforestation) have changed during the past 10 years. Trends are incredibly valuable so that everyone has common information. A document including graphs of the 100 most important variables would be beneficial so that trends during the past 10 to 20 years could be examined. A participant said the Federal Emergency Management Agency performed a hazardous risk communication study in Culebra that measured 16 parameters (e.g., land use, high risk areas) and released the results as a GIS map overlay.

A participant noted there are many opinions in Puerto Rico; the federal government, however, can be objective, and that objectivity is needed. There are data that all agree are valid, but objectivity in assessing these data still would be helpful. Dr. Hopton remarked that participants had mentioned several times that more data are not needed; however, data are needed for decision-making, and the current data will be questioned in terms of quality. The four metrics that ORD selected are data intensive; three are infinite in

their data needs. As much data as possible is needed because not all data are at the appropriate spatial scale. How are data obtained? If the data have been collected, why are they difficult to obtain? Data collected with public funds need to be available, so it is necessary to determine where data can be found. Another data topic is generalizability. The United States aggregates the local data that it collects to obtain a generalizable average, but different portions of the population will behave differently.

A participant suggested that Puerto Rico graduate students could collect data; this would allow collection of data while training new scientists. Another participant said that before data are compiled, it is necessary to determine what research others are performing. The benefit of this symposium is the ability to network. How can the data be compiled if others do not know data exist? ORD should become a "bulletin board" for Puerto Rico to publicize data that feed into the measures of sustainability. Dr. Hopton thought the data should be kept locally. Although the University of Puerto Rico is a government entity, it is perceived differently than a government agency, so this could be one option for a data repository. A participant said that EPA initiated this effort and is interested and asked why it could not provide an outlet for the data and information created daily. A common repository for Puerto Rico sustainability data is needed. Another participant thought that it was a good idea to have a common repository for data but had strong reservations about sharing data through the ORD website because it becomes the property of the federal government. Dr. Hopton suggested that it was better to find a local repository because ORD's Puerto Rico project may not have funding in 2013 or future years.

A participant remarked that collaboration could hinder the collection of data. Is it better to have more data or better to have the best variables? Dr. Hopton asked what variables are needed. Inexpensive, simple, and less-precise data may be more beneficial than expensive, more-accurate data. A participant said that most of the variables are supposed to be collected by the government. Establishing a database/platform within the local governments to share and collect data may be a better approach. Another participant noted that a good deal of geophysical and chemical research has been compiled, and more than 150 peer-reviewed papers are available.

A participant thought the group was discussing two different issues. As a group, it is necessary to address the issues in an orderly manner. Another participant said that it was necessary to develop a blueprint for sustainability to ensure the research in Puerto Rico is useful to establish a baseline. The system will change (e.g., elections), and many variables (e.g., gasification, landfills) must be taken into account. It is beneficial to collaborate to discuss expectations. A participant did not think that it mattered where the platform was established; the many data at different levels cannot be integrated. Another participant said that if the repository is placed at the federal level, it could be used as a national security tool.

A participant noted the driver of any political system is participation. Another participant commented that decision-making in Puerto Rico is dominated by a certain group; the public never is consulted about its vision for Puerto Rico. The citizens benefit from science, particularly when it is used for decision-making. A participant stated that some entities with funding to collect data influence the results. Researchers are not trained with the political process in mind nor how to broker information for decision-makers. There are "honest brokers" and "entrepreneurs." How can scientists become more entrepreneurial when making their research more policy relevant? Researchers have not studied methods to organize themselves to better move research through the policy process. Scientists can examine behavior and determine how to be better entrepreneurs of their data in certain situations, even though this goes against their training.

A participant remembered the first time that he heard the term "sustainability" in 1975; the word invokes freedom and democracy. It must be framed in terms of both.

A participant thought that usability must include a scale of action, and planning implies scales of action. It is necessary to identify what data are available on what scales so that data can be organized and better

utilized. How can a project be funded to achieve sustainable goals? Short-, medium- and long-term goals are needed. Deciding how and when to act is a temporal issue.

A participant noted that because of the Autonomous Municipalities of the Commonwealth of Puerto Rico Act, the government does not have power over *municipios*; therefore, it is difficult to institute goals.

Dr. Hopton reiterated that it is necessary to find a balance within the overlap among the three pillars; there must be environmental, economic, and social benefits while recognizing there will be trade-offs. Once the benefits have been demonstrated, others will buy in. It is necessary to ensure that decision-makers have the tools they need from a scientific perspective.

A participant asked for clarification that EPA is seeking from this group "a" vision for sustainability in Puerto Rico rather than "the" vision. Dr. Hopton agreed that this is a starting point. One lesson learned during the symposium is that inclusion and representation must be increased. ORD scientists needed to choose a place to begin, so those researchers found through a literature search were invited to participate. The expectation was the symposium would initiate a dialogue so that researchers could provide input about what actions need to be taken to ensure a sustainable Puerto Rico. The goal was for the decision-makers to be present for the discussion so they could indicate why they are not using the data the researchers make available. In turn, the researchers could incorporate this information into their research plan and improve their research so that it is used for decision-making.

A participant stated that it was difficult to develop a list of actions to promote sustainability in Puerto Rico following 2 days of presentations. Another participant asked about ORD vision of outputs. His vision is to change the mindset of individuals. Achieving a new state of consciousness regarding sustainability would be a great contribution to sustainability in Puerto Rico.

Dr. Hopton explained that ORD had invited the heads of every Puerto Rico agency. Local researchers also were invited because the office wanted to reach out to the wider scientific community working on sustainability in Puerto Rico to collaborate; the ORD researchers recognized they do not have the toolset to help Puerto Rico best. The goal was to bring everyone together to determine what collaborations and actions are needed to move the island toward a path of sustainability. The collaborators could develop a research plan and work together with the common goal of improving the system. A participant said that if this was the goal, the format of the meeting should have been a roundtable discussion rather than a workshop. Dr. Hopton replied the original intention was to have breakout sessions, working groups, a budget, more staff and a facilitator, but unforeseen circumstances forced a decision between the current format and canceling the effort completely. The ORD staff is comprised of three members trying to reach out to the local community to obtain the expertise and knowledge to be a success. This staff will continue to attempt to initiate a dialogue with decision-makers and discuss the conversations and presentations at this meeting.

A participant said that visions would be different for different individuals. Working at the local level may be feasible, but scaling the effort up to the island level may be difficult. Another participant thought the main issue was that Puerto Rico has many scientists who can provide expert advice, but the decision-makers do not care to hear it. The question is how to allow scientists to provide data to decision-makers and the public so that it is understandable and can be used to provide a vision of sustainability for Puerto Rico. This vision must be based on scientific information and not on a top-down approach. A participant noted that sustainability initiatives foster job growth, so the economic benefits will resonate with decision-makers and the public.

A participant noted that it is important to communicate to the decision-makers there is economic benefit in "doing the right thing." The media should be aware of this discussion to further incentivize decision-makers; a reporter from *Caribbean Business* should have been invited. A participant thought that it was

important the data are publicly available so the public can make a decision and pursue action from their policy-makers. A participant explained that part of "Policy Analysis 101" is that politicians do not go to the public unless they know the outcome. It is necessary to know in advance, what is desired of the decision-makers and then make them accountable. Dr. Hopton explained that decision-makers have told EPA that if ORD provides the tools, they will use them. The researchers must develop these tools. Many countries have realized the importance of sustainability and are incorporating it into their plans; these can be models for decision-makers in Puerto Rico. It is important to be inclusive and work with the decision-makers to develop tools for sustainable decisions.

A participant stated there are contacts who can tell whether government data is of good or poor quality; it is necessary to evaluate the data, compare data from different sources, and use this information to make decisions. Key people need to receive these data. What entity should collect it? A task force should be established to explore sustainable choices; some visions are not sustainable. Instead of business as usual, sustainable alternatives must be sought and implemented.

A participant said that development has been highlighted in the media. The current development model must be reconceptualized. If the sustainable vision is aligned with items in the current agenda, then the resulting actions can be undertaken quickly and easily. The first three objectives should be given to the task force with a deadline.

Dr. Hopton said that ORD researchers would like to develop a collaborative research project with sustainability experts and tailor it so that decision-makers can use it to improve the future of Puerto Rico. The collaboration would use government funds to reach out to academia and NGOs, taking into account what the decision-makers need. Dr. Heberling added the metrics have been presented to the Puerto Rico government, but metrics cannot be used as goals.

A participant noted the first tenet of sustainability is the community and the public must be engaged. Another participant agreed with the creation of a task force to move forward with the sustainability effort. There needs to be a commitment from this group to continue compiling information and promoting the sustainability effort. It would be beneficial to create a document that expresses the needs (i.e., What knowledge is needed to move forward?). A participant thought that it was important to summarize the recommendations from the presenters at this symposium and present them to the decision-makers. A participant remarked that decision-makers are fluid entities.

Dr. Hopton asked whether the first duty of the task force should be to meet regularly. The participants agreed that regular meetings of the task force were important. A participant thought the task force should be comprised of sustainability researchers. The heads of the universities were suggested as stakeholders who should be included, but another participant thought their main concern would be the capacity building of students rather than sustainability.

Dr. Hopton said that if the task force presents accomplishments, even small ones, the effort will be seen as positive, and it will grow. The government must agree that sustainability is important, and then a vision can be formulated. A participant thought that indicators of attitude, knowledge, and self-reported behaviors were needed. Another participant said that it was necessary to engage the decision-makers so they did not just "listen and smile." A participant noted the decision-makers of today might not be the decision-makers of tomorrow. All parties should be approached, and the task force should transcend parties so that it continues no matter which party is in office. If the task force is seen as something belonging to the current government, it may be discarded when there is a new government. Dr. Hopton agreed and said the original goal was to have accomplishments established by the time of the election so that it would be a large enough effort to guarantee that it would go forward during the next administration. A participant noted there must be wider dissemination of information to encourage adoption of sustainability practices; if all six of the

political parties include sustainability in their platforms, the effort will have a basis for continuing. Another participant agreed that a release of information could change government efforts.

A participant reiterated the need for an official clearinghouse for data and information. Data must undergo quality assurance/quality control (QA/QC), and researchers and decision-makers must be careful regarding the comparability of data. Dr. Hopton said that ORD could provide its data to those who request it. It is available on EPA's Environmental Science Connector, which requires registration with the Agency before it can be accessed.

Day 2 Wrap-Up

Dr. Hopton highlighted the plan for the following day and recessed the meeting at 6:46 p.m.

JUNE 7, 2012

Discussion Regarding Lessons Learned, Identification of Target Questions for Decision-Makers and Plans for a Coordinated Research Agenda

Dr. Hopton called the meeting to order at 9:51 a.m. He explained the original goal for the day was to include discussion with decision-makers. With those present, the new goal was to develop a document that will compel decision-makers to acknowledge the problem of unsustainable development on Puerto Rico and that it needs to be addressed in an inclusive manner; they must take action to make Puerto Rico sustainable. The objectives remained the same as described on Day 1, except a new goal was added to initiate a dialogue between researchers working on the Puerto Rico system, recognizing that ORD needs to include experts on Puerto Rico.

The lessons learned from the symposium are as follows:

- Scientists have different visions, perspectives, research, and information regarding sustainability in Puerto Rico.
- It is recognized that data are missing, and there is a need to emphasize critical data gaps.
- Data need to be centralized, categorized in terms of quality, and made more readily available.
- Representation must be increased to ensure that all interested parties have a voice.
- Based on participation, sustainability research is well established in Puerto Rico; only a very small subset was represented at the symposium.
- Communication about sustainability research in Puerto Rico, on and off the island, is lacking.
- A cohesive collaborative effort in the sustainability community is lacking.
- There are many frameworks for studying sustainability, but which one(s) is the right one for Puerto Rico?
- The social science perspective on sustainability in Puerto Rico is lacking.
- Participants think that Puerto Rico needs a clear vision of sustainability for the long term. It is necessary to determine the current state of sustainability on the island and then decide the future direction.

- Opportunities for data sharing and collaboration became obvious during the symposium.
- The symposium created a missing forum for scientific discussion.
- Organized discussions among scientists need to continue.
- This symposium/workshop is a first step, rather than a final answer.
- Scientists need to translate information to make it accessible to everyone (e.g., policy-makers, other disciplines, the public, communities).
- ORD's research will provide a tool to show whether Puerto Rico is moving toward or away from sustainability. Given the limitations and decision-maker needs, research opportunities need to be identified to enhance decision-making.

The messages to decision-makers identified during the workshop are as follows:

- It is necessary to establish a vision for Puerto Rico with associated goals. What does Puerto Rico want to achieve? Can scenarios reveal how to accomplish this? Goals must include social, economic, and environmental aspects.
- The approach instituted must be from the bottom up; everyone needs to participate.
- Data issues need to be addressed (e.g., QA/QC to ensure that available data are of the highest quality).
- Collaborative efforts, partnerships and alliances are needed to leverage dwindling resources and enhance the knowledge base. A transdisciplinary approach must be employed that includes nonacademics, nonresearchers, decision-makers and the public, in addition to multidisciplinary researchers. There are existing opportunities that can be explored.
- The research community must be better organized.
- Sustainability must be addressed with short-, medium- and long-term goals.
- Commitment is needed at all levels of government.

The recommendation and request to decision-makers resulting from the lessons learned and the developed messages is that a task force be formed to address the issues related to sustainability in Puerto Rico. The task force can be operated at the *municipio* or island level. Dr. Hopton opened the discussion at this point.

A participant thought that in terms of the research community being better organized, researchers are organized but perhaps not in the most effective manner. It may be necessary to change this statement to, "The research community must change the way in which it is organized." Currently, it is too fragmented, and consensus is needed.

A participant remarked that a hierarchy of ideas is needed. Several items are being discussed: Is Puerto Rico on a sustainable path? What components are needed to get the island to sustainability? Will this effort be based on a research agenda for sustainability? If so, education is the first step; everyone must be educated before beginning to develop a strategy. Research and education can be linked.

The participants discussed the fact the University of Puerto Rico at Río Piedras has established the Center for Renewable Energy and Sustainability with support from the U.S. Departments of Defense and

Education. The campus also has a sustainability initiative. The campus at Mayagüez has a sustainability component as well. Education and capacity building allows decision-makers to see the vision; there must be research and political thrusts. Another participant noted that she has proposed a new class on her campus that focuses on the will toward sustainability. A participant commented that many actions regarding sustainability occur on the island in addition to those at the universities. What is the message that researchers want to convey to the decision-makers? The message must include clarity about the components: education, research and others. Sustainability is broader than setting indicators for the government; it is about people making better, educated, informed choices.

A participant noted the need to establish achievable goals; the capacity to educate the public is limited. It may be more beneficial for the group to focus on research. Another participant commented the pillars of sustainability tie all of these components together. The components are about the environment, economy, and society and help people to understand where they are coming from and where they want to go.

A participant said that it would be helpful to examine countries that already are following a sustainable pathway. In addition, political will is needed to reach sustainability goals and deadlines. Funding also is needed because the research agenda is dictated by available funding. Priorities also drive the research agenda, and it is necessary to align sustainability with government priorities. Many scattered issues impact decision-making and, therefore, sustainability.

A participant thought that perhaps an academic model should not be followed. Subdividing the issues into thrusts, as was proposed earlier, is an excellent idea to organize scattered issues. Best practices also must be investigated. The participant reiterated the need for education, research, and capacity building.

A participant had a different point of view and did not see research as a pillar. The effort must be science- and data-based. A decision already has been made that this is of value. The process, models and changes cannot be compared and contrasted without scientific evidence. Target audiences that need to be reached for education or to start facilitating behavioral changes may not see the same value.

A participant remarked that sustainability deals with social and economic issues in addition to the environment. Sustainability is based on conflict. Puerto Rico has many problems with population loss resulting from increased unemployment and crime rates. These issues need to be addressed via research so the resulting information can be used to confront the problems. There are other aspects of sustainability that must be included in the discussion (e.g., loss of farmland, drug addiction, crime, lack of public transportation, the number of cars on the island, unemployment). Social issues affect the capacity of Puerto Rico to hold its population. The sustainability discussion must be expanded to include a transdisciplinary approach with a focus on social issues. Another participant agreed the legacy of social sustainability tends to be less prominent in the sustainability literature. There is a recognized need to focus on social research so that it is brought on par with research in the natural sciences. Dr. Hopton said that ORD recognized the need to include social science in its research. Dr. Heberling added that ORD is attempting to integrate social science into its research while recognizing EPA's mission. The researchers realized that it was only weakly included in the Puerto Rico research and recognized that it needed to be integrated better.

A participant commented that pollution is a problem across the globe and not just in Puerto Rico. Everything is interconnected, and it is necessary to understand why building occurs in the manner that it does to understand its effects on the environment and social issues. Another participant agreed the vision of sustainability must include research within environmental, economic, and social parameters. Additionally, the research goals must include useful information for all stakeholders. Another participant remarked on the need for decision-makers to follow the plan for sustainability, which must be based on research. Dr. Hopton summarized the government must state that it has a clear goal that it wants to achieve and then institute a mechanism to achieve its vision and goals that includes researchers, NGOs and stakeholders. The goal is for the effort to become self-sustaining and adapt as the system changes, which is inevitable.

A participant noted that no one has developed a specific strategy for sustainability in Puerto Rico. NOAA and the Nature Conservancy have been providing instruction to the Puerto Rico Department of Natural Resources and the Environment. Local and island managers need to work in a manner consistent with Puerto Rico culture but are forced to follow NOAA's agenda.

A participant remarked on the need for a baseline. For example, increased tourism creates a different scenario for the island. Current groups are working in a fragmented manner, with each having its own agenda. It is necessary to prioritize actions for funding. If decision-makers do not consider all of the information, then important sectors may not be funded. Decisions irreversibly affect coastal regions when they are not prioritized. Dr. Heberling noted the task force members would bring their own agendas; it is not up to the workshop participants to determine the action items for the task force. Much more discussion is needed.

In response to a question from a participant, Dr. Heberling said that it was up to the task force to determine the role of researchers. A participant added creating a task force will help build policies to advance research. The task force will be instrumental in accomplishing these tasks.

A participant said that decisions should be made based on the scientific information available. The science will be proven in future extreme events that scientists have been warning about; as more stakeholders engage in the process, the political will to deal with these issues will increase. A participant noted the task force will be a policy instrument of the governor and is needed to move toward a vision of sustainability for Puerto Rico. Research must be a component of this instrument.

A participant suggested a sustainability website and white paper as tools to increase information exchange. Sustainability is complex and requires the engagement of communities, experts and various sectors to develop a sustainability vision that will be adopted by policy-making bodies. Another participant thought the website and/or white paper should include available graphics of indicators over time. Puerto Ricans are visual people, and this will help them understand what has been happening. A participant agreed the graphs might show where change is needed; the 2012 condition should be a baseline for moving forward. Models can be used to show trends and scenarios; the resulting questions will trigger additional research. Commitment is needed at all levels of society in addition to the government. A participant noted that society affects change in Puerto Rico rather than the government; the government often is an obstacle to change. In addition, the target audience for this effort needs to be better defined. Dr. Hopton noted the government can add stability, but everyone needs a voice within the bottom-up effort.

A participant noted that civilians lack enforcement support from agencies regarding environmental and social issues. Even though they do not understand the process, civilians must perform their own enforcement.

The participants discussed information flow, noting that universal access to data and information is needed; agencies and information generators must commit to posting information on a "cloud" repository. If the information is available, then researchers, decision-makers, NGOs, communities, and so forth can access it. Community outreach is needed to publicize the information is available. Government agencies should provide training on request regarding what information is available, how to access it, and how it can be used. There is no public information law in Puerto Rico, which results in a lack of transparency. In addition to dissemination, it is necessary to package information in a useful manner. Some entities charge for each page of information accessed, which can become cost prohibitive. Puerto Rico must pass a law that is similar to the U.S. Freedom of Information Act. Finally, information can "go viral" on social networks.

At this point in the discussion, the participants used the lessons learned, messages and recommendations that Dr. Hopton had presented as a template for modifying them and expressing their points of view. The

resulting PowerPoint presentation developed by the participants can be found in Appendix S. The new observations were as follows:

Lessons Learned Regarding the Vision of a Path Toward Sustainability

- Participants think that Puerto Rico needs a clear vision of sustainability for the long term. It is necessary to determine the current state of sustainability on the island and then decide the future direction.
- There are many frameworks for studying sustainability, but which one(s) is the right one for Puerto Rico?
- There is an opportunity for developing collaborative partnerships in the sustainability community.
- Stakeholder participation must be increased.

Lessons Learned Regarding Research

- Scientists have different visions, perspectives, research and information.
- Many issues relate to data:
    - It is recognized that data are missing, and there is a need to emphasize critical data gaps.
    - Data need to be centralized, categorized in terms of quality, and made more readily available.
    - Opportunities for data sharing and collaboration became obvious during the symposium and workshop.
    - Information is lacking regarding available public data.
- Based on participation, sustainability research is well established in Puerto Rico; only a very small subset was represented at the symposium.
- There is a lack of communication about sustainability research in Puerto Rico among researchers, as well as between researchers and policy-makers on and off the island.
- The social science perspective on sustainability in Puerto Rico is lacking.
- The symposium created a missing forum for scientific discussion.
- Organized discussions among scientists need to continue.
- This symposium/workshop is a first step rather than a final answer.
- Scientists need to translate information to make it accessible to everyone (e.g., policy-makers, other disciplines, the public, communities).
- ORD's research will provide a tool to show whether Puerto Rico is moving toward or away from sustainability. Given the limitations and decision-maker needs, research opportunities need to be identified to enhance decision-making.

Messages Regarding the Vision of a Path Toward Sustainability

- It is necessary to establish a sustainability vision for Puerto Rico with associated goals. What does Puerto Rico want to achieve? Can scenarios reveal how to accomplish this? Goals must include social, economic, and environmental aspects.
- The approach instituted must be from the bottom up; everyone needs to participate.
- Data issues need to be addressed (e.g., QA/QC to ensure available data are of the highest quality).
- Organized discussions must continue.
- Collaborative efforts, partnerships, and alliances are needed to leverage dwindling resources and enhance the knowledgebase. A transdisciplinary approach must be employed that includes nonacademics, nonresearchers, decision-makers and the public in addition to multidisciplinary researchers. There are existing opportunities that can be explored.
- Sustainability must be addressed with short-, medium- and long-term goals
- Commitment is needed at all levels of society.
- Government agencies and researchers should support data collection and make data available to diverse users in a user-friendly manner.

Message Regarding Research

- The research community must convert to issue-based thinking rather than discipline-based thinking.

The participants next discussed the recommendation to create a task force. Dr. Hopton said that it was important to ensure broad representation on the task force. NGOs know how to perform public outreach, and it is important the task force include members who know how to do this. The task force may be established at the federal, island or *municipio* level, depending on the goals of the effort.

A participant noted the need for media coverage and public education about the task force effort; the process must be transparent so that Puerto Ricans will trust it. The media should be used as a tool. There should be media coverage about this symposium/workshop and its outcomes, focusing on the fact that researchers were present and stated that broader participation is needed. This should come from EPA. Drs. Hopton and Heberling promised to follow up with Region 2 about a press release regarding this symposium/workshop. Another participant said that he had spoken to *Caribbean Business* about including information on the symposium to reach members of the business community and investors.

A participant stated that it is necessary to explore the unequal power distribution regarding who will be able to attend task force meetings; there may be individuals who are very interested in participating but do not have the capacity to attend as a result of a variety of reasons (e.g., lack of child care).

Dr. Hopton said that once the vision and goals are established, the task force could determine its tasks. The government must be included because it can institute the process and compel action. The task force will be responsible for achieving the vision with its associated goals (e.g., increased agriculture, decreased mortality). The task force will engage experts related to the goals who can address the problems at the appropriate scale. It is necessary to meet the needs of stakeholders, which can be accomplished by including them in the process. The task force should remain in place no matter which party is in power and continue working through regime changes.

Recommendation To Establish a Task Force

The participants recommend that a task force be established to explore sustainability in Puerto Rico. The task force should:

- Establish tangible action items, with timelines and finite deadlines.
- Organize future meetings similar to this symposium/workshop.
- Identify key stakeholders.
    - Employ a transdisciplinary approach that ensures that members possess a range of knowledge, expertise, and communication skills (e.g., developing a common language).
    - Examine all sectors, including academia, NGOs, unions, business, religious, community, industry, government, tourism, and so forth.
- Determine additional action items.
    - Consult citizens (who bring knowledge) and technical advisory groups (that bring expertise) to support the capacity building (e.g., training) of task force members.
    - Establish a vision-building process.
    - Determine what institutional framework already exists for sustainability for Puerto Rico.
- Be held accountable.
- Ensure adaptability.
- Promote media relations.
- Support participation (e.g., of community groups, mothers with children).
- Consider sector the task force belongs (e.g., academia, government).

The participants discussed potential questions for decision-makers, including a discussion about Puerto Rico Sustainability Law #267, which is the responsibility of nine commissioners housed within the EQB. This law may need to be reviewed and revised. The infrastructure of this law could be used as the basis for the task force.

A participant noted that academia is the only sector remaining in Puerto Rico in which citizens have some trust, although it would be ideal to house the task force within the governor's office. Another participant remarked that if placed within the governor's office, the task force would not receive funding. A previous environmental task force within the office never received a budget, and its members paid their own expenses. Everyone agreed on the need for federal and local financial commitment. Dr. Hopton said that it would be difficult to obtain such a commitment; the more costly the task force, the less likely that it will be established.

A participant noted that a self-sustaining task force would be a challenge to establish and asked what other resources could be used to support the task force. Another participant said there would be a meeting with the Puerto Rico DNER on June 29, 2012. The agencies and sectors present may be able to provide input and knowledge. This should be a starting point. There will be a presentation from the working groups that

have been exploring critical climate change indicators and scenarios, and this will provide the opportunity to explore synergies between the climate change and sustainability efforts. A participant thought the questions should be addressed to a broader audience than decision-makers because multiple disciplines will be involved in the answers.

Questions for Decision-Makers

- Does it make sense to establish a task force?
- Should a committee be appointed to review and revise the Puerto Rico Sustainability Law #267?
- Can the government commit to a task force and make it self-sustaining?
- Is a task force the best way to support and grow this type of collaborative effort?
- Does the government agree with the action items identified for the task force? What other action items should be listed for the task force?
- Who should be represented on the task force?
- Who should take the lead?

Day 3 Wrap-Up

The participants discussed the next steps. Everyone agreed that it is important there be an incentive for decision-makers to participate in the next symposium; media coverage may provide this. The participants identified the following next steps:

- Publish proceedings of the symposium/workshop.
- Solidify collaborations.
- Broaden questions for decision-makers (create an approach).
- Establish a portal for researchers working in Puerto Rico.
- Develop a scientifically sound strategy for sustainable environmental management in Puerto Rico.
- Make easily understood information available for use by decision-makers and the public.
- Ensure that decision-makers and representatives from the business sector are present at the next meeting; media coverage could provide this incentive.

Dr. Hopton closed the meeting by stating there had been an obvious need for this event and the effort to establish a sustainability vision for Puerto Rico. The symposium/workshop was a good first step, and the goal is to involve the appropriate individuals to further the effort, regardless of government support. It is possible to proceed in the right direction, and the fact the governor's office sent a representative is a good sign. Dr. Hopton adjourned the meeting at 2:43 p.m.

Appendix A

Participant List

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Appendix B

Quantifying Sustainability in Puerto Rico – A Scientific Discussion

Matthew E. Hopton and Matthew T. Heberling

Of ce o Research and Deve opmen
National R sk Management Research Laboratory Sus ainable Technology D v s on

June 5, 2012

Objectives

- Discuss issues pertinent to sustainability in PR
- Discover what researchers are currently studying in PR related to sustainability and how that research can affect or help decision makers
- Learn how EPA ORD research goals can be enhanced and applied in collaboration with research described above
- Plan coordinated research program and implementation of activities to move Puerto Rico towards a more sustainable future

Office of Research and Development

- We are a scientific research organization
- Our research may aid decisions or regulations
  - –We provide the science and information to help inform credible decisions
- Our "customers" include
  - –Regions
  - –Program Offices
  - –American public

The Path Forward, circa 2010

- "… important to move ahead with several key elements of the Transformation Initiative – integrated multidisciplinary research, focus on problems of broad national interest, and a closer interaction with our program and regional partners – this alone is not sufficient to elevate our work to the next level if we are to truly address the complex environmental problems of the 21st century."

The True North

- "… the future of ORD includes a recognition that the goal of sustainability is our "true north," that scientific and technological innovation is essential to the success of our mission, that we need to couple our excellence in problem assessment with an equal excellence in solving problems, and that we must act with a sense of urgency."

Sustainability

- "Attaining a society that can meet its needs while preserving the ability of future generations to meet their needs is our primary goal. Our solution to a problem must not only solve the problem at hand, but it also must not create a new problem as a result. As stated earlier, sustainability must be our true north."

Sustainability without a name

- "EPA was not created to deal with the usual mix of social problems whether they be poverty, jobs, housing, education, crime …. In a real sense, EPA's mission transcends all of these. That mission is the preservation of life itself."

Administrator William D. Ruckelshaus
May 18th, 1983

Research Priorities

- Air, Climate, and Energy
- Chemical Safety for Sustainability
- Safe and Sustainable Water Resources
- Sustainable and Healthy Communities
- Homeland Security
- Human Health Risk Assessment

Sustainable and Healthy Communities

- EPA researchers and their partners and stakeholders are working together to form a deeper understanding of the balance between the three pillars of sustainability—environment, society, and economy.
- Their transdisciplinary work will provide the decision tools and data that communities need to make proactive, strategic decisions aimed at a prosperous, more environmentally sustainable future.

Sustainable and Healthy Communities

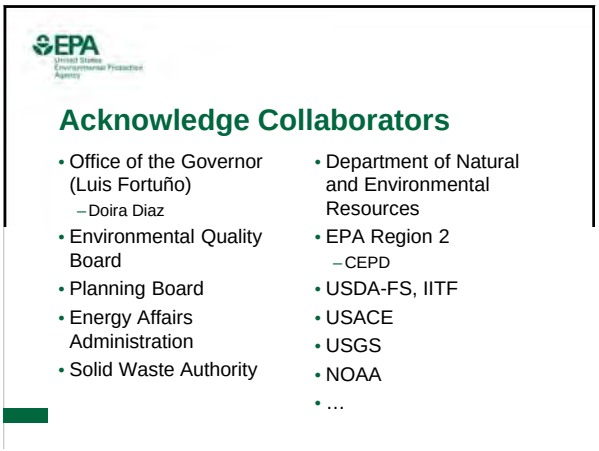
- Three Focus Areas
  1. Develop comprehensive approaches to help communities become more sustainable
  2. Develop decision support tools, models and metrics that can be used to improve sustainable community practices
  3. Meet EPA's regulatory requirements

Research in Puerto Rico

- ~40 team members
  - –Coral reef management in the Guánica Bay watershed (Bill Fisher, Task lead)
  - –Sustainability metrics research

Sustainability Metrics Goals

- Develop decision support tools and data for examining system sustainability
- Identify trends in moving toward or away from sustainability


EPA
Acknowledge Collaborators
• Office of the Governor (Luis Fortuño)
– Doira Diaz
• Environmental Quality Board
• Planning Board
• Energy Affairs Administration
• Solid Waste Authority
• Department of Natural and Environmental Resources
• EPA Region 2
– CEPD
• USDA-FS, IITF
• USACE
• USGS
• NOAA
• …

Appendix C

Puerto Rico Sustainability Metrics Project

Matthew T. Heberling and Matthew E. Hopton

Quantifying Sustainability in Puerto Rico: A Scientific Discussion
San Juan, Puerto Rico

Office of Research and Development
National Risk Management Research Laboratory, Sustainable Technology Division, Sustainable Environments Branch

June 5, 2012

Outline

- Sustainability
- San Luis Basin sustainability project
  - Lessons from the SLB Project
- Puerto Rico sustainability project
- Economic metric results
- Next Steps

1

Sustainability

- "…development that meets the needs of the present without compromising the ability of future generations to meet their own needs." WCED (1987: 43)
- Three pillars: associated economic, social, and supporting environmental systems must work in concert to maintain desired level of functioning (UN 2002)

2

Sustainability

- Very broad, complicated, and challenging; it can lead to different interpretations (Prugh et al. 1999):
  - Political: social justice and equity of wealth distribution
  - Economic: well-being rises over the long term
  - Ecological: conservation of ecosystem processes
  - Engineer: efficiency of energy and material use
- A collaborative, interdisciplinary approach is necessary
  - Ecologists, Economists, Engineers, Geographers, Policy and law, Outreach specialists
- A single metric or index will not capture everything

3

Motivation

- Federal government must integrate economic, social and environmental policies to achieve sustainability
- Therefore, EPA and its partners
  - "will develop integrating decision support tools… and supporting data and analysis that will guide decision makers toward environmental sustainability and sustainable development."
- Our hope is for local decision makers to use these tools and analysis as a part of future environmental management decisions.

4

Goal

- Produce a straightforward, inexpensive methodology
  - Used to measure and monitor the prosperity and environmental quality of a regional system
- Pilot tested approach in San Luis Basin (SLB), Colorado

5

Our sustainability definition

- Economic, social, and supporting environmental systems must work in concert to maintain a desired level of functioning
  - Must persist "indefinitely"
- Any single component not "sustainable" means the system is not "sustainable"

6

Metrics versus indicators

- Indicator – measures one characteristic of a system (Mayer 2008)
  - CO_2 emissions
  - Biological diversity
- Metric – combines many indicators through aggregation to measure sustainability
  - Ecological footprint
- We emphasize metrics over indicators to capture/quantify system dynamics
  - Indicators have value

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Metric response

- Some metrics can identify a system as sustainable
  - We thought it more informative to identify where a system is heading
- Sustainability is a moving target
  - What is considered sustainable today may not be tomorrow
- Identify trends through time
  - Do not focus on absolute values
  - Identify direction system is moving

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Metrics of Sustainability

- Multidimensional problem requires multiple metrics
  - Consumption of resources by humans impacts environment
    - Ecological Footprint Analysis (EFA)
  - Sustainability is anthropocentric and human well-being can influence environmental interest
    - Green Net Regional Product (GNRP)
  - Energy is required to maintain system order and function
    - Emergy Analysis (EmA)
  - Systems have an inherent order
    - Fisher Information (FI)

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Recommendations from SLB

1. Examine past decisions and how the metrics changed
2. Continue calculating the metrics for subsequent years
3. Determine if other metrics may better assess sustainability
4. Develop trend analyses and/or approaches for estimating confidence intervals
5. Develop models of alternative future scenarios
6. Test these multiple metrics in other regions
7. Examine correlation among metrics to determine whether certain metrics could be dropped
8. Consider use of other scientific approaches for holistic results

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Lessons learned

- Involve stakeholders early
- Involve decision makers early
  - Include tools that address specific issues
- No "one-size fits all" metric
  - Tailor the tools to fit the region

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Puerto Rico Sustainability Metrics Project

- Antipodal case study compared to San Luis Basin
- Knowledge gained from the SLB Project informs Puerto Rico Project.
  - More interactive process to identify issues and additional indicators that address specific policy needs
  - Develop approach for using metrics as decision support
- **Outcomes for 2012**:
  - 2012 Scientific Symposium/Workshop
    - Identify and collaborate with researchers working on sustainability issues in Puerto Rico
    - Organize efforts to holistically address those issues and extend beyond USEPA expertise

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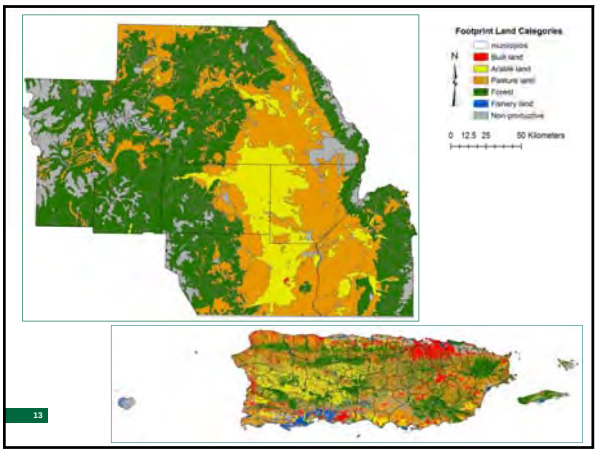

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Process for metric research

- Formalized (based on GEMI *The Metrics Navigator*)
  - Knowledge of the system: Issues, goals, and decision makers
    - Encourage collaboration and public participation
  - Choose relevant metrics that match knowledge
  - Determine data availability for each metric: Collect and create data
  - Calculate metrics and interpret, evaluate results
  - Communicate to public and decision makers
  - Publish publicly-available and easily understood report for use by decision makers and public

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Four metrics as a starting point

- Propose 4 metrics from SLB
  - Four metrics are still relevant
    - Basic knowledge of environmental systems
    - Solid, well-established metrics
    - Peer-reviewed methodology
    - Test methodology in industrialized region
- Make methodology more useful to decision makers
  - Incorporate or supplement with indicators that capture issues of known importance

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Objectives

1. Determine applicability of using existing datasets to estimate metrics at a regional scale
2. Calculate metrics through time (1960-present)
3. Compare and contrast results to determine if region is moving toward or away from sustainability

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Ecological Footprint Analysis (EFA)

- Captures the supply and demand of biologically productive land
  - EF Balance = (supply) – (demand)
- Simplified methodology
  - 35 versus ~150 variables

- USEPA Lead: Matthew Hopton (hopton.matthew@epa.gov)

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Green Net National Product (GNNP)

- Captures the welfare of the system
  - GNNP = (real value of consumption) + (real value of net investments)
    - Net investment includes the stocks of environmental resources, man-made, and foreign capital
      - e.g., solid waste, air pollution, mangroves, value of time

Environmental Justice

- Measures pollution distribution to determine if environmental inequality exists

- USEPA Leads: Matthew Heberling (heberling.matt@epa.gov) and Shanshan Wu (wu.shanshan@epa.gov)

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Emergy Analysis (EmA)

- Energy memory or embodied energy
- Captures the flow of energy through the system
  - sum of all kinds of available energy used up, directly and indirectly, to make an item, solar emjoules (Odum 1996)
- Two indices:
  - Total emergy used
  - Fraction of renewable to total emergy
- Data collection ongoing

- USEPA Lead: Cissy Ma (ma.cissy@epa.gov)

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Fisher Information (FI)

- Well functioning systems exist in well ordered dynamic regimes where dynamic order does not change with time
  - Captures the dynamic changes in the condition of a system
- Uses data that characterize the state of system
  - Production, consumption, environmental, etc.

- USEPA Leads: Heriberto Cabezas (cabezas.heriberto@epa.gov) and Leisha Vance (Vance.Leisha@epa.gov)

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Criteria (away from sustainability)

- Measures of strong sustainability
  - EFA – ecological balance decreasing
  - EmA – fraction of renewable to total emergy moving away from 1
- Measures of weak sustainability
  - FI – steadily decreasing over time
  - GNNP – decreasing through time

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Differing systems

- Ecological Footprint
  - Different consumption patterns, land use, population
- GNNP
  - Different components of natural capital depreciation
- Emergy
  - Different goods, services, and energy uses
- Fisher Information
  - Depends on time series data, specific to the system under study

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Stakeholder meeting December 2009

- Met with stakeholders and decision makers to identify issues

- US EPA Region 2, CEPD
- NOAA-NWS
- NOAA-CFMC
- USDA-FS
- USGS
- USACE
- Office of the Governor
- Planning Board
- Environmental Quality Board
- Energy Affairs Administration
- Solid Waste Authority
- Department of Natural and Environmental Resources
- University Researchers

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Relevant questions for stakeholders

- What issues matter to Puerto Rico and sustainability?
  - Shiels et al. 2008
    - Soil erosion
    - Mass-wasting process (slope movement)
  - Martinuzzi et al. 2009
    - Land/habitat loss/transformation
    - population growth/density

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Relevant questions for stakeholders

- What issues matter to Puerto Rico and sustainability?
  - Ault et al. 2008
    - Coral reef fisheries
  - Caribbean Water Science Center Science Plan 1999
    - Water quantity (and quality)

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Important issues

- Our list
  - Soil erosion / mass wasting
  - Habitat loss
  - Land use
  - Population growth
  - Coral reef / fisheries
  - Water quality
  - Water quantity
- Stakeholder list
  - Soil erosion / mass wasting
  - Habitat loss
  - Land use
  - Population growth
  - Coral reef / fisheries
  - Water quality
  - Water quantity
  - Invasive species
  - Trash / solid waste
  - Energy use
  - Air quality

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Relevant questions for stakeholders

- Who are the relevant decision-makers for island metrics?
- What current research activities are planned or ongoing at government agencies or universities related to sustainability metrics or decision support?
  - Avoid duplication of ongoing efforts
  - Supplement local efforts
    - Coordinate to make cohesive effort for sustainability
    - Review literature
    - Symposium/workshop brings researchers together

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Relevant questions for stakeholders

- What are the data needs?
  - What data are available?
    - Time period and frequency
    - Resolution
      - Municipios
      - Puerto Rico
  - Who are the best people to talk about data and availability?

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Current Status

- Data collection and preliminary calculations are wrapping up
- Identifying collaborations to broaden the research effort and supplement the core metrics
  - Stakeholder list not addressed: Soil erosion/mass wasting, habitat loss, coral reef/fisheries, water quantity, invasive species

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Economic metric of sustainability

- Economists: Will utility (satisfaction) of future generations be lower than current generation?
  - Define sustainability as non-decreasing utility (future utility does not decrease below current level)
  - Consumption including all commodities (market, environmental, home produced, etc.) and amenities influences utility

30

GDP/GNP

- Measures market transactions
  - Market prices for aggregate value of economy's output
  - Never intended to measure welfare (function of utility)
  - Ignores
    - Leisure
    - Taking care of ones own kids, housework, etc.
    - Nature's contribution to welfare
  - Need to account for the loss of value of capital (i.e., depreciation)
    - Capital: physical assets that are used in association with labor and other inputs to produce goods and services

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Augmented GNNP

- Captures the welfare of the system (Pezzey et al. 2006; Mota et al. 2010)
  - Augmented because time is included as a stock that causes changes in production (exogenous technological change)

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Augmented GNNP

$$GNNP^{w}(t) = NNP(t) - \mathbf{e}\mathbf{E} + bM - J + (Q^{R} - f_{R})\dot{S} + Q^{t}$$

- Net National Product: GNP has been adjusted for the depreciation of physical capital (e.g., machinery)
- eE is the damage cost of emissions
- bM-J is net benefit from mangroves
- $(Q^{R} - f_{R})\dot{S}$ is value of rents from crushed stone depletion
- Value of time, Q^{t}

- Pezzey (2004) developed one-sided test of unsustainability

$$\dot{GNNP}^{w}(t) \leq 0$$

  - Interpret as decreasing utility in the future
  - Cannot say whether economy is sustainable

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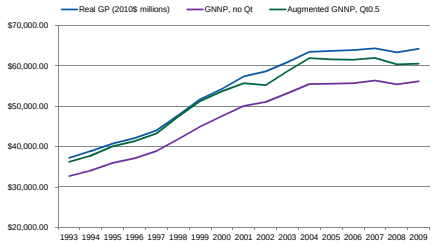
Preliminary Estimate of GNNP (1993-2009)



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Next Steps

- Proceedings identifying existing research and potential collaborations
- Written protocol for identifying and calculating the metrics in Puerto Rico
- Scientifically-sound strategy for sustainable environmental management in Puerto Rico
- Journal articles presenting the metrics and results

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Appendix D

Legacies of Socio-economic Transitions on the Structure and Function of a Tropical Drainage Basin: Resilience and Sustainability Implications

Carla Restrepo[1]
Johanna Colon[1]
Jenitza Melendez[1]
Jan Sendzimir[2]

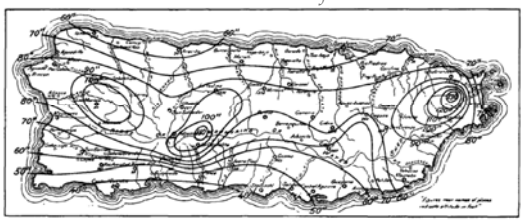
Department of Biology, UPR-RP[1]
IIASA[2]




The Beginning of a Beginning

Fassing 1909

Porto Rico mean annual rainfall 1899-1909



The Beginning of a Beginning

Alexander 1902

As above intimated, there exist in Porto Rico some interesting and seemingly valuable waterfalls. Among the best known and perhaps the most important, we may mention the following, viz;

Salto de Rio de La Plata, near Comerio; Salto Rio Blanco, Salto Morones, in Arecibo River, near Utuado; Salto Maldonado, in Arecibo River; Salto Sanches, in Arecibo River; Salto Palmieri, in Arecibo river; and Salto Paso Palma, in Yayuya.

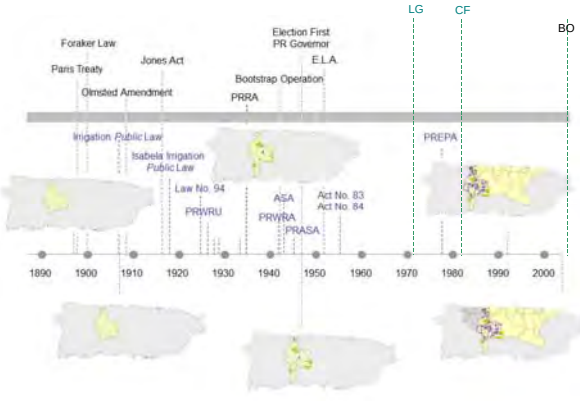
A franchise has just been granted for the development of the first-mentioned fall, the object being to utilize its power to operate a railroad from Catano to Ponce. Promoters are also investigating some of the other falls with a view to their development for electrical plants and other purposes. We hope soon to be able to present some details as to the size of the above-mentioned falls, their available power, and other information relative there to of value to engineers and agriculturalists.

The Beginning of a Beginning

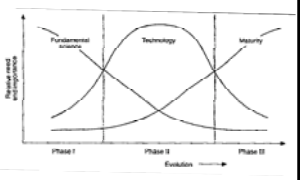
Fassing 1909

The rainfall of the north side of the island differs from that of the south side not only in being greater in quantity but also in being more certain to fall in amounts sufficient for all the needs of plant growth at all seasons of the year. On the south side periods of **4** or ***5*** weeks with little or no rain are of frequent occurrence, while periods of 2 to 3 months with less than an inch of rainfall are not uncommon.

The scheme of irrigation now being provided for along the south coast will, in great measure remedy the evils of an irregular and insufficient rainfall. In the mountains, but a few miles distant, there is an abundant water supply, available at all seasons of the year, which can be carried to the cane fields at comparatively small cost. At the present time it is costing the planters from $25 to $50 per acre per year to pump ground water for irrigating their cane fields.



- Water multiple uses
- Water a valuable resource
- Water a resource that can be moved around by means of technology / infrastructure development
- Water a commodity that connects people far away

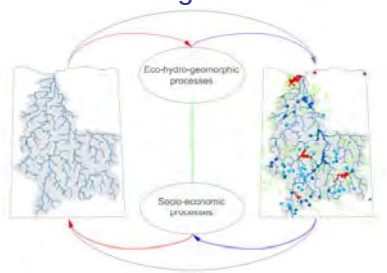


Society ⟷ Infrastructure ⟷ Environment

http://www.emeraldinsight.com/journals.htm?articleid=842885&show=html

- The Beginning of a Beginning
- Sustainability of a Tropical Drainage Basin
- Conclusions

Sustainability of a Tropical Drainage Basin



Stream network SN_0
Water quality WQl_0
Water quantity WQt_0

Stream network SN_1
Water quality WQl_1
Water quantity WQt_1

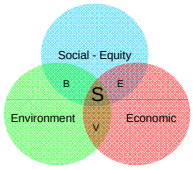
Sustainability

- Population and Human Resources
- Human settlements (urban)

- Food security
- Species and ecosystems

- Energy
- Industry (material; commodities)

EEE's

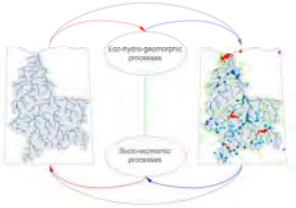


- Aesthetics
- Ethics

Sustainable development, development that meets the needs of the present without compromising the ability of future generations to meet their own needs

Resilience

- Water withdrawal for consumption, irrigation, and industrial processes
- Water for waste dilution
- Water management to gain land and/or prevent flooding



$SN_0 \neq SN_1$
$WQl_0 \neq WQl_1$
$WQt_0 \neq WQt_1$

Ecological resilience is the amount of disturbance a system can absorb without changing its state or structure and function

Questions

- What are the relationships between stream and infrastructure networks and patterns of human occupation in the Rio Grande de Arecibo Watershed (RGAW)
- How do socioeconomic conditions and water quality indicators vary across the RGAW?
- Is there a relationship between socioeconomic and water quality variables?

Regime shifts in socioeconomic and water quality variables in the Rio Grande de Arecibo Watershed (RGAW)

Rio Grande de Arecibo Watershed

- Municipalities of Arecibo, Utuado, Jayuya, and Adjuntas
- 33,170 ha
- 188 people km^{-2}

Puerto Rico's "Superaqueduct"

Methods

- Historic data
  - Infrastructure
  - Population size
- Water quality (USGS, PRQB, PRHD)
  - Nitrogen
  - Phosphorus
  - Total coliforms
  - Fecal coliforms
- Socioeconomic (US Census Bureau)
  - Population
  - Housing
  - Income
  - Literacy

SS

LS

Methods

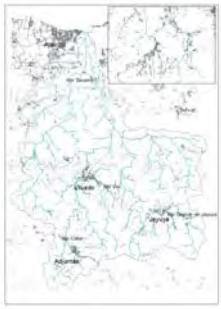
- Ordination techniques to
  - Reduce data dimensionality
  - Create socioeconomic and water quality indices

	Density (people km^{-2})	Housing 1	Income 1
Factor	200	1110	25,000
Arrozal	105	1800	28,000
Hato Arriba	115	1115	24,500
Hato Abajo	130	1005	23,000

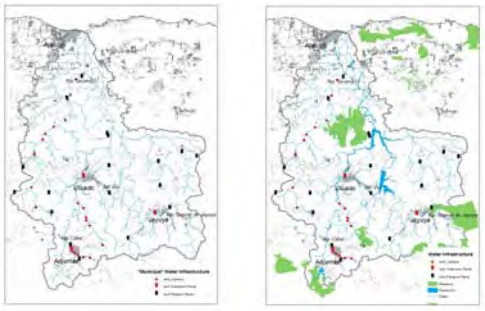
- Examine relationships between socioeconomic and water quality at sub watershed scales

	PC 1	PC2
Factor	0.1	-0.2
Arrozal	-0.2	0.3
Hato Arriba	0.3	0.1
Hato Abajo	0.4	-0.5

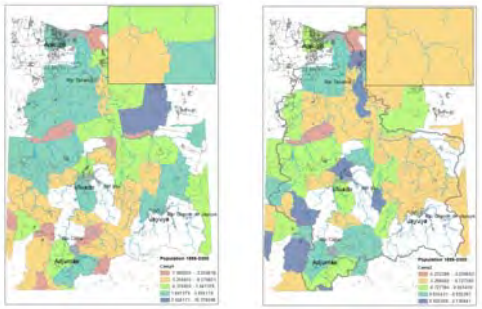
Stream Network and Human Occupation



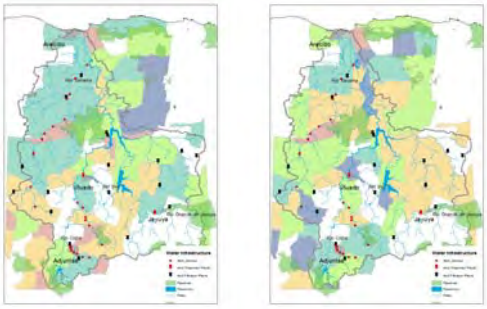
Public Infrastructure Network and Human Occupation



Stream Network and Population Dynamics



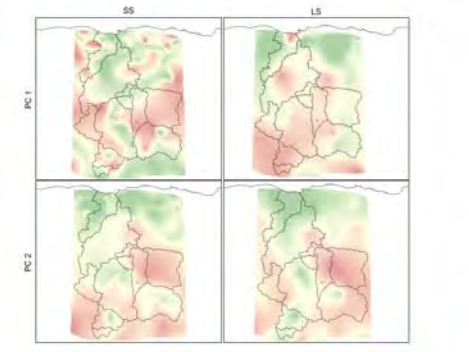
Public Infrastructure and Population Dynamics



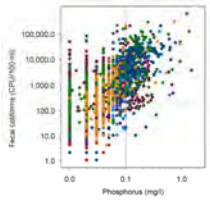
Ordination socio-economic data

	SS		LS	
	PC 1	PC 2	PC 1	PC 2
Density				0.33
Median Age				0.32
Urban		0.31	0.31	
Rural		-0.30		-0.34
Occupied	0.37		0.34	
Median Year Built Structure				-0.30
No Plumbing				
Unemployed	0.31		0.28	
Social Security	0.30		0.32	
Public Assistance	0.30			
Salary Income		0.33		
Self-employment Income				
Social Security Income		0.27		0.36
Public Assistance Income		-0.29		
Retirement Income				
Other Income				
No School				
Elemental School	0.31		0.26	
Intermediate School	0.32		0.29	
High School	0.33		0.31	
College 1		0.35	0.30	
College 2		0.37		

Ordination socio-economic data



Ordination water quality data

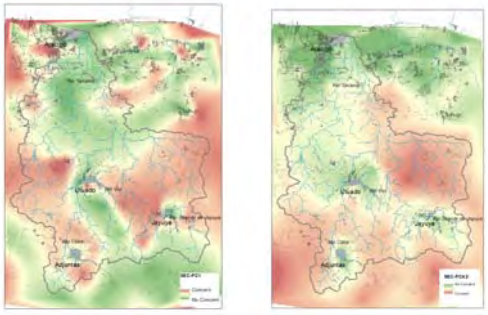


	PC 1	PC 2
Nitrogen	0.31	-0.76
Phosphorous	0.42	-0.43
Total Coliform	0.50	0.28
Fecal Coliform	0.51	0.26
Fecal Streptococcis	0.47	0.30

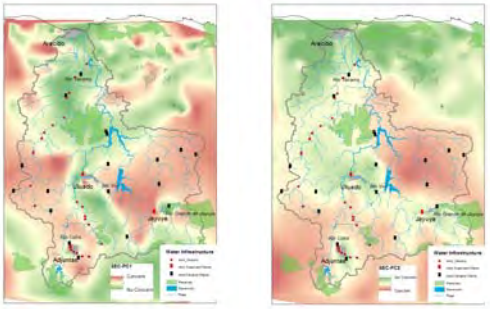
Ordination water quality data

	SS		LS	
	SE PC1	SE PC 2	SE PC 1	SE PC 2
WQ PC 1	0.098	0.511	0.290	0.110
WQ PC 2	0.494	0.104	0.225	-0.058

Stream Network and Socioeconomic Indices



Public Infrastructure Network and Socioeconomic Indices



- The Beginning of a Beginning
- Sustainability of a Tropical Drainage Basin
- Conclusions

Conclusions

- Stream networks are key elements in the organization of human settlements
- Public infrastructure networks have impacted human populations
- Socio-economic indices are spatially heterogeneous and may suggest regime shifts
- Socio-economic and water quality indices were correlated in one instance
- Areas of socio-economic concern seem to be associated with areas where public infrastructure projects have been develop

Acknowledgements

- Programa de Ciencias Ambientales UPR-RP
- Sr. Ángel Meléndez (PREQB)
- Sra. Rosa Vázquez (PREQB)
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- Sra. Amarilis Rodríguez (PWSSP)
- Mr. Senen Guzman (USGS)
- Sra. Marta Rivera (AAA)
- DEGI
- Jose Juan Terrasa

Appendix E

Resident Perceptions and Valuation of Green Areas and Riverbank Hypothetical Improvements in a Tropical Urban Watershed

Luis Santiago, Julio Verdejo and Raúl Santiago

EPA Quantifying Sustainability in PR Symposium, San Juan, PR
June 5, 2012

Our Interdisciplinary Research Team

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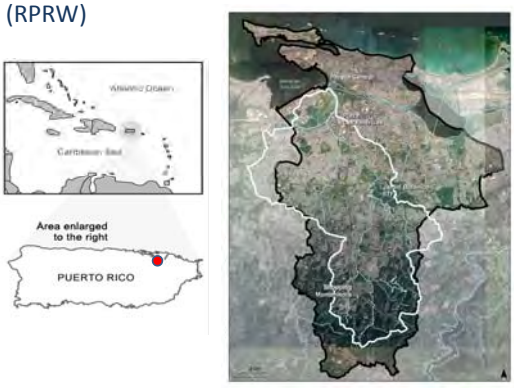
Luis Villanueva, Department of Environmental Sciences, UPR
Elvia Meléndez, Professor, Department of Environmental Sciences, UPR
Diana García, Department of Environmental Sciences, UPR
Ariel E. Lugo, PI, International Institute of Tropical Forestry, US Forest Service

Intensive Studies: Research Questions

The following presentation will discuss:

- An understanding of the perceptions of residents towards green areas and bodies of water
- An estimation of the valuation attributed by residents to green areas and bodies of water

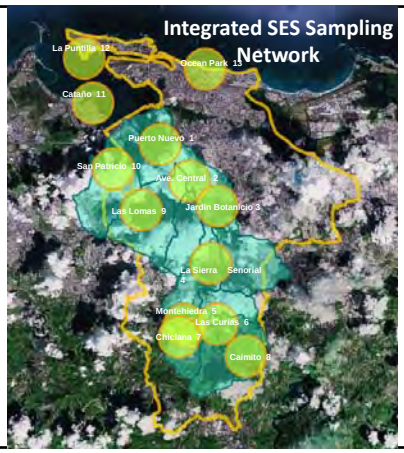
San Juan and the Río Piedras River Watershed (RPRW)

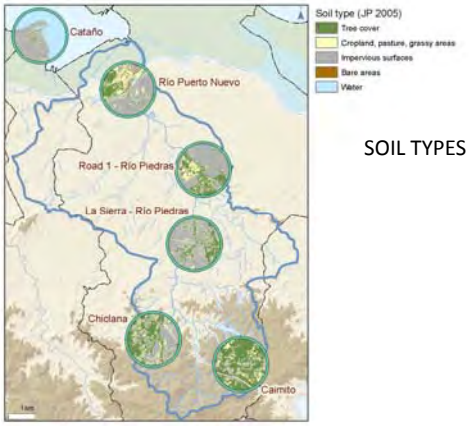


- A watershed where more water flows through potable water and sewer pipes than its rivers and tributaries.

Map: Raúl Santiago

Urban System Change and Social-Ecological Vulnerabilities



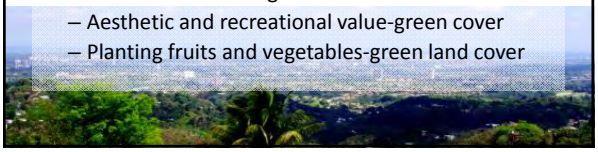


SOIL TYPES

STREETS AND ROADS

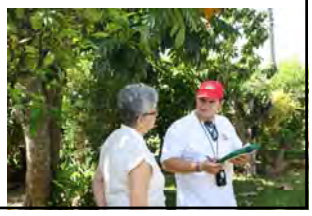
Green Infrastructure and Ecosystem Services

- The contribution of green infrastructure to the socio-ecological system:
  - Flood control – soil permeability
  - Temperature regulation – green cover
  - Pollution control-green cover
  - Soil conservation – green cover
  - Aesthetic and recreational value-green cover
  - Planting fruits and vegetables-green land cover



Sampling: In-Person Interviews

- 441 in-person interviews
  - 30 students participated in the sampling efforts
- Sampling period: January to August, 2011
- Interview Duration: 20 minutes
- Representative sample
  - Stratified and convenience sample (Seguinot and Hernández, unpublished)



Sampling: Housing Sales Data

- 2005-2009 housing sales data was obtained from a local real estate firm (Luis Abreu & Associates)
- Property addresses (number, street names and zip codes) were used to geocode the geo-referenced points of housing sales.
- We defined a viewshed representing visible green areas from a property
- We also estimated residential housing distance to public green areas, rivers, streams and shopping malls.

Resident Perceptions: Relationship with the River

Progressive isolation from the river due to human intervention, such as channelization

- Residents who visited the river are, on average, older than those who have not visited it
  - Average Ages: 54.0 vs. 48.7
- Two out of every three residents who know the river's location have never visited the river

Resident Perceptions: Preference for Trees

There seems to be a gap between a stated preference for trees in properties and the reduction in public and private green areas in the watershed

- Groups who stated preference for trees in their property:
  - **87%** of men
  - 73% of women
  - 85% of residents in single housing units
  - 91% of residents in apartments
  - 83% of property owners
  - 92% of those renting housing units
- However, 76% of residents who identified trees in their property as a problem, do not recognize them as a problem in their neighborhood

Estimation of Green Area Valuation

- Hedonic Valuation of
  - Access to public parks
  - Views of green areas from residences
- Contingent valuation of riverbank restoration

The Hedonic Method and Factors that Influence the Sales Price

The Hedonic method is an "indirect" valuation method in which we do not observe the value consumers have for the characteristics directly, but infer it from observable market transactions (Champ, Boyle & Brown **2003)**

Factors considered (directly or indirectly) when purchasing a home

- Physical characteristics
- Its distance to other amenities

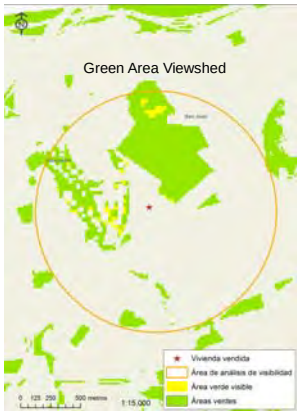
Hedonic Method: Linear regression

Dependent Variable:

- Housing purchase price

Independent variables:

- Physical housing characteristics
- Socioeconomic data
- Distance to
  - rivers and streams
  - shopping centers with more than 46,450 m^2 of retail space
  - public green areas greater than 3,930 m^2
- Visible green areas from a housing unit



Preliminary Results

- There is no statistically significant relationship between the purchase price of properties and **distance to large public** urban green areas within the Rio Piedras watershed.
- We found a positive and statistically significant relationship between green area visibility and property purchase price.

Contingent Valuation Method of Watershed Restoration Efforts

- A Contingent valuation exercise of stream and riparian environmental services was conducted with the intent of assessing feasibility of a voluntary contribution (WTP) for collaborative management funding.

Contingent Valuation Method: Comparison of Scenarios

Contingent Valuation Method Results

- None of the variables explaining resident connection to nearest stream were statistically significant.
- Median WTP was estimated at $155.48 per household per year.
- Expected median revenue is $4.8 million per year.

Beyond San Juan ULTRA-**EX**: In-Depth Work

- Continue characterization of green areas and bodies of water in the watershed
- Identify sustainability indicators in consultation with stakeholders.
- Quantify and value important ecosystem services in the watershed

www.sanjuanultra.com

Acknowledgements

University of Puerto Rico

National Science Foundation

US Forest Service, International Institute of Tropical Forestry

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Appendix F

Green Area Loss in San Juan's Suburban Neighborhoods:
Estimation Methods, Environmental Consequences, and Preliminary Identification of Precipitating Factors and Processes

san juan ULTRA

Luis Enrique Ramos, Luis Villanueva and Luis Santiago
EPA Quantifying Sustainability in PR Symposium.
San Juan, PR - June 5, 2012

Why study suburban green areas?

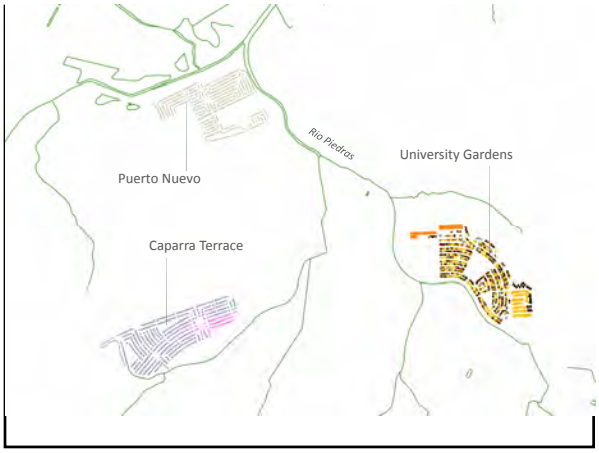
- Urban and suburban private and public residential green areas are considered beneficial for the natural environment and for society's well-being.
- These provide significant health, economic, and ecological benefits (James et al. 2009).
- **Their continuous detriment and/or loss are considered** problematic.
- Suburban residential areas constitute the majority of San Juan's metropolitan footprint.
- Green areas are an intrinsic element of the suburban landscape; their loss represents the erosion of an utopian vision that sought a healthier and closer relationship between man and nature.

Research

- Socioeconomic, physical/spatial, and land-use trends, as well as technological and regulatory characteristics, as they evolve in time, are documented and analyzed.
- The study also attempts to quantify the loss of environmental services and seeks to identify the socioeconomic and technological factors and processes associated with suburban green area loss.

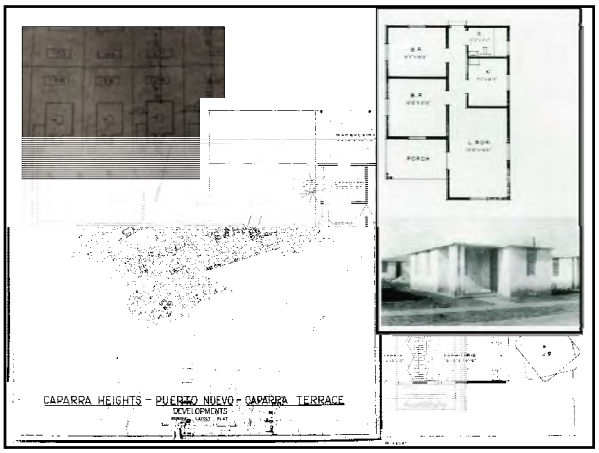
Objectives

- Design and apply methodologies for suburban green area loss/gain estimation.
- Use of quantitative and qualitative techniques for socio-ecological analysis.
- **Understand the link between socio-economic** trends, technological conditions, and cultural/legal factors that influence green/grey area dynamics in suburban neighborhoods.
- Expand the discussion on Neighborhood Decline Cycle Theory by incorporating explicit environmental issues.



Methodology 1
Green Area Loss Quantification

- Original green/gray area scenario is reconstructed in digital AutoCAD format for each neighborhood. Historic aerial and ground level photographs, architectural plans, site plan, and cadastral maps among other sources were used to define initial residential structures footprint.
- **Tabulated buildings footprint area from the year of construction for** each neighborhood is subtracted from year 2008 updated buildings footprint area from San Juan's cadastral map GIS data system.
- The difference constitutes a proxy for green area loss due to increase in building footprint. Since this methodology does not accounts for green area loss due to paving, street planting strip loss, or swimming pool construction, it constitutes a minimum threshold for green area loss in the neighborhood.



Methodology 2

Green Cover Loss Quantification (in process)

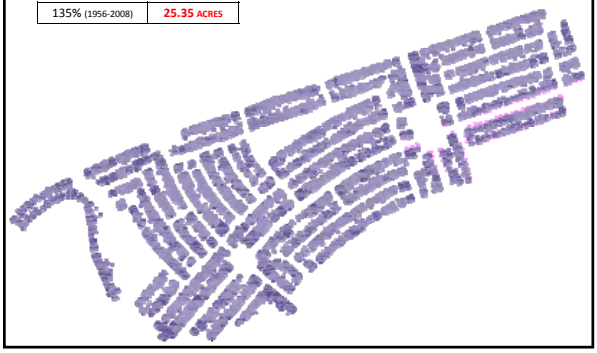
- Year 2010 infrared orthorectified aerial imagery for each neighborhood is compared to orthorectified historical aerial photographs close to the year of construction for each neighborhood.
- **Change in green area coverage is quantified.**

Puerto Nuevo

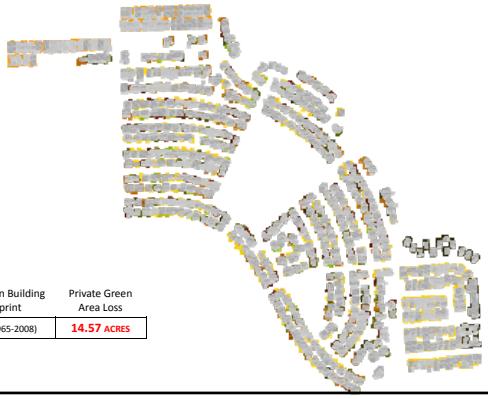
Increase in Building Footprint	Private Green Area Loss
209% (1948-2008)	25.83 ACRES

Caparra Terrace

Increase in Building Footprint	Private Green Area Loss
135% (1956-2008)	25.35 ACRES

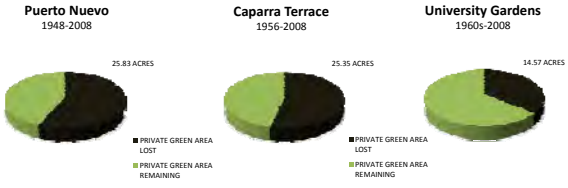


University Gardens



Increase in Building Footprint	Private Green Area Loss
63% (1965-2008)	14.57 ACRES

Private Residential Green Area Loss Ratios



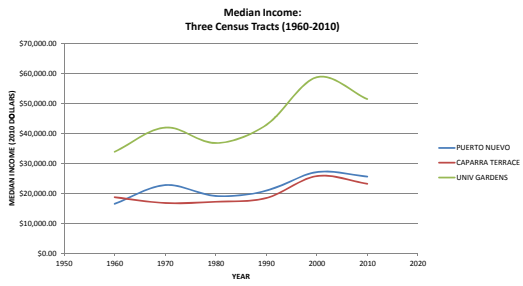
Environmental Services Affected by Suburban Green Area Loss

- Augmentation of Heat Island Effect
- Waterproofing of ground surface and obstruction of groundwater hydrologic cycle
- Increase of storm water runoff and increase in sedimentation in governing body of water
- Diminished carbon absorption capacity
- Degraded aesthetic qualities and hindrance of suburban landscape functionality and benefits
- Loss of habitat for both local and foreign flora and fauna species (Biodiversity)
- Loss of noise absorption capacity
- Loss of spiritual/psychological well-being (Biophilia)

Socioeconomics

- In addition socio-economic and housing data was compiled using US Censuses for the years 1960, 1970, 1980, 1990, 2000 and 2010 for each neighborhood.

GRAPHS



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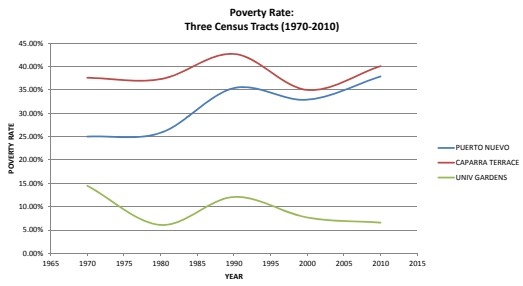

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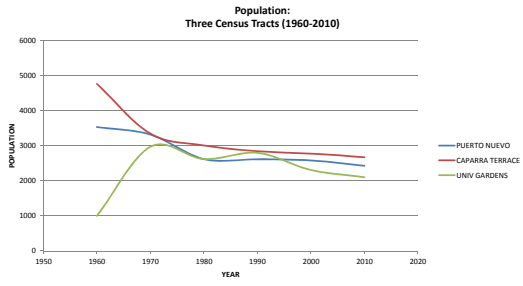

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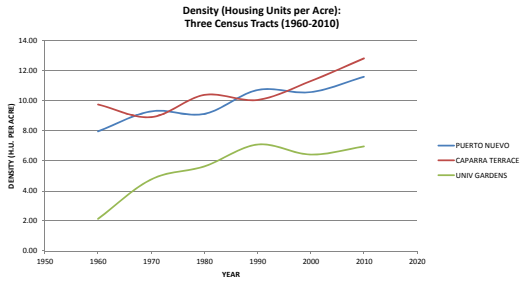

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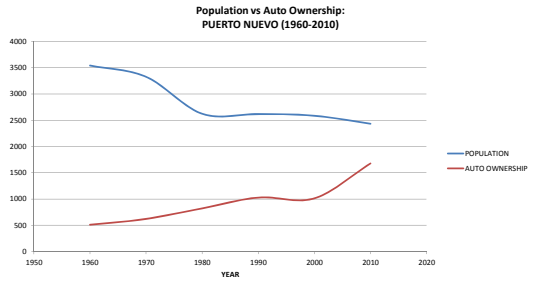

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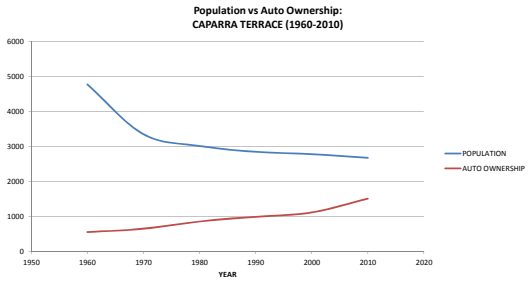

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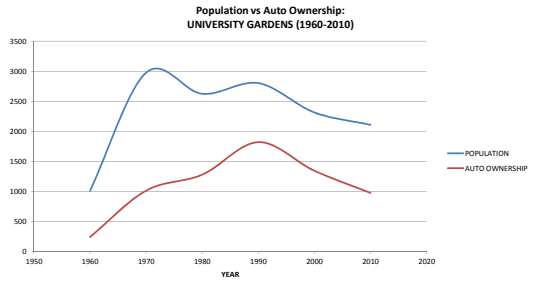
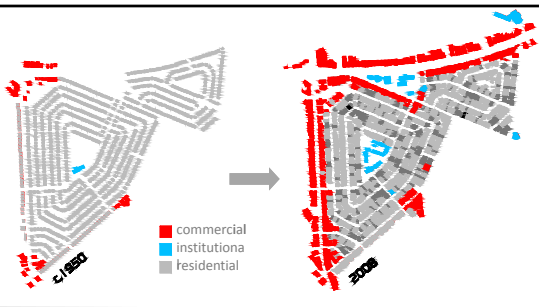


Preliminary Findings

- Loss of green areas has occurred in all three private residential areas, with the exception of most condominium properties.
- In older working-class neighborhoods green area loss is significantly larger.
- Endogenous and exogenous factors have also been associated with green area loss in residential areas:
  1. **Residential-to-commercial land-use conversion along suburban arterial avenues**; rapid economic growth and development in San Juan during mid-twentieth century contributed in fostering a burgeoning tertiary sector of the economy that accommodated along these busy corridors.
  2. **Increase in automobile ownership; as result, ample planting strips and residential patios** rapidly succumbed to driveway and carport constructions, on-street and sidewalk parking. Communities originally geared for working class families, with smaller lot size and narrower local streets, were especially vulnerable to green area loss due to the emergent transportation technology.
  3. **Increase in low-rent housing units and density**; as result, an increase in building footprint. Population succession, higher rental percentage, lower income levels, absentee owners, and higher poverty ratios in the older inner-ring neighborhoods indicate trends associated with neighborhood decline cycle.
  4. **Cultural preferences** also explain part of the explanatory variables associated to building footprint increase: new balconies, larger kitchens, larger bedrooms, new walk-in closets, personal libraries, architectural facades/gestures are some of the alterations to original structures observed on each neighborhood.



Typical hyper-commercialized arterial avenue

Typical local internal residential street

Preliminary Findings

- The environmental and socio-economic trends identified by this study in older inner-ring neighborhoods present an unsustainable process of neighborhood decline with negative consequences to the local and surrounding socio-ecological system.
- From a public policy standpoint, these areas need to be addressed by government in a proactive and comprehensive way as they represent substantial areas of the **built environment in San Juan City and the Rio Piedras watershed**.
- The strategic central location of older inner-ring suburbs within the metropolitan area, their adjacency to the main arterial avenues and transport networks, their proximity to central commercial/work/institutional destinations, their inherent and latent urban design attributes (Ramos 2008), and the current decelerating real estate valuation not only reveals the socio-economic underperformance of these neighborhoods, but also the opportunity and their potential for evolving into more sustainable human settlements through simultaneous physical redevelopment and socio-economic revitalization **programs in which lost green areas and environmental services can be recuperated**.

Beyond San Juan ULTRA-**EX**: In-Depth Work

- Increase the sampling of neighborhoods with diverse socioeconomic and morphological-typological characteristics so as to conduct **statistically significant studies**.
- Quantify loss of environmental services due to suburban green area loss.
- Perform statistical regression analysis between socioeconomic variables and green area loss ratios.

Acknowledgements

- National Science Foundation
- US Forest Service, International Institute of Tropical Forestry
- Fundación Puertorriqueña de Conservación
- University of Puerto Rico
- Municipio de San Juan
- Centro de Recaudacion de Ingresos Municipales (CRIM)
- Centro Para Puerto Rico, Fundación Sila M. Calderón
- IGERT, Universidad de Puerto Rico
- US Geological Survey
- Archivo General de Puerto Rico (AGPR)
- Archivo de Arquitectura y Construccion de Puerto Rico (AACPR)

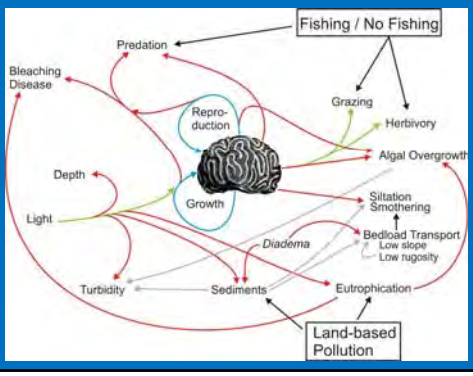
Appendix G

Integrated Management As an Essential Component of Sustaining Coral Reefs and Associated Fisheries

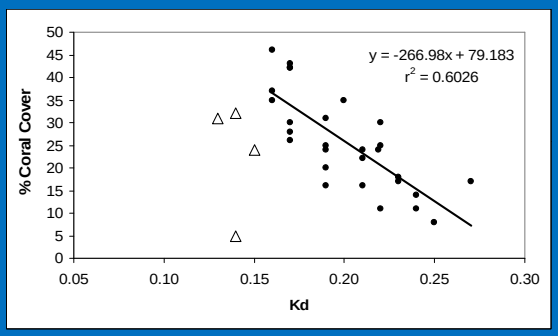
Richard S. Appeldoorn

Department of Marine Sciences
University of Puerto Rico - Mayaguez

Coral reef ecosystems are complex, nonlinear socio-economic systems

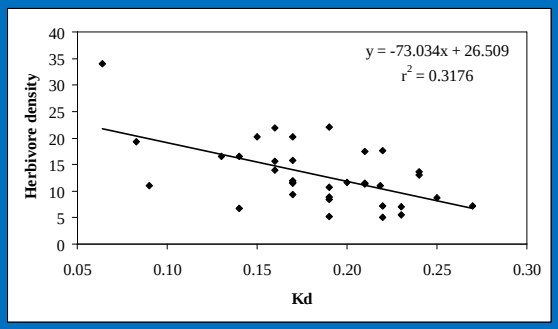


Coral Cover Declines with Turbidity



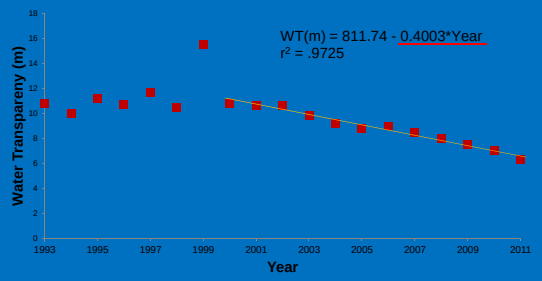
Source: Bejarano and Appeldoorn, in review

Overall Fish and Herbivore Abundance Decline with Turbidity



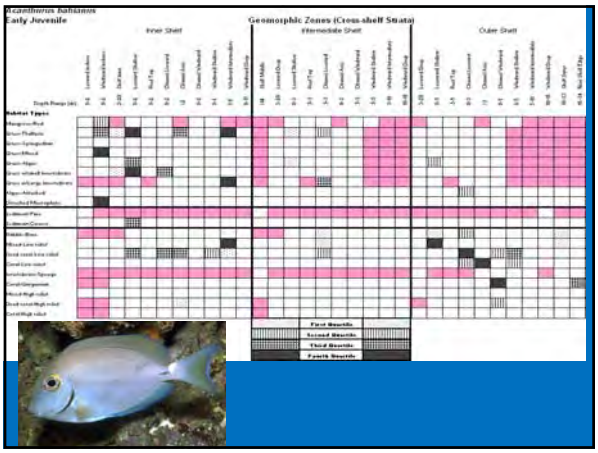
Source: Bejarano and Appeldoorn, in review

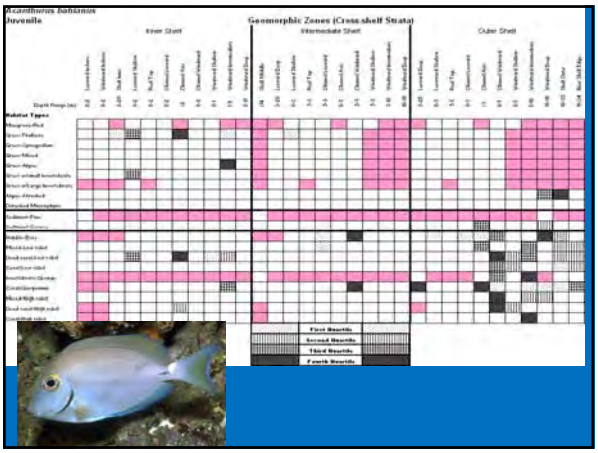
Trends in Turbidity



Source: CARICOMP data – E. Weil – Department of Marine Sciences, UPRM

Connectivity Across the Seascape Enhances Productivity


Acanthurus bahianus
Early Juvenile
Geomorphic Zones (Cross-shelf Strata)
Inner Shelf
Intermediate Shelf
Outer Shelf
First Quartile
Second Quartile
Third Quartile
Fourth Quartile


Acanthurus bahianus
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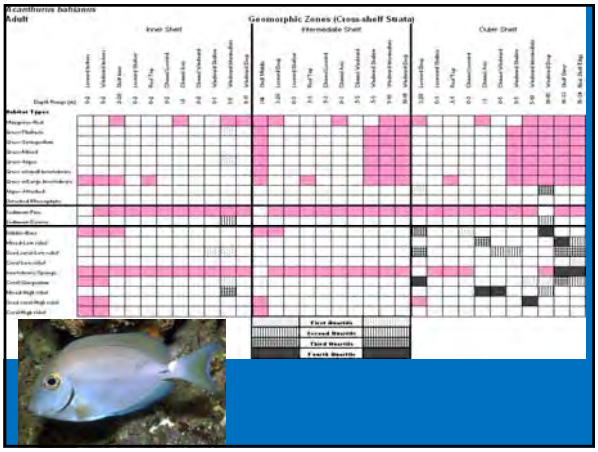
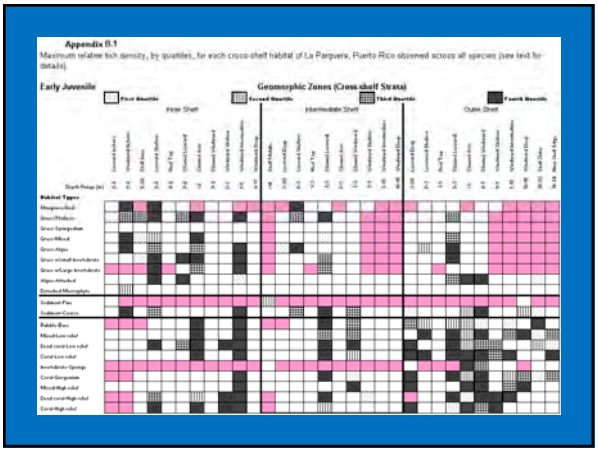
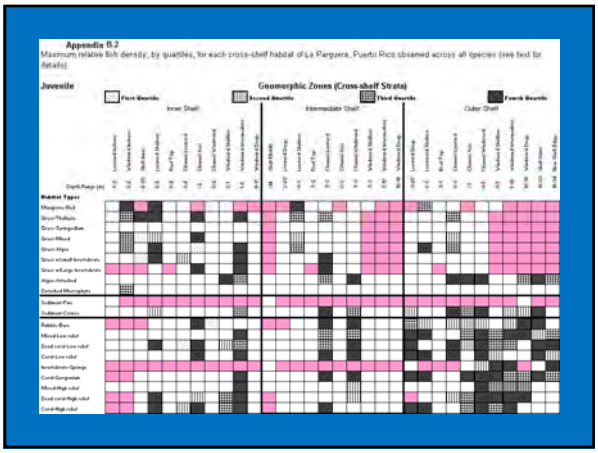
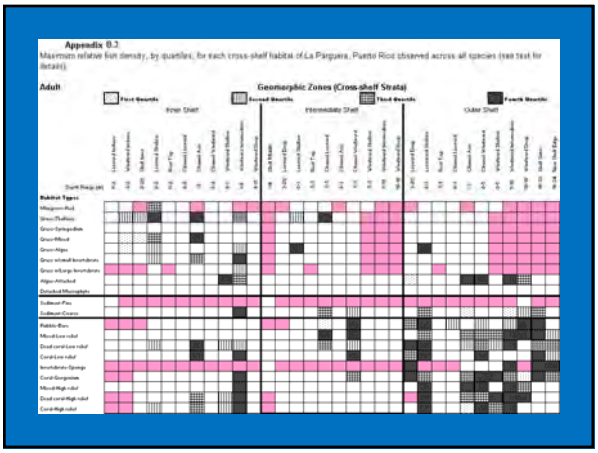

Acanthurus bahianus
Adult
Geomorphic Zones (Cross-shelf Strata)
Inner Shelf
Intermediate Shelf
Outer Shelf
First Quartile
Second Quartile
Third Quartile
Fourth Quartile


Appendix B.1
Early Juvenile
Geomorphic Zones (Cross-shelf Strata)
First Quartile
Second Quartile
Third Quartile
Fourth Quartile
Inner Shelf
Intermediate Shelf
Outer Shelf


Appendix B.2
Juvenile
Geomorphic Zones (Cross-shelf Strata)
First Quartile
Second Quartile
Third Quartile
Fourth Quartile
Inner Shelf
Intermediate Shelf
Outer Shelf

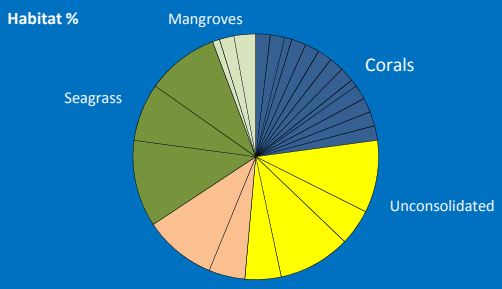

Appendix B.3
Adult
Geomorphic Zones (Cross-shelf Strata)
First Quartile
Second Quartile
Third Quartile
Fourth Quartile
Inner Shelf
Intermediate Shelf
Outer Shelf

Ecosystem Function → Ecosystem Services

- Settlement/Recruitment
- Nursery Habitats
- Connectivity
  - Nutrient/Biomass Flows
  - Feeding Migrations
  - Ontogenetic Migrations
- Planktiovry
- Herbivory
- Production
- Spawning sites

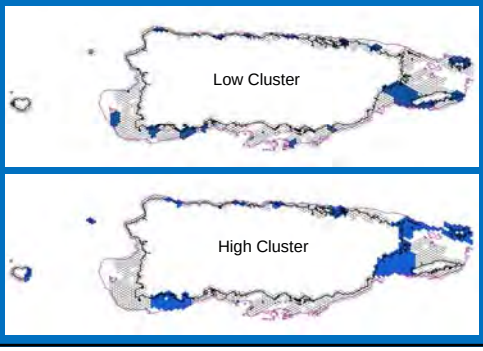
- Commercial Fisheries
- Recreational Fisheries
- Snorkeling/Diving
- Beach Sand Production
- Shoreline Protection
- Education
- Scientific Research
- Bio-active Compounds
- Passive Values
  - Hereditary Value
  - Future Use
  - Existential Value
  - Biodiversity

Link Habitats to Representation and Function



Identify Critical Habitat

Best selection from Marxan



Important Criteria

- Shoreline to shelf edge inclusion
- 40km between selected areas for larval connectivity
- Replication of targets

Resilience Requires First Principles for Fisheries Management

- Maintain Ecosystem Integrity
  - (Biodiversity conservation)
- Maintain ecosystem function
- Rigorously protect habitat
- Protect water quality
- Precautionary approach
- Maintain reference points for monitoring
- Are limits to production
  (control extraction)

Appeldoorn (2008)

Management Tactics

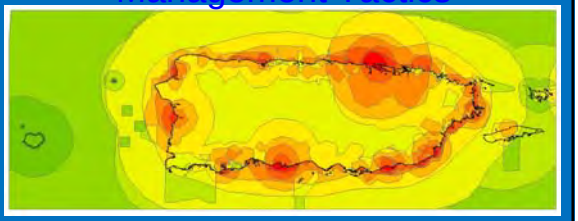
Marine reserves
- control areas (reference points for monitoring)
- protect spawning stocks, trophic structures, EFH
- control fishing effort

Close spawning aggregations

Protect
- herbivores (no entangling nets),
- predators (no spear guns),
- spawners (large mesh),
- habitat (no trawling)

Reduce overfishing (large mesh, traps with escape panels)

Management Tactics



Adjust CZM & water quality standards
- match ecosystem needs (corals, seagrass)
- use spatial zoning as appropriate

More rigorous coastal construction permitting decisions
- improve Environmental Impact Assessments (EIAs)
- Set rigid guidelines for exemptions & variances

Star Coral Wars
Episode IV- A New Hope

- Integrated Watershed Approaches
  - Jobos Bay
  - Guanica Bay
- Erosion Control
- Biocriteria
- Marine Reserves
- Coastal and Marine Spatial Planning

Appendix H

AN INTERDISCIPLINARY EROSION MITIGATION APPROACH FOR CORAL REEF PROTECTION – A CASE STUDY FROM THE EASTERN CARIBBEAN

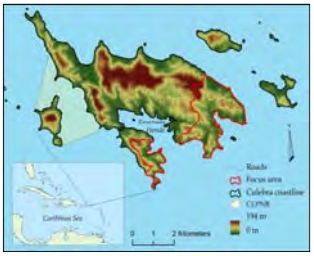
Carlos E. Ramos-Scharrón,
Juan M. Amador Gutiérrez
Edwin A. Hernández-Delgado

Agenda

- Project Background
- Objectives
- Methods
- Results, discussion and recommendations
- Conclusions
- Future projects

Project Background

- Culebra is an island located approximately 19 miles east of the main island of Puerto Rico
- It supports coral reef ecosystems characteristic of northeastern Caribbean marine biodiversity, and they represent highly valuable sources of fishing, tourism and recreational activities



Project Background

- Coral reefs in the Commonwealth of Puerto Rico (PR) are among the most highly threatened reefs of the entire Caribbean as a consequence of the combined effects of climate change, coral bleaching, increased incidence of disease, overfishing, and the delivery of inland pollutants
- Reduction in 50 to 80% coral coverage since 1997 in Luis Peña Natural Reserve has been observed

Objectives

- To describe an innovative framework by which technical knowledge gathered by marine ecologists, watershed scientists, and civil/environmental engineers can be best employed in the development of an erosion mitigation strategy.

Methods

- Multi-Step Approach
  - Step 1
    - collecting the basic information to describe coral reef abundance and condition,
    - estimating watershed-scale sediment loading rates, and
    - evaluating the feasibility of on-site installation of erosion control measures

Methods

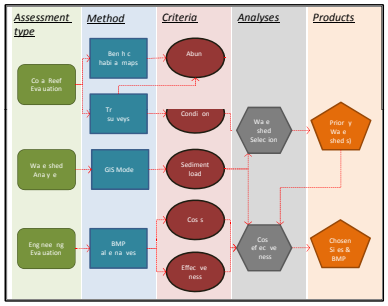
- Multi-Step Approach (cont.)
  - Step 2
    - formalize an approach to select the watersheds and associated marine habitats that merit a preferred status for i the implementation of erosion control activities
    - Considerations for assessing need for mitigation/protection
      - (1) *resource abundance*- the amount of surface prone for coral reef growth and/or the abundance of particular coral species of concern;
      - (2) *resource condition*- the observed condition of the coral reef ecosystem; and
      - (3) *stress level*- sedimentation stress defined by annual sediment yields

Methods

- Multi-Step Approach
  - Step 3
    - choosing the specific sites (i.e., sediment sources) and methods to be implemented within the priority areas by invoking a sediment reduction cost-effectiveness analysis

Methods

Flowchart displaying the general scope of the proposed, interdisciplinary erosion mitigation **strategy described** here



Coral Reef Assessment

- Abundance of Coral Reef Habitats
  - Based on its areal coverage, and relied upon pre-existing benthic habitat maps (NOAA-NOS)
  - Sea bottom classified by the *Habitat* attribute (3rd tier):
    - Coral reef and colonized hard-bottom
    - Submerged aquatic vegetation
    - Unconsolidated Sediments
    - Others

Coral Reef Assessment

- Structure and Condition
  - Modified Rogers et al. Protocol (1994)
  - Data was obtained at depths typically ranging from 3 to 7 m
  - Data used for this study included percent cover of benthic components:
    - live coral, macroalgae, algal turf, crustose coralline algae (CCA), and cyanobacteria
    - These also allowed calculations of live coral to algal ratios as well as coral to cyanobaterial ratios

Watershed Assessment

- The unpaved road network in Culebra is considered to be overall the island's most important anthropogenic source of sediment

Watershed Assessment

- Erosion and sediment yield assessments relied upon application of the STJ-EROS model
- STJ-EROS estimates erosion rates from both natural and anthropogenic sources of sediment based on empirical **equations developed from data collected on St. John** (USVI), an island with a similar physical setting as Culebra
- Unpaved roads on Culebra were found to be similar to those from which the STJ-EROS road erosion algorithms were developed in terms of substrate, road prism geometry, and range of slopes.

Watershed Assessment

- The eight watersheds of interest covered a total area of 6.8 km^2 or about a quarter of the total landmass of Culebra. Individual watersheds ranged in drainage areas from 9.1 ha at Punta Soldado (PSO) to 274 ha at Puerto Del Manglar (PDM)

Watershed	Drainage area (ha)	Proportion of Area with High SDR (%)	Proportion of Area with Moderate SDR (%)	Total roads (km)	Unpaved roads (km)	Number of drainage points
Punta Soldado (PSO)	9.1	99%	1%	0.09	0.09	0
Ensenada Malena (EMA)	18	60%	40%	0.52	0.52	7
Cayo Dakiti (CDA)	44	41%	59%	1	0.31	6
Bahia Mosquito (BMO)	132	17%	83%	7.4	5.3	34
Ensenada Fulladosa (EFU)	70	99%	1%	6.9	4.5	42
Puerto Del Manglar (PDM)	274	16%	84%	12.8	9.7	49
Playa Larga (PLA)	52	78%	22%	2.1	1.8	8
Playa Zoni (PZO)	81	28%	72%	3.9	1.9	14
Total	*680*			34.7	24.1	*160*

Best Management Practices

- "...a variety of site planning, design, and construction activities to minimize the production and transport of sediments"
- General limitations:
  - **an already existing and thus mostly immovable road** network layout;
  - a characteristically rugged topography, and
  - a lack of locally available specialized materials and equipment that significantly increases costs and therefore reduces the number of BMPs that would otherwise be considered feasible

Best Management Practices

- Three main types of BMPs evaluated
  - those methods that improve the resistance to erosion processes by preventing the direct contact of rain and runoff with the soil surface (Type I)
  - minimize the amount of flow on the unpaved road surface and thus reduce its erosive energy
  - Those that attempt to capture as much sediment as possible while runoff is transported through or discharged from the road prism (Type III)

Best Management Practices

- BMP selection in most cases is site specific and a combination of these individual BMPs is usually the most effective alternative. Therefore, we developed three general road designs or treatments, each incorporating a different sub-set of BMPs

Treatment name	Inside ditch	Vegetated ditch	Check dams	Rolling dips	Paved gutter	Energy dissipater	Wire mesh pavement	Costs (U.S. $ per m)	Post-treatment erosion rates
Unpaved with rolling dips	✓	✓	✓	✓		✓		$325	~30%
Unpaved with paved gutter	✓	✓	✓		✓	✓		$350	~30%
Paved with gutter	✓	✓			✓	✓	✓	$600-$650	~20%

Prioritization Strategy

- Limitations
  - coral reef condition assessments are based on a single, one-time observation
  - erosion analyses explicitly lacks the capacity to understand sediment dynamics and effects once delivered to the marine environmentSite and BMP Selection

Prioritization Strategy

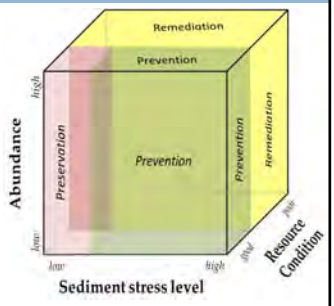
- Watershed Selection
  - The combined watershed and marine habitat evaluation procedure presented here is based on three criteria:
    - (1) abundance of the marine resource,
    - (2) marine resource condition, and
    - (3) stress level
  - Each of the three criterion being considered for analyses can be graphically portrayed as the axis of a three-dimensional cube

Prioritization Strategy

Sediment stress level is displayed along the x-horizontal axis from low to high (left to right).

Resource abundance is graphed in the y-vertical axis from low upwards to high abundance.

Resource condition lies along the z-depth axis from good to poor (foreground to background).



Prioritization Strategy

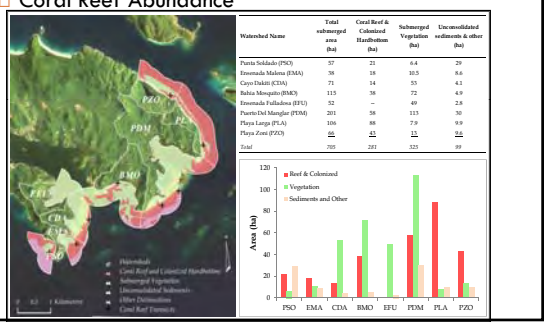
- Watershed Selection
  - The cube also serves to map the justification or goal of erosion control activities being implemented. Implementation of erosion mitigation strategies for coral reef protection can be justified on the basis of three main motives:
    - (1) Preservation,
    - (2) Prevention, and
    - (3) Remediation

Prioritization Strategy

- Site & BMP Selection and Cost-Effectiveness Analysis
  - cost-effectiveness may be defined by the total amount of funds spent installing BMPs relative to the amount of sediment that will no longer reach coastal waters (i.e., sediment 'savings') as a result of their implementation
  - cost-effectiveness for the case in Culebra will be described in terms U.S. Dollars spent on BMPs per ton of sediment 'saved' ($ ton^{-1})

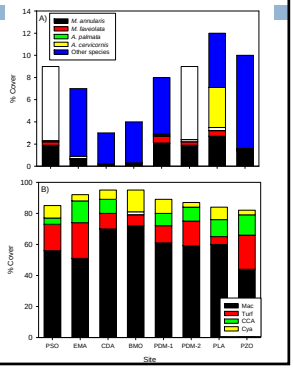
Results, Discussion and Recommendations

- Coral Reef Abundance



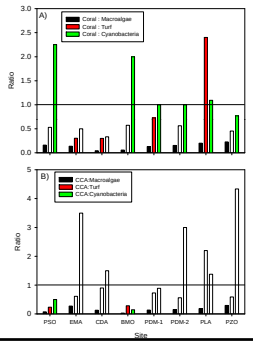
Results, Discussion and Recommendations

- Coral Reef Condition
  - Mean coral reef benthic parameter values for the eight study sites in Culebra. From top: A) Percent coral **cover of four of the most** sensitive Scleractinian coral species (*M. annularis*, *M. faveolata*, *A. palmata*, *A. cervicornis*); B) Percent cover of the four most important algal functional groups: macroalgae (Mac), turf, crustose coralline algae (CCA), and cyanobacteria (Cya).



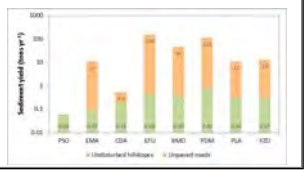
Results, Discussion and Recommendations

- Coral Reef Condition
  - '*Coral : algal*' ratios and '*crustose coralline algae* (CCA) *: algal*' ratios across the eight study sites in Culebra



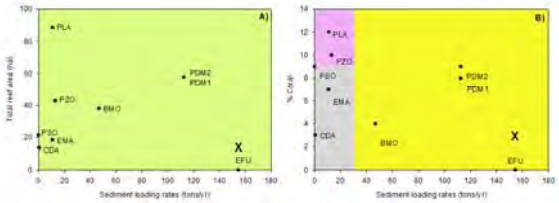
Results, Discussion and Recommendations

- Watershed Assessment



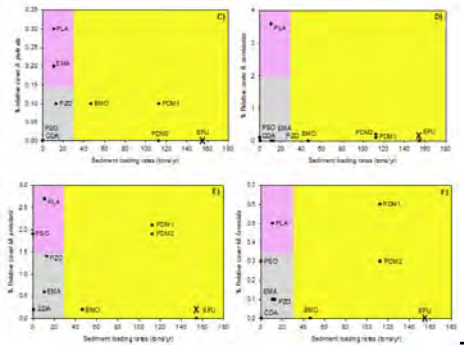
Results, Discussion and Recommendations

- Watershed-Marine Habitat Selection



- Relationship between sediment loading rates and several benthic parameters across impacted coral reefs in Culebra: A) Total reef area; B) Percent living coral cover
- Colors represent the justification for erosion control actions as follows: Yellow= remediation; Gray= prevention; and Pink= preservation. Point 'X' denotes a more realistic condition for CDA due to its down current oceanographic connectivity with EFU and the rest of Ensenada Honda

Results, Discussion and Recommendations



Results, Discussion and Recommendations

- Watershed-Marine Habitat Selection
  - Same analysis was performed for the following parameters relative to sediment loading rates:
    - Percent total algal cover;
    - Percent macroalgal cover;
    - Percent algal turf cover;
    - Percent crustose coralline algae (CCA) cover;
    - Percent cyanobacterial cover; and
    - *Coral : Macroalgae* ratio.

Results, Discussion and Recommendations

- Watershed-Marine Habitat Selection
  - Two areas that merit to be analyzed in more detail with respect to their sediment loads and coral conditions are EFU and CDA
  - The marine habitat directly connected to EFU consists of an important submerged aquatic vegetation area, therefore no argument for erosion control could be justified based on a strict interpretation of our scheme that only considers the abundance and condition of the immediately adjacent reef systems
  - Erosion control in the EFU watershed could be justified based on the argument that marine systems are interconnected through complex ecological functionalities so that benefits to a SAV-dominated area could also serve to improve conditions on nearby reef areas

Results, Discussion and Recommendations

- Site and BMPs Selection
  - The PDM watershed was chosen as the target area for conducting cost-effectiveness analyses because of its high sediment yield rates, its relatively extensive unpaved road network, and the poor to moderate condition of its adjacent marine resources.
  - Watershed Description:
    - 9.4 km of unpaved roads, sub-divided into 104 individual road segments which in total deliver 112 tons of sediment every year into the receiving coastal waters
    - The average road segment has a length of 90 m and a slope of 7% with individual values ranging between 12 – 390 m and from 0% to 25%, respectively
    - Twenty-seven road segments individually contribute more than 0.82 tons yr^{-1}, which is the estimated background sediment yield level for this watershed

Results, Discussion and Recommendations

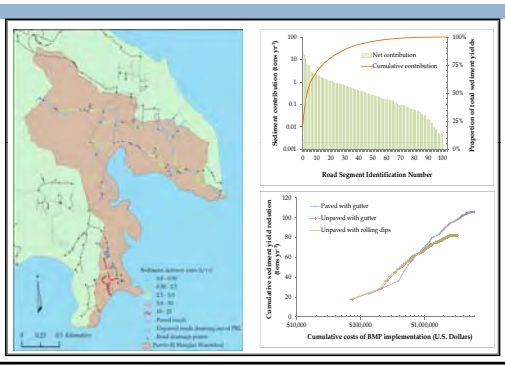
- Cost-Effectiveness Analysis

Treatment name	Inside ditch	Vegetated ditch	Check dams	Rolling dips	Paved gutter	Energy dissipater	Wire-mesh pavement	Costs (U.S. $ per m)	Post-treatment erosion rates
Unpaved with rolling dips	✓	✓	✓	✓		✓		$215	~70%
Unpaved with paved gutter	✓	✓	✓		✓	✓		$350	~70%
Paved with gutter	✓	✓			✓	✓	✓	$600-$650	~10%

Puerto del Manglar Watershed BMP Implementation

Treatment	Sediment Load Reduction (ton/yr)	Percent Reduction	Cost of Implementation ($)	Cost-effectiveness Measure ($/ton reduced)
Unpaved with rolling dips	82	~70%	$3,000,000	$37,100
Unpaved with paved gutter	82	~70%	$3,300,000	$40,000
Paved with gutter	106	~90%	$ 61,000,000	$57,700

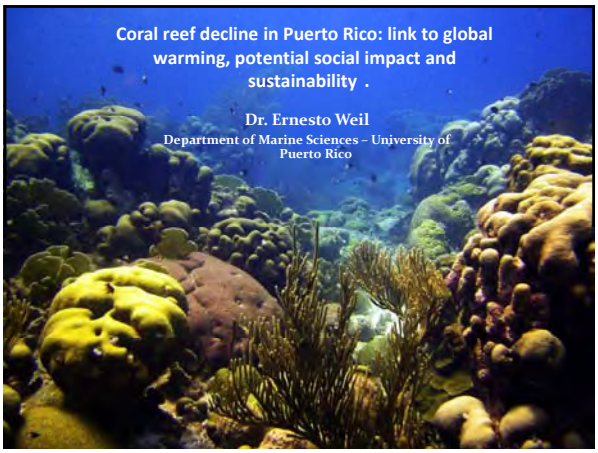
Results, Discussion and Recommendations



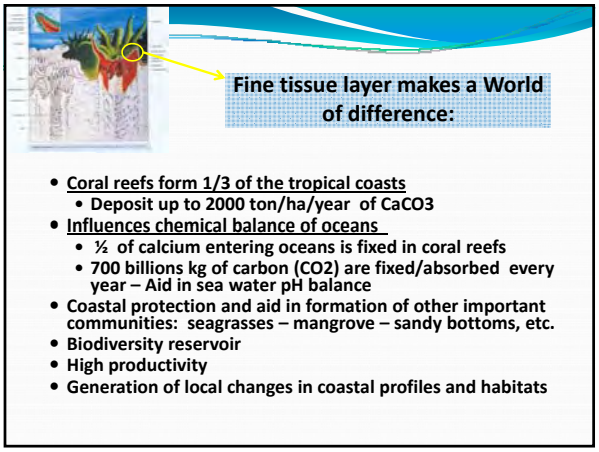
Conclusions

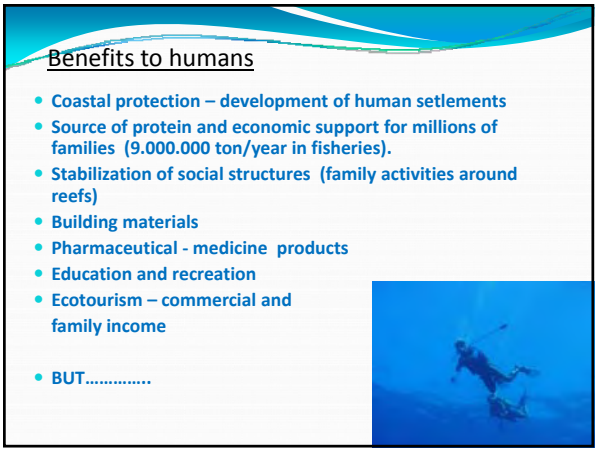
- The strategy serves in part to choose priority target watersheds for erosion control on the basis of the intentions of the mitigation efforts
- The cost-effectiveness analyses aids in choosing specific sites and erosion control methods to maximize the net reductions in sediment loads while minimizing costs
- Application of this cost-effectiveness analysis to one watershed in Culebra suggests that the choice of most effective erosion control method varies according to the amount of funds available for implementation

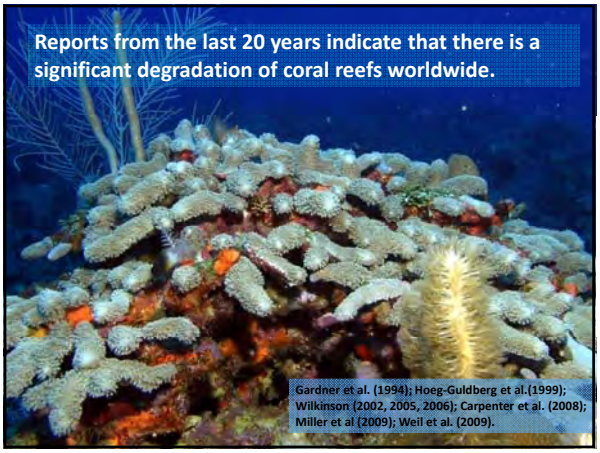
Appendix I

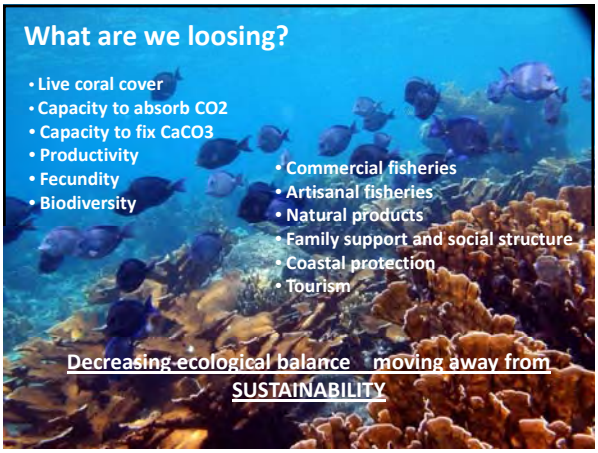

Coral reef decline in Puerto Rico: link to global warming, potential social impact and sustainability .
Dr. Ernesto Weil
Department of Marine Sciences – University of Puerto Rico


Coral reefs
"Highly diverse, complex and dynamic tropical marine communities supported by a stable, BIOGENIC calcium carbonate framework mainly produced by scleractinian corals .
Very old and widely distributed.
Survived four major extinction events in Earth s evolutionary history (400 MY= resilient)


Fine tissue layer makes a World of difference:
Coral reefs form 1/3 of the tropical coasts
Deposit up to 2000 ton/ha/year of CaCO3
Influences chemical balance of oceans
½ of calcium entering oceans is fixed in coral reefs
700 billions kg of carbon (CO2) are fixed/absorbed every year – Aid in sea water pH balance
Coastal protection and aid in formation of other important communities: seagrasses – mangrove – sandy bottoms, etc.
Biodiversity reservoir
High productivity
Generation of local changes in coastal profiles and habitats

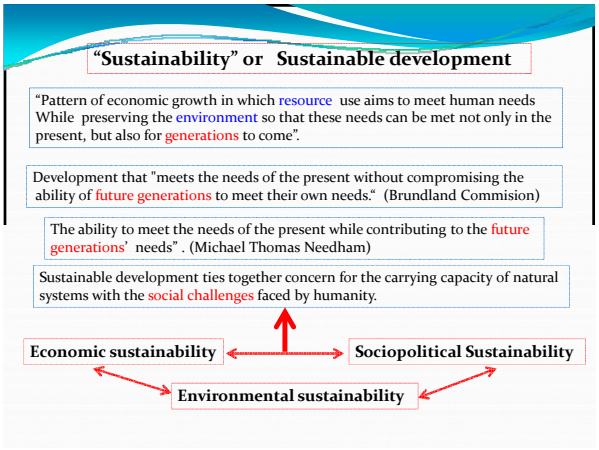

Benefits to humans
Coastal protection – development of human setlements
Source of protein and economic support for millions of families (9.000.000 ton/year in fisheries).
Stabilization of social structures (family activities around reefs)
Building materials
Pharmaceutical - medicine products
Education and recreation
Ecotourism – commercial and family income
BUT.....


Reports from the last 20 years indicate that there is a significant degradation of coral reefs worldwide.
Gardner et al. (1994); Hoeg-Guldberg et al.(1999); Wilkinson (2002, 2005, 2006); Carpenter et al. (2008); Miller et al (2009); Weil et al. (2009).


What are we loosing?
Live coral cover
Capacity to absorb CO2
Capacity to fix CaCO3
Productivity
Fecundity
Biodiversity
Commercial fisheries
Artisanal fisheries
Natural products
Family support and social structure
Coastal protection
Tourism
Decreasing ecological balance moving away from SUSTAINABILITY


What is going on???
What are the major threats to coral reefs and reef sustainability?


2 billion - 6 billion → 10 billion
WE THE PROBLEM
Common denominator to environmental problems

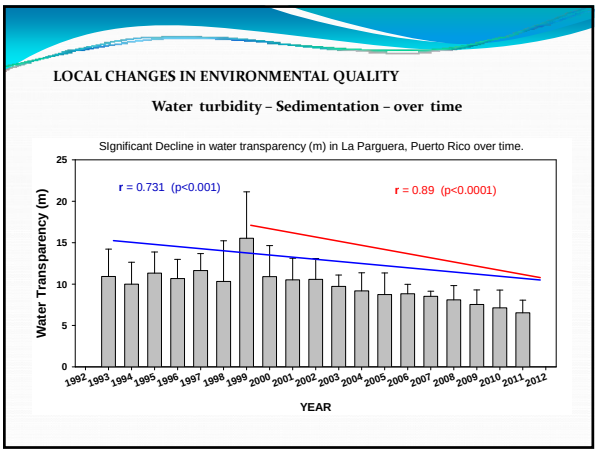

"Sustainability" or Sustainable development
"Pattern of economic growth in which resource use aims to meet human needs While preserving the environment so that these needs can be met not only in the present, but also for generations to come".
Development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." (Brundland Commision)
The ability to meet the needs of the present while contributing to the future generations' needs" . (Michael Thomas Needham)
Sustainable development ties together concern for the carrying capacity of natural systems with the social challenges faced by humanity.
Economic sustainability
Sociopolitical Sustainability
Environmental sustainability

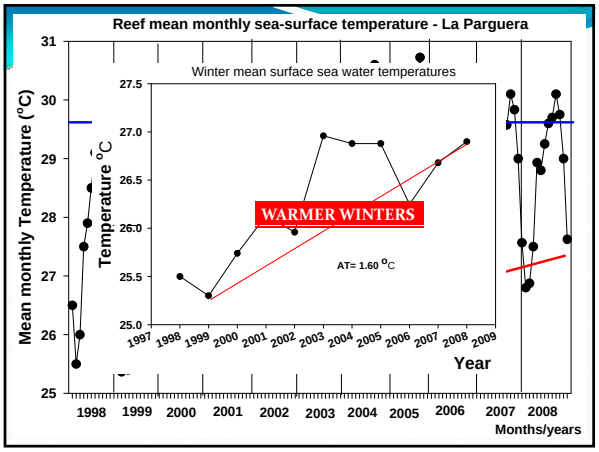

Anthropogenic - Population growth
Increased [CO2]
Global Climate Change
Natural hazards
Deforestation
Coastal development
Over fishing
Sewage (nutrients)
Anchoring – Groundings
Agriculture (pesticides)
Coral extraction
Oil-chemical spills
Uncontrolled tourism
Floating garbage – plastic bags, ropes, etc.
Temperature
UV
Acidification
Mass mortalities
Reduced reproduction
Reduced calcification
Increased bioerosion
Algae blooms
Population explosions
Bioerosion
Sedimentation
Hurricanes and storms
Dust storms
Environmental changes
Infectious Diseases
Bleaching
DEGRADATION OF CORAL REEFS = NO SUSTAINABILITY

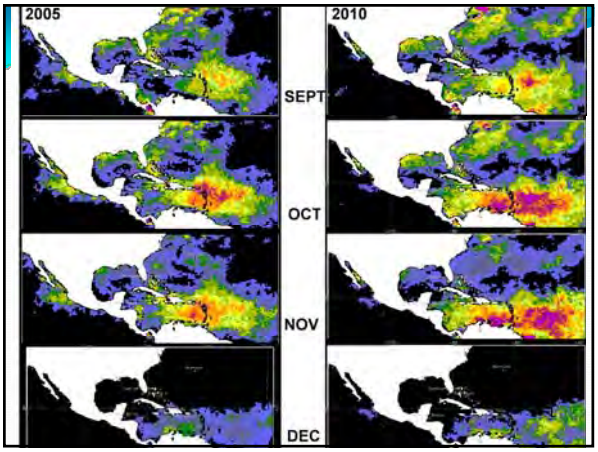

Caribbean Sea
PUERTO RICO
La Parguera

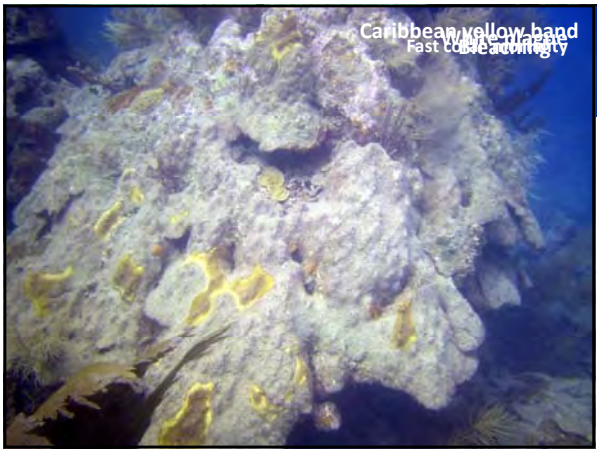

Sustained, but not sustainable, development (1936 2000's)

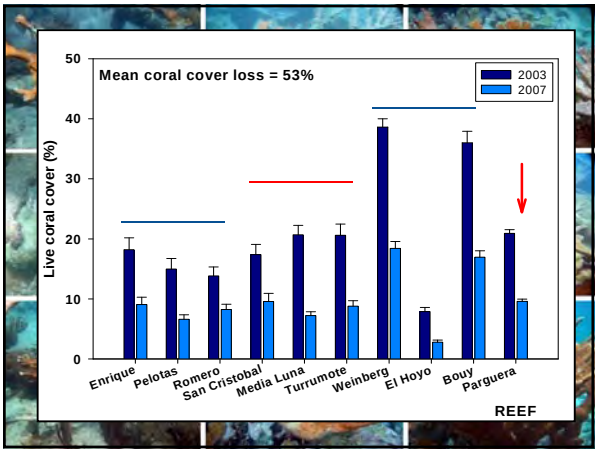

2000

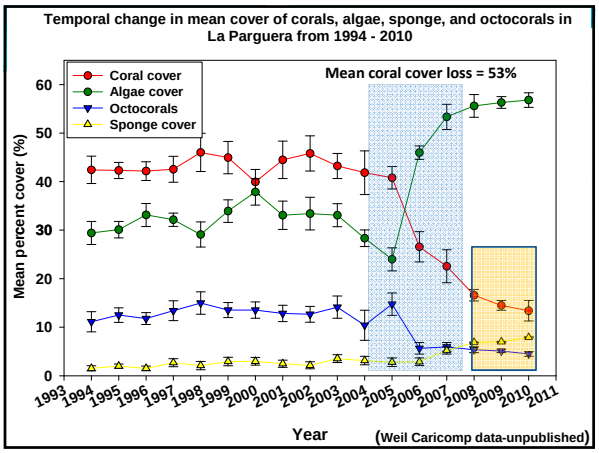

LOCAL CHANGES IN ENVIRONMENTAL QUALITY
Water turbidity – Sedimentation – over time
SIgnificant Decline in water transparency (m) in La Parguera, Puerto Rico over time.
r = 0.731 (p<0.001)
r = 0.89 (p<0.0001)
Water Transparency (m)
YEAR


Reef mean monthly sea-surface temperature - La Parguera
Winter mean surface sea water temperatures
WARMER WINTERS
AT= 1.60 °C
Mean monthly Temperature (°C)
Temperature °C
Year
Months/years


2005
2010
SEPT
OCT
NOV
DEC


Caribbean yellow band


Mean coral cover loss = 53%
2003
2007
Live coral cover (%)
Enrique
Pelotas
Romero
San Cristobal
Media Luna
Turrumote
Weinberg
El Hoyo
Bouy
Parguera
REEF

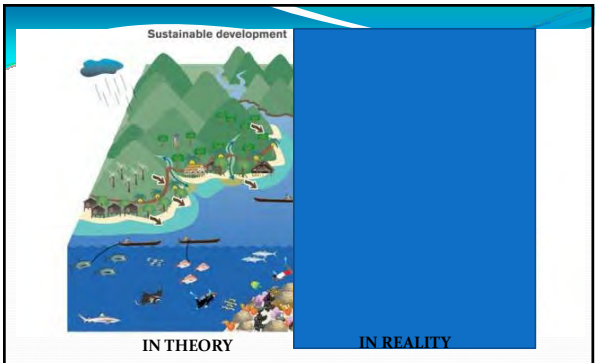


Impact of bleaching and diseases:

- Two intensive bleaching events affected 52 coral species, 22 octocorals, 3 hydrocorals, 2 zoanthids and 3 sponges.
- Eleven biotic diseases affected 42 coral species, 5 octocorals, 2 hydrocorals, 3 zoanthids, 2 sponges and at least 3 crustose coralline algae (CCA).
- Significant mortalities of corals and other important members of the coral reef community. Loss of habitat and productivity.

Epizootic consequences

- Changes in coral community structure – function
  - Replacement of dominant species – spp composition
  - Change in abundances and distribution
  - Reduction in live cover/biomass
  - Reduction in Biodiversity
  - Reduction in spatial heterogeneity / habitats
- Reduction in productivity
- Reduction in reproductive output – fitness
- Evolutionary consequences ?
- **Social consequences?**
- **Moving away from Sustainability**



Not possible to reach sustainability until local and global environmental deterioration is controlled. Not possible to control these unless we involve ALL STAKEHOLDERS in the process and control human population growth.

Reefs for the future? How? Where?

- Improve environmental conditions
  - Reduce stress factors, sedimentation, pollution, fisheries
  - Reduce CO_2 emissions, temperature stress
- Protect genetically diverse populations of main reef-building species = increase # and area of Marine Protected Areas (MPA).
- Better management and involvement of all stakeholders?
- REDUCE HUMAN POPULATION GROWTH

Final Remarks

- We have exceeded our capacity to feed, clothe and provide jobs and a decent standard of living for ourselves and future generations.
- Future global climate change can not be avoided and we can not predict the timing of those changes.
- New technologies are not the only answer, since they will always lag behind population growth. Future technology will be more important to our adaptation to climatic change – not to its prevention


We are all guilty as charged for being alive and consuming.
These are our problems and for sustainable development we all need to take responsibility
– DO YOUR PART!


THANK YOU!

Appendix J

"ACHIEVABILITY" vs "SUSTAINABILITY":
Including Community Acceptance Consideration in the Implementation of Renewable Energy Projects in Puerto Rico.

Marla Perez-Ortiz, PhD
Cecilio Ortiz García, PhD
Department of Social Sciences,
ITEAS (Tropical Institute of Energy, Environment & Society)
University of Puerto Rico-Mayagüez

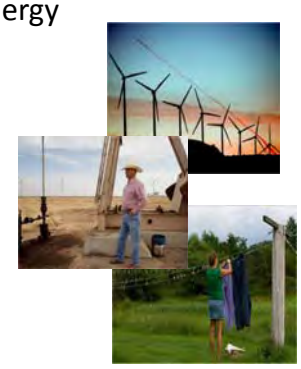
Objectives

1. What is "social acceptance" to renewable energy projects?
2. What are some of the most important findings of our research?
3. What is it's policy relevance?
4. What can policy makers do to move Puerto Rico towards sustainability, relative to my research?
5. What is necessary to implement my research island-wide?

WHAT IS "SOCIAL ACCEPTANCE" TO RENEWABLE ENERGY PROJECTS?

The Paradigm Shift of Renewable Energy

- Green vs. renewable vs. sustainable
- Smaller scale and lower energy density
- Below the surface vs. above surface resource extraction
- More visibility of projects
- "Soft" factors, not technical, become decisive in sitting decisions.



What is Social Acceptance?

It is a set of socio-political, community and market characteristics that determine the social sustainability of renewable energy projects.

Wüstenhagen et al. 2007

Achievabable does NOT mean Acceptable… or Sustainable

Parameters for achievability:

- Required surface area, or "footprint"
- Capital costs and potential electric energy contribution from each resource.
- Estimated availability and variability the resource
- The state of the technologies used to harvest their energy

(Irrizarry, O'Neill and Colucci, 2009)

Parameters for acceptability:

- Perception of procedural justice in the decision-making process
- Perception of equity in the distribution of costs and benefits associated with the project.
- Perceived economic, environmental and aesthetic consequences

(Ortiz and Perez, 2008)

Empirical research shows…

- 30% of non-finalized wind farm projects in Europe are stopped due to lawsuits and public resistance (Azau, 2011)
- Community ownership models have a positive effect on the local acceptance (Fabian David Musall* and Onno Kuik. 2011)
- It is NOT related to knowledge or attitudes towards renewable energy technologies in the abstract.

Sitting issues…

- Distrust – "Public trust (especially in the facility developer), early and continuous public involvement in the facility siting process, and an adaptive strategy that involves incorporating citizens' concerns into siting and operation decisions are associated with a higher likelihood of siting success." (Ibitayo and Pijawka, 1998)
- Environmental Justice – "Latent feelings of inequity in the community can be heightened by a previous contamination incidents. The incidents can amplify perceptions of environmental risk and reinforce perceptions of distributional, procedural, and process inequities…… We need to strengthen planning processes to involve environmental equity considerations." (Pijawka, 1998)

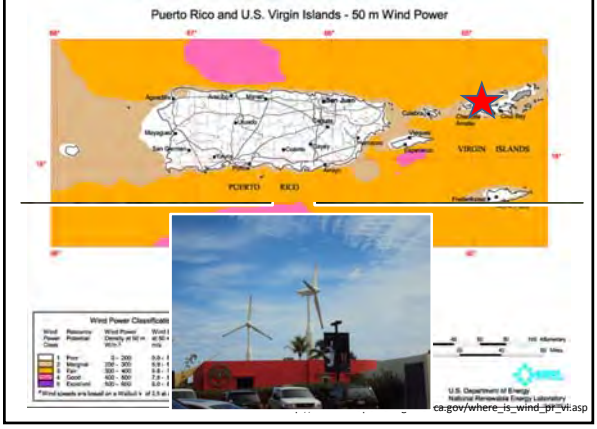
It is NOT NIMBY…

- "Regarding community acceptance of wind power schemes, the visual evaluation of the impact of wind power on the values of the landscape is by far the most dominant factor in explaining opposition or support." (Wolsink, 2006).
- "Local opposition cannot be explained by the egotistical motives of local residents. When the inclination to behave according to (supposed) backyard motives is investigated, the scale to measure this phenomenon appears to indicate commitment to equity issues and fairness of decision-making" (Wolsink, 2006).

WHAT ARE SOME OF THE MOST IMPORTANT FINDINGS OF OUR RESEARCH?

Our Methodology

- Survey to a sistematic random sample of 409 residents older than 18, in 3 communities previously targeted for the sitting of a wind energy project.
  - Vieques (n=157),
  - Cataño t1 (n=81), Cataño t2 (n=97)
  - and Camuy (n=74).



Stakeholder identification and analysis

Knowledge and Attitudes

- The most recognized renewable energy sources are wind and solar.
- There is a positive bias towards solar energy. Participants think that the sun is the cheaper energy source, that is safer and the least polluting. It is perceived as the most viable for development in the Island as well in their community.

Procedural Justice

- The developer is responsible for informing the community. The communication should be structured in the form of community meetings, not public hearings.
- Community participation is very important, mostly at the early stages of project development.
- The community should be involved in the project's approval and in selecting the project's location.
- The community needs to have access to independent experts for a neutral perspective on the technology and the project.

Distributional justice

- The community should be compensated if the project is approved against their will.
- Fair compensation schemes include:
  - discounts in the electric bill,
  - providing electricity to a local school or hospital,
  - or an activity that brings collective wellbeing.

Trust

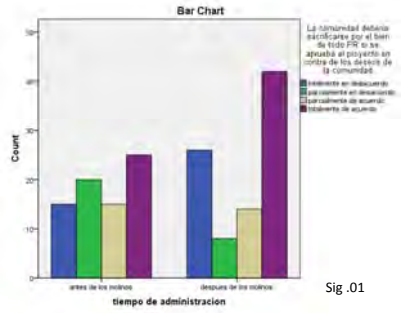
- The majority voted in the general elections, but it has little impact on the community's wellbeing.
- Distrust in the current decision making processes,
- Doubt that the government and the private sector have the community's interests and needs in mind when proposing new infrastructure projects.

CATAÑO AS A REAL LIFE EXPERIMENT (IN MORE WAYS THAN ONE…)

Knowledge about what kinds of energy sources are renewable.

Source	Before	After	Change
Solar	82.5%	79.2%	-
Hydro	68.4%	73.3%	+
Wind	64.9%	81.5%	+ (Sig .03)
Biofuels	29.8%	30.3%	+
Geothermal	22.8%	9.4%	-
Hidrogen	17.5%	6.7%	-
Waves	15.8%	9.4%	-
Coal	10.5%	6.7%	-
Natural Gas	10.5%	54.5%	+ (Sig .00)
Petroleum	8.8%	6.5%	-
Nuclear	3.5%	10%	+

The community should sacrifice for the good of all Puerto Rico



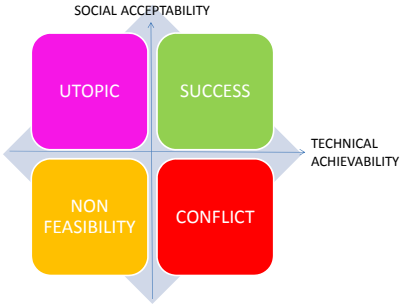
Sig .01

Perception about current decision-making process

Reactives	Before	After
Politicians care about what people like me think	78.5%	20.9%**
Mi community always participate in the government's decisions that affect us directly	53.8%	31.6%*
Public hearings have an impact of government's desicions	79.7%	47.3%**
The opinion of my community is taken into account when deciding where to locate infraestructure projects.	34.2%	31.2%*

WHAT IS THE POLICY RELEVANCE OF THE RESEARCH ON SOCIAL ACCEPTANCE?

If we want SUCCESS…



WHAT CAN POLICY MAKERS DO TO MOVE PUERTO RICO TOWARDS SUSTAINABILITY, RELATIVE TO MY RESEARCH ON SOCIAL ACCEPTANCE OF WIND TURBINES?

We propose…

- A Community Acceptance Index for Renewable Energy Projects at the community level (CAIREP).
  - Collect data on communities near identified renewable energy resources .
  - To integrate social acceptance information with renewable resources availability data into a map that identifies communities that exhibit high achievability and acceptability of renewable energy technologies.
  - To develop a policy "toolbox" for the successful implementation of renewable energy projects in Puerto Rico.

Research Questions

- Justice = How communities located where renewable resources can be extracted perceive current decision-making processes?
- Equity = How is the distribution of costs and benefits associated to renewable energy projects perceived?
- Impact = What are the perceived economic, environmental and aesthetic consequences of a renewable energy project in the targeted community?

Similar government initiatives to understand community acceptance:

Projects, agencies and organizations

1. "Beyond Nimbyism: a multidisciplinary investigation of public engagement with renewable energy technologies" by the UK Government's Economic and Social Research Council at The University of Manchester.
2. "Create Acceptance" (Cultural influences on Renewable Energy Acceptance and Tools for the development of communication strategies to promote acceptance among key actor groups) by the European Union at the Energy Research Centre of the Netherlands.
3. European Wind Energy Association
4. The International Energy Agency Implementing Agreement for Cooperation in the Research, Development, and Deployment of Wind EnergSistems.

Similar government initiatives to understand community acceptance:

Conferences and publications

1. 54th Topical Expert Meeting on Social Acceptance of Wind Energy Projects, **May 2007 at Luzerne, Switzerland**
2. 11 th World Wind Energy Conference & WWEC 2012 Fair "Community Power – Citizen's Power"
3. "Living with a wind farm The public acceptance issue", Wind Directionsm Sept. 2-11, Vol. 30 / no. 4
4. IEA Wind Task 28 Technical Report, 2010

WHAT IS NECESSARY TO IMPLEMENT THE RESEARCH ON SOCIAL ACCEPTANCE ISLAND-WIDE?

But first, we have to ask ourselves…

- Can we really define "sustainability"?
- Can Puerto Rico "move" towards sustainability?
- Been non-policy experts, can we really talk about the policy relevance of OUR research?
- Can we really say what is necessary to implement our research island-wide that we haven't said already?

Sustainability

"Sustainable development is a term that everyone likes, but nobody is sure of what it means" (Daly, 1996).

The Social Dimension of Sustainability

The key is broad participation!

"One of the fundamental prerequisites for the achievement of sustainable development is broad public participation in decision-making. Furthermore, in the more specific context of environment and development, the need for new forms of participation has emerged. This includes the need of individuals, groups and organizations to participate in environmental impact assessment procedures and to know about and participate in decisions, particularly those which potentially affect the communities in which they live and work. Individuals, groups and organizations should have access to information relevant to environment and development held by national authorities, including information on products and activities that have or are likely to have a significant impact on the environment, and information on environmental protection measures."

Chapter 23, Section III of the Agenda 21 ,1992 in Rio de Janeiro

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Appendix K

Puerto Rico, Renewable Energy Self-Sufficiency Roadmap

White Paper Presentation

Puerto Rico Renewable Energy Self Sufficiency Committee
August, 2011

Previous Work

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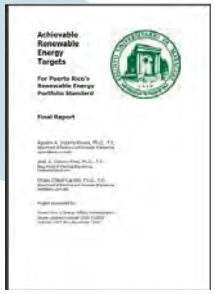
Project sponsored by:

Puerto Rico's Energy Affairs Administration
Under contract number 2000-132009
October 2007 thru November 2008



Puerto Rico Achievable Renewable Energy Targets
Available at http://aceer.uprm.edu/

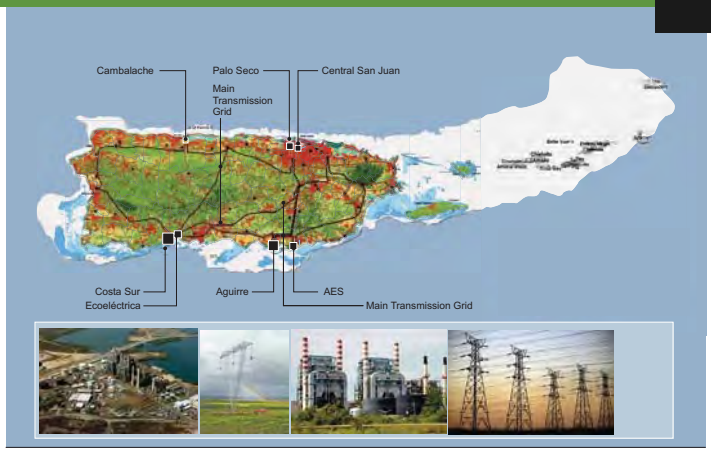
Various studies has shown that Puerto Rico has the resources necessary for energy self sufficiency. One of the most significant studies is the Puerto Rico Achievable Renewable Energy Targets (ARET), by the College of Engineering of the University of Puerto Rico, Mayagüez Campus. ARET was sponsored by the Puerto Rico Energy Affairs Administration.

Basic Premise

As a society we have agreed in achieving, in 20 years:

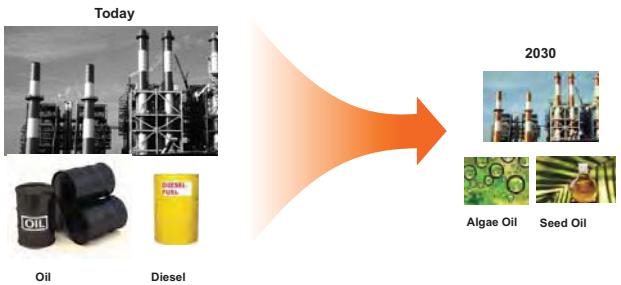
- The production of all our electricity with local renewable resources.,
- Maintain the price paid for electricity at the level of 2010 or lower.
- Dramatically improve the Puerto Rico economy
- Create thousands of new well-paid jobs.

The basic premise of this work is that Puerto Rico has agreed, as a society, in achieving self sufficiency in the resources necessary to produce all our electricity needs, while keeping the price paid for electricity at 2010 levels or lower. This study also assumes that future political will and public policies will be aligned with the goal of energy self-sufficiency.



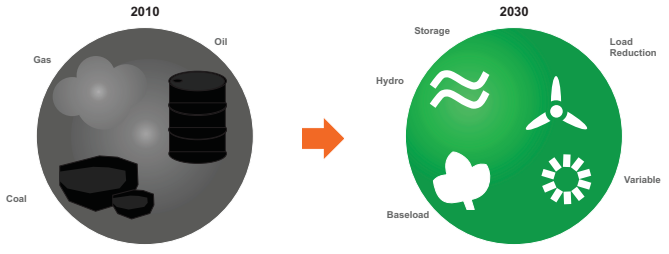
The location of the fossil fuel plants and the interconnection grid, was considered for sizing and placement of the renewable energy systems proposed. The energy storage and grid stabilization capabilities of the present fossil fuel burning facilities are assets in the implementation of large scale renewable energy systems.

Fossil Fuel Plants



The present fossil fuel plants will be used as baseload power producers using diminishing amounts of fossil fuels as the efficiency and energy production systems are put in place. Longer term, the oil burning plants will be conditioned to burn 100% biofuels produced within the development area of Puerto Rico, Virgin Islands and the Dominican Republic.

Renewable Energy Transition



Source: PREPA

The renewable energy production systems portfolio to replace the 100% of the present need of fossil fuels for the generation of electricity is a combinarion of: 1) Load Reduction systems, 2) Baseload Renewable Energy Production systems, 3) Variable Renewable Energy Production systems, 4) Hydro systems, and 5) Energy storage and frequency control systems, to provide the approximately 17 million kWhr per year of electricity proyected to be consumed in Puerto Rico, every year, during the next 20 years.

Renewable Energy Sources Considered

Load Reduction

- Conservation and energy efficiency
  - > Efficient Air Conditioners
  - > Efficient Lighting
  - > Efficient motors and appliances
- Solar water heating

Variable

- Solar
  - > Solar PV Residential
  - > Solar PV Commercial
- -Wind
  - > Offshore Wind
  - > Inshore Wind
- Waves
- Concentrated Solar

Baseload

- Biomass gasification
- Gasification of non-recyclable waste
- Energy from landfills
- Anaerobic digestion of cattle and poultry biomass
- Anaerobic digestion of sewage sludge
- Macro algae oil
- Micro algae oil
- Ocean-thermal

Storage and Frequency Control

- Network Attached Storage
- Pumped Water Storage

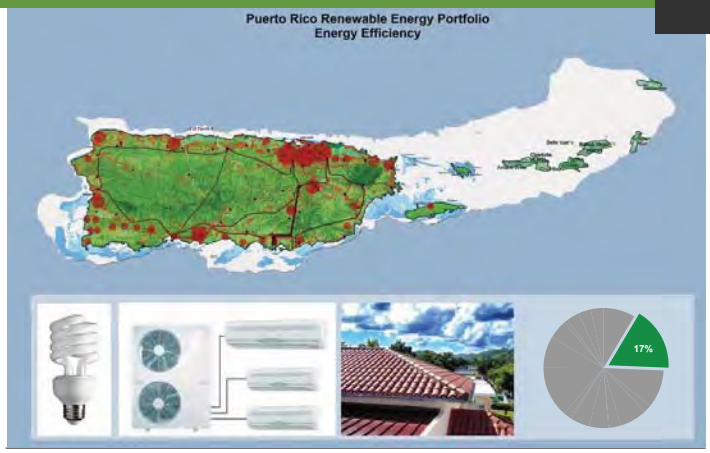
- Hydroelectric

Not Considered

- Source-Based Geothermal
- Gradient Geothermal
- Tide
- Large Scale Hydro

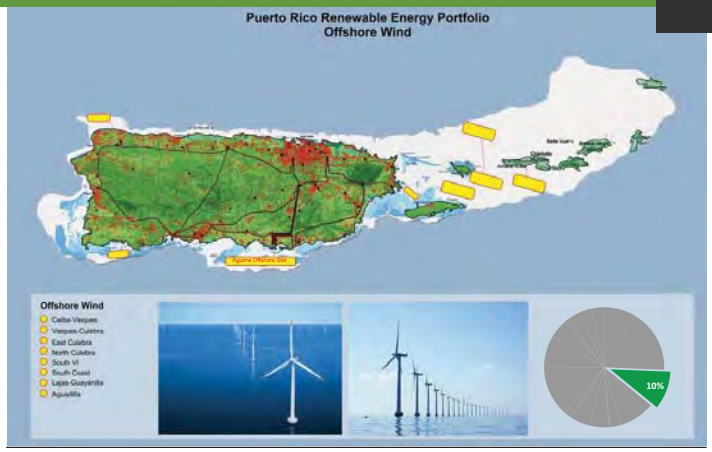
The total number of types of renewable energy sources considered is of 21 different types. Not considered were geothermal, tide and large scale hydro. The reason for this, was the lack of verifiable information in the actual amount of geothermal and tide resources, and space limitations associated with new large scale hydro facilities. Hydroelectric facilities were considered to be used mostly for frecuency control due to limitations in water availability.

Puerto Rico, Renewable Energy
Self-Sufficiency Roadmap



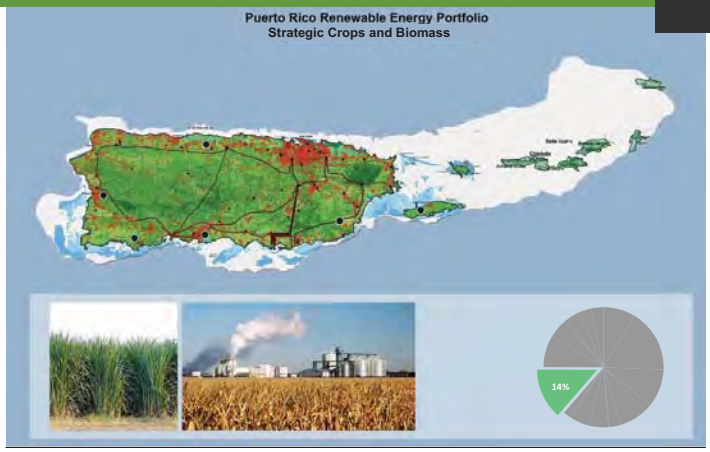
A net 17% reduction in energy load requirements was projected as technically and economically feasible given the experience with commercial, residential and industrial settings where energy efficiency improvements of over 25% have been easily achieved. Energy efficiency replaces baseload energy production through lighting replacement, air conditioning systems replacement and climatization of buildings and residences. An average energy efficiency improvement of 17% is equivalent to the electricity that produces a 500MW facility.

Puerto Rico, Renewable Energy
Self-Sufficiency Roadmap



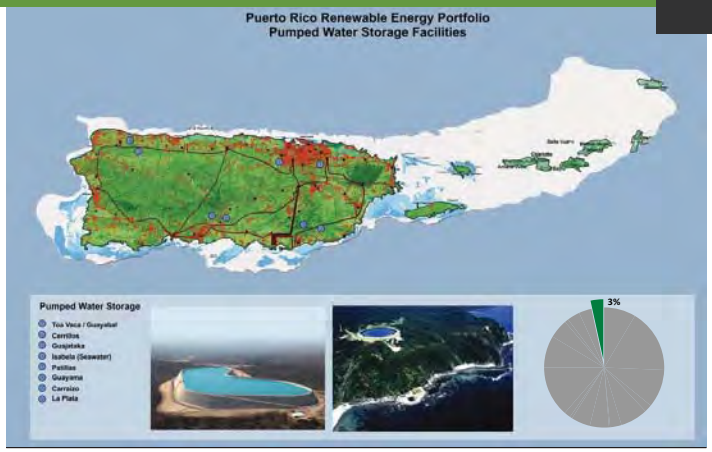
Offshore wind represents the largest single potential source of renewable energy for Puerto Rico. Even when the potential energy production capability at the shallow waters at the east coast of Puerto Rico is in the thousands of MW of effective capacity, the proposed effective capacity would be of approximately 300MW, enough to supply 10% of the projected Puerto Rico electrical energy demand. Given the offshore capacity factor of 30% this represents wind farms of about 900MW of installed capacity. This can be easily installed in just the Aguirre Offhore site.

Puerto Rico, Renewable Energy
Self-Sufficiency Roadmap



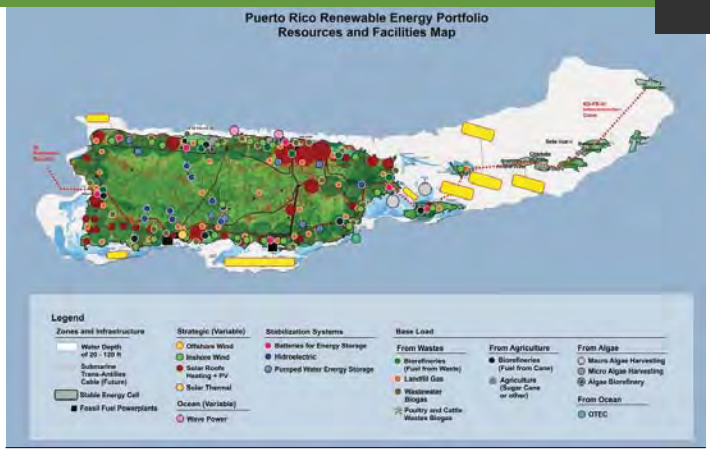
The single largest source of energy will be from biomass harvesting and its use through biorefineries. A total of 400 MW of effective power, equivalent to 14% of the electrical energy requirement will be produced through biorefineries that also produce electrical energy. The biorefineries will be able to produce electricity only or a combination of biofuels or other bioproducts.

Puerto Rico, Renewable Energy
Self-Sufficiency Roadmap



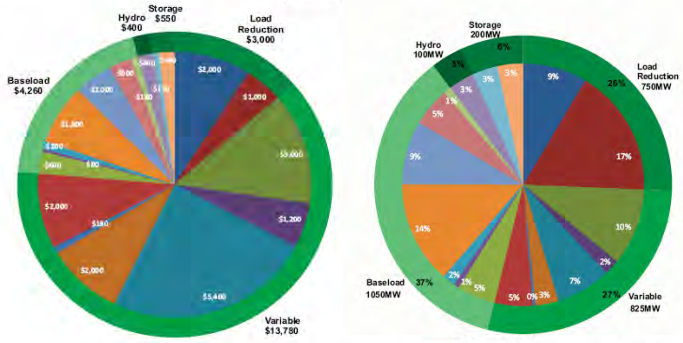
There are 8 pumped water storage facilities planned as part of the roadmap. These are of different kinds and are also part of an emergency water storage infrastructure. Pumped water storage systems store energy by pumping water to an elevated reservoir. When needed, the water in the reservoir is allowed to flow through a hydraulic turbine. These systems add capacity in an intermittent way by storing excess energy produced by other sources. It adds up to instant capacity as required.

Puerto Rico, Renewable Energy
Self-Sufficiency Roadmap



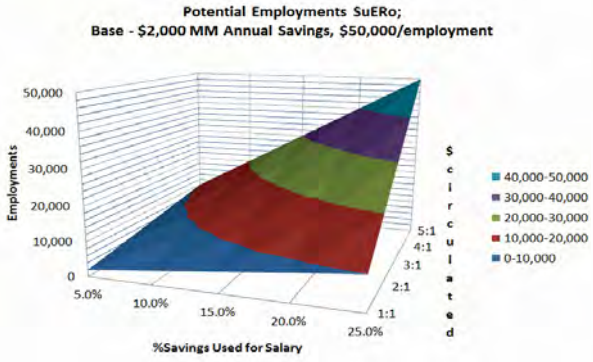
The combination of all the renewable systems add up to 2,925MW of effective power with a total production of 17,000 million of kWhr per year, this represents 100% of the electrical energy requirements projected, every year, for the next 20 years.

Total Renewable Investment (millions)



The investment required for all the renewable systems necessary for self sufficiency add up to $21,990 million. Variable energy production systems has the largest share of the investment with 63%, or $13,738 million, of all the investment required. The highest cost of the systems based in sun, wind and water is compensated by the fact that these systems do not need fuels for operation.

Emerging Commercial/Workforce Development Sectors



A key benefit from SuERo's implementation is the creation of both direct and indirect jobs. These can range between 2,000 to 50,000 depending on the % of the savings that is used for salaries and cash flow circulation of the savings. The latter will depend on the establishment of supporting renewable energy industries on the island. See next transparencies.

Expanded Local Industries/Workforce Development: Photovoltaic Panels

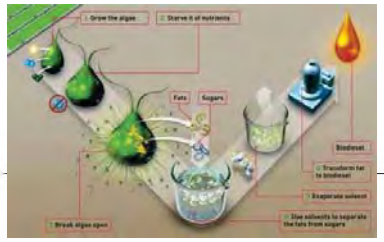
Base Quantity	100 MW/yr.
Opportunity Period	20 yrs.
Total Sales	$2000 MM
Sales/Year	$100 MM

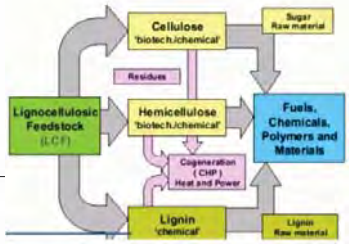
Unit Price → $1/W

The assembly of photovoltaic panels for local electricity consumption takes as a calculation basis 100 MW per year (the government guarantees purchasing 50 MW/yr for the first five years @ breakeven costs). The unit price is $1/W. The projected annual sales are approximately $100 million dollars.

Biorefinery Based Industry, Strategic Crops (6F)

10,000 Hectareas	100 million gallons fuel/ year	700 million pounds high value products/year
Yearly Income	$300+ million/ year	$500 – 1,000 million /year





Respuesta de Representante de la Cámara

¡Nos queda grande Colucci!

Acknowledgements

This work was supported in part by the U.S. Department of Education under grant 84.031S and University of Puerto Rico Mayagüez campus. Also we would like to acknowledge the participation at several workshops of representatives from the commercial, academic, NGO and government sectors.

Appendix L

Large-scale spread of vines and sustainability

Diana L. Delgado[1]
Carla Restrepo[1]
Rafael Arce

[1]Department of Biology
University of Puerto Rico-Río Piedras

Vine invasions around the World

Kudzu (*P. montana)* in Southeastern USA

Rubber vine (*C. grandiflora)* in Australia

Trumpet vine (*T. grandiflora)* in Hawaii

Increase in abundance of lianas in tropical forests

The New York Times

Science

WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION | ENVIRONMENT | SPACE & COSMOS

A Tree Hugger, With a Twist

By HENRY FOUNTAIN

BARRO COLORADO ISLAND, Panama — Stefan Schnitzer paused along one of the trails that crisscross this forested island in the Panama Canal waterway. Around him were trees, their high canopies muting the light from the tropical sun, the occasional woody vine, or liana, climbing up their thick trunks.

But Dr. Schnitzer's attention was turned to a break in the forest just a few yards off the trail.

There, in harsher sunlight, a tree stump was all but obscured by a riot of lianas, their tangled stems forming a heavy thicket. Clearly the tree had come down at some point, which created an opening in the forest canopy that allowed the vines to run amok.

"This is really typical of lots of tropical forest," said Dr. Schnitzer, a biologist at the University of Wisconsin-

What is so special about vines?

- Functional group of plants represented in > 80 families
- Can be woody (lianas) or herbaceous
- Common characteristic: need of other structures for support
- Important for agricultural and ornamental uses

Until recent years, vines had been mostly ignored in the literature

Vine invasions

Factors favoring vine success

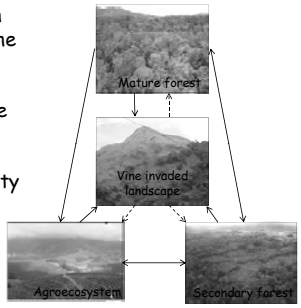
- Rapid growth
- Life strategy: structural parasites
- Greater dispersal ability

Consequences

- Alter landscape configuration
- Possible loss of function and services
- Infrastructure vulnerability

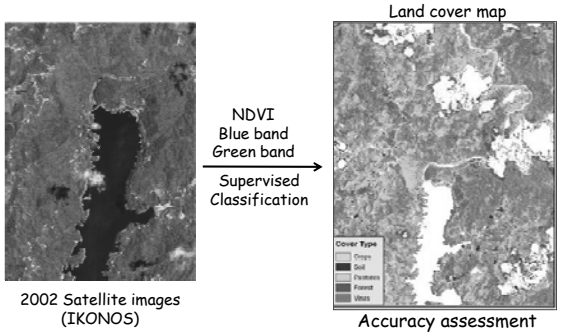
Vine invaded landscapes and sustainability

- Vine invaded landscapes can be seen as a new state of the system
- Conversion to this new state can affect the delivery of certain ecosystem services, thus decreasing sustainability
- This new state can be very resilient



Capacity to meet present needs without compromising the capacity of future generations to meet their own needs

Mapping vine patches: image processing and classification



2002 Satellite images (IKONOS)

Accuracy assessment

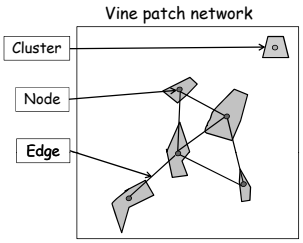
Networks modeling invasions

- Networks can be used to represent and measure connectivity
- Spatially explicit networks provide information about the configuration of the network in the landscape
- Tool use for management and conservation
- Provides information about the resilience of the network

Minor et al. 2009

Network analysis

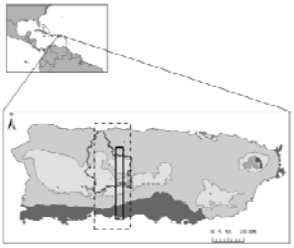
- Nodes- represent a vine patch >100m^2
- Edge- represent dispersal (100m) among patches



- Network Structure
  - Node degree - number of vine patches connecting a target node
  - Clusters - groups of connected vine patches

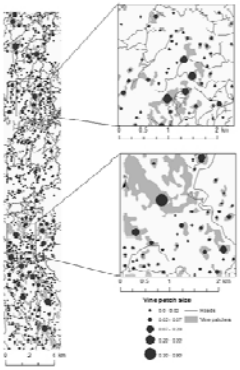
Study Area

- Complex mosaic of environmental conditions
- Diverse land uses
  - Dominated by second growth interspersed with old growth forests, agriculture, and urban areas



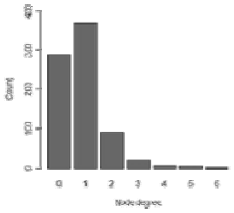
Location and size of vine patches

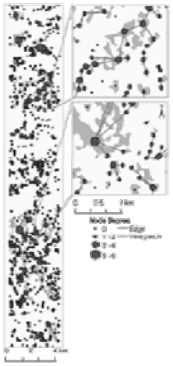
- 780 vine patches
- Vine patches cover 14 km^2 (8.2%)
- Land use under vine cover
  - 49% in croplands
  - 38% in forest
  - 12% in pastures
- Larger patches on croplands



Vine network node degree distribution

- 289 isolated patches
- 456 with 1-2 neighbors
- 16 highly connected patches (4-6 connections)



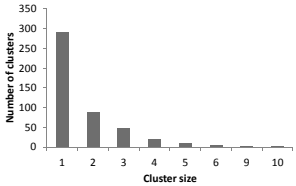


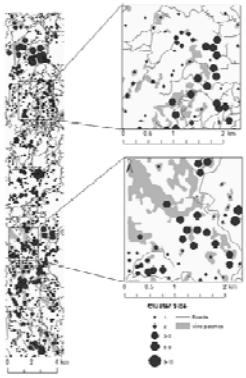
Conclusions

- The landscape is dominated by small vine patches
- The majority of vine patches are over crop lands and these patches are larger than those in other landuses
- **The majority of vine patches has a small number of** connections
- The landscape is dominated by clusters of vine patches of a small size
- Small number of vine species dominate in the use utility networks and can spread up to 41m.

Vine network cluster size distribution

- 534 clusters
- Range of cluster size:
  - 1 – 10 patches



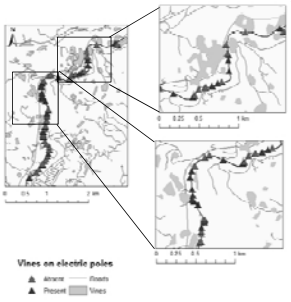


Acknowledgements

- Puerto Rico Louis Stokes Alliance for minority participation (PRLSAMP)
- David Managos
- Josimar Figueroa
- Juan Carlos Ortega

Vines presence on poles

- Vines present:
  - 113 poles (58%)
  - 101 lines (30%)
- Vine species included
  - *Cissus verticilata* (61%)
  - *Ipomoea spp.* (39%)
- Vine extend on average 11m (0.6m-41m, min-max)



Appendix M

Tropical Coastal Sustainability 101

Lessons learned from the slippery road towards sustainable practices in PR under a climate of change

Edwin A. Hernández-Delgado

University of Puerto Rico, Center for Applied Tropical Ecology and Conservation, Coral Reef Research Group

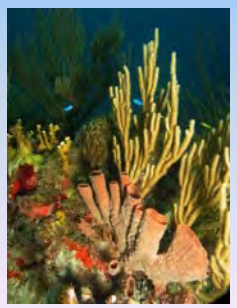
PO Box 23360, San Juan, PR 00931-3360

coral_giac@yahoo.com

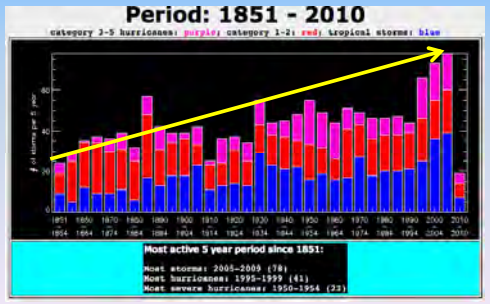
Quantifying Sustainability in Puerto Rico: A Scientific Discussion
U.S. Environmental Protection Agency
PR Convention Center, San Juan, PR, June 5-7, 2012

Objectives

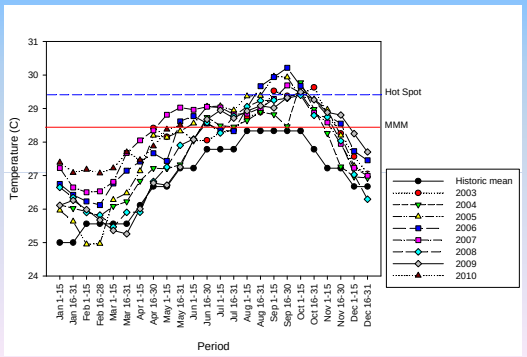
- Sustainable coastal ecosystems in PR: To be or not to be?
- Case studies from the Great Northeastern Reserve, PR.
- A sustainable community-based alternative for coral reef ecosystem management.
- Recommendations.



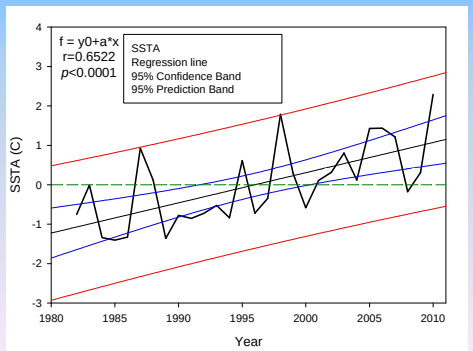
Lesson #1: Caribbean hurricane/storm frequency trends



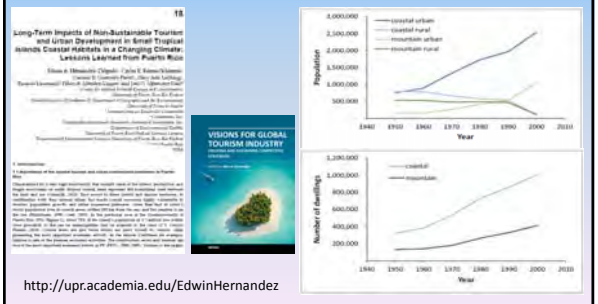
Lesson #2: Changes in mean annual SST in Culebra (2003-2010)



Changes in mean annual SST in PR (1980-2010)

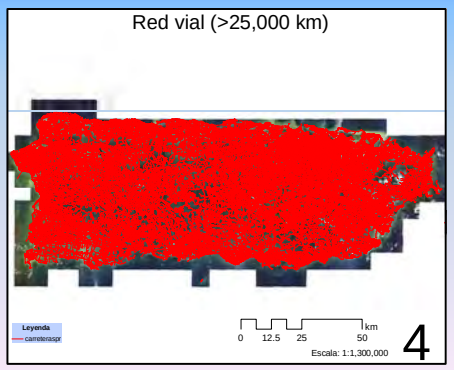


Lesson #3: Non-sustainable increase coastal urban development over the last six decades



http://upr.academia.edu/EdwinHernandez

Hernández-Delgado et al. (2012)



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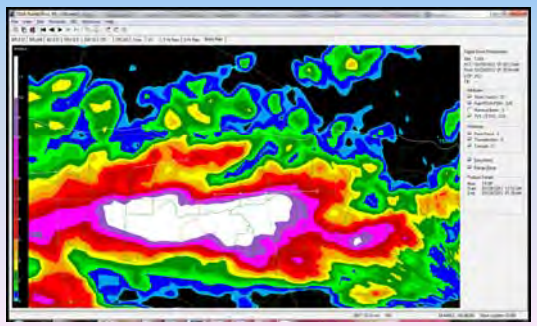
Lesson#4: Increased frequency of localized extreme rainfall events (i.e., March 29, 2012 – 20" rainfall/25 hr)



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Lesson #5: Potential indicators of non-sustainability in socio-economic development in PR

- Old-style, non-participatory, top-down approaches.
- Significant permanent negative environmental impacts "for the sake of **progress**".
- Continued socio-economic degradation.
- Lax regulations.
- Non-sustainable operations.

Hernández-Delgado et al. (2012)

Center for Applied Tropical Ecology and Conservation

Lesson #5: Indicators of non-sustainability in socio-economic development in PR

- Decision-making processes with significant conflicts of interests and corruption.
- Revenue leakage.
- Construction is often envisioned as the solution to economic constriction.
- Climate change impacts are not yet recognized as a major threat.

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Lesson #6: Dramatic chronic coastal water quality decline as a result of large scale development along watersheds and along the coast

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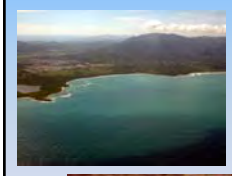
Great Northeastern Reserve? Really???



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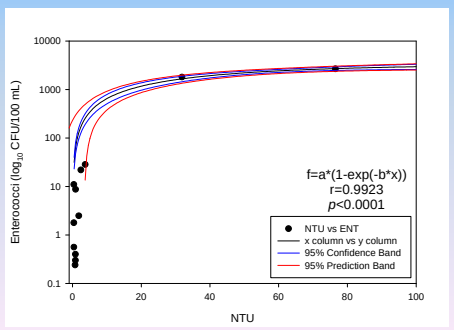
Lesson #7: Significant increase in fecal pollution with increasing water turbidity



Center for Applied Tropical Ecology and Conservation

Hernández-Delgado et al. (in prep.)

Lesson #8: Chronic fecal pollution, turbidity and eutrophication kill corals!

Bonkosky et al. (2009)

Hernández-Delgado et al. (2010)

Hernández-Delgado et al. (2011)

http://upr.academia.edu/EdwinHernandez

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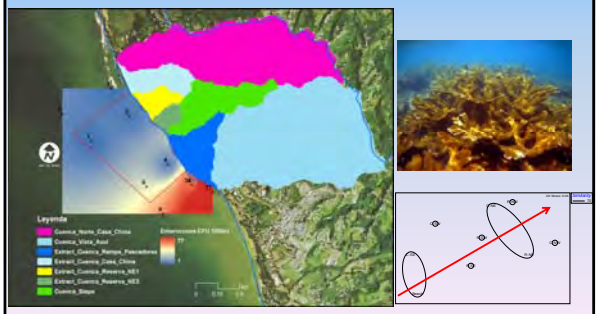
Lesson #9: GIS-based modeling shows impacts at sub-watershed level can significantly influence sewage pollution gradients

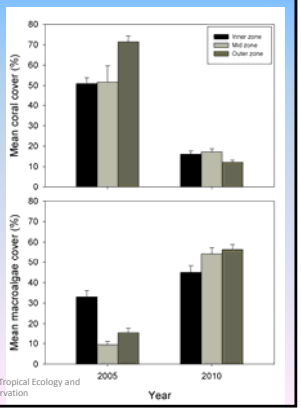


Tres Palmas Marine Reserve, Rincón

Center for Applied Tropical Ecology and Conservation

Méndez-Lázaro et al. (in press)

Lesson #10: Major coral reef decline over the last decades accelerated by unprecedented massive bleaching and coral mortality



Hernández-Pacheco et al. (in prep.)

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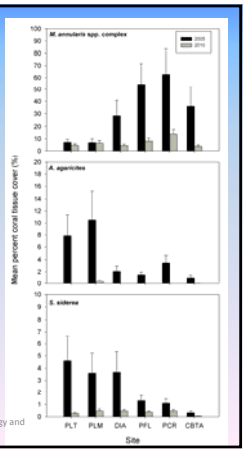
Significant loss of reef-building coral species



Hernández-Pacheco et al. (in prep.)

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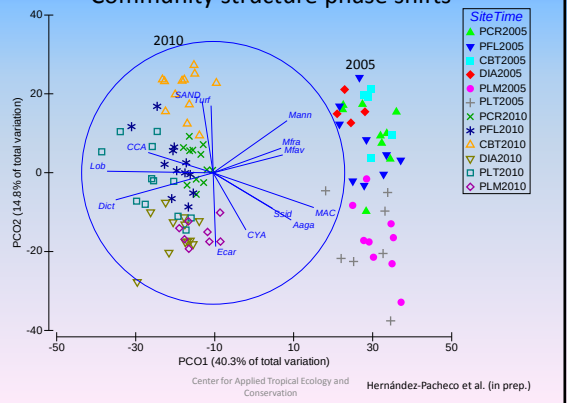
Community structure phase shifts



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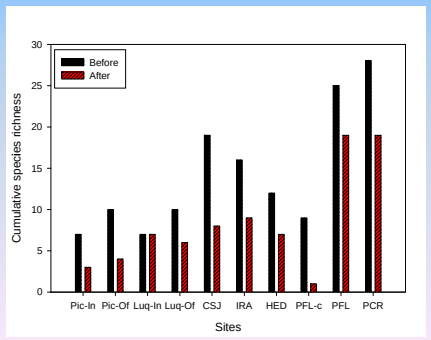
Hernández-Pacheco et al. (in prep.)

Lesson #11: Declining coral species richness across GNER



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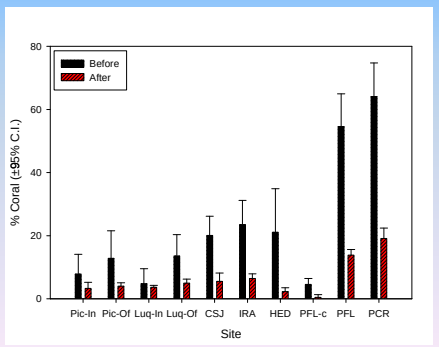
Hernández-Delgado et al. (in prep.)

GNER: Declining % living coral cover



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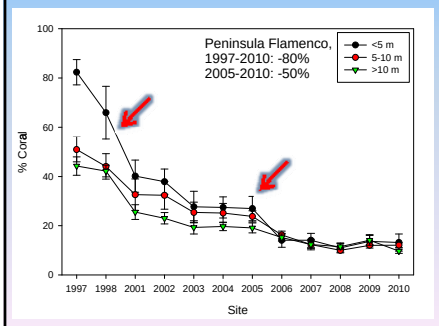
Hernández-Delgado et al. (in prep.)

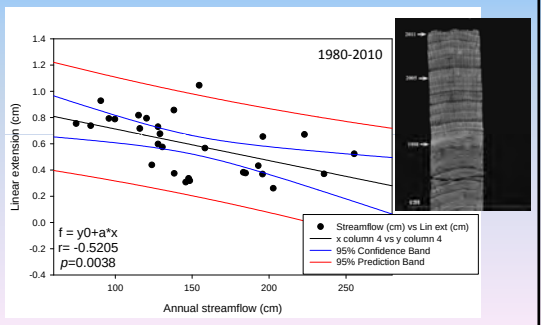
Lesson #12: Coral reefs in a road to slime?



Center for Applied Tropical Ecology and Conservation

(Hernández-Delgado et al., in preparation)

Lesson #13: Significant long-term decline in *M. annularis* growth rates with increasing Fajardo River flow



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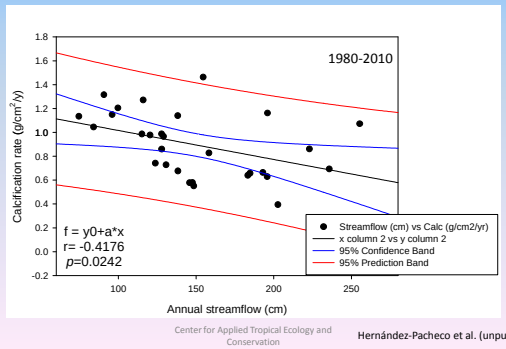
Hernández-Pacheco et al. (unpub)

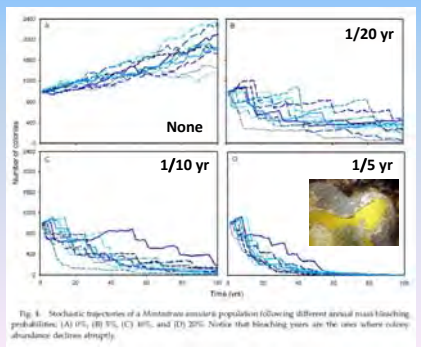
Significant long-term decline in *M. annularis* calcification rates with increasing Fajardo River flow



Center for Applied Tropical Ecology and Conservation

Hernández-Pacheco et al. (unpub)

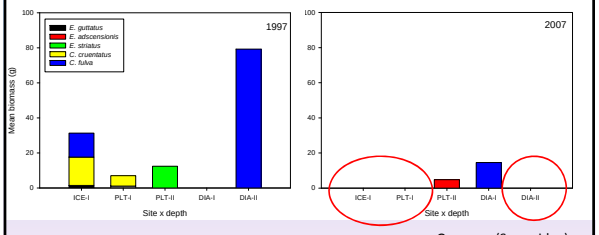
Lesson #14: Demographic models of recurrent massive bleaching and mass mortalities in *Montastraea annularis* suggest rapid extinction



Center for Applied Tropical Ecology and Conservation

Hernández-Pacheco et al. (2011)

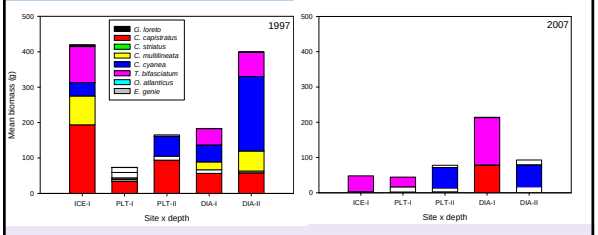
Lesson #15: Significant fish biomass decline (1997-2007)



Groupers (Serranidae)

Center for Applied Tropical Ecology and Conservation

Non-target fish biomass loss (1997-2007)



Center for Applied Tropical Ecology and Conservation

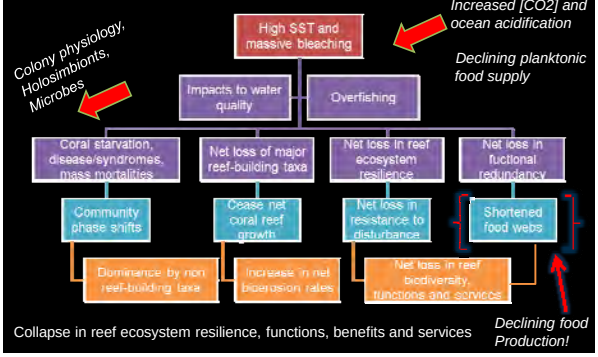
What does changes in fish communities mean?

- Overall decline across different trophic groups suggest significant non-sustainable impacts across large spatial and temporal scales due to:
  - Fishing impacts.
  - Environmental degradation.
  - Large-scale coral mortality as a result of climate change-related impacts.

Image: Michelle T. Schärer

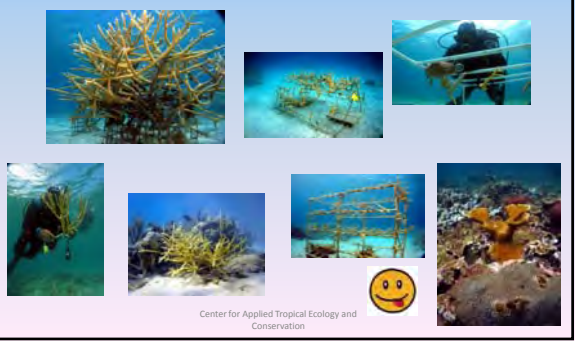
Center for Applied Tropical Ecology and Conservation

Combined long-term consequences of climate change and other human insults in coral reef functional roles



An alternate community-based sustainable approach to coral reef rehabilitation

Sociedad Ambiente Marino, Coralations, Vegabajeños Impulsando Desarrollo Ambiental Sustentable (VIDAS), UPR/CATEC



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Lesson #16: Coral farming aimed at multi-species reef rehabilitation

Center for Applied Tropical Ecology and Conservation

Community-based reef rehabilitation 101 in a climate of change

Restoration criteria	Benefits of community-based coral farming and reef rehabilitation in face of climate change
Conservation	Propagation and reintroduction of largely depleted coral species. Increased coral density to foster the recovery of coral reproduction at local scales and buffer the impact of reproductive isolation (Allee effects).
Reef accretion	Foster reef bio-construction by propagating and outplanting rapid-growing ecosystem engineer coral species. Help local coral reefs to increase accretion rates and adapt to projected rapid sea level rise.
Habitat structural complexity	Rehabilitate benthic habitat structural complexity, which provides shelter to a myriad of reef demersal species.
Biodiversity	Help replenish coral reef-associated biodiversity.

Center for Applied Tropical Ecology and Conservation

Community-based reef rehabilitation 101 in a climate of change

Restoration criteria	Benefits of community-based coral farming and reef rehabilitation in face of climate change
Ecological functions	Rehabilitate coral functional redundancy as fish nursery grounds by improving benthic habitat complexity.
Climate change adaptation	Rearing and propagation of high-temperature resistant, highly resilient, coral genetic clones with a higher ability to resist and recover from massive bleaching events will help improve overall reef ecosystem's resilience to future bleaching events.
Reconstruction of physically destroyed reef structure	Foster the seascape-level reconstruction of bomb-cratered, physically demolished, and coral-depleted reefs, with the aim of fostering the rapid recovery of coral reef functions.

Center for Applied Tropical Ecology and Conservation

Community-based reef rehabilitation 101 in a climate of change

Restoration criteria	Benefits of community-based coral farming and reef rehabilitation in face of climate change
Uniqueness	Whether a restored area is "one of a kind" (i.e., habitats of endangered or rare species). Significance across local, national and regional scales because of its unique biological features, ecological functions and improved connectivity value.
Naturalness	Degree to which the restored area helps in the recovery of reef's naturalness or lack of disturbance or degradation.
Dependency	Degree to which a species or a group of species depend on a restored area. Degree to which an ecosystem depends on ecological processes occurring within the restored area. Enhanced ecological functions on local scales will benefit overall reef ecosystem functions.

Center for Applied Tropical Ecology and Conservation

Community-based reef rehabilitation 101 in a climate of change

Restoration criteria	Benefits of community-based coral farming and reef rehabilitation in face of climate change
Representative-ness	Degree to which a restored area represents a habitat type, ecological process, biological community, geological feature or other natural characteristic, including the role as refuge for threatened or rare species.
Integrity	Degree to which a restored area is a functional unit or an effective, self-sustaining ecological entity or is functioning as a biological corridor between adjacent reefs.
Productivity	Degree to which the productive processes within a restored area contribute benefits to adjacent reefs (i.e., fostering coral larval recruitment, fish spillover effects), to other reef species (i.e., enhancing recruitment, shelter and/or feeding habitat), or to humans.

Center for Applied Tropical Ecology and Conservation

Community-based reef rehabilitation 101 in a climate of change

Restoration criteria	Benefits of community-based coral farming and reef rehabilitation in face of climate change
Connectivity	Degree to which a restored area is physically connected to other areas or degree of connectivity between colonies of any given species at other areas via surface currents. The rehabilitation of critically-located coral reefs will foster increased gamete and larval production of replenished coral species fostering potential higher recolonization of "downstream" reefs.
Regional significance	Degree to which the restored area represents a restored characteristic of the region or the degree to which the restored area fills a gap in a network of protected areas from the regional or sub-regional perspective.

Center for Applied Tropical Ecology and Conservation

Community-based reef rehabilitation 101 in a climate of change

Restoration criteria	Benefits of community-based coral farming and reef rehabilitation in face of climate change
Services	Increased coral densities will help to improve reef's greenhouse gases buffering role, it's natural breakwater function, particularly during storm and hurricane swells, its natural pharmacy function (source of natural products of bio-medical significance), and will improve reef-based fisheries productivity. If reef rehabilitation is carried out within a no-take reserve, it will further foster larger fisheries productivity and a spillover effect favoring fisheries productivity across adjacent habitats open to fishing.

Center for Applied Tropical Ecology and Conservation

Community-based reef rehabilitation 101 in a climate of change

Restoration criteria	Benefits of community-based coral farming and reef rehabilitation in face of climate change
Socio-economic benefits	Degree to which certain commercially-important species depend on a restored area. Degree to which a restored area plays an important link to adjacent fisheries. Degree to which reef restoration will impact the local economy in the long term and improve existing or potential value of an area to tourism activities. Degree to which reef restoration fosters the recovery of reef-based fisheries, improving catches on adjacent reefs, benefiting local artisanal fishers, and improving their livelihoods.
Education and outreach	Reef rehabilitation provides a useful hands-on, transformative educational tool aimed at empowering local base-communities to manage their coral reefs and carry out coral farming and reef rehabilitation in face of projected climate change impacts.

Final recommendations

- Community-based integration into all aspects of the process:
  - Discussion of problems.
  - Planning.
  - Decision-making.
  - Implementation.
  - Adaptation and revision.
- Scientists have the responsibility of translating technical knowledge into "normal" layman language.

Final recommendations

- To foster a sustainable development model in PR there is still a need for the immediate adoption of ***adaptation policies to climate change impacts***, with initiatives to:
  - ***Reduce the vulnerability*** of coastal natural and human systems against expected climate change effects.
  - ***Improve food security*** through appropriate agricultural and fisheries planning and management.

Final recommendations

- There is a need for the immediate adoption of adaptation policies to climate change impacts, with initiatives to:
  - ***Improve water quality and availability*** through appropriate water resources management.
  - ***Improve support to planning and operations in the public health sector*** (i.e. environmental monitoring, epidemiological studies, early warning systems).

Final recommendations

- There is a need for the immediate adoption of adaptation policies to climate change impacts, with initiatives to:
  - ***Improve disaster risk management*** (i.e., siting of critical infrastructure, preparedness and response to extreme events).
  - Prioritize ***capacity building*** of government institutions, private sectors, and academia.
  - Ensure greater availability of, access to, and use of ***climate services***.

Final recommendations

- ***Review and modify*** existing international policies of institutions such as World Bank, UNEP, USAID, EU, etc. of considering PR as a "developed nation", therefore excluding the island of significant funding and other resources directed towards capacity building on:
  - Environmental and socio-economic sustainability.
  - Biodiversity conservation and management.
  - Agriculture and fisheries development and management.
  - Climate change adaptation.

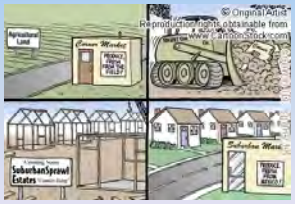
Final recommendations

- A ***moratorium*** in the PR government policy of fostering non-sustainable tourism and urban development across the coastal zone until an environmentally- and socio-economically sustainable strategy is implemented through:
  - A reviewed sound land use plan.
  - A climate change adaptation strategy.
  - The reincorporation of community-based participatory processes.

I. Noble (2012)

Final recommendations

- All permit applications still under consideration by Commonwealth and Federal government agencies, should be reanalyzed under ***more strict parameters*** to ensure long-term sustainability, as well as meaningful community-based participation.

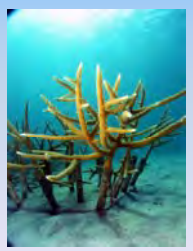


Final recommendations

- There is also a need to:
  - ***Eliminate*** the standard USEPA policy of fostering 301h waivers to PR regional sewage treatment facilities.
  - Establish a long-term ***coastal water quality monitoring program***.
  - ***Modify*** existing coastal WQ microbiological standards in PR.
  - Establish ***N and P standards***.

Final recommendations

- Community-based coral farming and reef restoration initiatives have resulted highly successful on local scales to ***rehabilitate coral reef*** ecological functions and ecosystem values.
- They have also resulted in important ***hands-on*** educational experiences that have fostered paramount ***transformation on behaviors***.
- There is a ***need to expand*** the current scale of community-based reef management efforts by improving funding to foster improved capacity building, training and education, and new projects across different localities in PR.



Final recommendations

- There is ***still an opportunity*** to ensure that today's investment in coastal tourism and urban development will not compromise the availability and quality of resources for future generations.
- We ***still have a chance*** to use a precautionary approach in our investment in coastal development to minimize the risk and vulnerability against projected climate change-related impacts.
- But ***we need to switch*** from the current non-sustainable model to a sustainable alternative.

Appendix N

Community-based efforts for the sustainable conservation and management of coral reefs at Vega Baja and Manatí,Puerto Rico

Ricardo Laureano*[1], Edwin A. Hernández Delgado[2], Samuel E. Suleimán Ramos[3], Mario Bosque [1] and Alberto Archilla[1]

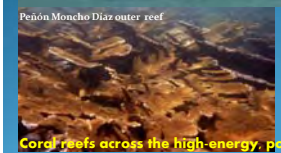
[1]Vegabajeños Impulsando Desarrollo Ambiental Sustentable (VIDAS), Vega Baja, PR; [2]University of Puerto Rico, Center forApplied Tropical Ecology and Conservation, Coral ReefResearchGroup, PO Box 23360, San Juan, PR 00931 3360, [3]Sociedad Ambiente Marino, PO Box 22158, San Juan, PR 00931 2158.

Acroporid coral populations have largely declined across the Atlantic over the last four decades

In a combination of natural and human factors, including climate change. We are responsible for a great amount of the damages.

The north shore reefs of PR are not an exception. There is no time to lose, the time to make transcendental decisions is right now

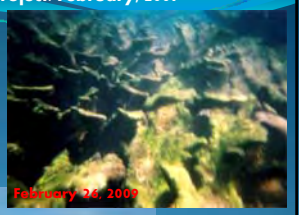
Vega Baja and Manatí issues

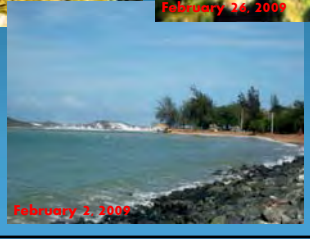


Coral reefs across the high-energy, poorly studied, northern coast of Puerto Rico still support impressive large thickets of threatened Elkhorn coral (*Acropora palmata*). Fringing reefs off Vega Baja (VB) and Manatí (Mnt) have very high densities of this species.

- If the government continues the practice of using the maritime terrestrial zone as a s te for permanent structures the whole archip e ago s going to end without the protection of the natural coastal barriers and the food source that the reefs represent.
- If we keep on us ng the water bodies as toi et bowls we are going to lose everything.
- The only way we can deal with the water evel rise assoc ated with global warming is with coral reef growing to stabilize the breakers
- And ... What about the enforcement???...

VB Public Beach reconstruction project. February, 2009





Without permits a private company contracted by VB Municipality impacted the ecosystems. Without sediments and erosion controls inland and in the waters.

In the next slide we will see that since 2004, that company have to follow an order from the EPA about water bodies, so they knew there was protocol to minimize impacts.

EPA Takes Act on to Ensure that Puerto Rico Highway Authority and Contractors Meet Stormwater Controls

Release date 03/17/2004

Contact Information

(214065) New York N.Y The U.S. Environmenta Protection Agency (EPA) announced today that it has taken act on on a large number of highway construction sites in Puerto Rico to ensure that the environmenta regu at ons of the Clean Water Act are being met. EPA evaluated sites in Puerto Rico and ssued Administrat ve Orders to those contractors that failed to subm t a Not ce of Intent (NOI) to obtain a Stormwater Construction Genera Permit (CGP) for construction sites. Based on information provided by the Highway Authority, there are many ongo ng construction pro ects throughout Puerto Rico at which NOIs were not submitted by their contractors

The Admin strat ve Orders cou d require that the Puerto Rico Transportation and Highway Authority and their contractors stop such activities as clearing, grading and excavat ng until the work is author zed by a CGP. Sites that already submitted NOIs and have mplemented al requ rements but did so late may continue clearing, grading and excavat ng

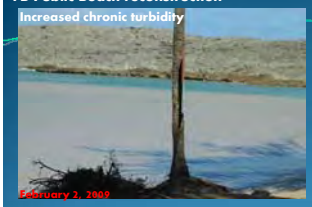
"When left uncontrolled, stormwater runoff can contaminate drinking water supplies and damage recreational waterways," said Jane M. Kenny, EPA Regional Administrator. "We are making progress to ensure that erosion and stormwater runoff from construction sites is controlled so as not to impair area waters. We will continue to enforce the law at other construction sites at which there is a failure to comply with the Clean Water Act."

These Administrative Orders are being issued to the Puerto Rico Transportation and Highway Authority and the following contractors:

- Construcciones Jose Carro SE
- Constructora Fortis, Inc.,
- M sener Construct on Inc.
- Tamrio Inc.,
- Unique Builders
- Kaiser Construction
- Eng. Jose J. San Miguel,
- Del Valle Group Eng neers & Contractors
- L. Reyes Contractors
- Cabimar SE,
- Eng. Jose Jimenez
- MP Antilles Construction
- Carro & Carro Contractor I Melendez
- DBA Construction
- Gurimar Construction
- Rio Construction Corp.,
- Rolbes Aspha t Co.,
- Construction Inc.
- Las P edras Construction & Demo t on Inc.

These orders also require that each operator submit mplement and certify a Stormwater Pollut on Prevent on Plan This is necessary to make certain that eros on and stormwater from construction sites is controlled so they do not impair water bod es

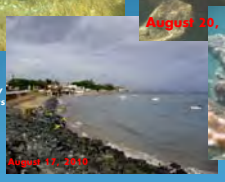
VB Public Beach reconstruction



Coral mortality during 686 road reconstruction.

Coastal rip rap VB, 2010

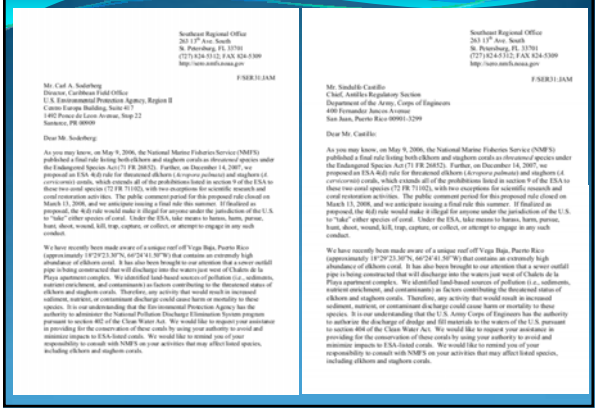
Once again a private company but this time hired by a central government agency the PR Road Authority that company was CD Bu ders They were allerted about the coral reef mportance of the area, and the measure s to take to minimize impacts But they continued their coral killing operation



Inadecuate and erosion controls (ec), moved sediments plumes to the inner reef, where the sediments of 2009 event could not reach.

1. External face of the underwater (ec), without mesh to minimize impacts, it have to be tighten to the sand.
2. As an anchor, a cement block, as a line a yellow poliethilene rope, (the SOP is nautical rope and umbrella anchors).

4(d) rule to VB



Southeast Regional Office
263 13th Ave. South
St. Petersburg, FL 33701
(727) 824-5312; FAX 824-5309
http://sero.nmfs.noaa.gov

F/SER31:JAM

Mr. Sindulfo Castillo
Chief, Antilles Regulatory Section
Department of the Army, Corps of Engineers
400 Fernandez Juncos Avenue
San Juan, Puerto Rico 00901-3299

Dear Mr. Castillo:

As you may know, on May 9, 2006, the National Marine Fisheries Service (NMFS) published a final rule listing both elkhorn and staghorn corals as *threatened* species under the Endangered Species Act (71 FR 26852). Further, on December 14, 2007, we proposed an ESA 4(d) rule for threatened elkhorn (*Acropora palmata*) and staghorn (*A. cervicornis*) corals, which extends all of the prohibitions listed in section 9 of the ESA to these two coral species (72 FR 71102), with two exceptions for scientific research and coral restoration activities. The public comment period for this proposed rule closed on March 13, 2008, and we anticipate issuing a final rule this summer. If finalized as proposed, the 4(d) rule would make it illegal for anyone under the jurisdiction of the U.S. to "take" either species of coral. Under the ESA, take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct.

We have recently been made aware of a unique reef off Vega Baja, Puerto Rico (approximately 18°29'23.30"N, 66°24'41.50"W) that contains an extremely high abundance of elkhorn coral. It has also been brought to our attention that a sewer outfall pipe is being constructed that will discharge into the waters just west of Chalets de la Playa apartment complex. We identified land-based sources of pollution (i.e., sediments, nutrient enrichment, and contaminants) as factors contributing the threatened status of elkhorn and staghorn corals. Therefore, any activity that would result in increased sediment, nutrient, or contaminant discharge could cause harm or mortality to these species. It is our understanding that the Environmental Protection Agency has the authority to administer the National Pollution Discharge Elimination System program pursuant to section 402 of the Clean Water Act. We would like to request your assistance in providing for the conservation of these corals by using your authority to avoid and minimize impacts to ESA-listed corals. We would like to remind you of your responsibility to consult with NMFS on your activities that may affect listed species, including elkhorn and staghorn corals.

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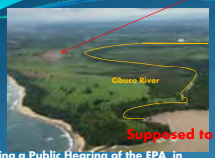
VB Landfill



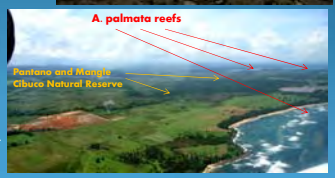
Supposed to be closed since 2010

❑During a Public Hearing of the EPA in March 2007. At Teatro America in VB yours truly submitted a public comment concerning the Elkhorn corals of the area

❑In 2010 a company named Newport Recycling supposedly started a process to move some of the waste and ...

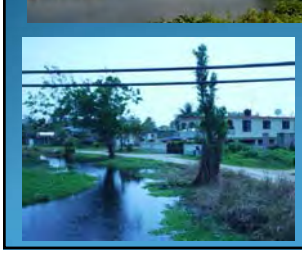
❑In 2012 the landfill is still open and administrated AWDI (atlantic waste and disposal) whose owner witnessed against the former mayor E. Santana that he (AWDI's owner) offered to Santana a considerable amount to arrange contracts. That ended in the extortion case that put the former mayor in prison

❑But the leacheate still drain into the river, and from the river to the sea ...



The question is, who is going to enforce the law ???

VB's Water Treatment Plant



❑After 30 years arrested the government said that the plant s working to cover VB's actual capac ty but that does not nc ude all the projects proposed nor al the v ages which are us ng septic tanks

❑Ca o Caba Caribe a tributary of the C buco River receives all the spill and then to the sea

❑The nutrients levels are very h gh that the water lillies are removed 2 or three times a year

❑Los Naranjos Community (maybe one of the oldest coastal village of PR north shore founded by freed slaves 135 years ago, who chose the area because of the fresh water springs the fishery and the land qual ty) get flooded several times a year. So the descendants of that brave people still suffers pre udices because no one help them with their problems 135 years ago nobody wants to l ve here, now they want to relocate them to make "beach condos

Los Tubos Beach, Manatí (Mnt)

Zoning change menace for hotels construction in the Buffer Zone of Laguna Tortuguero Natural Reserve

In Public Hearing and Public Reunions VIDAS made clear his position about the conservation of the area, and required a signed commitment to the Mnt mayor in which he would not promote a zoning change for the area

We required that commitment, because in a protected zone, the machine below broke eggs at a turtle nesting ground

We could not imagine, what would happen if we let them change the zoning

From VB to Mnt, we have evidence of nesting and eclosions of Dermochelys coriacea and Eretmochelys Imbricata
After few months of pressure and the collaboration of the Mnt Municipality Planner we received a document that looks like the mayors commitment (sorry about the skceptism). But to reach goals in benefit of our people, all the sectors have to be involved

If we have all this papers, rules and orders from the agencies. What happens with the enforcement???

- We know that an ESA case is not too profitable for the related agency, but for a community habitat restoration project is enough.
- We know that a CWA is profitable.

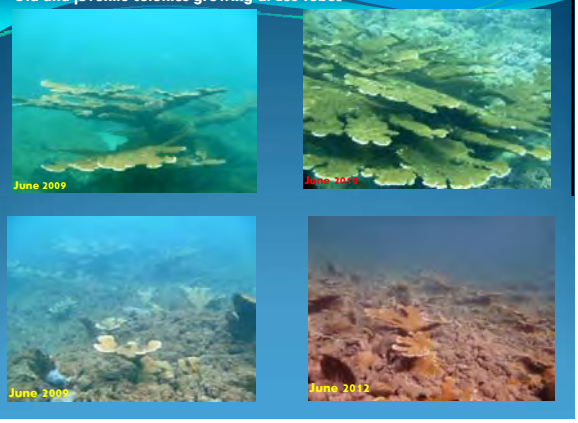
As a short story: There was a law enforcer specialized in Endangered Species (that learned a lot with us). He spent 2 years collecting information with us. He said that he need reports of the issues concerning the cases. We gave him 3 reports, he took them to Washington Department of Justice Environmental Division. A prosecutor came to an interview. He said the case have good possibilities and that's it. The agent ended transferred to another agency. This is how enforcement works???

We are talking about the 1st case of A palmata since the coral got listed in the ESA, possibly the biggest A palmata reef in the Federal jurisdiction.

The thing is that the only way to find real results is combining efforts.

We have been working that model with the academy , the scientific community and some agency members that believes in solidarity.

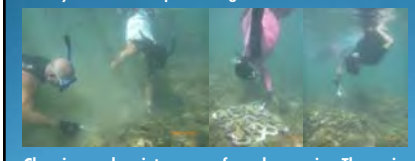
Old and juvenile colonies growing at Los Tubos



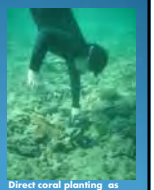
The image comprehends water sampling spots but it also demonstrates the dimensions of the reef. And some other details like ...

Low tech reef conservation efforts

Nursery units to develop coral fragments



Cleaning and maintenance of coral nurseries. The main part of any coral farming project



Direct coral planting as the fastest way to deve op living reef coverage

We Propose:

- Develop an ecofriendly runoff management plan, which works as model for other communities with similar issues. Here we livein the middle of 3 interconected ecological sensitivity areas, at S El Pantano y el Mangle de Cibuco Natural Reserve, at W Laguna Tortuguero Natural Reserve, and to the N one of the biggest coral reef barrier in the federal jurisdiction, para vivir aquí hay que tomar las providencias necesarias y parte de ello es la declaración de área prioritaria.
- Designate Los Jardines Submarino de Vega Baja a Manatí Natural Reserve, which includes the communities in the the develop of the Management Plan.
- Develop an educational program about the sustainable use and respect to the nature
- Foster communities with ecotourism projects, for the cultural benefits of our coastal villages

V.I.D.A.S.
Es una ONG (organización no gubernamental) fuera de líneas partidistas, el espacio de cada cual se respeta sobre todo el de la naturaleza, al fin y al cabo todos respiramos el mismo aire y usamos las mismas aguas.
grupo.vidas@gmail.com

VIDAS
VEGABAJEÑOS IMPULSANDO DESARROLLO AMBIENTAL SUSTENTABLE

Appendix O

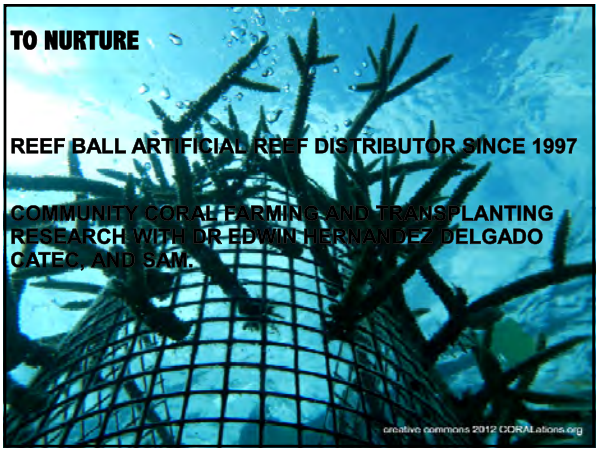
CORALATIONS

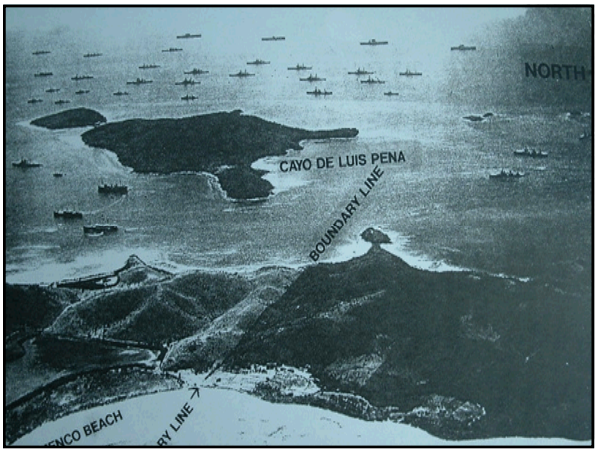
conserve • nurture • educate

conservar • cuidar • educar

www.coralations.org

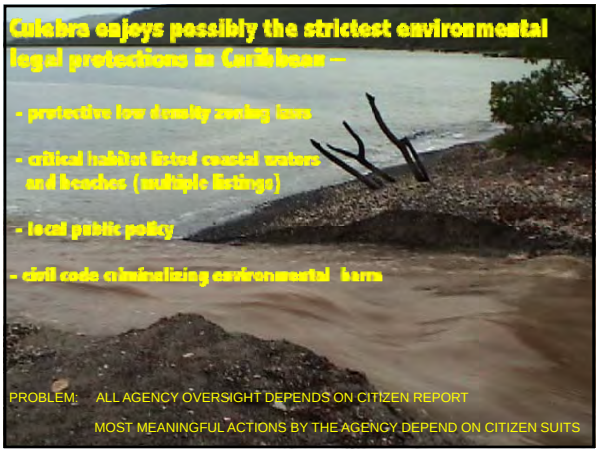
Founded in Puerto Rico as non profit in 1995
Registered 501(c)3






Posada del Coronel – builds road in river bed…
EPA site visit: January 11, 2007
NPDES violation issued September 11, 2007
Inteligentemente.
WESTERNBANK
El Banco del Pueblo


Costa Bonita Resort: Day of Grand Opening Regatta

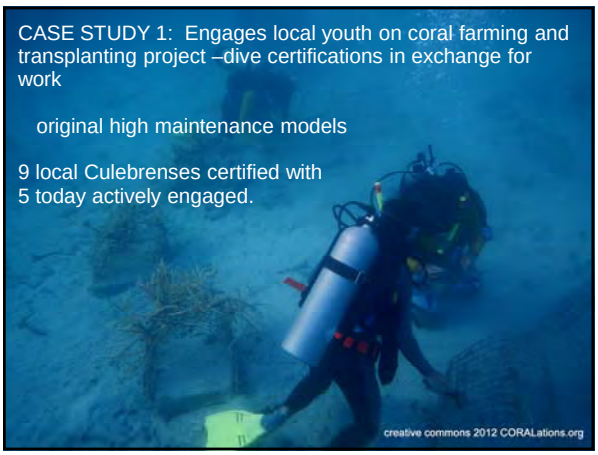

Culebra enjoys possibly the strictest environmental legal protections in Caribbean –
- protective low density zoning laws
- critical habitat listed coastal waters and beaches (multiple listings)
- local public policy
- civil code criminalizing environmental harm
PROBLEM: ALL AGENCY OVERSIGHT DEPENDS ON CITIZEN REPORT
MOST MEANINGFUL ACTIONS BY THE AGENCY DEPEND ON CITIZEN SUITS

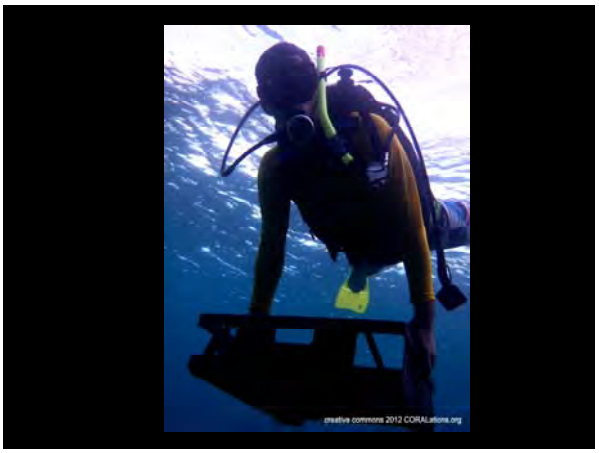

Bienvenidos a la Reserva Natural Canal de Luis Peña
AREA MARINA PROTEGIDA
PROHIBIDO
FIRST NO TAKE RESERVE DESIGNATED IN WATERS OF PUERTO RICO
PROPOSED BY LOCAL FISH ASSOCIATION IN 1981 – DESIGNATED 1999


TIME IS RUNNING OUT FOR THESE
"PROTECTED" SPECIES

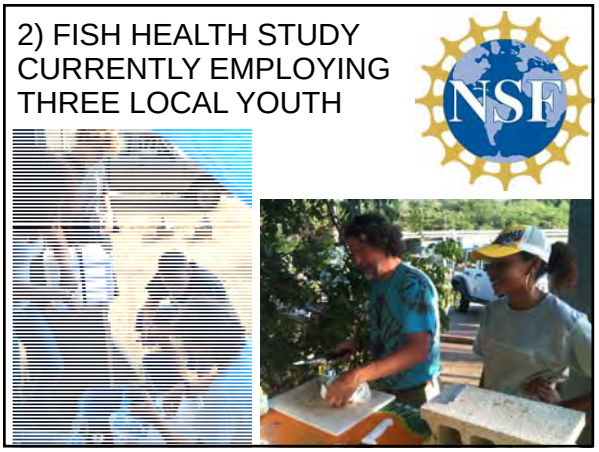

Current Environmental Education Tracks:
-apart from researchers
-focused on future stakeholders
-brochures, posters, coloring books, web
-requires time
Creative Commons CORALations 2011

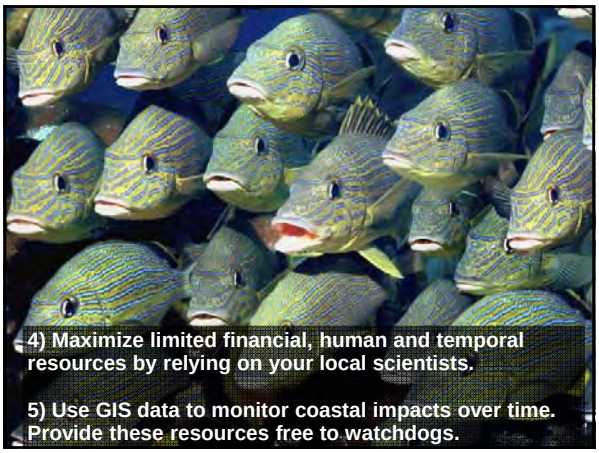

New Approach:
Using economic incentives to maximize limited human and financial resources in order to facilitate more sustainable behaviors.
Creative Commons CORALations 2011


CASE STUDY 1: Engages local youth on coral farming and transplanting project –dive certifications in exchange for work
original high maintenance models
9 local Culebrenses certified with
5 today actively engaged.
creative commons 2012 CORALations.org



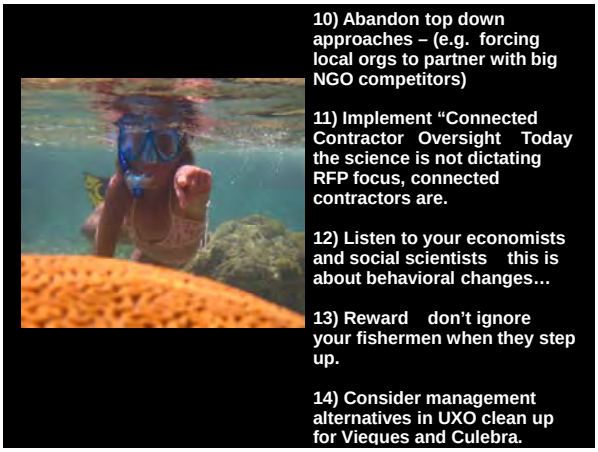
2) FISH HEALTH STUDY CURRENTLY EMPLOYING THREE LOCAL YOUTH




4) Maximize limited financial, human and temporal resources by relying on your local scientists.
5) Use GIS data to monitor coastal impacts over time. Provide these resources free to watchdogs.


6) Provide ethics seminars for employees
the amount of money a violator has should not influence enforcement actions.
7) Abandon mitigation deals.


8) PR needs to appoint a DA schooled and devoted only to environmental crimes only.
9) Abandon complex balanced fishery management legislation and work bottom up to create small MPAs with local communities.


10) Abandon top down approaches – (e.g. forcing local orgs to partner with big NGO competitors)
11) Implement "Connected Contractor Oversight Today the science is not dictating RFP focus, connected contractors are.
12) Listen to your economists and social scientists this is about behavioral changes…
13) Reward don't ignore your fishermen when they step up.
14) Consider management alternatives in UXO clean up for Vieques and Culebra.

Appendix P

The Automated Remote Biodiversity Monitoring Network

T. Mitchell Aide (Biology) and **Carlos J. Corrada Bravo** (Computer Science)

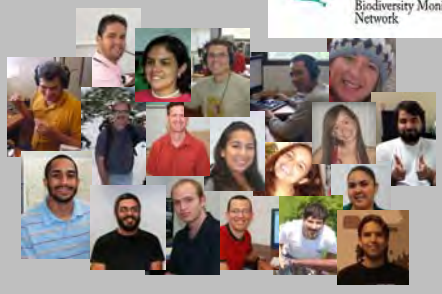
University of Puerto Rico – Rio Piedras

Quantifying sustainability in Puerto Rico

Research, management, and conservation communities need better long-term data for fauna….. How?

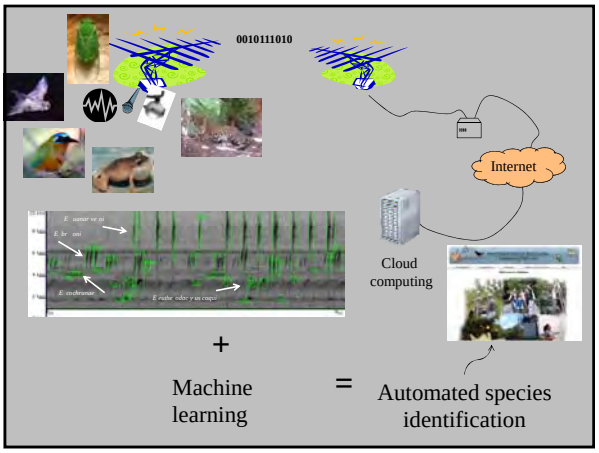
Typical	Automated data collection
Lots of field biologists?	Many sites
24 hours per day?	24 hours per day
365 days per year?	365 days per year
Observer bias	No observer bias
No permanent record	Real-time
	Open access
	Permanent (verifiable) record

TEAM -



Automated Remote Biodiversity Monitoring Network

- **Automated**
  - Technology
    - Wireless
    - Internet
    - Sound
    - Images
    - Real-time
- **Remote**
  - Solar energy
  - Difficult access
- **Biodiversity**
  - Birds
  - Amphibians
  - Insects
  - Bats
  - Fish
  - Marine mammals
- **Monitoring**
  - Frequent
  - Long-term
  - Many sites
  - Permanent record
- **Network**
  - User driven
  - Global
  - Cloud computing

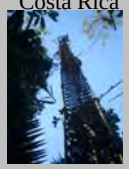


Permanent stations

El Verde, PR

Sabana Seca, PR

La Selva, Costa Rica

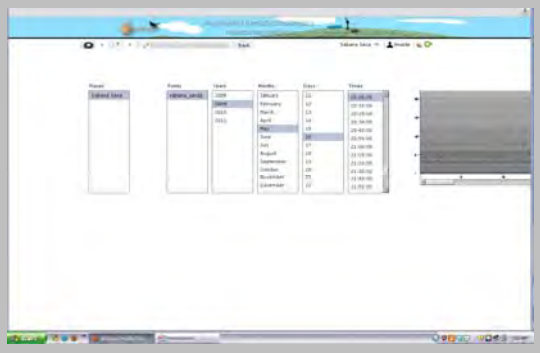


Hawaii

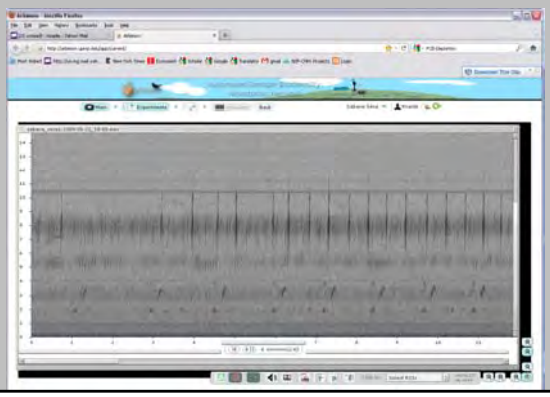
Portable recorder

Software - Dynamic Web page

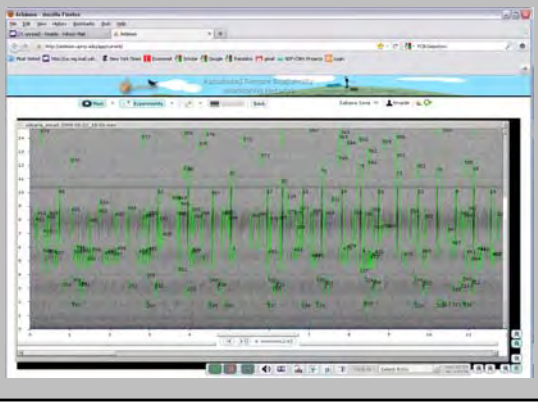
Access to the recording archive



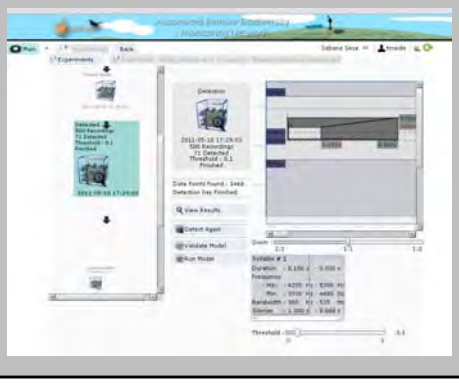
Web based visualizer + tools

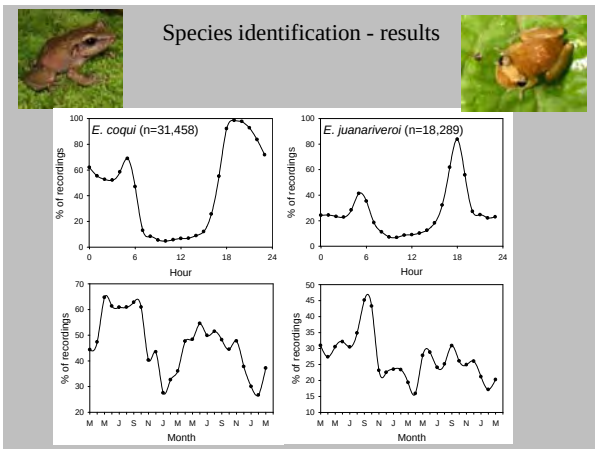


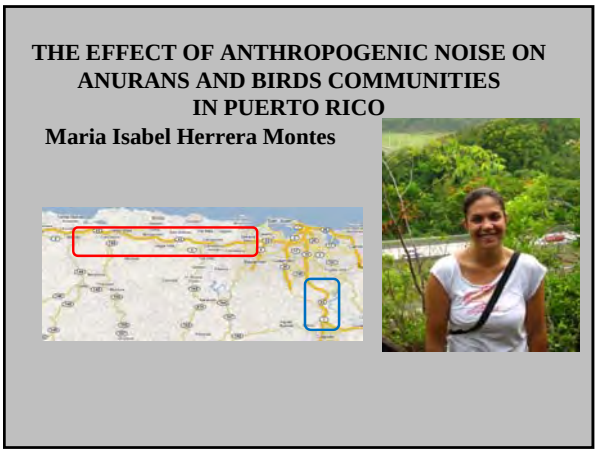
Algorithm produces regions of interest (ROIs)

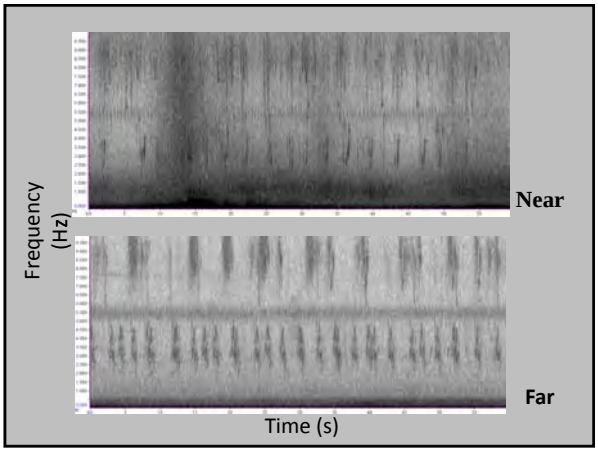


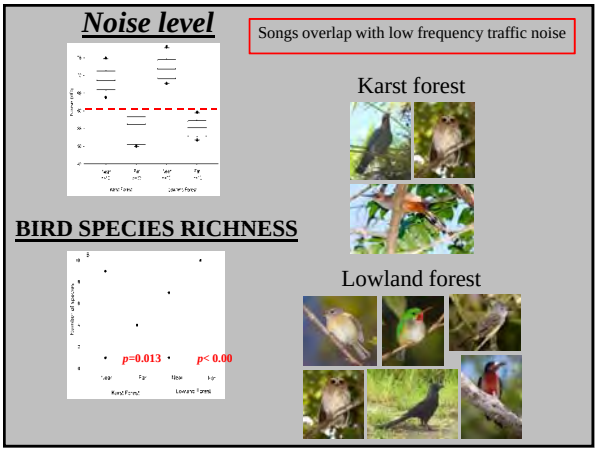
Automated species identification: **species detection**

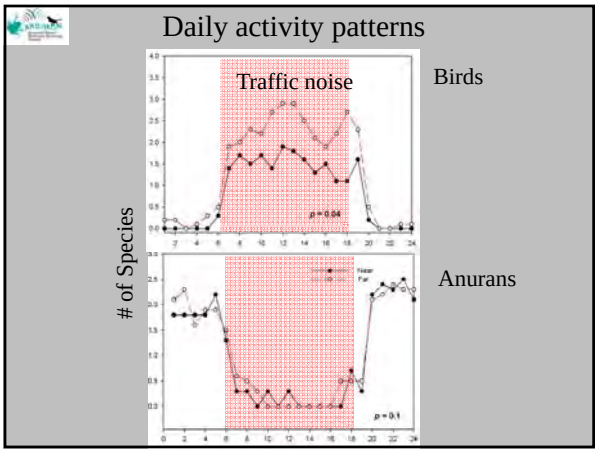


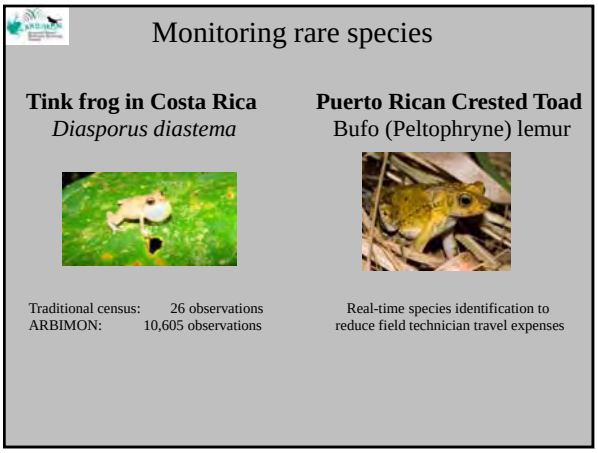

Species identification - results
E. coqui (n=31,458)
E. juanariveroi (n=18,289)
% of recordings
Hour
Month


THE EFFECT OF ANTHROPOGENIC NOISE ON ANURANS AND BIRDS COMMUNITIES IN PUERTO RICO
Maria Isabel Herrera Montes


Frequency (Hz)
Near
Far
Time (s)


Noise level
Songs overlap with low frequency traffic noise
Karst forest
BIRD SPECIES RICHNESS
p=0.013
p< 0.00
Lowland forest


Daily activity patterns
Traffic noise
Birds
Anurans
# of Species


Monitoring rare species
Tink frog in Costa Rica
Diasporus diastema
Puerto Rican Crested Toad
Bufo (Peltophryne) lemur
Traditional census: 26 observations
ARBIMON: 10,605 observations
Real-time species identification to reduce field technician travel expenses

Quantifying sustainability in Puerto Rico

Questions?

ARBIMON
Automated Remote Biodiversity Monitoring Network

Appendix Q

The Distribution of Pollution and Environmental Justice in Puerto Rico

Shanshan Wu and Matthew T. Heberling

Puerto Rico Workshop, June 2012

Office of Research and Development
National Risk Management Research Laboratory, Sustainable Technology Division, Sustainable Environments Branch

Introduction

This study attempts to understand environmental inequalities and health in Puerto Rico. We examine two related issues:

- Pollution distribution
  Environmental Gini Coefficient (Millimet and Slottje 2000)
- Environmental justice (Maguire and Sheriff 2011)
  - Visual displays (e.g., GIS)
  - Summary statistics
  - Regression analysis
    To investigate a relationship between toxic releases and several socioeconomic and demographic indicators;

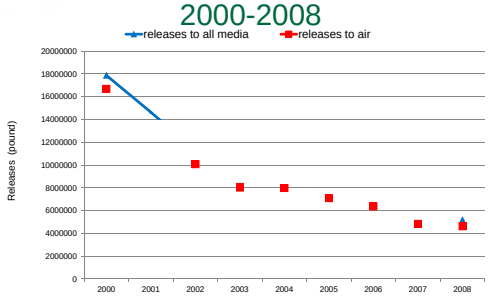
2

Data Description

- Toxic Releases Inventory (TRI)
  - Releases to all media (air, land, water, underground)
  - Releases to air
  - Time: 2000-2008
  - Number of municipios (50)
- Socioeconomic and demographic indicators
  - Data source: US Census website; American Community Survey
  - Time: 2005-2008
  - Number of municipios (50)

3

Toxic Releases 2000-2008



4

Distribution of Toxic Releases in Puerto Rico

- Environmental Gini Coefficient (Millimet and Slottje 2000)

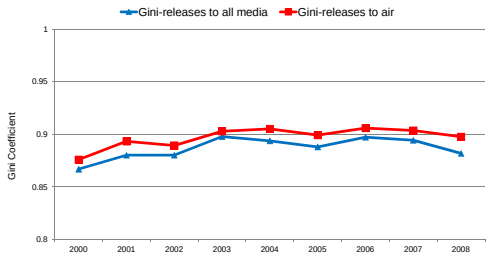
$$G = \frac{2\mathrm{cov}(E,F)}{\mu}$$

E: per capita releases
F: cumulative distribution of per capita releases
μ: mean value of per capita releases of all municipios
Cov: covariance

Gini is bounded within the interval (0,1); zero indicates perfect equality and one indicates perfect inequality.

5

Environmental Gini Coefficient 2000-2008



6

Environmental Justice in Puerto Rico

- USEPA: EJ is achieved when everyone enjoys the same degree of protection from environmental hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work.

http://www.epa.gov/environmentaljustice/index.html

7

Summary of Socio-Demographic Indicators

Indicator	Measurement	Expected sign
Race	% of population which is white, black, Asian and other Pacific, and other Hispanic(non-Puerto Rican such as Mexican, Cuban and other Hispanic and Latino)	% of nonwhite are expected to be positive
Population density	Total population divided by the size of each municipio	Positive
Poverty	% of population which lives below an acceptable poverty level	Positive
Education	% of population which is a high school graduate or has a bachelor's degree or higher	% of high school graduate is expected to be positive; % of bachelor's degree is expected to be negative

8

Indicator	Measurement	Expected sign
Housing rental status	% of total housing units which is renter occupied	Positive
Age	% of population which is under 14 or over 65	Both percents are expected to be negative
Unemployment	% of civilian labor force which is unemployed	Positive
Car ownership	% of workers over 16 driving alone to work	Negative

9

Model

$$\ln(1+e_i) = \beta_1 + \beta_2 white_i + \beta_3 black_i + \beta_4 asian_i + \beta_5 otherhispanic_i + \beta_6 popden_i + \beta_7 poverty_i + \beta_8 school_i + \beta_9 college_i + \beta_{10} rent_i + \beta_{11} under14_i + \beta_{12} over65_i + \beta_{13} unemployed_i + \beta_{14} vehicle_i + \delta_t + \varepsilon_i$$

- Data: 2005-2008, 50 municipios
- Econometric methodology
  - Quantile regression approach
  - Ordinary least squares (OLS); Tobit
- Main results (quantile regression results)

10

Releases to all media (per capita)	0.2 quintile	0.4 quintile	0.6 quintile	0.8 quintile
White (%)	0.193	0.848	1.504	-1.920
Black (%)	-0.323	-0.565	0.924	-3.272*
Asian or other Pacific (%)	14.932	52.113*	48.189	36.230
Other Hispanic or Latino (%)	10.360***	10.388**	4.343	26.244***
Population density	-0.0002***	-0.0002***	-0.0002	-0.0006***
Poverty	-0.874	-1.053	1.657	5.443
School	2.206*	4.348*	8.999	19.988**
College	-2.812**	-3.863	-4.995	-16.952***
Rent	0.661	1.401	1.511	-9.767*
Under14	-6.341**	-7.571	-18.152	-50.239***
Over65	-8.257**	-11.299*	-16.486	-27.475*
Unemployed	0.600	1.252	3.589	7.546**
Vehicle	-0.683	-0.865	-0.865	-13.102***
Pseudo R^2	0.06	0.12	0.17	0.38
F-test (Equality)	1.81 (0.005)			
Number of Obs.	166			

Releases to air (per capita)	0.2 quintile	0.4 quintile	0.6 quintile	0.8 quintile
White (%)	0.063	0.453	-0.149	-1.133
Black (%)	-0.115	-0.198	1.242	-0.421
Asian or other Pacific (%)	5.244	23.543	47.994	44.033
Other Hispanic or Latino (%)	4.045	9.476**	3.344	11.238
Population density	-0.00007	-0.0002*	-0.00008	-0.0005**
Poverty	-0.409	-0.812	1.463	8.040**
School	0.845	3.038	6.160	20.176**
College	-1.151	-3.091	-3.954	-10.356*
Rent	0.307	1.264	1.505	-5.189
Under14	-2.901	-6.587	-19.745*	-42.847***
Over65	-3.027	-8.735*	-16.900	-26.830*
Unemployed	0.082	1.211	3.298*	4.695
Vehicle	-0.267	0.265	2.000	-10.364**
Pseudo R^2	0.04	0.09	0.15	0.35
F-test (Equality)	1.56 (0.03)			
Number of Obs.	168			

Sensitivity analysis

- Income variables:
  - per capita income, average weekly wage
- Results:
  - Income differentials are not strongly related to releases in Puerto Rico (Carruthers 2008).

13

Summary

- Large estimates of Environmental Gini coefficient (close to 1) imply that toxic releases are unequally distributed in Puerto Rico, but inequality is not getting larger over 2000-2008.
- Indicators of non-white population, population density, education, age, unemployment and car-ownership all have clear and significant relationships with toxic releases.
- To policy makers, a focus on education and unemployment is important because both indicators are clearly and strongly related to toxic releases.

14

References

- Carruthers, D. 2008. Environmental Justice in Latin America: Problems, Promise, and Practice. Massachusetts Institute of Technology, Cambridge, MA.
- Maguire, K., and G. Sheriff. 2011. Comparing Distributions of Environmental Outcomes for Regulatory Environmental Justice Analysis. *International Journal of Environmental Research and Public Health*, 2011-8: 1707-1726.
- Millimet, D.L. and D. Slottje. 2000. The Distribution of Pollution in the US: An Environmental Gini Approach. Southern Methodist University, Department of Economics Working Papers No. 002

15

Appendix R

Comprehensive Vulnerability Management: Understanding Social Vulnerability to Disasters in Puerto Rico

Jenniffer M. Santos Hernández, MA, PhD Candidate
Department of Sociology and Criminal Justice
University of Delaware

Research

Main Research Projects

2003-2010 *Lead Graduate Research Assistant*, "National Science Foundation Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA)".

End User Integration Thrust: Brenda Phillips, MBA (UMASS), Havidán Rodríguez Ph.D (UDEL), and Walter Díaz Rodríguez, Ph.D (UPRM).

Undergraduate Students: Carla Russell, Desiree Grainger, Meghan Gunyuzlu, Jennifer Westfall, Letitia Coleman, Claudia Flores, Yesenia Rodriguez, Stephen Shinn, Chris Colindres, Jasmine Wynn, Spencer Schargorodski

2004-2006 *Lead Graduate Research Assistant*, "Population Composition, Geographic Distribution, and Natural Hazards: Vulnerability in the Coastal Regions of Puerto Rico" Disaster Research Center, University of Delaware, Physical Oceanography Laboratory (POL) and Center for Applied Social Research (CISA), University of Puerto Rico at Mayagüez.

Researchers: Havidán Rodríguez, Ph.D. (DRC), Aurelio Mercado, Ph.D. (POL) and Walter Díaz, Ph.D. (CISA)

Graduate Research Fellowship

2010-2012 *Research Associate*, Geographic Information Sciences and Technology Group (GIST), Climate Change Science Institute (CCSI), Oak Ridge National Laboratory (ORNL), U.S. Department of Energy (DOE), Oak Ridge, TN.

What is particular about the context of Puerto Rico?

- Because of Puerto Rico's topography, climatology, and geographic location, weather events are very probable. In addition, changing weather patterns have been observed. Those event have often led to disasters.
- Demographic and economic research shows that the development policies implemented in Puerto Rico did not or partially succeed (Rivera-Batiz & **Santiago, 1996; Dietz, 2004)**
- The industrial sector is declined and is argued that Puerto Rico has transitioned into a service economy. However, employment opportunities in the emerging sector are different and often less profitable than the ones vanishing (Alameda, 2000).
- To absorb the increasing unemployment, the public sector became the largest employer.
- All in all, Puerto Rico has been a laboratory for many social policies.

Physical Vulnerability

Physical Vulnerability in Puerto Rico

- Inadequate planning and zoning has lead to a large increase in the number of persons living in areas susceptible to storm surge, tsunami and flooding.
  - Over a million people in Puerto Rico reside in areas susceptible to flooding
- Governmental policy has also contributed to increasing physical vulnerability by allowing high-rise construction projects along coastal areas and by locating critical infrastructure in known at risk areas.

Añasco, 1996

Añasco, 2000

Why study Development?

- Amartya Sen (1999) : Development is: "…a process that enables freedom (1999:36)."
- Development often leads to vulnerability (Lewis, 1999)
- Sustainable Development and Disasters "the capacity to tolerate and overcome damage, diminished productivity, and reduced quality of life, from an extreme event without significant outside assistance (Miletti, 1999:4)
- Disasters are social processes (Oliver-Smith, 1998) and framing vulnerability as an issue of capital accumulation affords an opportunity to understand the differential impact and consequences of disasters.

Why Comprehensive Management?

- Comprehensive Vulnerability Management can be defined as "holistic integrated activities directed toward the reduction of emergencies and disasters by diminishing risk and susceptibility and building of resistance and resilience" (McEntire, Fuller, Johnston, and Weber, 2002).
  - Continual assessment to reduce all types of disaster vulnerability
  - A focus on how emergency management organizations reduce liabilities and increase capacities

Why focus on vulnerability?

- Disasters are "processes involving the combination of a potentially destructive agent(s) from the natural, modified, and/or constructed environment and a population in a socially and economically produced condition of vulnerability, resulting in a perceived disruption of the customary relative satisfaction of individual and social needs for physical survival, social order, and **meaning**." **(Oliver-Smith, 1998)**
- Vulnerability is often defined as "*the characteristics of a group and their situation that influence their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard; an extreme natural event or process.*" (Wisner et al., 2004:11)
- "vulnerability… involves the totality of relationships in a given social situation producing a set of conditions that render a society unable to absorb the impacts of natural or social agents without significant disruption of its capacity to fulfill the basic needs of its members." (Oliver-Smith, 2009)

MA Work: Social Vulnerability to Coastal Hazards

"A basic need in responding to disasters is to know the characteristics of the population residing in affected areas."[1]

Research Questions [2]

- How has vulnerability to disasters in Puerto Rico changed from 1990 to 2000?
- What geographic areas present a higher level of social vulnerability?

Methodology: Additive Model

$$\% \text{ VAR } X = ((X \div X \text{ Population}) \times 100)$$

Recode % VAR X (RVAR)

0.00 – 19.99 = 1
20.00 – 39.99 = 2
40.00 – 59.99 = 3
60.00 – 79.99 = 4
80.00 – 100.00 = 5

Social Vulnerability Index = $RVAR_1 + RVAR_2 + RVAR_3 + RVAR_4 + RVAR_5 + RVAR_6 + RVAR_7 + RVAR_8 + RVAR_9 + RVAR_{10} + RVAR_{11}$

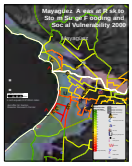
Variables examined 1990-2000:

- Population Density
- Poverty
- Renters
- Low education
- Children
- Female Headed Households
- Unemployment
- Elderly
- Disabled population
- Lack of access to transportation
- Lack of access to phone service

[1]National Research Council Committee on the Effective Use of Data, Methodologies, and Technologies to Estimate Subnational Populations at Risk, 2007

[2]Santos-Hernández, J. 2007. Development, Vulnerability and Disasters in the West Coast of Puerto Rico. MA Thesis. Department of Sociology and Criminal Justice, Disaster Research Center, University of Delaware.

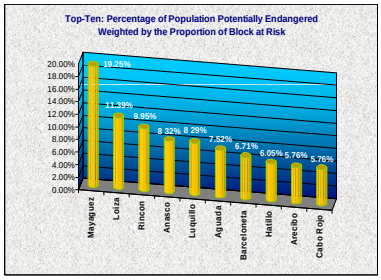
Social Vulnerability Research



Overview of the Findings:

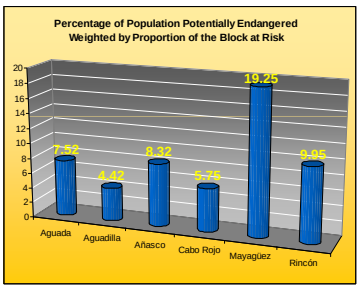
- While population residing in exposed areas increased from 1990 to 2000, about 12%, a decline in most vulnerability indicators is observed. This finding may also raise questions on the use of demographic indicators only to assess social vulnerability.
- High vulnerability is characteristic of deindustrialized areas.
- This research suggest the need to develop emergency preparedness and response plans that attend the needs of a changing population with relatively high levels of vulnerability.
- Our research also reveals the need to plan ahead and prepare to meet the needs of those with disabilities and of an increasingly elder population residing in areas exposed to hazards such as storm surge and tsunamis (e.g. evacuation and shelter).
- Despite the decline in vulnerability indicators, such as poverty and low education, they remain quite high, particularly in comparison to the United States.

Findings: Population Estimates for Tsunami Prone Areas



Municipality	Amount of People At Risk
Mayagüez	18949.2
Loíza	3706.9
Rincón	1469.37

Puerto Rico's West Coast



Municipality	Amount of People At Risk
Aguada	3160
Total	31500

Puerto Rico's West Coast: Average Social Vulnerability Indicators for Block Groups Exposed to Storm Surge Flooding from 1990 to 2000

WEST COAST Social Vulnerability Indicators	Exposed 1990	Not Exposed 1990	Exposed 2000	Not Exposed 2000
Population below Poverty	61.0%	67.3%	52.6%	56.2%
Renter Occupied Housing Units	33.3%	31.9%	35.0%	27.1%
Population w/ Low Education	54.4%	60.7%	45.2%	49.2%
Female Headed Households w/ Children	19.0%	16.8%	19.8%	18.8%
Unemployed	22.1%	23.0%	23.8%	24.4%
Population under 18	29.8%	33.0%	25.5%	28.2%
Population above 65	12.8%	9.7%	14.2%	11.3%
Population w/ Disabilities	24.9%	26.1%	31.8%	31.5%
HU w/ no vehicle	34.3%	35.1%	33.2%	30.0%
HU w/ no phone	37.2%	44.6%	27.1%	27.5%
Social Vulnerability	22.6	23.6	21.4	21.2

Disaster Decision Support Tool (DDST)
www.udel.edu/DRC/DDST

"Geospatial data and tools should be an essential part of all aspects of emergency management." [1]

Objectives

- Disseminate maps and research findings to the end-user community
- Develop a scalable risk and disaster-related geographic information platform
- Provide end users with no GIS training or access to GIS software with geographic information products that they can consume and incorporate into their decision-making in a no cost and considerably easier online application.

Spatial Information includes:

Vector Layers
- Roads
- Hydrography
- Buildings Footprints
- Neighborhoods
- Coastal Barriers
- Airports
- Schools
- Hospitals
- Flood Prone Areas
- Tsunami Areas
- Storm Surge Areas
- Social Vulnerability Assessment 1990 and 2000
- Demographic and Socioeconomic Information at the municipal, tract, block group, and block (if available) levels

Raster Layers
- Aerial Imagery
- IKONOS
- Digital Elevation Models (DEMs)
- Hillshades

[1] *National Research Council. 2007. "Successful Response Starts with a Map". Washington, DC: The National Academies Press.*

PhD Work: Emergency Management and Disaster Policy

Topic: Disaster Policy and Emergency Management in Puerto Rico
- Theoretical Approach: Max Weber – The emergence of bureaucracy and increasing rationalization

Research Questions
- How is the governance of disasters and emergencies shared in Puerto Rico?
  - What are the legal mechanisms supporting emergency management in Puerto Rico and how they emerged?
  - What is the structure of the emergency management organization in Puerto Rico?
  - How does the current organizational structure of Puerto Rico's shape preparedness efforts?
  - What disaster reduction policies are in place and what are some of the challenges they confront?
  - How the existing organizational features affect social vulnerability to disasters?

Emergency Management and Disaster Policy

- In-depth interviews with emergency managers at all levels and NWS personnel.
- Our research highlights important differences in terms of the role of emergency managers, the levels of training, access, preferences, use of information sources, and in the organizational features of the State Emergency Management Agency (AEMEAD).

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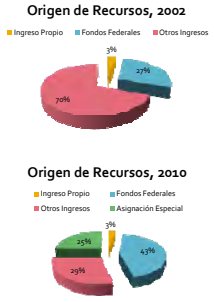
Preliminary Findings

- Shared conventions, expectations, and cultural concerns are brought to bear when making decisions (Douglas, 1992)
  - Long standing issue of unemployment
  - Politics mediate organizational learning (e.g. cyclical changes in the number of employees)
  - Increasing reliance on federal funds
  - Discrepancy between the events perceived as more frequent, more dangerous, and preparedness efforts.
  - The exportation of U.S. emergency management policies to Puerto Rico translates into a mock bureaucracy. Moreover, it imposes new forms of vulnerability (e.g. language limitations).



Case Study: Dorado, Puerto Rico

- Dorado, Puerto Rico
- Precipitation Event - May 31, 2010

Case Study: Cataño, Puerto Rico

- To examine the evolution of risks in Cataño and the role of the municipality in Puerto Rico's development.
- Site presents the convergence of "natural", industrial, and environmental risk
- Caribbean Petroleum Corporation Explosion (CAPECO) – October 23, 2009
- Communities coalition and changing structure
  - Bay View
  - Cataño Pueblo
  - Cucharillas
  - Juana Matos
  - Palma
  - Puente Blanco
  - Puntilla
  - Sector Vietnam

Source: University of Puerto Rico-Río Piedras Archive

Preliminary Findings

- Themes:
  - Transportation systems and changes in land use
  - Changes in energy production, storage, and distribution
  - Soil changes
  - Community organizations
  - Community resistance to government intervention
  - Community adaptations
  - Drugs and violence
  - Long standing history of environmental and health issues (e.g. air and waterways pollution, respiratory, skin, and cancer prevalence, among others)
  - Concerns about unknown risks
  - Multiple leaders and conflicting messages
- The CAPECO explosion illustrates the pre-existing vulnerability in the region.

Concluding Remarks

- This research suggest the need to develop emergency preparedness and response plans that attend the needs of a changing population with relatively high levels of vulnerability. However, the majority of disaster scholars are not experts in bringing about massive cultural change (Aguirre, 2002: Can Sustainable Development Sustain Us)
- It is necessary to plan ahead and prepare to meet the needs of the elderly and those with disabilities (e.g. evacuation and shelter)
- There is a need to develop and implement programs that increase awareness and mitigation for hazards that more frequently affect communities.
- The need to review emergency management and disaster policies:
  - Promote individual awareness and responsibility in a context of competing priorities and limited resources,
  - Develop assessment capabilities,
  - Training to maximize the use of the technology available and reduce unnecessary costs,
  - Promote organizational learning,
  - Collaborate and provide guidance to community organizations,
  - Revise contradicting policies,
  - Standardize emergency management functions at all levels,
  - Reduce/eliminate patronage
  - Adopt and enforce a land use plan
  - Provide residents with a worst case scenario to facilitate preparedness and create awareness (Right to Know Act, 1986).

Questions

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Appendix S

Quantifying Sustainability in Puerto Rico – A Scientific Discussion

Workshop

7 June 2012

Outline

- Recap: 2-day Symposium
- Recap: Facilitated Session
- Questions for decision makers
- Coordinated Research Agenda

Recap: 2-day Symposium

- Objectives
  - Discuss issues pertinent to sustainability in Puerto Rico
  - Discover what researchers are currently studying in Puerto Rico related to sustainability and how that research can affect or help decision makers
    - Initiate a dialogue between researchers working on the Puerto Rico System
  - Learn how EPA ORD research goals can be enhanced and applied in collaboration with research described above
  - Plan coordinated research program and implementation of activities to move Puerto Rico towards a more sustainable future

What did we learn?

- Scientists had different visions, perspectives, research, and information
- Recognize data are missing, but need to emphasize critical data gaps
- Data need to be centralized, categorized in terms of quality, and made more readily available
- Need to increase representation: all interested parties need a voice
- Based on participation, sustainability research is well established in Puerto Rico: only a very small subset was represented here
- Lack of communication about sustainability research in Puerto Rico both on and off island

What did we learn?

- Lack of cohesive collaborative effort in the sustainability community
- Many frameworks for studying sustainability: which one(s) is the right one for Puerto Rico?
- Lack of social scientist perspective
- Participants think Puerto Rico needs a clear vision for the long-term
  - Need to figure out where we are in terms of sustainability and then determine where we want to go
- Opportunities for data sharing and collaboration became obvious

What did we learn?

- Symposium created a missing forum for scientific discussion
- Organized discussions need to continue
- This symposium/workshop is a first step, not a final answer
- Scientists need to translate information to make it accessible to everyone (policy makers, others disciplines, public, communities, etc.)
- ORD's research will provide a tool to show if Puerto Rico is moving toward or away from sustainability
  - Given limitations and decision maker needs, research opportunities need to be identified to enhance decision making

Messages

- Need to come up with a vision for Puerto Rico and establish goals
  - e.g., what does Puerto Rico want to achieve, can scenarios reveal how to get there
  - Must include social, economic, and environmental goals
- Has to be a bottom-up approach (everyone needs to participate)
- Data issues need to be addressed

Messages

- Collaborative efforts, partnerships, and alliances are needed (opportunities exist)
  - Leverage dwindling resources
  - Enhance knowledge base
  - Transdisciplinary approach
- Research community needs to start thinking issue-based rather than discipline based
- Need to be better organized as a research community
- Sustainability needs to be addressed with short, medium, and long term goals
- Commitment needed at all levels of government

Request

- Task force
  - Establish tangible action items with timelines
  - Organize future similar events
  - Identify key participants
    - Ensure transdisciplinary approach
  - Other action items to be determined
  - Must be held accountable

Questions for decision makers

- Does it make sense to establish a task force and is it compatible with Law 267 2004?
- Can you commit to a task force and is it possible to make it self-sustaining?
- Is a task force the best way to support and grow this type of collaborative effort?
- Do you agree with the task force action items listed? What other action items should be part of the task force?
- Who should be represented on the task force?
- Who should take the lead?

Questions for decision makers

- Does Puerto Rico have a stated vision for its sustainability?
  - If not, is one under consideration? Should the vision building process be external to the research effort?
  - If so, is there a reevaluation process?
- A research agenda needs to be established in collaboration with decision makers
  - What information do you need to consider to move forward with such an agenda?
  - What do researchers need to know to have a successful collaborative effort with decision makers?

Next Steps

- Proceedings of the symposium/workshop
- Solidify collaborations
- Establish a portal for researchers working in Puerto Rico
- Scientifically-sound strategy for sustainable environmental management in Puerto Rico
- Publish publicly-available and easily understood information for use by decision makers and public