

UNIVERSITY OF PENNSYLVANIA
SCHOOL OF ARTS AND SCIENCES

Department of Earth & Environmental Science
Senior Research Conference

April 29, 2009
360 Hayden Hall
0900-1800

Individual abstracts, arranged alphabetically by author, follow the schedule

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SENIOR RESEARCH CONFERENCE APRIL 29, 2009

8:00-9:00 Registration, continental breakfast, and transfer of PowerPoint presentations to the computer in room 360

9:00: **Welcome and Introduction:** (*Robert Giegengack*)

Session I: ENVIRONMENTAL SCIENCE (*Fred Scatena*)

9:15: Jessie Atterholt: **Phylogenetic and Ecomorphological Questions Raised by an Enigmatic, Recently Discovered, Early Cretaceous Fossil Bird**

9:35: Kevin White: **Elevated CO₂ and Nitrogen Addition Stimulate Marsh Vegetation Growth through Different Mechanisms**

9:55: Philip A. Ferry: **Coral Bleaching and Coral Disease: The Rise of a Dangerous Synergy**

10:15: Frank Anderson: **Temperature Change and Potential Decline of Tropical Amphibians in Puerto Rico**

Session II: ENVIRONMENTAL REGULATION (*Stan Laskowski*)

10:35: Michelle Jacobson: **The Impact and Future of the National Flood Insurance Program**

COFFEE BREAK (*10:55-11:10*)

Session III: SUSTAINABILITY, the 3Rs, and ENVIRONMENTAL DESIGN (*Yvette Bordeaux*)

11:10: Sarah-Jane Littleford: ***Jatropha curcas* Biofuel in Small-Scale Rural Applications**

11:40: Annie M. Winter: **The Role of International Non-Governmental Organizations (INGOs) in Rural Development in Nepal**

12:00: 11:55: Pallavi Biswas and Jenny Hong: **Greening Roofs: a Cross-Sectional Study**

12:20: Julian Goresko: **Composting Opportunities for Beer-Brewing By-Products**

LUNCH BREAK, 360 HAYDEN HALL

Session IV: ENERGY AND POWER (*Edward Doheny*)

2:00: James Andersen: **Development of Wind Power in the United States**

Session V: ENVIRONMENTAL HEALTH (*Richard Pepino*)

2:20: Lauren Cowen: **Public Health Implication of Anthropogenic Climate Change: Air Pollution, Pollen and Asthma**

2:40: Ashley Hopkins: **Indoor Air Quality: the Role of Ambient Formaldehyde in Reported Asthma Cases**

Session VI: ENVIRONMENTAL EDUCATION (*Jane Dmochowski*)

3:00: Yael Bortnick: **Seward's Melting Icebox**

3:20 Thomas P. Harker: **Why Wilderness?**

3:40: Megan Folz: **Climate-Change Education in the Grade-School Classroom**

RECEPTION, 360 HAYDEN HALL (4:00 – 6:00)

Development of Wind Power in the United States

James Andersen

Wind-power development in the United States has seen dramatic growth in the past two decades. Federal and State economic incentives have been essential factors contributing to the rise of clean, renewable wind power as a viable and popular competitor to conventional energy sources. If not for these enticements, wind-power growth would stagnate and fail to gain a prominent foothold in our national energy portfolio.

Temperature Change and Potential Decline of Tropical Amphibians in Puerto Rico

Frank Anderson

I constructed a temperature history from daily records at 15 NCDC and LTER climate stations in Luquillo National Forest, NE Puerto Rico. Of those stations, 11 have shown increases in daily maximum temperature (Tmax), and 4 show decreases or no change (one of these records, Bislay, only covers the period 2000-2007). Only 13 of the 15 sites recorded daily minimum temperatures (Tmin); of those, 8 showed an increase in Tmin, 2 remained level, and 3 showed a decline in Tmin. The sites vary in magnitude and rates of temperature change, but sites at similar elevations and similar degrees of urbanization show similar trends in temperature change. Many sites show a slightly accelerated rate of increase of both Tmax and Tmin, starting in the 1970s, possibly influenced by local urban heat-island effects and global trends of warming. Data from East Peak (the site at highest elevation) show a decrease of about 1.6F from 1969 to 2008. From the observed uniformity across the temperature records, I conclude that NE Puerto Rico has experienced accelerated change in the past 30-60 years, which is consistent with observations at other, similar tropical locations.

Evidence is accumulating to support the conclusion that amphibians are facing a global mass extinction. Possible causes for the decline in both numbers and diversity of amphibians include alien pathogens and human activity. Climate change is now widely considered to be one of the stresses leading to the decline of climate-sensitive populations of amphibians. Some species of endemic amphibians in Puerto Rico are experiencing well-documented declines, while other species are showing resilience to human impact. Generally, frogs in NE Puerto Rico are experiencing more severe declines at higher elevations than at lower elevations, despite the fact that in NE Puerto Rico sites at higher elevation are less developed than sites on the coastal plain.

Three species of *Eleutherodactylus* (*E. karlschmidti*, *E. jasperi*, and *E. eneidae*) are presumed to be extinct. Burrowes (2004) showed that 8 of 11 populations of 6 different species of endemic *Eleutherodactylus* had shown significant declines in numbers at elevations above 400m. This is just one example of the global decline of tropical amphibians that has been well documented in the past 15 years.

(Frank's work was supported with a travel grant from the NSF-funded Luquillo LTER Project)

Phylogenetic and Ecomorphological Questions Raised by an Enigmatic, Recently Discovered, Early Cretaceous Fossil Bird

Jessie Atterholt

In recent years, the Lower Cretaceous (?lower Aptian) Xiagou Formation has yielded approximately 80 avian partial skeletons, many with soft-tissue traces, from sites in the Changma Basin of Gansu Province, northwestern China. The most abundant taxon amongst these is the basal ornithuran *Gansus yumenensis*. Enantiornithians have also been identified in the sample. Here I describe two incomplete, semi-articulated appendicular skeletons, the first consisting of a partial pelvic girdle and complete pelvic limb, and the second comprised of a largely complete pelvic limb. Both specimens bear characters diagnostic of Enantiornithes, and are referred to as a new taxon, *Qilianornis graffini* gen. et sp. nov. The exceptional three-dimensional preservation of these specimens (compared to the crushed, nearly two-dimensional condition typical of avian specimens from the Jehol Group of northeastern China) reveals important new information *apropos* enantiornithian anatomy, evolution, and diversity.

(Jessie's work was supported by the Paleobiology Research Fund of the Department of Earth and Environmental Science)

Greening Roofs: a Cross-Sectional Study

Pallavi Biswas and Jenny Hong

The full meaning and extent of “going green” has become more ambiguous as the phrase has become widespread in usage. In this project we hope to increase dialogue at the University of Pennsylvania about what it means to “green” a roof by bringing the roof down to eye level. We have exposed the Penn community to the key environmental benefits of greener roof options by building and displaying an outdoor educational demonstration.

Four roof types are compared in full-scale cross-section models to demonstrate sustainable roof options for roof renovations and new construction: 1) an extensive green roof, 2) an intensive green roof, 3) a cool/white-top roof, and 4) a black asphalt roof. The black asphalt roof represents the conventional roof type for base comparison. Each roof section is displayed in a clear acrylic container on one of four benches. The arrangement of the four benches in close proximity to one another encourages visual and tactile comparison. The outdoor placement of the benches demonstrates the varying abilities of each roof type to absorb stormwater runoff and to resist heat absorption. Educational signage explains the key features and components of each roof type.

The benches sit on the Meyerson Hall Plaza, an ideal location for our project because it is an outdoor space enjoyed by the design community. It is important for the Penn community – particularly members of PennDesign – to understand fully the key environmental benefits of sustainable roof types. The installation is designed to promote dialogue among students and faculty alike. In addition, it will serve as an educational tool for those who wish to implement these roofs in their own projects.

This exhibit will run on Meyerson Plaza until May 11th, 2009. After its completion, we hope to donate this project to the Kings Court English House green roof as an educational display.

(Pallavi and Jennie were supported by a Vagelos Grant for Undergraduate Research)

Seward's Melting Icebox

Yael Bortnick

In this study I and my research assistant sampled 130 Alaskans via a telephone survey between February and April 2009 to determine if Alaskans support climate-change policies, and what factors predict this support. Alaska was chosen for this study because impacts of climate change are already visible across the state, and I hypothesized that this condition might affect how citizens view climate-change policies. The purpose of this study was to compare the results of the telephone survey against previous national studies to see if there is a difference in how people who are already faced with realities of climate change view adaptation and mitigation policies.

The majority of Alaskans are certain that global warming is happening and that it is caused primarily by human activity. Furthermore, they believe that global warming is already affecting Alaska, and that the effect will be serious in extent before the year 2020. However, Alaskans have little confidence in state politicians, and they believe those politicians are not doing enough to address the effects of climate change in the state. Indeed, the majority of Alaskans support climate-change regulation. Unlike in national samples, general policy support in Alaska cannot be predicted by demographic variables. Factors which influence overall policy support among Alaskans are related to world views - such as political ideology and religious affiliation - and beliefs about climate change, such as what one believes is the primary cause of global warming and whether one believes he/she will be personally affected.

(Yael's work was supported by a Greg and Susan Walker Endowment Grant and a Vagelos Undergraduate Research Fund Award)

Public Health Implication of Anthropogenic Climate Change: Air pollution, pollen, and asthma

Lauren Cowen

Background: The incidence of asthma has been growing at a rapid rate in recent years and may be linked to large-scale global industrialization and urbanization. Focus of asthma research and prevention has primarily been on indoor triggers. However, in light of current anthropogenic climate-change concerns, it is important to consider the impact of ambient allergens/irritants (i.e. pollen and air pollution) on the incidence and exacerbation of asthma.

Objectives and Methods: I reviewed published studies on the associations between air pollution, pollen, global climate change, and asthma. Given that air pollution is the one variable that can be directly influenced by human efforts, I also completed background research on air-pollution-regulation policy for the U.S. (representing a developed and democratic country) and China (representing a developing and communist country) to understand better the current situation and opportunities for policy change. Regions vary greatly in atmospheric concentration of pollen and in severity of air pollution. For this reason, I choose Atlanta and Beijing as more specific areas for case studies.

Conclusions: Available evidence strongly supports the positive association between 4 of the major 'criteria' air pollutants (O₃, NO₂, SO₂, particulate matter – especially diesel-exhaust particulate matter) and asthma symptoms, with children showing a greater vulnerability. The precise mechanisms, however, are still uncertain. Besides directly affecting human respiratory symptoms, air pollution appears to interact with pollen allergens to increase allergenicity and facilitate deposition of pollen on sensitive tissue. Thus, air pollution and pollen interaction may not only act to increase asthmatics' predisposed symptoms, but may also lead to an increase in asthma incidence. Anthropogenic global warming may influence the amount and allergenicity of pollen allergens present in the environment, and may increase the inventory of aeroallergens. Evidence of respiratory health improvements in individuals residing in conditions of high or improved air quality (e.g.: rural environments, Atlanta after Olympics-related transportation adjustments, and East Germany after reunification) suggests that the adverse impact of air pollution on airway inflammation is reversible.

The U.S. Clean Air Act of 1990 institutionalized the EPA's role in establishing and overseeing the current NAAQS for air pollutants deemed harmful to public health and environment. Although relatively successful, 25% of counties in the U.S. still failed to meet the standards for at least one airborne pollutant from 1990 to 1998; this non-compliance continues to be a concern (Teague & Bayer 2001). Government agencies, schools, and physicians should educate susceptible individuals about the importance of monitoring daily Air Quality Indices. Better coordination must be developed among local, state, and national governments.

The success of Chinese air-pollution mitigation is hampered by the country's economic demands and complicated political situation. International pressure associated with the 2008 Summer Olympics in Beijing provided motivation to make immediate changes. China is in the process of switching from coal as the primary energy source to alternate sources, and progress is already noticeable. Diesel-exhaust particulate matter and NO₂ released from vehicle emissions are of primary concern, as China's use of motor vehicles has dramatically increased. Attention should be focused on improving traffic infrastructure and developing public transportation.

Coral Bleaching and Coral Disease: The Rise of a Dangerous Synergy

Philip Ferry

Mass bleaching events have become the predominant threat to health of coral-reef communities worldwide. The correlation between these bleaching events and environmental conditions such as water temperature, salinity, pH, and nutrient abundance have only begun to be understood. Physical disturbance of coral reefs from human activity or extreme weather systems such as hurricanes has also attracted growing attention from scientists around the world. Much research today focuses on the threat that coral diseases pose to these reef ecosystems, especially in the Caribbean. In the United States Virgin Islands, reef-building *Acropora* coral species are especially at risk of irreversible degradation. The threat posed by bleaching and disease in this area is especially foreboding, and the necessity to fully understand the synergy between the two has never been more apparent.

Climate-Change Education in the Grade-School Classroom

Megan Folz

Alerting our nation's population to the implications of climate change and the science that underpins our understanding of the process is an imperative that must be addressed. In this thesis, I address the education of grade-school students about the subject of climate change and global warming, particularly the grade-school students in New Jersey. Students hold various misconceptions about global warming; many students confuse the mechanisms controlling global warming and ozone depletion. An effective way to help correct student misconceptions is to present a student with a cognitive conflict, a science-based challenge to his/her (mis)conception, and replace the misconception with the more correct information. I am concerned mainly with New Jersey students, because New Jersey is likely to be affected by global climate change, and most severely impacted by sea-level rise. Of the New Jersey public schools that were surveyed for this paper, 66% did not even breach the topic of global climate change in the curriculum.

I propose a lesson plan designed to be adopted by the Bayshore Discovery Project (BDP), a non-profit educational organization located in southern New Jersey. The lesson goals are: 1) to evaluate confusion between global warming and ozone depletion, and if confusion exists, to differentiate between the two processes; 2) to explore the reasons why the greenhouse effect is good for our planet and why it is important; 3) to explore the ways humans affect the environment and can enhance the greenhouse effect, and how that can cause global warming and climate change; and 4) to discuss how climate change may affect New Jersey.

It is dangerous to leave student knowledge of global climate change in the hands of politics, media, and popular culture. Students will be much more able to make informed decisions if they are aware of the scientific bases of the mechanisms of global climate change.

Composting Opportunities for Beer-Brewing By-Products

Julian Goresko

Beer breweries produce enormous amounts of organic food waste – in recent years, the largest breweries have generated waste equivalent to 10% of all U.S. civilian food waste. One growing application for reusing these by-products is composting. Multiple studies have now demonstrated the viability of using spent grain, trub, excess yeast, and brewery effluent as composting agents. Not only does composting work to divert organic waste from landfills, but it can generate revenue and new job opportunities while reducing reliance on chemical fertilizers, herbicides, and pesticides. Breweries have the opportunity to capitalize on composting as a waste-management strategy while reducing waste-disposal costs and creating new public-relations opportunities.

Why Wilderness?

Thomas P. Harker

Wilderness is defined by the absence of humans and their influence. However, even ancestral humans inhabited and impacted the landscape. While many human impacts are not perceptible, some actually create more preferred, aesthetically pleasing landscapes. Furthermore, ancestral humans may have reaped adaptive benefits from the presence of other people whom they perceived to represent integral parts of a landscape; human presence does not necessarily affect landscape preference negatively. Therefore, humans have not inherited a preference for wilderness.

Indoor Air Quality: The Role of Ambient Formaldehyde in Reported Asthma Cases

Ashley L. Hopkins

Studies from the late 20th century indicate that the link between ambient formaldehyde and reported asthma cases is inconclusive. However, scientists and health officials should revisit that possible link, because patterns of human behavior have changed in the 21st century. Westerners now spend an increasing amount of time indoors, and children spend most of their time indoors either in school or in their homes, where they are exposed to formaldehyde-emitting materials in those interior spaces. That exposure may trigger asthma attacks or respiratory irritation in individuals who have formaldehyde sensitization. Small children, whose respiratory systems are still developing, are the most vulnerable to formaldehyde sensitization; therefore, health officials should stress increased vigilance of formaldehyde sources for families with small children, as well as methods for remediation of those sources. Asthma attacks due to the presence of ambient formaldehyde are manageable, but health officials should spend time studying the link and educating the public about the risk.

The Impact and Future of the National Flood Insurance Program

Michelle Jacobson

The National Flood Insurance Program (NFIP) has imposed fundamental changes on the political and environmental landscape in the United States. The policy was enacted in 1968 to protect insurance companies and their clients from repetition of the failures that the industry faced after Hurricane Betsy's destruction of the Florida coastline in 1965, but the Program has only led to unintended environmental and political issues.

My interest in the National Flood Insurance Program and Plan and its effect stems from my numerous encounters with the plan. Since I grew up in a home covered by the NFIP, the government's role in assisting with the re-development of properties damaged by floods or coastal storms has always been a topic of concern to me. In addition, the intersection of politics and the environment has always been of great interest to me. The way that policies affect the environment (via both intended and unintended effects) will become increasingly important as the "green sector" of the economy becomes more developed, and the government takes a larger role in environmental development.

In 1968 the NFIP established the Federal government as a re-insurer, guaranteeing that flood-insurance companies would be able to pay out their clients' claims; it has many underlying problems and has created even bigger environmental issues. Serving as a re-insurer to insurance companies places the government in an awkward position when it comes to providing additional rescue support services to these flood areas. As we have seen, even when fully funded, FEMA efforts often do not meet immediate citizen needs. The NFIP has also spurred the development of coastal areas. Since property owners can be certain that they will receive payouts on their insurance, coastal development has increased. The number of times an individual can receive payment on an NFIP policy is also not limited. Therefore, the program creates incentives for people to rebuild in the same dangerous areas, creating not only harm for themselves, but also for rescue workers who must take care of them, and for the government that has agreed to ensure that insurance claims are paid. The NFIP Program also raises issues of equity and imposed insurance requirements.

While the NFIP is a helpful tool to enable the Federal government to protect its citizens' properties, a major overhaul with increased restrictions and regulations must be implemented. Congress needs to revisit the issue of floodplain definition and include more areas under the flood-insurance requirement. Citizens and developers need to be held accountable for their decisions and not depend on the federal government for endless aid. The government must make a change to the cycle of dependency many of these individuals have come to enjoy and create a more mutually beneficial program.

***Jatropha curcas* Biofuel in Small-Scale Rural Applications**

Sarah-Jane Littleford

Production of biodiesel from the seeds of the *Jatropha curcas* plant is a promising technology for rural Zimbabwe. With a deteriorating political and economic climate, foreign currency has become increasingly scarce in Zimbabwe. As a result, electricity supply from neighboring countries has decreased, and load shedding has become common throughout the country. This has left many rural areas without electricity supplied by a national grid. Rural health clinics in such areas are hence operating far below their capacity, resulting in increased morbidity and mortality rates, diminished community physical and psychological well-being, and an overall reduction in regional productivity. *Jatropha curcas* biodiesel production in rural areas may alleviate the difficulties faced by rural health-clinic staff, as it would allow for use of a generator system to convert biodiesel to electric energy; such a system would power hot-water heaters, sterilizing equipment, and it lights for nighttime emergencies.

Through examining the various steps of biodiesel production, I offer recommendations regarding both modification of *Jatropha curcas* cultivation for small-scale, rural users, and the availability in the country of the equipment necessary to exploit this opportunity.

Community involvement is necessary for successful implementation of a *Jatropha curcas* cultivation project. This should be straightforward to establish, as a result of the many side benefits of the plant, including improved soil fertility, increased resistance to erosion, and protection of food crops from grazing animals.

Although further research is necessary to determine the most suitable methods of cultivating and producing biodiesel from a still undomesticated plant, *Jatropha curcas* is demonstrated as a multi-use crop with many positive impacts on the community. *Jatropha curcas* shows great potential for small-scale implementation in the rural areas of Zimbabwe.

(Sarah-Jane's work also represents the Senior Thesis required of students who have designed and completed an Individualized Major; Sarah-Jane's Individualized Major is entitled "Sustainable Development")

Elevated CO₂ and Addition of Nitrogen Stimulate Growth of Marsh Vegetation

Kevin P. White

Plants typically respond positively to elevated CO₂, but questions persist about Nitrogen, particularly in coastal wetlands. To test the growth response of vegetation in a high marsh ecosystem under conditions of elevated CO₂, an open-top chamber experiment was conducted along a sub-estuary of the Chesapeake Bay. The system, composed of a C₃ sedge, *Schoenoplectus americanus* (formerly *Scirpus olneyi*), and two C₄ grasses, *Spartina patens* and *Distichlis spicata*, was exposed to two levels of carbon dioxide (CO₂) (ambient and ambient + 340 ppm) and two levels of nitrogen (N) addition (0 and 25 g N yr⁻¹). Peak standing biomass, belowground growth, and turnover were estimated for two consecutive growing seasons. Nitrogen stimulated productivity, but elevated CO₂ reduced that stimulation. *Schoenoplectus* was stimulated by N through increased turnover, while CO₂ yielded more belowground growth. Although the global perturbations of elevated CO₂ and N addition both stimulated productivity in this system, they did so through different mechanisms.

(Kevin's work was supported by an NSF Research Experience for Undergraduates Grant to the Smithsonian Environmental Research Center, and by a Greg and Susan Walker Endowment Grant)

The Role of International Non-Governmental Organizations (INGOs) in Rural Development in Nepal

Annie M. Winter

Nepal remains one of the poorest and most underdeveloped countries in the world, with a per capita Gross Domestic Product (GDP) hovering around \$270, and 42 percent of the population living below the poverty line. Each year, Nepal loses some 10 billion Nepali rupees (\$15 million) in terms of health expenses, loss of productivity, and adverse effects on tourism due to poor hygiene and deficient environmental sanitation. Studies have shown that a one-dollar investment in sanitation yields an eight-dollar return, an 800 percent return on investment. The United Nations' Millennium Development Goals outline a plan to halve by 2015 the percentage of the global population without sustainable access to proper sanitation and drinking water. Under Nepal's *National Water Plan*, 100 percent of the population will have access to a water supply by 2017 (with 27 percent of them having access to a medium- or high-quality water supply), and, similarly, everyone will have access to sanitation facilities (U.N. Millennium Development Goals). These goals are vital to Nepal's development as a modernizing nation and as a new democracy, but the policies must be implemented effectively and at the proper level. In this paper I outline a framework within which non-governmental organizations could improve water supply in the Lower Mustang region. I consider factors such as: the capacity of the local government and the people, barriers to improved water supply, and an assessment of various strategies that have been undertaken by NGOs, both in Nepal and in the Indian state of Kerala.