A Publication of the Environmental Research and Education Foundation

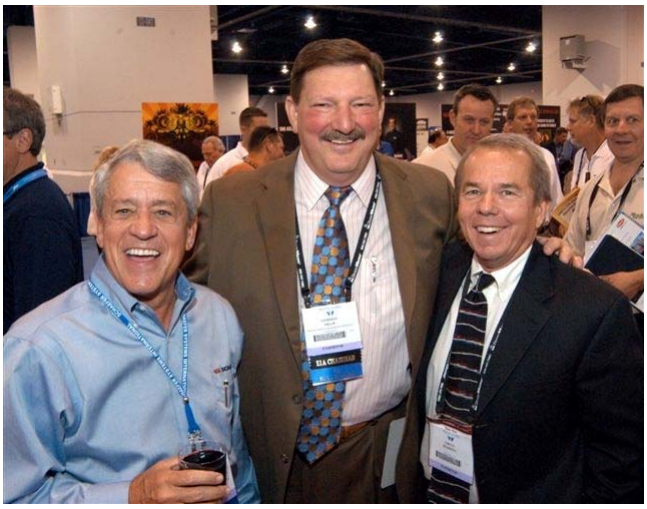
EREF NEWS

Developing environmental solutions for the future

www.erefdn.org

In This Issue

15th Annual EREF Auction at WasteExpo Raises over $800,000



Las Vegas proved to be good luck for the Environmental Research and Education Foundation (EREF), where the 15th Annual Auction was held to raise money for the foundation's mission: *developing environmental solutions for the future*. Donors gave generously and bidders raised their paddles high in support of EREF's efforts. A struggling economy and tight budgets meant every penny counted, but the pennies and dollars rolled in to see the total amount raised over $800,000!

The bleachers filled to the brim, and the bar became a flowing fount as the crowd gathered to participate in the auction. Fast-talking professional auctioneer Gary Seybold, of Ritchie Brothers, led the crowd through the 37 lots for bid. From vintage cigars and golf prints, to trips and hunting outings, to roll-out carts and front loader trucks, there was something for everyone. The EREF wishes to thank all donors, bidders, participants and volunteered for their contributions to the foundation's biggest fundraiser of the year. For details on donating to the 2010 Auction or Raffle, contact Sarah Mickelsen at smickelsen@erefdn.org or 703-299-5139 x10. See you in Atlanta!

Thank You 2009 Donors

Special thanks to the following for doing their part to make this event a success!

EIA Member Major Equipment & Service Donors
Autocar LLC
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Cram-A-Lot/J.V. Manufacturing
E-Z Pack
Heil Environmental Industries
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Perkins Manufacturing
Lonnie C. Poole, Jr.
PTR Baler and Compactor
RDK Truck Sales & Rentals
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Republic Services, Inc. – Jim O'Connor
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Stellar Industries, Inc.
Veolia Environmental Services
Wastequip
Pioneer, Galbreath, and Toter
Waste Management, Inc. – David Steiner

Other Donations and Support
Ameri-Kan
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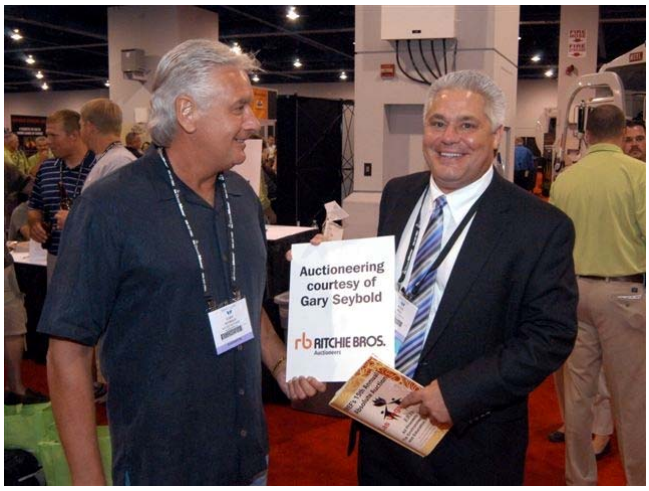
GES Exposition Services
Don Link
Parker Hannifin Corporation
SP Industries, Inc.
Ritchie Brothers Auctioneers
Volunteers: Christine Carruth, Lauren Roche, Ann-Margaret Staley, Alice Jacobsohn, and LindaLee Bartlett

Waste Equipment Technology Association (WASTEC)
All Auction bidders, Raffle ticket purchasers, and event attendees!!

Gratis Advertisement
Penton Business Magazines
WASTEC's E-News
Waste Industry News (EIA Publication)
WasteAge Magazine

Additional thanks to
KRD Trucking – donor of the raffled Harley Davidson Thunder Mountain motorcycle

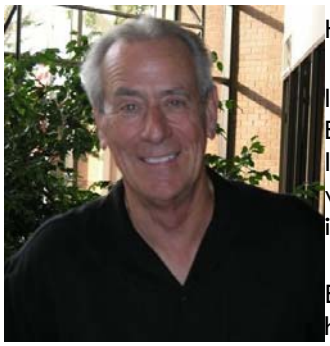


Congratulations Steve Squitieri, winner of the Harley Davidson

Steve Squitieri of New York was the winner of the 2009 Raffle Prize, and is now the proud new owner of a 2005 Harley Davidson Thunder Mountain Motorcycle.

The motorcycle was generously donated by KRD Trucking. In compliance with Nevada law, a local charity was chosen to receive the proceeds: The Boys and Girls Clubs of Southern Nevada. EREF also benefitted thanks to Republic Services, Inc.'s offer to match the Boys and Girls Clubs donation. Many thanks to KRD Trucking, The Boys and Girls Clubs of Southern Nevada, and Republic Services, Inc. for making the raffle a success!

From the President
Michael J. Cagney



Hello everyone,

I would like to introduce you to Bryan F. Staley, Ph.D., P.E. who joined EREF as its Vice President of Environmental Programs just about eight months ago. Bryan grew up on a dairy farm in Maryland and later his family moved to North Carolina. He graduated from North Carolina State University in 1994 with a BS in Biological and Agricultural Engineering, from the University of Tennessee in 2000 with a MS in Biosystems Engineering, and completed his Ph.D. at North Carolina State in August 2009.

Bryan is a gifted researcher and a professional engineer with 12 years experience. Over the course of his career he has collaboratively worked on engineering projects and is skilled at directing and participating in joint efforts to accomplish common goals. We are VERY glad to have him on staff at EREF.

Relative to personal observations Bryan is of course quite intelligent and knowledgeable on environmental issues as it relates to solid waste; but he also has a keen wit, is very engaging, and as a very telling element from my point of view - he is absolutely, unequivocally devoted to his family.

Bryan, his wife Ann Margaret, and his son Isaac will be living in Raleigh, NC. Please join with me in welcoming them to the EREF family!

Board News

From the Chairman
Paul R. Mitchener

Hello Everyone,

Welcome to my first newsletter as Chairman. I have been involved with the foundation for more than a decade and it was a great privilege to be asked to be Chairman this year, although my timing could have been better!!

These are truly unprecedented times we are living in and without a doubt, the effects are being felt throughout our industry just like any other. As Chairman of the foundation, it is my duty to help lead the board through these difficult times and still maintain our mission to fund research and our scholarship program. This mission is even more important today than it was yesterday, EREF research will help the solid waste industry be more innovative and efficient and better serve those at the heart of our economy; and scholarships we provide will support the higher education of our young people whose knowledge of environmental science will form the backbone of our industry long into the future.

It is with some pride and with a great deal of respect and gratitude that I report that, even in these times, the EREF has a cadre of donors who continue to support us. Foremost amongst them are the donors to our annual auction held at WasteExpo this and every year for the past 15 years – a list of auction donors is available here. Then there are many other donors who continue to make meaningful contributions to the foundation directly, or for specific projects, or for scholarships, or through our golf tournament; their enduring participation will allow us to make over $830,000 in research grant payments and over $85,000 in scholarships this year alone.

I am also grateful to my fellow board members for devoting the time to attend and paying for the cost of board meetings; no small commitment in itself this year, as in others past. With their skills and experience, the board members continue to promote the foundation's mission today and look forward to doing the same in 2010 and beyond.

As Michael Cagney noted in his comments, this year we welcome Bryan Staley, Ph.D., P.E. to EREF as Vice President of Environmental Programs. Many of you may not know this but Bryan was an EREF scholar when he was at North Carolina State University. He has a significant task on his hands, to lead the sharp end of our research and education agenda. He has already started very well in this regard and is currently making the Research Council an important body in our industry. If you have not done so already, I would urge any of you that are interested to reach out to Bryan and find out more about the Research Council and how you can get involved in it.

Thank you for you interest in EREF and its work. These are challenging times, but not insurmountable if we remain committed to our mission.

Lonnie Poole Golf Course at North Carolina State University

On July 31, 2009, long time EREF Board member Lonnie C. Poole, Jr. joined golf legend Arnold Palmer and hundreds of other donors and dignitaries for the grand opening event of the NC State Lonnie Poole Golf Course. The course broke ground in July, 2007 and after 25 months, the kudzu-covered land overlooking downtown Raleigh was transformed into an environmentally friendly, Audubon-approved course that Poole believes will be a city landmark before long.

Poole described the course as a classy and unique golf course, carved out of 200 acres of untouched land. "The thing I really like about it is if you hit a ball out of the fairway, it doesn't land in someone's backyard. Most of the golf course is still wilderness, right in the shadow of downtown Raleigh."

Palmer, a 69 time PGA victor and arguably one of the most notable players in golf, gave the course his seal of approval at the opening event. "It's wonderful, I'm very pleased," Palmer said.

Poole, who graduated from NC State with a degree in civil engineering, expressed his enthusiasm as well. "I couldn't be more pleased with the way it turned out," Poole said. "I can't think of anything at the University I would rather have my name on."

Meeting - Board of Directors June 2009

Photos
Upper left: Michael Jobe (Heil); Jim Dowland (Waste Management); Richard Burke (Veolia); and Butch Joyce (Joyce Engineering) look on as Bryan Staley presents project information.
Upper right: Paul Mitchener, Board Chairman; Michael Cagney, and Bryan Staley engage in discussion

Above: Paul Mitchener (Macquarie Infrastructure Management USA); Bryan Staley (EREF); Bob Stearns (SCS Engineers); Max Goodrich (Bank of America); Bob Riethmiller, (PTR Baler & Compactor); Kevin Walbridge (Republic Services) review financials

Honorariums & Memorials

In appreciation of *Eric Peterson*'s mentoring and guidance and in celebration of his career; and in support of the Robert P. Stearns/SCS Scholarship program
~ Robert & April Dick

In memory of *Clarence "Ed" Kottman*, husband of Kathleen Cagney Kottman
~ Michael J. Cagney

In memory of *James Alfano*, father of Jackie Thomson
~ Michael J. Cagney

In memory of *Richard J. Burke*, father of John Burke
~ Michael J. Cagney

In memory of *Anne Mitchener*, mother of Paul Mitchener
~ Michael J. Cagney

Join us for the 2009
EREF Fall Classic Golf Tournament
Friday, October 16

Tournament Details
Palmetto Dunes Robert Trent Jones Course
7 Trent Jones Lane
Hilton Head, SC 29928
http://www.palmettodunes.com/robert-trent-jones-course.php

Event Hotel Details
Hilton Head Marriott Resort and Spa
Hilton Head, South Carolina
Request rate code (as available): EREF Foundation
$159 - $189 (island view to ocean front)
Marriott Central Reservations 888-511-5086
http://www.hiltonheadmarriott.com/

Hosts  **and** 
Richard Burke and Jim O'Connor, Chairmen

Sponsors to-date include
Veolia ES Solid Waste, Republic Services, Caterpillar, Mack Trucks, Inc., Waste Industries, Volvo Construction Equipment, Perkins Manufacturing, Agru, ESI Liners, Heil Environmental, WasteExpo, Waste Age, E-Z Pack, Big Truck Rental, Orion Apparel, Arsenault Associates, Cummins, Wastequip/Toter, KRD Trucking, FleetPride, Labor Ready and Rehrig Pacific Co.

Additional information here, sponsorship information available here

Research News

EREF Research Program Re-Structured

The EREF Board of Directors unanimously approved a re-structuring plan for how research projects are reviewed and funded. First and foremost, potential grantees are required to justify how their proposed research fits within EREF's mission to develop and evaluate new approaches to manage solid waste; second, if they are a fit within EREF's mission, proposals undergo a peer-review process by technical experts familiar with the proposed applications; third, proposals that pass the peer review level are sent on to the EREF Research Council, which is a sub-committee of highly technical representatives from the solid waste industry and academia, who guide the research program and recommend proposals for funding to the EREF Board of Directors. "The changes to the research program have been very positive", stated Dr. Bryan Staley, EREF's Vice-President of Environmental Programs "in the past we received many proposals that had little relevance to EREF's mission. With the changes we have made the quality of proposals has improved dramatically , which translates into benefits for the solid waste industry." Staley added "the improved Research Council structure will undergo its first 'test drive' at the next Research Council meeting in October". Michael Cagney, the EREF's President and CEO noted, "The streamlined process set in motion by Bryan Staley relative to the proposal process will have very positive impact going forward; we appreciate Bryan's organizational skills and very clear vision for the research activities of the EREF ."

For additional information on the Research Council, including participation details, contact Dr. Bryan Staley at bstaley@erefdn.org or 703-299-5139 x11.

New Grants Awarded

Despite a difficult year, the EREF has been able to award two research grants in 2009 thus far. North Carolina State University was awarded $37,384 over 1 year to monitor the behavior of biogenic organic carbon in landfills. One of the primary objectives of the project is to document the carbon sequestration occurring in multiple landfills using methods that are expected to satisfy any agency's carbon accounting program in which sequestration is considered. A second objective of the study is to implement a new analytical method for quantifying lignin. Lignin is a carbon containing compound that does not degrade under the anaerobic conditions typically found in landfills. As a result, accurate quantitation of this compound is important when evaluating carbon sequestration. Previous methods used to analyze lignin content have been hampered due to interference from non-lignin containing materials such as plastics, synthetic textiles and rubber. It is anticipated that results from this study will provide more accurate estimates of the fate of carbon in landfills.

A second grant for $25,000 has been awarded to Michigan State University for 1 year to monitor moisture consumption during gas production from landfills and how this phenomenon affects the permitting of evapotranspirative (ET) landfill caps. Initial calculations suggest moisture equivalent to roughly 78 inches of water may be lost in the landfill gas over a landfill's lifetime. The project aims to quantify moisture consumption during gas production for MSW landfills and to evaluate the net change in water storage for landfills with an ET cap. It is anticipated that results from this research will impact how water balances are performed on landfills and determine how ET landfill caps may be permitted for widespread use in sub-humid climates.

Project Updates

The Environmental Research and Education Foundation began 2009 with 14 active research projects. Currently, four projects have been completed and final reports will be posted on the EREF website in Fall 2009. Selected summaries of recent and current projects are listed below.

Electricity Production from Leachate using Microbial Fuel Cells
Grantee: University of New Hampshire

A microbial fuel cell takes advantage of a microbe's metabolism during the decomposition of organic material. As the microbe metabolizes the material, electrons can be shuttled to and through a wire. Electrons transported through a wire are defined as an electrical current. As a result, electricity can be generated off of microbial activity in leachate that would otherwise be lost. This study represents an initial evaluation on the feasibility of using microbial fuel cells to generate power from landfills and was recently completed. Results show:

(a) Leachate has excellent potential as a substrate for microbial fuel cells given its high alkalinity and conductivity.
(b) On average, about 750 millivolts electricity was generated from every 250 gallons of leachate. When implemented at field scale this could result in megawatts of power.
(c) A side effect of the electricity generation is reduction in pollutant levels. This study showed 60% removal of ammonia and 50-90% removal of biochemical oxygen demand could be achieved from the leachate.

Significance: The application of microbial fuel cell technology represents a 'next generation' landfill operating strategy. Although the research is relatively fundamental in nature, it is a foundation for future work that may contribute to a more complete utilization of landfills as a renewable energy source. The technology can also be used as a technique to treat leachate.

Reusable To-Go System
Grantee: Eckerd College

Waste from disposal food packaging, including to-go containers, represents a significant waste stream. The implementation of reusable to-go containers minimizes waste discards. However, a challenge is developing a system to property manage the implementation of to-go containers at various locations where such containers are used. The objective of this study has been to develop a reusable to-go container system, particularly for college campuses. The study should be completed by late 2009 and key results thus far are:

(a) The system was initially developed and implemented successfully at Eckerd College.
(b) The project has been widely disseminated at/in:
    * 4 TV news stations
    * 3 newspapers
    * 3 periodicals
    * 15 websites/blogs
    * 5 conferences related to sustainability/food service.
(c) The reusable to-go container system has been implemented at over 40 schools or universities nationwide.

Significance: Implementation of the program diverts food containers from landfills that are typically un-recyclable due to food particulates or liquid saturation.

Landfill Gas Management: A Roadmap for EREF Directed Research

Grantees: N.C. State and the University of Central Florida

There is currently a lack of understanding related to the myriad of factors involved in landfill gas production, collection, fugitive emissions and attenuation in landfill covers. As a result, landfill owners are unable to:

- predict gas production rates and their variation
- precisely specify the fraction of the generated gas that is collected
- quantitatively track the generation and release of non-methane organic compounds (NMOCs) and hazardous air pollutants (HAPs) as well as account for their attenuation in landfill covers
- eliminate sources and causes of odors

The EREF Research Council has identified landfill gas management as a high priority area of research. The objective of this work is to develop a roadmap for EREF-directed research to understand and quantify all aspects of gas generation, collection attenuation and emissions. Thus far a detailed literature review and summary of studies has been completed related to landfill gas modeling. It was determined that modeling landfill gas production is difficult due to sparse or low quality data, poor estimates of gas yield, and limited field data. The project also noted that quantification of fugitive emissions (CH_4, NMOSs, HAPs) must be measured directly to achieve acceptable accuracy. A survey was also conducted related to optimizing the gas collection system design and odor management. The survey found that water accumulation, gas well spacing and number and collected gas quality are primary design challenges for collection systems. It addition, it was noted that odor sources need to be more succinctly defined to determine the best odor prevention methods.

Significance: This work provides a tool for mission-oriented research by EREF as related to landfill gas. Such research is critical given increased focus by policymakers and regulators and the industry will be in the strongest position is it can show it has: (1) good data, (2) a program to address data gaps, (3) a desire to improve its environmental footprint as much as practical.

Fugitive Gas Emissions Measurements from Landfills

Grantee: SCS Engineers

Current estimates by the Intergovernmental Panel on Climate Change (IPCC) suggest landfills are one of the largest sources of man-made greenhouse gas emissions. Gas production, consisting primarily of methane and carbon dioxide, from landfills is typically burned to create energy or flared. Fugitive emissions that avoid collection are also released; however, quantification of these emissions is largely unknown due to limitations in the measurement techniques used. The purpose of this study was to evaluate the following 5 emission measurement techniques at field scale to determine the pros and cons of each method based on accuracy, technological viability and economical use:

1) Vertical radial plume mapping (VRPM)
2) Micrometeorological eddy-covariance
3) Flux chamber measurements & methane oxidation
4) Differential absorption light detection and ranging (DiAL)
5) Mobile plume Fourier transformed infrared spectroscopy (FTIR)

The final report is currently being compiled for this project. However, preliminary results show:

(a) The VRPM (Method 1) is less accurate as the distance from the emissions source increases.
(b) Variation for the VRPM method ranged from 18 % to 30%, regardless of distance.
(c) The DiAL (Method 4) and FTIR (Method 5) methods were able to measure methane fluxes as low as 1 g methane per second with a variation of ~20%.
(d) However, DiAL is substantially more expensive and the data obtained is less representative than FTIR.

Results from Methods 2 and 3 are still being analyzed and are not available at this time.

Significance: Collectively, these results will provide a greater understanding of the pros and cons for the measurement methods available to measure landfill emissions and this study is the most comprehensive performed thus far. It is anticipated that the study will provide direction regarding which technique provides acceptable accuracy at a reasonable cost. In addition, it is likely the results will be considered by the US EPA for inclusion in guidance documents for measuring landfill emissions.

Post-Closure Care Methodology – Evaluation of Critical Data Needs
Grantee: Geosyntec Consultants

By regulation, closed landfills in the U.S. must continue monitoring key elements (i.e. leachate, landfill gas, groundwater, landfill cover system) to ensure public health and welfare are not impacted, a process defined as 'post closure care'. Unfortunately, regulations are not specific and do not establish definitive criteria for the cessation of post closure care. This means landfill owners, under the current framework, could have fiduciary responsibility for their closed landfills in perpetuity. Between 2002 and 2006, EREF funded the development of a technically-based methodology to determine when post-closure monitoring of landfills could be terminated. The objective of this project is to evaluate the availability and importance of the data needed for this methodology. Data from 10 landfill sites across the U.S. were used for validation.

Key results so far are show the primary data limitations found relate to collected landfill gas data and records of total waste tonnage. As a result, the methodology is being modified given these limitations. Additionally, the study demonstrates the methodology can be used successfully with actual data from closed landfills.

Significance: Verification and acceptance of performance based post-closure care criteria by regulators would allow landfill owners to definitively demonstrate that a closed site poses no significant threat to public health and welfare. This would permit owners to terminate their financial responsibility for sites that meet the methodology criteria. In some cases this could result in monitoring periods of less than 30 years.

Scholars

Three New Scholarships Awarded in 2009

Congratulations to Kyle Bibby, Jim Levis and Laura Knudsen, the 3 new scholars who received scholarship awards from EREF in June, 2009.

Kyle Bibby
Yale University, Ph.D. student
EREF Scholar 2009

A native of Naperville, Illinois, Kyle Bibby was first introduced to research at the University of Notre Dame. During his undergraduate experience he developed an ardent interest in the study of Environmental Engineering, and his research in this field earned him a Slatt Undergraduate Fellowship. Kyle spent the summer before his senior year working as an intern with Metcalf and Eddy of New York doing applied research. His time spent there learning under respected research professionals ignited his desire to earn a PhD. Following his graduation in 2008 Kyle accepted a position at Yale University in the PhD program for Environmental Engineering. Currently, Kyle does his research under the direction of Professor Jordan Peccia in Yale's Environmental Biotechnology Laboratory. The focus of his research involves the use of molecular biology tools and bioinformatics to study environmental pathogens, namely viruses. Following his graduate work, he hopes to join industry in an applied research setting. In his free time, Kyle enjoys fishing, golf, and watching college football.

Jim Levis
North Carolina State University, Ph.D. student
Francois Fiessinger Scholar 2009

Jim Levis received his B.S. in mechanical engineering from Carnegie Mellon University in 2004. During his undergraduate studies he researched micro-electro-mechanical systems and received college honors for this work. After graduation, he worked as a quality engineer for Westinghouse Electric Company in Columbia, South Carolina for two years. In 2006, he began his graduate studies at North Carolina State University in the environmental systems program earning his M.S. in civil engineering in 2008. He is currently pursuing his Ph.D. in the environmental systems program and researching the effects of climate change policy on solid waste management operations.

Laura Knudsen
University of Indiana-Bloomington, Master's student
PTR Baler and Compactor Scholar 2009

Laura Knudsen is entering her last year of graduate work at the School of Public and Environmental Affairs at Indiana University (Bloomington, IN). Upon graduating in May 2010, she will have a Master in Environmental Science (concentration in Environmental Toxicology, Chemistry and Risk Assessment) and a Master in Public Affairs (focus in Environmental Policy and Natural Resource Management). Laura is fascinated by waste and recycling matters in general, and particularly intrigued by hazardous waste issues. She finished a summer fellowship with the Environmental Protection Agency's Office of Solid Waste and Emergency Response in Washington, DC where she researched and presented work on community involvement regarding renewable energy reuse projects on contaminated land sites. Laura's research passion is electronic waste recycling and she intends to focus on this area in the coming year.

Current Scholar Updates

Shahzeen Attari
Ph.D., Carnegie Mellon
EREF Scholar 2005

Thank you so much for all your support these past years. I am finally graduating with my joint Ph.D. in Engineering and Public Policy & Civil and Environmental Engineering.

A group from CMU won a prestigious award from Johnson control (http://www.eeforum.net/awards.html) (see photo, I am second from left).

One of my papers was recently published in Ecological Economics (referenced: Attari, S.Z. *et al.* (2009) **Preferences for change: Do individuals prefer voluntary actions soft regulations, or hard regulations to decrease fossil fuel consumption?** Ecological Economics, 68 (1701 –1710)). I will be presenting this paper at the USSEE conference in Washington D.C. at the end of May (http://www.ussee.org/conference09/) and a social dilemmas conference in Kyoto, Japan in August (http://www.plan.cv.titech.ac.jp/fujiilab/icsd/).

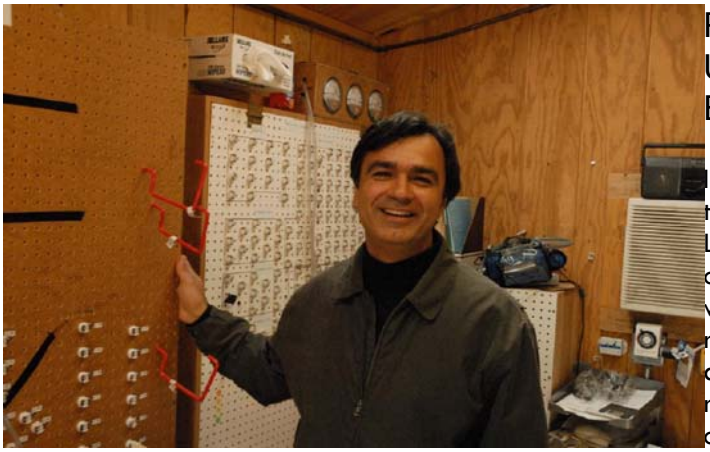
Come fall, I will be joining the Earth Institute at Columbia University (http://www.earth.columbia.edu/sections/view/9) to continue my research on the human dimensions of climate change with the Center for Research on Environmental Decisions (CRED, http://www.cred.columbia.edu/).

As part of my Ph.D., I completed my last experiment that maps lay perceptions of energy consumption, and am currently preparing the paper for journal submission. The title and abstract of the paper are below:

Title: **Lay perceptions of energy consumption**

Abstract: An experiment studied how participants (n=505) perceive energy consumption and savings for household, transportation, and recycling behaviors. Participants showed a tendency to overestimate energy consumption and savings for low-energy behaviors and underestimate energy consumption and savings for high-energy behaviors. On average, participants underestimated the amount of energy used or saved by different behaviors. Pro-environmental attitudes and higher numeracy scores were associated with more accurate perceptions of energy consumption. Surprisingly, participants who reported engaging in a greater number of environmental behaviors had less accurate perceptions of energy consumption. On average, participants reported that engaging in energy-conserving behaviors would not be difficult for any of the behaviors considered.

Thank you for all your support through my Ph.D.



Ramin Yazdani
University of California, Davis - Ph.D. candidate
EREF Scholar

I have been working on the analysis of the collected field data from the full-scale, aerobic bioreactor landfill at Yolo County Central Landfill. The results of my analysis suggest that, even when sufficient oxygen is supplied within a wet landfill, anaerobic pockets persist where a portion of the refuse degrades anaerobically and that the refuse oxygen transfer to immobile gas zones will limit the degree of aerobic waste degradation. Moisture content of the waste plays a key role in determining the level of aerobic activity and the decomposition of waste. I am preparing a draft manuscript for publication in the Journal of Environmental Science and Technology. The title of this manuscript is, "The Influence of Leachate Recirculation and Air Flow on Aerobic Bioreactor Performance."

I have also been busy making presentations at several conferences in the past year. In September 2008, I presented a technical paper at the Global Waste Management Symposium in Colorado, entitled, "Performance of an Anaerobic Digester for Biodegradation of Green Waste." In November 2008, I gave an oral presentation on the landfill bioreactor and green waste digester project results at a state-wide conference organized by the California Integrated Waste Management in Napa, California.
My oral presentation was called, "Harvesting Emerging Technology". In December 2009, I was invited to present my bioreactor research findings at the National Research Council Committee on Geological and Geotechnical Engineering in Irvine, California. The objective of this meeting was to assist in prioritizing future research projects for sustainable management of municipal solid waste, a program which is funded by the National Research Council.

I plan to continue with the analysis of data collected from the full-scale bioreactor landfill project and the green waste digester project at Yolo County Central Landfill. Additionally, I am aiming to work on and submit a second manuscript for publication in the coming year.

I am grateful to the Environmental Research and Education Foundation for their financial support over the past academic year.

Susan De Long
Ph.D., University of Texas-Austin
Fiessinger Scholar 2006

This past academic year has been exciting and rewarding. I will be finishing my Ph.D. and graduating in August, and I have accepted a tenure-track faculty position at Colorado State University. At CSU, I will develop a research program with a key focus on generating bioenergy from waste materials using molecular biology tools that I developed during my doctoral research. I am very excited to have an opportunity to continue the work that I have been doing while funded by EREF and develop new strategies for dealing with solid waste.

In the past academic year, I have also obtained some exciting results in the laboratory. The focus of my dissertation research has been on the development of molecular biology tools for investigating biological waste degradation (i.e., using bacteria to break down pollutants and waste materials). Molecular biology tools for investigating pollutant degradation are becoming increasingly popular because they allow researchers to study biodegradation at a fundamental level, offering new insights into what factors lead to successful degradation. Molecular biology tools can be used to track specific genes that can tell us if the bacteria present can degrade the waste materials. Furthermore, molecular tools can be used to track the activity of these genes to determine if the bacteria are actively degrading the waste materials.

Over the past academic year, I have developed molecular biology tools for application to biological treatment of the widespread groundwater contaminant perchlorate. In this model system, I have completed the development of tools to quantify the amount and activity of two key genes responsible for perchlorate degradation. A manuscript has been prepared and will be submitted to the journal of *Applied and Environmental Microbiology* soon. The next stage of developing these tools was to apply them in the field. Perchlorate contamination is present in potential drinking water sources across the country, and there is a great deal of interest in using biological treatment processes to treat these drinking water sources. I applied the molecular tools I developed to a laboratory-scale reactor and two pilot-scale reactors treating perchlorate contaminated water. Using these tools, I was able to

quantify key genes and gene activity under different reactor operating conditions to directly determine how the reactor operating conditions affected the bacteria responsible for degrading the perchlorate. A second manuscript is being prepared to report the findings of this study. At CSU, I will be able to develop and use similar tools to optimize breakdown of biodegradable waste materials for energy generation. Waste materials should not be viewed only as a burden but as a resource, and I hope that my research will help to realize the potential of waste as an energy source.

Mohan Dangi, P.E.
Ph.D., Johns Hopkins University
Fiessinger Scholar 2007

In 2008-09 academic year, I have published two manuscripts in the Journal of *Waste Management & Research*. Following are the abstracts of the publications:

Use of stratified cluster sampling for efficient estimation of solid waste generation at household level

Relatively few studies have been performed to characterize municipal solid waste (MSW) at household level. This is due in part to the difficulties involved with collecting the data and selecting an appropriate statistical sample size. The previous studies identified in this paper have used statistical tools appropriate for analyzing data collected at a material recovery facility or landfill site. This study demonstrates a statistically sound and efficient approach for characterizing MSW at the household level. Moreover, a household approach also allowed for consideration of the socio-economic conditions, level of waste generation, geography, and demography. The study utilized two-stage cluster sampling within strata in Kathmandu Metropolitan City (KMC) to measure MSW for two weeks. In KMC, the average household solid waste generation was 161.2 g capita^{-1}d^{-1} with an average generation rate between 137.7 and 184.6 g capita^{-1}d^{-1} for a 95% confidence interval and 14.5% relative margin of error. The results show a positive relation between income and waste production rate. Organic waste was the biggest portion of MSW, and hazardous waste was the smallest of the total. Sample size considerations suggest that 273 households are required in KMC to attain a 10% relative margin of error with a 95% confidence interval.

Searching for a way to sustainability – technical and policy analyses of solid waste issues in Kathmandu

Kathmandu Metropolitan City has attempted to reorganize its solid waste management numerous times. The German Technical and Financial Aid Organization led early efforts that were followed by a number of more recent experiments that left the city with an unsustainable solid waste management system following the termination of foreign aid. To examine this failure, the research team evaluated household surveys, field observations, interviews, and other primary and secondary information within the context of technical, social, and institutional analyses. The survey results show that the solid waste collection rates are far below the 90% claimed by the metropolis and street sweeping consumes approximately 51% of its solid waste budget. As a result of the relatively low collection rates city residents are encouraged to dump waste into public lands. Consequently, too much of the city's resources are focused on sweeping rather than collection. Kathmandu needs to recognize informal waste picking, privatize, use local techniques, build capacity, promote bottom-up and participatory styles of management, and regulate policies to maintain solid waste management.

Other progress

I am in the process of submitting another manuscript, Solid Waste Generation in Kathmandu, Nepal, to the *Waste Management & Research*. In addition, I gave a presentation at the Department of International Health of the Johns Hopkins School of Public Health on February 27, 2009, titled, Solid Waste Management in Kathmandu, Nepal: A Case of Permanent Dysfunction.

I will graduate with the degree of Doctor of Philosophy (Ph.D.) on May 21, 2009 from the Department of Geography and Environmental Engineering of the Johns Hopkins University.

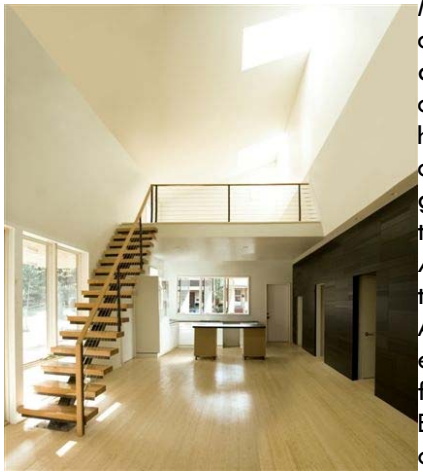
Junbeum Kim
Ph.D., Arizona State University
EREF Scholar 2007

I lived in a whirl of Ph.D. research in the past year. I finished E-waste (as a part of my Ph.D. research) and Sustainability network theory and models and graduated with a Ph.D. in Civil, Environmental and Sustainable Engineering from Arizona State University. Currently, as a postdoctoral associate researcher, I am working about Bioenergy and Biomass in Department of Bioproducts and Biosystems engineering at University of Minnesota. During my Ph.D. study, I published 5 journal papers and had 16 conference presentations about E-waste and network analysis. I really appreciate EREF for their support during the past two years.

Anne-Marie Armstrong
Yale University, Master's student
SCS/Robert P. Stearns Scholar 2007

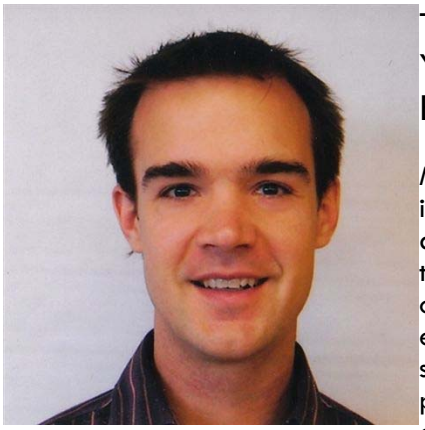
I am nearing the completion of my second year as a graduate student at Yale University's School of Architecture. My research continues to be centered on the examination of the resource requirements for the making and maintenance of the contemporary built environment. The focus of the research to date has been primarily on the practice of deconstruction. Deconstruction implies the careful process of dismantling a building in an effort to salvage as many valuable components for resale, reuse and recycling. Construction-related waste accounts for about one-fourth of total landfill waste in the U.S., according to the Pollution Prevention Resource Exchange. Many natural resources used in building materials are becoming scarce.

Thus, practicing reuse and recycling can strengthen and sustain our natural resources. However, the challenge with the practice of deconstruction is that the majority of buildings are not designed, detailed or constructed such that these materials can be readily and economically recovered. With this constraint in mind, I have been investigating how the architect, designer or contractor might strategically design a building such that it can be economically taken apart and the components reused at the end of the building's life-cycle.
The study argues that for the useful output of deconstruction to increase there requires a fundamental shift on the part of the architect to imagine, from schematic design, the eventual destruction or dismantling of their own project (not something architects like to think about typically). Thus far the project looks to historic and vernacular architectural precedents such as the reuse of materials in Ancient Rome and the flexible construction of Caribbean chattel houses, as well as the use contemporary architectural case studies such as Chartwell School in Seaside, California by the architecture office EHDD Architecture, which was designed to be adaptable over time and partially deconstructed at the end of its life-cycle.



My research has benefited greatly from participation in the design, construction and recent completion of an energy efficient and affordable residential house in downtown New Haven for a disabled veteran and her family. Beyond volunteering and participating in the hands-on construction of the house, I acted as the sustainable coordinator, helping to ensure that that the home would be energy efficient and that local building materials would be purchased for construction. I established a relationship with a Connecticut-based photovoltaic company which generously donated solar PV panels for the home. The photographs included show snapshots of the process of construction over time. The house was recently published in the trade journal *Architectural Record* and will be also written up in the design magazine, *Metropolis* by the end of this year.
As a future architect, a deeper understanding of the relationship between building and environmental practices and their impact on successful waste management practice is essential for contributing to a successful and sustainable built environment. I am truly grateful to the Environmental Research and Education Foundation for their continuing and generous support over the past two academic years.

Recent journal publications (by other authors):
"House for war veteran design by Yale Students" *Architectural Record* (October 2008)
Metropolis magazine: article related to sustainable New Haven house pending publication in 2009
Recent journal publications (by author):
"Occupying a Third Space: The Haskell Free Library on the Quebec-Vermont border". *Thresholds 36: Difference* (January 2009) MIT Press.
"New Haven Housing design" *Retrospect* (September 2008) Yale University Press.



Tim Kramer
Yale University, Master's student
EREF Scholar 2008

My first year at the Yale School of Forestry and Environmental Studies has been a time of immense learning and exploration. As is customary in a Masters of Environmental Science degree here, I have spent the past year building my academic foundation while also beginning to develop the outlines of my future research, which is to be completed next year. The School of Forestry and Environmental Studies has a strong focus on climate change policy and an emphasis on developing practical solutions that combine financial and policy mechanism with solid science. Given the recent national focus on U.S. cap and trade policy and Yale's prominence in this area, this has been an exciting area of study with prominent speakers and applied seminars on the subject. It has been especially insightful to see the potential that waste management industry has to be a part of the solution.

Over the course of the year I have developed a strong interest in how the growing voluntary and regulated carbon markets can be used by waste management facilities to generate additional revenues. Currently, methane capturing and flaring at landfills is one of the most profitable sources of carbon credits on the voluntary market. Improved waste management practices have a distinct advantage in the carbon markets since significant emission reductions can be made at a relatively low risk to investors. As the U.S. moves towards a cap and trade carbon market, I want to assess how this more regulated market can be developed in such a way that will actively encourage the continued participation of the waste management industry. Effective policy development will be key in this area.

Yale actively encourages master students to understand the science behind many of the policies that we seek to work with. In this light I will be spending a portion of my summer working with Prof. Mark Bradford who is examining how the spread of urbanization is affecting the soil carbon cycle in western North Carolina. Working hand in hand with carbon science experiments offers a great opportunity for me to understand the fundamental science behind climate change, which is the basis for these developing carbon market.

This coming year, I will be conducting research on how landfills, functioning as storages sites for carbon, can be accounted for in future cap and trade policies. As paper and wood products become buried in a landfill they are effectively removed from the carbon cycle making landfills in carbon accounting terms, a "carbon sink". I have begun working with several forestry and industrial ecology professors to develop waste management accounting metrics that can be adjusted to account for these previously unaccounted for carbon reductions found in the waste cycle. These reductions will be and are an integral part of the carbon cycle and should be included in efforts to address the ever-growing problems of climate change.

I am very excited about my coming year when I will be able to move forward with my research and publish my work in conjunction with the outstanding faculty here at Yale. In my efforts, the financial support provided by the Environmental Research and Education Foundation has been invaluable.

Kurt Flor
Baylor University, Master's student
PTR Baler & Compactor Scholar 2008

I have completed my first year of business school at Baylor University. Throughout my first two semesters, I have worked hard to positively change the academic and business attitudes of my peers, faculty, and national business colleagues through my research and desire to implement waste-to-energy technologies in developed and developing countries. In December 2008, I assembled a group of first and second year students to compete in the 2009 Leeds Net Impact Case Competition, the nation's premier business case competition concerning issues of sustainability and social/environmental stewardship. The Leeds

competition consisted of two rounds and only 20 of more than 90 teams received an invitation to the semi-final round. Although it was the first time Baylor had ever competed in the competition, the team was able to make it into the semi-finals. In addition to leading the Baylor team, I saw that the Leeds competition would be a great venue to introduce advanced waste-to-energy technologies to the primary sponsor, Vail Resorts. The concept of waste-to-energy technologies was new to judges and our fellow competitors but after the competition, they were able to see solid waste in a totally different fashion.

In January 2009, I put together a team of four first year MBA students in hopes of competing in the Wake Forest Business Plan Competition. The competition is one of the most well-known business plan competitions in the nation, distinguishing itself from many others by competing under the scenario of a two-minute elevator pitch, pitching the business plan in front of actual venture capitalists inside a moving elevator. Teams had to first submit an entry to the competition, either competing in the Regular Business Plan or Social Enterprise tracks. After submission of the Executive Summary of a business plan, the Wake Forest panel of judges—which included competition sponsors, venture capitalists, and business profession—invited teams to the semi-final round of competition.

I lead the Baylor team on a business plan writing campaign, in which we had to complete a full business plan in the form of an Executive Summary as part of our entry to the Wake Forest Competition. I saw this opportunity to test the idea of implementing advanced waste-to-energy technologies within developing under the scrutiny of businessmen, venture capitalists, and business school professors. Within the Baylor team, I took the position as Chief Executive Officer and was responsible for overseeing the research of three branches of business (Operations, Finances, Marketing) explained in the Energress (the name of our waste-to-energy company) business plan. I was responsible for writing the Executive Summary and the Full Business Plan for the Energress entry. The mission statement of Energress, as stated in the Executive Summary: To reduce landfill waste and improve the standard of living of slum residents in a developing country through the development of a waste-to-energy plant; this plant will utilize solid waste as a resource to produce electricity, employ working-age slum residents, and implement education programs that will benefit the children of those residents. After the panel of Wake Forest Competition judges reviewed all the entries, they extended a semi-final invitation to teams they thought were worthy of further competition. The team from Baylor was invited as one of ten Social Enterprise business entries.

During the first year of business school, I focused on methods of how to apply my research concerning waste-to-energy technologies in the real world. So often the business arena acts as a hindrance to great technologies simply because these technologies have difficulty in realizing themselves in the real world. After the success of leading two different teams to two different business competitions, I have demonstrated that waste-to-energy technology is a viable environmental as well as business solution to increasing waste accumulation and energy consumption. The EREF scholarship has helped me to keep focus on my life goal to bring waste-to-energy technology to developing countries. By combining research with business, I have demonstrated that my goals are feasible at the national and international stage. I would not have been able to do this work without the EREF scholarship.

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