HUDSON RIVER ENVIRONMENTAL SOCIETY

2014 Hudson River Symposium: *Watershed Influences in a Changed World*

Wednesday May 7th, 2014

Student Union Building
SUNY at New Paltz
New Paltz, New York

Invited Speakers 9:00-3:45
Poster Session and Reception 3:45-5:30

Confirmed Speakers:

Colin Beier, SUNY ESF
Jerry Carlson, NYS DEC
David Chandler, Syracuse U.
David Church, Orange Co. Planning
Rocky Geyer, Woods Hole
Karin Limburg, SUNY ESF
Raymond Najjar Jr., Penn State U.
Gregory O'Mullan, Queens College
Emma Rosi-Marshall, Cary IES
Patrick Sullivan, Cornell U.
Dennis Swaney, Cornell U.

Climate change, urban sprawl, land use, introduced insects, disease, and pathogens have far reaching effects throughout the Hudson River watershed. These impacts, whether new or newly discovered, are changing our understanding of the influences the watershed has on the Hudson River estuary. Understanding these issues is critical for directing future research and developing the right solutions to minimize impacts.

During this symposium, several invited experts will discuss the most recent scientific understandings of the changes in the watershed, recommend where science can lead to better understanding, and present novel approaches to minimizing impacts. A contributed poster session and reception will follow the presentations.

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HUDSON RIVER ENVIRONMENTAL SOCIETY

2014 Hudson River Symposium:
Watershed Influences in a Changed World

State University of New York at New Paltz, Student Union Building
May 7, 2014 8:00AM -5:30 PM
(*Talks Start at 9:00; Poster Session & Reception Starts at 3:45*).

Agenda

8:00 – 8:45: Registration and Light Breakfast
8:45 AM: Introductions & Announcements: CRREO & HRES

Watershed Influences and Change *(9:00 to 10:30)*

"Climate Change in the Mid-Atlantic Region: Implications for the Hudson River" - **Raymond Najjar Jr.**, *Penn State University*

"Human Impacts on the Hudson River Physical Regime -- Global vs. Local" - **Rocky Geyer & Dave Ralston,** *Woods Hole Oceanographic Institute*

"Trends in Anthropogenic N Inputs to the Hudson River Watershed" – **Dennis Swaney,** *Cornell University*

10:30 AM – 11:00 – Coffee Break

Fisheries and Wildlife Linkages (11:00 – 12:00)

"Climate Change and Urban Sprawl – Impacts to Anadromous Fish" – **Karin Limburg**; *SUNY Environmental Science and Forestry*

"Using Cross-system Science to Link Terrestrial, Aquatic, and Estuarine Management in the Face of Climate Change" – **Pat Sullivan**; *Cornell University*

12:00 -1:00 – Lunch with remarks from **Frances Dunwell**, *Manager, NYS DEC Hudson River Estuary Program*

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Water Quality, Stream Ecosystems, and Forest Health (1:00 – 2:30)

"Bacterial Water Quality of the Hudson River Estuary: Agents of Concern, Ecological Connections, and Emerging Research Priorities"– **Greg O'Mullan**; *Queens College*

"Climate Change Impacts on Northeast Stream Ecosystems" - **Emma Rosi-Marshall**; *Cary Institute of Ecosystem Studies*

"Invasive Species and Climate Shifts are Changing New York Forests: Can We Manage the Change?" – **Jerry Carlson**; *NYSDEC, Lands and Forests*

Management Options (2:30 – 3:30) (20 min each)

"Watershed Benefits: How Ecosystem Services can Sustain the Hudson River in a Rapidly Changing World" – **Colin Beier**; *SUNY Environmental Science and Forestry*

"Green Infrastructure Opportunities for Balancing Hydrographs in Urban Settings" - **David Chandler**; *Syracuse University*

"What Local Government can do about Sprawl and Climate Adaptation – Lessons from the Mid-Hudson Regional Sustainability Initiative" - – **David Church**; *Orange County Department of Planning*

3:30 – "Meeting Summary: All doom and gloom or is there hope?" - **Dennis Suszkowski,** *Science Director***,** *Hudson River Foundation*

3:45 PM – 5:30 PM – **Poster Session & Reception**

Conference Collaborators and Sponsors:

SPEAKER ABSTRACTS

Watershed benefits: how ecosystem services can sustain the Hudson River in a rapidly changing world

Colin Beier, Jesse Caputo
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SUNY College of Environmental Science and Forestry

The concept of ecosystem services (ES) is now widely used in environmental sustainability research and decision-making. Ecosystem services can be simply defined as the benefits people receive from nature - and this basic idea holds much promise for sustaining social and ecological systems and their interactions. In places like the Hudson River - where complex drivers of change interact with historical legacies of land use, pollution, and resource extraction (among many others) - there is a pressing need to measure how, when, and where ecosystem processes create either tangible benefits or undesirable outcomes for society. Conversely, there is a need to evaluate when and where societal demand for services exceeds or 'misfits' the functional capacity of ecosystems. This presentation outlines recent efforts to address these needs with an ES approach that utilizes existing data to grasp complexity while providing real-time decision-support. Here our focus is on methods for measuring the capacity of watersheds and wetlands to regulate water quantity and quality in response to land use, climate change, pollution, and major storm events. We hope to show how ES science can support both the understanding and stewardship needed to sustain the Hudson River in a rapidly changing world.

Invasive species and climate shifts are changing New York forests: Can we manage the change?

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NYSDEC, Lands and Forests

The impact of invasive species on natural resources have reached global recognition status. The northeastern area of the U.S. is the undisputed leader in numbers of exotic invasive arrivals and in the consequences of their establishment. NY is the center of this zone and the State has suffered and continues to suffer from more arrivals and greater consequences from the loss of scarce and highly valuable forest resources. New York forests have grown dramatically in size, area and age since the turn of the 20th century. In 1900 the State was at an all-time low with an estimated 6 million acres of forest; by the turn of the 21st century we had doubled that to an estimated 19 million acres. This suggests more than half of our forests are relatively young, historically unmanaged, occupy sites with uncertain growth potential and, since they are mostly on private lands, highly fragmented. These are frequently reported conditions which favor establishment and spread of non-native forest pests. Now we must manage in these uncertain landscapes within the context of trying to preserve and conserve what must by nature change.

We are subjected to this paradox of sustaining resources that are constantly changing. Mix in the impact of unknown non-native forest pests, and an element of uncertainty in the predictability of the consequences of any new arrivals is added. We can't eliminate all forms of disturbance or change, but we can sustain our ecosystem health in terms of maintaining processes within acceptable ranges of change over acceptable time frames. We can focus our intent and definitions on the rates of change that are "natural" or desirable-acceptable and those that are not. We can acknowledge the inevitability of change and aim for determining consensus or democratic goals that help us to accept the damage when it occurs. In essence we would plan for what we want over the years rather than reacting to unforeseen losses.

Green Infrastructure Opportunities for Balancing Hydrographs in Urban Settings

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Sustainable solutions for mitigating the impacts of urban discharge to local streams and receiving water bodies often focus on attenuation of the storm water hydrograph. Installations of green infrastructure (GI) often seek to increase storm water storage at strategic locations through enhanced volumetric capture or infiltration, whereas low impact development (LID) often seeks to minimize runoff generation at the source. In either case, infiltration at the land surface is critical to the efficacy of these approaches. Similarly, the distribution of surface runoff travel time to the stream also determines the hydrograph form. Infiltration data from a wide range of engineered porous surfaces in Syracuse NY are compared to native soil to support a discussion of the use of distributed infiltration zones to balance urban stormwater hydrographs.

What Local Government Can Do About Sprawl and Climate Adaptation: Lessons from the Mid Hudson Regional Sustainability Plan Initiative

David E. Church
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Commissioner of Planning, Orange County, New York

Local governments in New York State retain significant, leadership roles in the oversight, management, and permitting of land uses. In recent decades these same governments have had a mixed record in addressing the consequences of marketplace and institutional realities. These realities have helped advance a predominance of automobile dependent development, or "sprawl", outside of the historic urban and village centers that dominated more than two centuries of prior land use preferences. More recently, localized and regional realities of climate change have compounded these consequences. Together these issues are essential components in addressing *sustainability*.

In 2013 the seven county Mid-Hudson Region, one of ten economic development regions in New York State, completed a Regional Sustainability Plan. Financed by NYSERDA, this public/private collaboration analyzed baseline realities as well as trends in the Mid-Hudson Region. Findings include the identification of a predominance of aging, inefficient building stock and an over-reliance on automobile dominated infrastructure as leading challenges to a sustainability region. Recommendations and priority projects are defined and presented, focused on what local governments can best do as leaders to address sustainability – including sprawl and climate change and adaption. Led by a goal of reducing indigenous sources of greenhouse gas emissions, the Mid-Hudson Plan includes recommendations and projects in five (5) focus areas: Land Use/Transportation, Energy, Materials Management, Agriculture and Open Space, and Water.

Human Impacts on the Hudson River Physical Regime -- Global vs. Local

W. Rockwell Geyer, David K. Ralston
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The physical regime of the Hudson River is highly variable at timescales of hours to seasons, due to natural variations in forcing mainly by the tides and run-off. Given this large-amplitude variability of currents, salinity structure, and suspended sediment, can we detect long-term changes in the physical regime? How can we distinguish natural from human-induced change? How important are global, changes such as sea-level rise and changes in climate relative to local human modifications of the environment such as dredging and watershed modifications? The preliminary findings of an observational and modeling study indicate that dredging is the human-induced factor with the most significant long-term impact on the physical regime. Channel deepening in the early 20th century has led to a half-meter increase in tidal range in Albany, but the dredging reduces the severity of floods by increasing the flow capacity of the river. As for long-term changes in precipitation and river flow, the data are inconclusive. The only certain factors associated with global-scale climate change are sea-level rise and warming, but neither of these represent significant forcing agents on the physical regime, due to the much larger variance associated with the natural variability and that due to extreme events.

Climate Change and Urban Sprawl – Impacts to Anadromous (and other) Fish

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Christopher C. Nack
John R. Waldman
SUNY-ESF

Warming trends for the past century have been demonstrated for the Hudson River estuary. Concurrently, urbanization of the watershed has hardened surfaces, particularly near streams. These changes have altered habitats for diadromous and resident fishes alike. We draw

examples of how temperature changes affect American shad and river herring spawning; how climate, overlain on a backdrop of other changes, has altered species mixes; how urbanization affects habitats; and how large storms, exemplified by the hurricanes of 2011, may have variable impacts.

Climate change in the Mid-Atlantic region: Implications for the Hudson River

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Andrew Ross
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The observed and projected climate of the Mid-Atlantic Region of the United States is reviewed with emphasis on related impacts to the Hudson River and its estuary. Temperature, precipitation, streamflow, and precipitation intensity have increased in the Mid-Atlantic Region, whereas wind speeds have declined. The historical warming is in agreement with simulations of the climate that incorporate greenhouse gas increases. Though such simulations also predict increases in precipitation and streamflow, the magnitude and seasonal timing is not captured well, suggesting that much of the region's hydrometeorological change during the past 100 years, including the 1960s drought and subsequent pluvial, was natural. Significant relationships exist between the region's climate and prominent climate modes, such as the Pacific Decadal Oscillation. Climate models consistently simulate warming of the Mid-Atlantic region throughout the 21st century, though the amount of warming is strongly model-dependent. Differences due to emissions scenarios begin to emerge only by about 2050 but become dramatic by 2100. Precipitation projections for the Mid-Atlantic Region are more equivocal than those of temperature, though most models simulate a wetter winter and spring, a drier summer and fall, and an overall increase in the intensity of precipitation. Given this, restoration and protection efforts in the Hudson River and its estuary should acknowledge the high likelihood that warming and sea-level rise will continue. Also likely but with somewhat less confidence is the expectation that streamflow will become more variable on seasonal and synoptic (weather-event) timescales.

Bacterial Water Quality of the Hudson River Estuary: Agents of Concern, Ecological Connections, and Emerging Research Priorities

Greg O'Mullan
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Queens College

Increasing population and aging sewage infrastructure combine to threaten local water quality,

while improved management and expanded recreational use challenge society to adopt a new vision for clean water in the Hudson River Estuary (HRE). Historical data sets indicate that average bacterial water quality has improved significantly for some regions of the lower HRE and provide reasons for optimism. However, as some large regional inputs of sewage-associated microbes have been reduced, expansion of fecal indicator bacteria monitoring programs demonstrate the importance of local inputs and short time scale variability in understanding sewage contamination. In order to optimize management effort and create a more mechanistic understanding of bacterial water quality, we must begin to evaluate not only the input and transport of sewage-associated bacteria, but also their ecology within the estuary. Information from new tools, such as molecular genetic characterization of microbial communities, has begun to elucidate the diversity and environmental dynamics of the microbial sewage contaminants. Particle association, water-sediment interactions, genetic transfer, and factors influencing environmental persistence and community succession are all important components required to create predictive water quality forecasts and optimize management priorities. Finally, recent flooding events and emerging research have demonstrated that microbial contaminants delivered to the estuary do not always remain within the shoreline, providing additional reasons to value clean water and reduce sewage pollution.

Climate Change Impacts on Northeast Stream Ecosystems

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Climate change has the potential to change a number of variables in northeastern stream ecosystems. In addition to changes in precipitation and water temperature, northeastern forest structure is currently changing due to forest succession from past harvest, forest clearings, and new pest invasions (ash borers, adelgids). In addition, the seasonality of snowmelt is potentially occurring earlier in the season, while leaf out may not change as much because it is driven by photoperiod. Because streams integrate watershed-scale processes, aquatic ecosystem function is coupled to changes in terrestrial ecosystems. Thus, forest structure and forest dynamics (i.e. timing of leaf out), may strongly affect how stream ecosystems function. In this talk, we will explore the potential consequences of climate change on northeastern stream ecosystems using recently collected data and published literature to provide insights into the many changes that may be predicted to occur in the future. We will present data on the relationship between riparian forest structure and age, compared to incoming light, algal chlorophyll a, metabolism, and nutrient uptake measured in 13 northeastern streams draining forests aged 30-400 years old in the Northeastern US. Our findings suggest that the sensitivity of stream ecosystem function to climate change will depend on the function of interest. Combined, these data demonstrate that the response of northeastern streams to climate change will be multi-faceted and that predictions about the future of northeastern streams will require a solid grounding in the many potential factors that influence these ecosystems.

Using Cross-system Science to Link Terrestrial, Aquatic, and Estuarine Management in the Face of Climate Change

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Understanding biological and geo-physical connections is critical when responding to the observed impacts of climate change and urbanization in the Hudson River Valley as well as associated impacts to the Estuary. A management framework that broadly considers cross-system linkages among terrestrial, aquatic, and estuarine systems may be more effective at addressing threats that otherwise may be missed by the compartmentalized structure typically found in most state and federal conservation programs. Management priorities for the Hudson River Estuary should also take into account cross-system connections, suitable scales for promoting sustainability, the human-environment interface and ecosystem complexity. Collaborative efforts to construct and implement such a framework are important as are clearly identified methods for validating linkages and monitoring the consequences of management actions. Greater focus on understanding the interdependence of these systems will improve the health of this highly valued ecosystem

Trends in anthropogenic N inputs to the Hudson watershed

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Bongghi Hong
Bob Howarth
Cornell University

The Hudson watershed spans a highly diverse landscape, from the Adirondack forests of its northern regions, and the agricultural areas of the Mohawk and central Hudson, to the NYC metropolitan area in the southern region of the watershed. Anthropogenic sources of nitrogen vary correspondingly. Transport of nitrogen from its source regions is largely driven by environmental factors, including temperature and hydrology, both of which are strongly dependent on patterns of weather and climate. Here, we discuss trends in regional nitrogen inputs and the factors that affect them in the Hudson basin, along with implications for the future.

POSTER ABSTRACTS

Dams and Culverts: Barriers and Aquatic Connectivity

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Andrew Meyer
DEC/Cornell University

For centuries, aquatic barriers, such as dams and culverts, on streams in the Hudson River Estuary Watershed have been negatively affecting natural stream flow, sediment deposition, and the movement of wildlife. In recent decades interest has grown for the removal of unwanted dams and the overhaul of poorly installed and undersized culverts. There is especially high interest in taking action where rare or threatened species reside. Often the sizeable price of removal or retrofitting existing structures is a major deterrent to restoration. While initial costs may be high, the benefits accrued are usually well worth the investment. Upgrading culverts to meet appropriate size requirements will lead to decreased maintenance and less frequent replacement, both substantial money savers. In addition to biodiversity benefits and more natural sediment regimes, human enjoyment of the watershed is boosted as well. Other benefits include allowing seasonal variability in water flow, and the removal of impediments to recreational boaters, all of which may result in a steady return of municipal funds through increased public recreation. The DEC's Hudson River Estuary Program has been actively identifying and mapping aquatic barriers over the past several years to determine the best ways to aid in ecological restoration. Through projects to identify biologically important barriers in the entire Estuary watershed and to survey culverts in focal watersheds, the Estuary Program is creating a list of locations where aquatic barrier restoration could help human communities and ecosystems.

The Hudson Data Jam Competition

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Alan Berkowitz
Cornelia Harris
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The Hudson River Valley is one of the most inspirational and influential regions in our country, and has been intensely studied by scientists for decades. Since many of the river's stories are not well known by the people who call the Hudson River Valley home, we have worked for nearly ten years to increase place-based knowledge of the Hudson River in local schools. Yet much of the science behind the stories remains hidden in plain sight. Students have difficulty reading and interpreting scientific data, which undermines their ability to understand

the complexity of this dynamic ecosystem and to critically examine relevant environmental issues.

That's why we've begun the Hudson Data Jam Competition, a fun challenge for middle school and high school students to apply scientific understanding and creatively tell a data-based story about the Hudson River watershed. Students use Hudson River watershed data to create a graphic, rap song, sculpture, puppet show, children's book, or anything else they can dream up. The Hudson Data Jam and the parallel initiative the Baltimore Data Jam have been modeled after successful Desert Data Jams held at the Asombro Institute for Science Education in Las Cruces, New Mexico.

Researchers from throughout the watershed are invited to help with online judging of student projects, highlight their own work at the 2014 Hudson Data Jam Awards Showcase, and to contribute their own data for next year's Hudson Data Jam Competition.

A spatial and temporal study of Didymo, a nuisance river algal species, in the eastern Catskills, New York

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David C. Richardson
SUNY New Paltz, Department of Biology

Didymosphenia geminata, commonly called didymo, is a stream algal species found at low densities in nutrient poor streams and rivers throughout the northern hemisphere. However, recently didymo has spread to rivers in the northeastern United States, including New York, and has begun forming large blooms covering vast portions of riverbeds. Rivers within the Hudson and Delaware watersheds are some of the streams with increasing didymo growth. We examined didymo mat accumulations to assess spatial and temporal changes in these blooms across the eastern Catskills region in Ulster and Sullivan Counties throughout the 2013 summer. We compared didymo blooms at sample sites along the Esopus, Rondout, and Neversink Creeks. We also compared didymo blooms from one site in Esopus Creek near Mt. Tremper to data from 2010-2012 from that same location. We also sampled all sites within one day and performed correlations between didymo metrics such as cell density, mat size, and chlorophyll *a*. The Rondout site closest to the reservoir had the highest blooms over the summer with constant cold-water flow supporting growth. In Esopus Creek, high discharge decreased didymo densities in both 2011 and when we measured in 2013. We found a negative correlation between biofilm ash free dry mass and the frequency of dividing cells, suggesting that didymo allocates energetic resources for either stalk growth or reproduction depending on nutrient concentrations. Our work has added to spatial and temporal datasets and may lead to possible suggestions for future didymo management and removal.

Reproductive, Genetic and Ecological Assessment of the Invasive Potential of Hardy Kiwi (*Actinidia arguta*) in the Northeast United States

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Danilo D. Fernando
SUNY Environmental Science and Forestry
Steve Young
New York Natural Heritage Program

Hardy kiwi (*Actinidia arguta*) is a woody vine that has become a valuable fruit crop over the past 25 years. It can withstand frost and so it can be successfully cultivated in the northeastern US. It is referred to as the "fruit of the future" because of its very promising economic importance and many health benefits. Recently, populations have been found to be overcrowding native flora in several areas in the northeast (Rockland, ME; Lenox, MA; Morristown, NJ; Lime Rock, CT, and Bedford, NY in the Hudson River watershed). These dense hardy kiwi populations indicate invasive tendencies. Therefore, there is an urgent need to address this issue, particularly since both policy makers and fruit growers are at a standstill. For this to be accomplished, information on the species' reproduction, genetics and ecology must first be established since essentially all published reports on these aspects are from the more common species such as *A. deliciosa*. The results of this study will help in our understanding of the ability and potential of hardy kiwi to establish new populations away from cultivation. The results will also provide the necessary data for decision makers and site managers to be able to confront theissue of invasiveness, as well as the development of strategies for its possible control or continued existence in the northeast. Our preliminary genetic analysis indicates that the populations in NY are not clonal but rather composed of genetically distinct individuals and the implications of this to invasiveness will be presented.

Demonstration Site Network of the Hudson River Sustainable Shorelines Project

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Christina Tobitsch
Brian Cooke
formerly Student Conservation Association & NYSDEC Hudson River NERR

Shorelines along the Hudson are being modified to protect against erosion and support development and waterfront revitalization. The methods used can affect how shorelines perform as habitats for fish and wildlife. To increase confidence that less traditional shoreline protection methods are suitable in the Hudson, we have gathered information about the

construction, cost and performance of several projects. We have composed case studies based on funding and design documents and interviews with designers and property owners. The case studies, posted online, provide a virtual tour of a network of six ecologically enhanced engineered shoreline sites over the 150-mile length of the Hudson Estuary. This network of sites demonstrates that if correctly designed, ecologically-engineered structures serve to prevent or reduce shore erosion while emulating the physical and biological conditions of naturally occurring, stable shorelines. The assessment process for selection of sites and details of three case studies will be presented.

Putting Natural Areas on the Map in Hudson Valley Municipalities

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Ingrid Haeckel
Karen Strong
NYSDEC Hudson River Estuary Program and Cornell University Department of Natural Resources

If asked to draw a map of municipal resources, a local leader might include roads, reservoirs, and other built systems; parks and farmland; and possibly the town's development centers. But elements of “green infrastructure” such as forests, streams, floodplains, and wetlands often are not considered in a town’s traditional view of its resources. And despite the essential ecosystem services they provide, these important natural areas are often overlooked during decisions about land use.

For over a decade, Cornell University and the Hudson River Estuary Program have been collaborating to shift this paradigm in the Hudson estuary watershed. Through partnership projects, the program has developed new data layers and conservation priorities to inform land-use planning in watershed municipalities. To make these data available and understandable to community leaders, outreach staff developed the “Habitat Summary” tool in 2005. Content has expanded in the last few years, and now integrates program data with science-based information from a variety of sources, in order to provide a comprehensive overview of a community’s natural areas. Habitat Summaries include maps, tables, and interpretation and discussion to assist municipalities with understanding their relationship to the estuary, and recognizing and valuing their important natural areas and habitats.

To date, Habitat Summaries have been delivered to 33 watershed communities and the program continues to receive requests from new municipalities. The summaries fill a gap in local knowledge of biological resources, while supporting the regional priorities of the Hudson River Estuary Action Agenda. Efforts have resulted in municipal plans and practices that will ultimately help to sustain the health and resiliency of the entire estuary ecosystem.

Inventory of Research Projects in the Hudson Mohawk Watershed

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Emma Bird
Evan Kamber
Alistair Hall
Vassar College

In collaboration with the Mighty Waters Initiative and the Environmental Consortium of Colleges and Universities we are compiling a database of research projects in the Hudson/Mohawk watershed. We have begun by collecting data from Poster Abstracts from the Vassar College Undergraduate Research Summer Institute, Vassar College Summer Ford Projects, Environmental Consortium annual conferences and Hudson River Environmental Society conferences. We are standardizing the information from these abstracts and consulting with the authors for information which is lacking in the abstracts. We have begun to prepare an interactive map which shows where in the watershed what kinds of research are being undertaken and by whom. Our aim is to help researchers, from K-12 through professional, discover what is being studied so as to enhance their ability to undertake new or collaborative research projects.

The distribution of sodium chloride in groundwater in Dutchess County

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Stuart Findlay
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Neil Curri
Sean Carroll
Cornell Cooperative Extension Dutchess County, Millbrook New York

Road salt is a potential threat to natural systems and human health. Salt spread on roads for ice and snow control can potentially accumulate in groundwater that is accessed by humans for drinking water. The behavior of salt in groundwater is largely unknown but is important to understand so that policy makers and the public can make informed decisions about placement, maintenance and testing of well water supplies. Likewise, an understanding of the dynamics of salt in groundwater can inform road maintenance departments about appropriate management practices, especially around water supplies. The goal of this project is to understand how salt is distributed in the groundwater tapped by wells in Dutchess County and what controls the distribution. Using GIS, we have analyzed salt concentrations relative to road distribution around wells, land use, geology, elevation and other geographical characteristics. Well data consist of analyses commissioned by the Dutchess County Health Department in 2008 from 125 wells throughout Dutchess County together with sodium and chloride data from about 900 wells by the

towns of East Fishkill, Fishkill and Wappingers Falls (2008-2013). All of the data are public data.

Monitoring the Hudson and Beyond with HRECOS: The Hudson River Environmental Conditions Observing System

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The Hudson River Environmental Conditions Observing System (HRECOS; "*re-cōs"*) is a network of environmental monitoring stations distributed throughout the Hudson River Watershed. Stations are equipped with sensors that continuously record a suite of water quality and weather parameters every 15 minutes. Each station is equipped with remote telemetry for transmitting all data in near-real-time to www.hrecos.org, where users can download data and plot graphs. The goals of HRECOS are to provide baseline monitoring data necessary for applied research and modeling, improve the capacity of research entities to understand the ecosystem and manage estuarine resources, provide policy makers and emergency managers with timely data products to guide decision making, support the use of real-time data in educational settings, and provide information for planning recreational activities (boating, kayaking, fishing, etc.). HRECOS is operated and funded by a consortium of government, research, and non-profit institutions. The system builds upon existing regional monitoring activities, including the NOAA National Estuarine Research Reserve System-Wide Monitoring Program (SWMP), NYSDEC's Rotating Integrated Basin Studies (RIBS), USGS monitoring efforts, and modeling and monitoring efforts in the NY-NJ Harbor by Stevens Institute of Technology. All data and products of HRECOS are freely available to the public at www.hrecos.org.

The effect of summer storms on the water quality of the SUNY New Paltz campus, a small watershed of the Wallkill River in the mid-Hudson valley.

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Alison Uhrlass
Alex LeTourneau
Emily Vail
KT Tobin
David Richardson
Department of Biology, State University of New York at New Paltz

Increased frequency and severity of storms due to climate change will directly affect biogeochemical cycles within aquatic ecosystems in the eastern US. Anthropogenically impacted watersheds, like the Saw Mill Brook watershed in the mid-Hudson valley, are highly

susceptible to large storms. Throughout the summer 2013, we instituted water quality and quantity monitoring to determine how an ecosystem comprised of a series of campus ponds responded to storm events. Our monitoring occurred at several temporal scales including traditional weekly and storm sampling for biological and chemical parameters. A buoy equipped with environmental sensors was installed in the largest pond to take high frequency measurements of dissolved oxygen, conductivity, and turbidity. Following storms, dilution in the pond caused a sharp decrease in conductivity and fecal coliform bacterial densities; erosion caused sediment to enter and, consequently, turbidity increased. Additionally, total phosphorus increased resulting in an algal bloom with highly variable dissolved oxygen fluctuations. This data will provide the baseline as SUNY New Paltz implements campus wide green infrastructure practices such as vegetated bioswales, rain gardens, and permeable pavement to alleviate these storm related water quality issues.

Restoration of Riparian Forests, Monitoring Trees Growing on the Tribs

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Beth Roessler
NYSDEC HudsonRiver Estuary Program's Trees for Tribs

The Hudson Estuary Trees for Tribs is a project of the New York State Department of Environmental Conservation's Hudson River Estuary Program that offers free trees and shrubs to landowners for the replanting of riparian buffers on tributaries in the Hudson River watershed. The Trees for Tribs project was created to protect water quality, fish and wildlife. Restoration of vegetation along these tributaries is also important for long term bank stability and the reduction of land loss through erosion. Human development has often cleared these areas to the detriment of the stream, banks, and the watershed as a whole. Replanting these areas is an attempt to restore the ecological services and the water quality of the Hudson River Estuary and its tributaries. Since its creation in 2007 the Hudson Estuary Trees for Tribs project has, with the help of over 5,000 volunteers, planted over 33,000 native trees and shrubs along more than 15 miles of tributaries. Staff from the Hudson Estuary Trees for Tribs program collect data on growth, survivability, and vigor from a subset of past plantings. This monitoring data is then used to evaluate the program, and to alter practices and planting protocols. This poster is a current summary of the Trees for Tribs project based on monitoring data, and the amount of land that has started the process of returning to forested riparian zones.

Hudson River Watershed Changes and Effects on Jamaica Bay, Hudson Estuary

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Sediment cores were extracted from Yellow Bar, Big Egg, JoCo, and Old Mill Creek Marshes, Jamaica Bay, NY. Pollen and macrofossil stratigraphy, loss-on-ignition (LOI), x-ray fluorescence (XRF) analysis, and C/N isotope analysis provide insight into the history of changes recorded in the estuary. Increases in ragweed (Ambrosia) and other light-loving weedy species (Chenopodiaceae) demonstrate the arrival of Europeans throughout the watershed as upland forests were cleared. Declines in oak (Quercus), pine (Pinus), hickory (Carya) and hemlock (Tsuga) remain as the percentages of these trees have not recovered to pre-European levels. In contrast, birch (Betula) does increase again due to its pioneering attributes. Phragmites grass on the landscape increases throughout the estuary. At three sites, large declines in inorganic matter take place at the time of European impact, possibly through human alteration of sediment discharge into the bay due to dams and millponds. At the same time, isotopic shifts in N-15 in the sediment demonstrate the effects of shifts in human and animal populations on nutrient loads within the marsh. As sea level rises and a warmer climate ensues, what can we expect of species changes in the marshes, and how will their valued services be impacted? How will nitrogen pollution change in the future? What can we do to ensure the health of these valuable resources, particularly where they are not protected?

Targeting and coordinating research to address two of the estuary's biggest challenges – water infrastructure and climate change

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The New York State Water Resources Institute at Cornell University, in partnership with the Hudson River Estuary Program of the New York State Department of Environmental Conservation, supports multidisciplinary teams of researchers in their study of two main themes: 1. Water resources infrastructure and, 2. Hudson Estuary resilience in the context of climate change and extreme weather. Issues of water resources infrastructure such as assessment,

management and planning are inherently complex and require multidisciplinary teamwork. Water infrastructure has implications for public health, ecological habitats and economic vitality. Lack of adequate funding and emerging environmental challenges necessitate immediate action to ensure that our water infrastructure continues to provide services to residents and the environment. With this in mind, WRI-supported research explores technical, social and financial aspects of this issue and seeks to provide strategic policy-oriented and management solutions. Estuary resilience work combines research, demonstration, and educational outreach projects to address the challenges of flooding, stream and watershed management, and climate change adaptation. Researchers and educators are delivering programs for municipal officials, landowners, highway personnel and contractors, as well as lesson material for K-12 classrooms. We provide an overview of the work being supported, as well as specific project descriptions, reports, publications, and fact sheets.

Climate Mode Influences on the Hudson River Estuary

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The impact of climate modes on the Hudson River estuary was investigated at an array of time scales. Hudson River streamflow and Hudson watershed-averaged precipitation and air temperature were linked with climate modes using a correlation analysis. It was shown that climate modes may impact the Hudson River estuary through changes in streamflow and air temperature. Low-frequency relationships with climate modes were analyzed using a wavelet coherence analysis. A 22-year periodicity in Hudson watershed-averaged precipitation and temperature was found to be consistent with changes in the Pacific Decadal Oscillation and the El-Niño-Southern Oscillation.

Zebra Mussel (*Dreissena polymorpha*) Effects on Diet and Condition of Early-Stage Fishes in the Hudson River

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Invasion of zebra mussel (*Dreissena polymorpha*) in the Hudson River in the early 1990s sharply reduced phytoplankton biomass and markedly altered estuarine energy flow. Previous

studies suggest that early-stage fishes of several species were negatively impacted by the invasion; one such species was the American Shad (*Alosa sapidissima*). The objective of the present study is to assess feeding success indicated by condition index of shad over multiple years, including pre and post mussel invasion years. We hypothesized reduced feeding success and thus lower bodily condition among shad in zebra mussel impacted years. Analysis to test this hypothesis is possible thanks to 21 years of early-stage fish samples collected as part of the Hudson River Utilities' long-term monitoring program. Results varied with developmental stage. We found that condition of post yolksac larvae varied among years, such that condition was relatively high in some pre-invasion years and relatively low in some post-invasion years. Condition of post-metamorphic young-of-year shad was notsignificantly affected by year. We are conducting analyses of gut fullness and diet composition to complement analyses of condition.

Environmental change in the Shawangunks: how acid rain and fish introduction have caused a trophic cascade in Lake Minnewaska

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Lake Minnewaska, located within Minnewaska State Park, has historically been a clear, acidic, and fishless lake. Recently, increases in pH and the introduction of a minnow species, *Notemigonus crysoleucas,* have rapidly changed the ecosystem. Lake Minnewaska serves as a study system to test the synergistic effects of internal and external drivers on environmental change in protected and managed ecosystems. We hypothesize that *N. crysoleucas* zooplantivory has allowed the phytoplankton population to boom, causing a trophic cascade and lowered water quality. We measured pH, chlorophyll *a,* total phosphorus (TP), secchi depth, conductivity, and dissolved oxygen in Lake Minnewaska from 2012-2013. The population of *N. cryoleucas* was estimated via a mark and recapture method. The plankton communities were also assessed using density counts and microscopic identification. Increases in chlorophyll *a* and TP, decreases of secchi depth, and anoxic conditions in the hypolimnion each summer and fall indicate that the lake has risen to mesotrophic levels. The average size and density (individuals/L) of the zooplankton indicate that *N. cryoleucas* were having a significant effect on the trophic levels of the lake. The decrease in zooplankton populations and increase in phytoplankton populations is causing a degradation of the water quality. This could ultimately impose a threat on rare aquatic life inside of a rare aquatic ecosystem, as Lake Minnewaska is home to a globally rare sphagnum moss and a behaviorally unique population of two-lined salamander. This research is a result of strong collaboration with stakeholders, governmental agencies, and non-profits.

Spatial Analysis of Boil Water Advisories Issued During an Extreme Weather Event in the Mohawk-Hudson Watershed

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Water infrastructure in the United States is aging and vulnerable to extreme weather. In August 2011, Tropical Storm Irene hit the eastern part of New York and surrounding states, causing great damage to public drinking water systems. Several water supply districts issued boil water advisories (BWAs) to their customers as a result of the storm. We conducted a spatial analysis of boil water advisories issued in the Mohawk-Hudson water districts after Tropical Storm Irene. The objective of the study was to identify major factors that led water supply systems to issue BWAs by assessing watershed characteristics, water supply system characteristics and treatment plant parameters of water districts. Thirty one of the 678 water districts in the Mohawk-Hudson watershed issued BWAs in the aftermath of TS Irene in August 2011. Our results suggest that the probability of a BWA being issued by a water supply district is enhanced by high precipitation during the storm, high density of septic systems, lack of recent maintenance and low population density. Interviews with water treatment plant operators suggested physical damage to water distribution systems were the main causes of boil water advisories during storms. BWAs result in additional costs to residents and communities, and the public compliance with the advisory instructions is low, so efforts must be made to minimize their occurrence. Prior investments in infrastructure management can proactively address municipal water supply and quality issues.