

Upcoming Events

FES Seminar Lecture Series: Gary Dunning

Burke Auditorium, Wednesday October 5, 12:00-1:00 pm.

This talk will address conflict resulting from choices over land-use when all relevant stakeholders are not engaged in the process. As global pressures rise on forests to deliver an ever increasing flow of goods and services, the number and intensity of these conflicts will rise as well. The Forests Dialogue (TFD), an organization based at FES, was established to help reduce conflict among forest stakeholders through dialogue. This talk will examine how TFD's new 4Fs (food, fuel, fiber and forests) Initiative will help address the challenges facing forests.

Gary Dunning is the Executive Director of the Forests Dialogue and F&ES M.E.S. '96. He was previously the Executive Director of the Yale's Global Institute of Sustainable Forestry, the Director of the Yale Forest Forum, and National Roundtable Coordinator for the Seventh American Forest Congress. Gary has taught Agroforestry in Kenya Forestry College, and conducted research in Community Forestry in Papua New Guinea.

28th Annual Doctoral Student Research Conference

Burke Auditorium, 3rd floor, Kroon Hall. Friday, October 7, 2011 (all talks are free and open to the public)

"The scholarship of our doctoral students is the reason why the National Research Council gave our program a top rating," said Dean Peter Crane. "Their concern for people and the planet is what we're all about at the School of Forestry & Environmental Studies." Fifteen doctoral students, who are in various stages of their studies, will talk about developments in their research. The conference begins at 9 a.m.

For schedule and more information, visit <http://environment.yale.edu/news/6107/>, contact the conference's organizers, Martin Bouda (martin.bouda@yale.edu), and Timothy Terway (timothy.terway@yale.edu), or [Download the Doctoral Conference Poster here](#)

Journal Publications

Significant efflux of carbon dioxide from streams and rivers in the US

Authors: David E. Butman and Peter A. Raymond

Published: 2011, Nature Geoscience (accepted, in press)

Abstract: The evasion of carbon dioxide from inland waters was only recently included in assessments of the global carbon budget^{1,2}. Current estimates of carbon dioxide release from global freshwater systems, including lakes and wetlands, range from 0.7 to 3.3 Pg C per year^{1,3-6}. However, these estimates are based on incomplete spatial coverage of carbon dioxide evasion, and an inadequate understanding of the factors controlling the efflux of carbon dioxide across large drainage networks⁵. Here, we estimate the amount of carbon degassed from streams and rivers in the United States using measurements of temperature, alkalinity and pH, together with high resolution data on the morphology and surface area of these waterways. We show that streams and rivers in the United States are super-saturated with carbon dioxide compared to the atmosphere, emitting 97 ± 32 Tg carbon each year. We further show that regionally, carbon dioxide evasion from streams and rivers is positively correlated with annual precipitation, which we attribute to climatic regulation of stream surface area and the flushing of carbon dioxide from soils. Scaling our analysis from the U.S. to temperate rivers between 25°N and 50°N we estimate a release of around 0.5 Pg carbon to the atmosphere each year.

Estimating carbon stock in secondary forests: decisions and uncertainties associated with allometric biomass models

Authors: Van Breugel, M., J. Ransijn, Dylan Craven, F. Bongers, and Jefferson S. Hall.

Published: 2011. *Forest Ecology & Management*. 262 (8): 1648-1657.

Abstract: Secondary forests are a major terrestrial carbon sink and reliable estimates of their carbon stocks are pivotal for understanding the global carbon balance and initiatives to mitigate CO₂ emissions through forest management and reforestation. A common method to quantify carbon stocks in forests is the use of allometric regression models to convert forest inventory data to estimates of aboveground biomass (AGB). The use of allometric models implies decisions on the selection of extant models or the development of a local model, the predictor variables included in the selected model, and the number of trees and species for destructive biomass measurements. We assess uncertainties associated with these decisions using data from 94 secondary forest plots in central Panama and 244 harvested trees belonging to 26 locally abundant species. AGB estimates from species-specific models were used to assess relative errors of estimates from multispecies models. To reduce uncertainty in the estimation of plot AGB, including wood specific gravity (WSG) in the model was more important than the number of trees used for model fitting. However, decreasing the number of trees increased uncertainty of landscape-level AGB estimates substantially, while including WSG had limited effects on the accuracy of the landscape-level estimates. Predictions of stand and landscape AGB varied strongly among models, making model choice an important source of uncertainty. Local models provided more accurate AGB estimates than foreign models, but high variability in carbon stocks across the landscape implies that developing local models is only justified when landscape sampling is sufficiently intensive.

Organic yerba mate: an environmentally, socially and financially suitable agroforestry system

Authors: Montagnini, F., Eibl, B., Barth, S. R.

Published: 2011. *Bois et Forêts des Tropiques* 308: 59-74.

Abstract: Trade in yerba mate, *Ilex paraguariensis* Saint Hilaire, is a lucrative business in Argentina, Paraguay, and Brazil. The leaves of yerba mate are consumed as a tea, with a market expanding to the USA, Europe and Asia, as it contains antioxidants and is energizing, making it an alternative to coffee. Approximately 5 percent of the area of Misiones province, Argentina, is in yerba mate production. Many farmers do not reach expected yields due to lack of adequate technology. Organic yerba mate (grown without the use of agrochemicals) can get higher price with most cooperatives having it as one of their products. Typically grown in monocultures, its management can cause erosion and soil exhaustion; however, yerba mate grows in subtropical forest and is shade tolerant so it can be grown in agroforestry systems (AFS). The study examined organic AFS of yerba mate by conducting semi-structured interviews with farmers in Misiones, including family farms as well as larger farms, private companies, and reserves. This review recorded a large number of native species growing in combination with yerba mate. The extra work involved in organic practices is compensated by higher prices. Yerba mate AFS with native trees improve soil fertility without relying on fertilizers, while providing additional income. The following native tree species are recommended for growing in combination with yerba mate: *Balfourodendron riedelianum*, *Cordia trichotoma*, *Nectandra lanceolata*, *Bastardiopsis densiflora*, *Cedrela fissillis*, *Jacaranda micrantha*, *Araucaria angustifolia*, *Ocotea puberula*, due to their monopodial development and self pruning ability; as well as *Tabebuia heptaphylla*, *Enterolobium contortisiliquum*, *Peltophorum dubium*, *Parapiptadenia rigida* and *Anadenanthera macrocarpa* of broader crown, all with good growth and high quality timber. Other tree, herb or shrub species of fruit, medicinal or ornamental value can be also added to increase farm diversification. Finally the study concludes that agroforestry systems combining yerba mate with indigenous trees can promote the spread of organic yerba mate production and diversify income in Argentina and elsewhere.

Split Incentives in Household Energy Consumption

Authors: Gillingham, Kenneth, M. Harding, and D. Rapson

Published: 2012, *Energy Journal*, 33(2): 37-62.

Abstract: We explore two split incentive issues between owners and occupants of residential dwellings: heating or cooling incentives are suboptimal when the occupant does not pay for energy use, and insulation incentives are suboptimal when the occupant cannot perfectly observe the owner's insulation choice. We empirically quantify the effect of these two market failures and how they affect behavior in California. We find that those who pay are 16 percent more likely to change the heating setting at night and owner-occupied dwellings are 20 percent more likely to be insulated in the attic or ceiling. However, in contrast to common conception, we find that only small overall energy savings may be possible from policy interventions aimed at correcting the split incentive issues in California.

The International Collaboration on Air Pollution and Pregnancy Outcomes: Initial results

Authors: Jennifer D Parker, David Q Rich, Svetlana V Glinianaia, Jong Han Leem, **Michelle L Bell**, Matteo Bonzini, Michael Brauer, Lyndsey Darrow, Ulrike Gehring, Nelson Gouveia, Paolo Grillo, Edith H van den Hooven, Bin Jalaludin, Bill M Jesdale, Johanna Lepeule, Rachel Morello-Frosch, Geoffrey G Morgan, Rémy Slama, Frank H Pierik, Angela Cecilia Pesatori, Shella Sathyanarayana, Juhee Seo, Matthew Strickland, Lilian Tamburic, and Tracey J Woodruff

Published: 2011, Environmental Health Perspectives, 119(7) p. 1023-1028

Abstract: The findings of prior studies of air pollution effects on adverse birth outcomes are difficult to synthesize because of differences in study design. The International Collaboration on Air Pollution and Pregnancy Outcomes was formed to understand how differences in research methods contribute to variations in findings. We initiated a feasibility study to *a*) assess the ability of geographically diverse research groups to analyze their data sets using a common protocol and *b*) perform location-specific analyses of air pollution effects on birth weight using a standardized statistical approach. Fourteen research groups from nine countries participated. We developed a protocol to estimate odds ratios (ORs) for the association between particulate matter $\leq 10 \mu\text{m}$ in aerodynamic diameter (PM_{10}) and low birth weight (LBW) among term births, adjusted first for socioeconomic status (SES) and second for additional location-specific variables. Among locations with data for the PM_{10} analysis, ORs estimating the relative risk of term LBW associated with a $10\text{-}\mu\text{g}/\text{m}^3$ increase in average PM_{10} concentration during pregnancy, adjusted for SES, ranged from 0.63 [95% confidence interval (CI), 0.30–1.35] for the Netherlands to 1.15 (95% CI, 0.61–2.18) for Vancouver, with six research groups reporting statistically significant adverse associations. We found evidence of statistically significant heterogeneity in estimated effects among locations. Variability in PM_{10} –LBW relationships among study locations remained despite use of a common statistical approach. A more detailed meta-analysis and use of more complex protocols for future analysis may uncover reasons for heterogeneity across locations. However, our findings confirm the potential for a diverse group of researchers to analyze their data in a standardized way to improve understanding of air pollution effects on birth outcomes.

Community-level spatial heterogeneity of chemical constituent levels of fine particulates and implications for epidemiological research

Authors: Michelle L Bell, Keita Ebisu, and Roger D Peng

Published: 2011, Journal of Exposure Science and Environmental Epidemiology, 21(4), p. 372-384

Abstract: Studies of the health impacts of airborne particulates' chemical constituents typically assume spatial homogeneity and estimate exposure from ambient monitors. However, factors such as local sources may cause spatially heterogeneous pollution levels. This work examines the degree to which constituent levels vary within communities and whether exposure misclassification is introduced by spatial homogeneity assumptions. Analysis considered $\text{PM}_{2.5}$ elemental carbon (EC), organic carbon matter, ammonium, sulfate, nitrate, silicon, and sodium ion (Na^+) for the United States, 1999–2007. Pearson correlations and coefficients of divergence were calculated and compared to distances among monitors. Linear modeling related correlations to distance between monitors, long-term constituent levels, and population density. Spatial heterogeneity was present for all constituents, yet lower for ammonium, sulfate, and nitrate. Lower correlations were associated with higher distance between monitors, especially for nitrate and sulfate, and with lower long-term levels, especially for sulfate and Na^+ . Analysis of 30located monitors revealed measurement error for all constituents, especially EC and Na^+ . Exposure misclassification may be introduced into epidemiological studies of $\text{PM}_{2.5}$ constituents due to spatial variability, and is affected by constituent type and level. When assessing health effects of PM constituents, new methods are needed for estimating exposure and accounting for exposure error induced by spatial variability.

Survival analysis of long-term exposure to different sizes of airborne particulate matter and risk of infant mortality using a birth cohort in Seoul, Korea

Authors: Ji-Young Son, Michelle L Bell, and Jong-Tae Lee

Published: 2011, Environmental Health Perspectives, 119(5), p. 725-730

Abstract: Several studies suggest that airborne particulate matter (PM) is associated with infant mortality; however, most focused on short-term exposure to larger particles. We evaluated associations between long-term exposure to different sizes of particles [total suspended particles (TSP), $PM_{\leq 10}$ μm in aerodynamic diameter (PM_{10}), ≤ 10 – 2.5 μm ($PM_{10-2.5}$), and ≤ 2.5 μm ($PM_{2.5}$)] and infant mortality in a cohort in Seoul, Korea, 2004–2007. The study includes 359,459 births with 225 deaths. We applied extended Cox proportional hazards modeling with time-dependent covariates to three mortality categories: all causes, respiratory, and sudden infant death syndrome (SIDS). We calculated exposures from birth to death (or end of eligibility for outcome at 1 year of age) and pregnancy (gestation and each trimester) and treated exposures as time-dependent variables for subjects' exposure for each pollutant. We adjusted by sex, gestational length, season of birth, maternal age and educational level, and heat index. Each cause of death and exposure time frame was analyzed separately. We found a relationship between gestational exposures to PM and infant mortality from all causes or respiratory causes for normal-birth-weight infants. For total mortality (all causes), risks were 1.44 (95% confidence interval, 1.06–1.97), 1.65 (1.18–2.31), 1.53 (1.22–1.90), and 1.19 (0.83–1.70) per interquartile range increase in TSP, PM_{10} , $PM_{2.5}$, and $PM_{10-2.5}$, respectively; for respiratory mortality, risks were 3.78 (1.18–12.13), 6.20 (1.50–25.66), 3.15 (1.26–7.85), and 2.86 (0.76–10.85). For SIDS, risks were 0.92 (0.33–2.58), 1.15 (0.38–3.48), 1.42 (0.71–2.87), and 0.57 (0.16–1.96), respectively. Our findings provide supportive evidence of an association of long-term exposure to PM air pollution with infant mortality

Towards a Quantitative estimate of future heat wave mortality under global climate change

Authors: Roger D Peng, Jennifer F Bobb, Claudia Tebaldi, Larry McDaniel, Michelle L Bell, and Francesca Dominici

Published: 2011, Environmental Health Perspectives, 119(5), p. 701-706

Climate change is anticipated to affect human health by changing the distribution of known risk factors. Heat waves have had debilitating effects on human mortality, and global climate models predict an increase in the frequency and severity of heat waves. The extent to which climate change will harm human health through changes in the distribution of heat waves and the sources of uncertainty in estimating these effects have not been studied extensively. We estimated the future excess mortality attributable to heat waves under global climate change for a major U.S. city. We used a database comprising daily data from 1987 through 2005 on mortality from all nonaccidental causes, ambient levels of particulate matter and ozone, temperature, and dew point temperature for the city of Chicago, Illinois. We estimated the associations between heat waves and mortality in Chicago using Poisson regression models. Under three different climate change scenarios for 2081–2100 and in the absence of adaptation, the city of Chicago could experience between 166 and 2,217 excess deaths per year attributable to heat waves, based on estimates from seven global climate models. We noted considerable variability in the projections of annual heat wave mortality; the largest source of variation was the choice of climate model. The impact of future heat waves on human health will likely be profound, and significant gains can be expected by lowering future carbon dioxide emissions.

Environmental health indicators and a case study of air pollution in Latin American cities

Authors: Michelle L Bell, Luis A Cifuentes, Devra L Davis, Erin Cushing, Adrianna Gusman Telles, and Nelson Gouveia

Published: 2011, Environmental Research, 111(1), p. 57-66

Abstract: Environmental health indicators (EHIs) are applied in a variety of research and decision-making settings to gauge the health consequences of environmental hazards, to summarize complex information, or to compare policy impacts across locations or time periods. While EHIs can provide a useful means of conveying information, they also can be misused. Additional research is needed to help researchers and policy-makers understand categories of indicators and their appropriate application. In this article, we review current frameworks for environmental health indicators and discuss the advantages and limitations of various forms. A case study EHI system was developed for air pollution and health for urban Latin American centers in order to explore how underlying assumptions affect indicator results. Sixteen cities were ranked according to five indicators that considered: population exposed, children exposed, comparison to health-based guidelines, and overall PM_{10} levels. Results indicate that although some overall patterns in rankings were observed, cities' relative

rankings were highly dependent on the indicator used. In fact, a city that was ranked best under one indicator was ranked worst with another. The sensitivity of rankings, even when considering a simple case of a single pollutant, highlights the need for clear understanding of EHIs and how they may be affected by underlying assumptions. Careful consideration should be given to the purpose, assumptions, and limitations of EHIs used individually or in combination in order to minimize misinterpretation of their implications and enhance their usefulness.

Developed land-use and infants' respiratory symptoms

Authors: Keita Ebisu, Theodore R Holford, Kathleen D Belanger, Brian P Leaderer, and Michelle L Bell

Published: 2011, Environmental Research, 111(5), p. 677-684

Abstract: Children's respiratory health has been linked to many factors, including air pollution. The impacts of urban land-use on health are not fully understood, although these relationships are of key importance given the growing populations living in urban environments. We investigated whether the degree of urban land-use near a family's residence is associated with severity of respiratory symptoms like wheeze among infants. Wheeze occurrence was recorded for the first year of life for 680 infants in Connecticut for 1996–1998 from a cohort at risk for asthma development. Land-use categories were obtained from the National Land Cover Database. The fraction of urban land-use near each subject's home was related to severity of wheeze symptoms using ordered logistic regression, adjusting for individual-level data including smoking in the household, race, gender, and socio-economic status. Nitrogen dioxide (NO₂) exposure was estimated using integrated traffic exposure modeling. Different levels of urban land-use intensity were included in separate models to explore intensity-response relationships. A buffer distance was selected based on the log-likelihood value of models with buffers of 100–2000 m by 10 m increments. A 10% increase in urban land-use within the selected 1540 m buffer of each infant's residence was associated with 1.09-fold increased risk of wheeze severity (95% confidence interval, 1.02–1.16). Results were robust to alternate buffer sizes. When NO₂, representing traffic pollution, was added to the model, results for urban land-use were no longer statistically significant, but had similar central estimates. Higher urban intensity showed higher risk of prevalence and severity of wheeze symptoms. Urban land-use was associated with severity of wheeze symptoms in infants. Findings indicate that health effect estimates for urbanicity incorporate some effects of traffic-related emissions, but also involve other factors. These may include differences in housing characteristics or baseline healthcare status. We investigated whether urbanicity is associated with infant's respiratory health. We assessed urbanicity with satellite imagery and infant's health with cohort data. Urbanicity was associated with severity of wheeze symptoms in infants. Urbanicity captures several aspects of urban life, such as traffic-related emissions.

Policy perils of ignoring uncertainty in oil palm research

Authors: Gary D Paolia, Kimberly M Carlson, Aljosja Hooijer, Susan E Page, Lisa M Curran, Philip L Wellsa, Ross Morrisond, Jyrki Jauhiainen, Alice M Pittman, David Gilbert, and Deborah Lawrence

Published: 2011, Proceedings of the National Academy of Sciences, 108(25), p. 108

Abstract*: Success of the emerging Low Emissions Development paradigm in Southeast Asia depends on mitigating impacts of oil palm (OP) expansion on carbon-dense ecosystems, especially tropical peatlands. To this end, Koh et al. (1) mapped OP planted before 2002 across Peninsular Malaysia, Sumatra, and Borneo to estimate emissions and biodiversity losses from peatland conversion (~880,000 ha). Unfortunately, emissions scenarios are oversimplified, remote-sensing (RS) methods are unsuitable for OP monitoring, and recommendations for peatland restoration are overstated. The article risks misinforming national and international climate change policies under development. Koh et al. overestimated emissions from aboveground biomass (AGB) conversion to OP. [...] We estimate emissions from AGB losses as 75–111 million MgC, 18–45% less than the authors' mean estimate. Conversely, Koh et al. underestimated belowground C emissions. [...] Their unique use of radar to map OP advances RS methods for regional land-cover inventories. However, this method is inadequate for monitoring "future land-use change driven by oilpalm" to "facilitate...sustainable development." In Indonesia, the ~4.97 million ha of mature plantations mapped by Koh et al. in 2010 missed ~2.7 million ha of OP evidently too young (<8 y) or in patches too small (<200 ha) to be detected with their methods. [...] Finally, the authors markedly overstated potential for rehabilitating ~2.3 million ha of "clear-felled peatlands." First, most "cleared" areas may already be planted with OP. Recent work in Sarawak (www.sarvision.nl) shows that 65% of peatlands deforested from 2005 to 2010 were planted to OP and are unavailable for restoration. Additionally, rehabilitating deforested tropical peatlands is far more difficult and costly than appreciated (5). Enormous investments are required to raise water levels, control fires, and replant native species within the complex sociopolitical milieu of rural Southeast Asia. Finite dollars for peatland conservation must prioritize protecting forested peatlands, not restoring deforested ones. We laud scientists like Koh et al., who wish to engage policymakers. However, clearly communicating uncertainties and assumptions of policy-oriented research is essential. Instead, the authors oversimplified a complex story, with no sensitivity analysis to explore uncertainty in peatland oxidation emissions or alternative land-cover change pathways preceding OP development. Southeast Asian countries developing emissions reductions strategies face tough choices balancing agricultural expansion with forest protection; proper treatment of uncertainty surrounding emissions from OP will help countries plan for worst- and best-case scenarios and design research aimed at informing policy decisions.

***this abstract is slightly abbreviated for the purpose of this newsletter. Abbreviations clearly marked with [...]**

Book and Book Chapter Publications

The Banana Tree at the Gate: The History of Marginal Peoples and Global Markets in Borneo

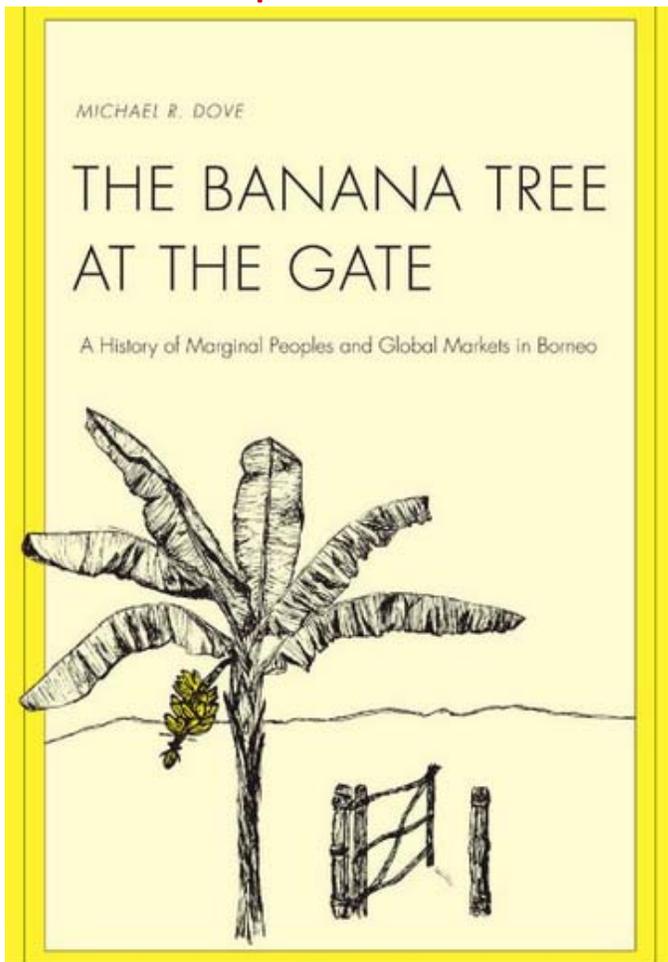
Author: Dr. Michael R. Dove

Published: 2011, Yale University Press

Winner of the 2011 Julian Steward Award as given by the Anthropology and Environment Section of the American Anthropological Association. (About the book: see Research Spotlight, below.)

Research Spotlight:

Dr. Michael Dove's book, *The Banana Tree at the Gate: The History of Marginal Peoples and Global Markets in Borneo*



(Yale University Press 2011), has been awarded the 2011 Julian Steward Award by the Anthropology and Environment Section of the American Anthropological Association. The Anthropology and Environment Section awards this prize to the best monograph in environmental anthropology each year. The award will be officially presented to Dr. Dove at the AAA meetings this November at the Anthropology and Environment business meeting.

The “Hikayat Banjar,” a native court chronicle from Borneo, characterizes the irresistibility of natural resource wealth to outsiders as “the banana tree at the gate.” Michael R. Dove employs this phrase as a root metaphor to frame the history of resource relations between the indigenous peoples of Borneo and the world system. In analyzing production and trade in forest products, pepper, and especially natural rubber, Dove shows that the involvement of Borneo’s native peoples in commodity production for global markets is ancient and highly successful and that processes of globalization began millennia ago. Dove’s analysis replaces the image of the isolated tropical forest community that needs to be helped into the global system with the reality of communities that have been so successful and competitive that they have had to fight political elites to keep from being forced out.

Michael Dove is a Margaret K. Musser Professor of Social Ecology, Professor of Anthropology, Director of the Tropical Resources Institute, and Curator of Anthropology in the Peabody Museum. Dove’s research focuses on the environmental relations of local communities, especially in South and Southeast Asia, where he has worked for over 35 years.



Grant Awards

Monitoring improvements in environmental quality that will occur as the result of restoration of a well-studied salt marsh ecosystem

Sponsor: YSI Foundation

PI: Gaboury Benoit

Total Amount: \$30,000

This proposal is for a project to monitor improvements in environmental quality that will occur as the result of restoration of a well-studied salt marsh ecosystem. The West River estuary between West Haven and New Haven, Connecticut, has been tide gated for nearly a century, creating a degraded fresh-tidal system with reduced water quality and biodiversity. A local NGO has obtained major funding to install self-regulating tide gates that remain open except during rare flood events. This restoration will re-establish salt water flushing that will dramatically increase tidal range, water quality, and salinity. These improvements in the physical characteristics of habitats will almost certainly lead to beneficial changes in plant and animal communities. We will quantify environmental conditions with high temporal resolution monitoring of the system's hydrology and water quality. These key drivers will have a substantial effect on vegetation, fish, and bird communities, which we will also monitor in parallel research. Importantly, the marsh should respond quickly enough to make an experiment possible in the two year lifetime of the proposed grant. The restoration is a unique opportunity to assess ecological responses in a large scale Before-After-Control-Impact (BACI) experiment. Data will be collected before and after restoration of tidal exchange and the results compared to quantify the impact of the restoration. As a control, the research protocol will be replicated at a similar system, located within the same city, but which will not be restored. Both the experimental and control marshes are located in urban park areas. The restoration can be expected to provide benefits to neighbors and park users as well as to wildlife. There are many ecosystem restoration projects taking place worldwide, but very few of them are adequately monitored to see if they are successful and how they affect wildlife populations and human communities.

Extreme Heat and Human Health: Characterizing Vulnerability in a Changing Climate

Sponsor: National Institutes of Health

PI: Roger D Peng (John Hopkins University), Michelle Bell

Total Amount: \$481,764

Evidence of human-caused climate change over the past 50 years has been well documented. Global surface temperature has increased approximately 0.70 oC over the past 50 years and much of that increase can be attributed to anthropogenic sources. Climate change is anticipated to affect human health largely by changing the distribution of known risk factors such as extreme heat episodes, floods, droughts, air pollution and aero-allergens, and vector- and rodent-borne diseases. In particular, an expected increase in the frequency, intensity, and severity of extreme heat episodes, will likely have a profound impact on the public's health. Changes in the levels of air pollutants such as particulate matter and ozone can potentially exacerbate the already severe effects of heat. Designing interventions and mitigation strategies to protect the public's health will require first developing a clear understanding of how extreme heat episodes affect mortality and morbidity and identifying populations that are most vulnerable. This project will be an applied study focused on the effects of climate change- induced extreme heat on cardiovascular morbidity and mortality in the US elderly population (age > 65 years). Our goals are to (1) conduct a national study of the cardiovascular mortality and morbidity effects of extreme heat episodes in a vulnerable population (the elderly); (2) evaluate the extent to which biological, socio-economic, and environmental factors modify vulnerability to extreme heat; and (3) estimate the impact on cardiovascular mortality and morbidity of future extreme heat episodes using temperature projections from the most up-to- date global climate model simulations for the 2020-2100 time period under a range of assumptions about pollutant emissions, population health, population age structure, climate adaptation, and climate modeling approaches. This project brings together a multi-disciplinary team with expertise in biostatistics, environmental epidemiology, atmospheric science, engineering, large database management, and climatology.

Effects of Fine Particle Composition on Birth Outcomes

Sponsor: National Institutes of Health (NIH)

PI: Michelle L Bell, Kathleen Belanger (Yale Public Health)

Total Amount: Approximately \$2,700,000

Preterm delivery, low birth weight and small for gestational age (SGA) are major causes of infant mortality and severe morbidity in the U.S. For African Americans, these risks are nearly doubled. Several studies have implicated air pollution, especially PM_{2.5}, as a risk factor for adverse birth outcomes. A challenge in this research is that particles vary widely in chemical composition by region and season. Due to lack of scientific evidence on which types of particles are most harmful, particles are regulated by size. We will investigate two aspects of the chemical composition of particles: 1) levels of individual PM_{2.5} chemical components (e.g., nickel); and 2) levels of PM_{2.5} from specific sources (e.g. oil combustion), to investigate the relationship between exposure to specific types of particles and birth outcomes. PM_{2.5} total mass filters from CT and MA will be analyzed for levels of 49 chemical components. This chemical component data will be used in source apportionment modeling to estimate PM_{2.5} from specific sources (e.g. motor vehicles). Associations will be assessed between birth outcomes and PM_{2.5} chemical components (Aim 1) and between birth outcomes and the levels of PM_{2.5} from particular sources (Aim 2). In Aim 3 we will examine traffic PM_{2.5} with three exposure methods: 1) the chemical component most associated with traffic from Aim 1; 2) traffic PM_{2.5} levels from Aim 2; and 3) traffic-related air pollution estimated through a GIS traffic model. In our preliminary studies, risk of low birth weight increased 8-13% per interquartile range (IQR) increase in exposure to specific PM_{2.5} components. Findings from this study will identify the components or sources of PM_{2.5} with the greatest impact on birth outcomes and could lead to interventions targeted at the sources most toxic to infant health.