SCIENCECHRONICLES

April 2013

Image: Algae bloom as art. Credit: Mary Taffe via Flickr user 350.org and a Creative Commons licsense.

Special Issue: Water Quality

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Editor's Note

Nitrogen: We can't live without it, but we can't live with too much of it, either. It is both the source of humankind's rapid domination of planet Earth (through nitrogen-based fertilizers sparking the "green revolution" of agriculture) and one of the nine planetary tipping points that could usher in our demise.

This special issue of *Science Chronicles* looks at water quality and how nitrogen — from human waste, agriculture and air pollution — is destroying waterways. We focus on case studies from the East Coast of the United States, but that is not to ignore what is perhaps the most notorious example, the agricultural areas of the U.S. Midwest and their runoff into the Gulf of Mexico.

In this issue you'll find:

- A proposition: TNC's **coastal restoration efforts will fail** if we don't tackle water quality says Marci Bortman. Consider the problem of human waste on Long Island Sound.
- A primer: How the slow build-up of nitrogen globally is altering estuaries and how we can begin to approach the **problem of management**. Ivan Valiela looks at Waquoit Bay, Cape Cod.
- A solution: TNC is starting to think about water quality issues in some places. Mark Bryer presents some **innovative work** in the Chesapeake Bay.
- A step-back: Tim Tear says we can't ignore the contribution of **nitrogen from air pollution**. Embrace your inner chemist for a journey through the history and chemistry of nitrogen.
- A surprise: When it comes to human wastewater's **impacts on coral reefs**, nitrogen may not be the primary culprit says Steph Wear.

These articles ask what many around the Conservancy are asking: Shouldn't we make water quality a conservation priority? This issue is meant to be a conversation-starter. Where should the conversation go from here? We want to hear from you.

— **Darci Palmquist**, managing editor, *Science Chronicles*

The Mission(s) of *Science Chronicles*:

1. To bring you the latest and best thinking and debates in conservation and conservation science;
2. To keep you up to date on Conservancy science — announcements, publications, issues, arguments;
3. To have a bit of fun doing #1 and #2.

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Sally Palmer
Mind Your Bias: Shattering the Glass Ceiling and Cinderella's Slippers

By Sally Palmer, director of science, The Nature Conservancy in Tennessee

Image: Students at a microscope drawing workshop. Image credit: Flickr user scalefreenetwork via a Creative Commons license.

Early in my career with TNC, I attended a conference session called "Navigating your Career with The Nature Conservancy" (or something like that). There were about 50 of us in the room, and we were led through a presentation about how to grow in our careers — including overcoming challenges and institutional obstacles.

After the presentation, several people in the audience asked interesting questions about strategies to utilize when facing structural or managerial obstacles that one employee could not hope to address alone. The answer to the question was, "Well, you have to be the change." Now, the presenter was someone who had once worked for TNC, but left TNC, and the point of the session was to learn about navigating your career with TNC. I could feel the steam rising off my ears as I walked out the door.

Most media regarding women in the workplace leave me with steamy ears. They tend to emphasize individual choices women ought to make to improve their own lots and ignore very real cultural limitations and institutional practices that, over time, hold women back. Plus, they are almost always limited to the perspective of white women who are citizens of the U.S., with advanced educations and socioeconomic status. This happens to be my perspective, and I find it tiresome to listen to us argue with one another when many women in the world would love to have our "problems."

But is my attitude part of a problem?

I'm now asking myself this question because I was sucked in by the media blitz surrounding Sheryl Sandberg's new book, *Lean In*. My science brain was set off by the discussions of behavioral cues and how humans — men and women, as individuals and collectively — respond to them. Humans are nothing if not adaptable, and women can be particularly adept at adapting to real or perceived barriers. I bought the book.

Sandberg's primary concern is that even after 50 years of social, educational and professional progress women are still not equally represented in government and private sector executive leadership. She acknowledges that her emphasis is limited in scope largely to educated women in the developed world. But she argues that achieving true leadership equality should be a top priority, both to capitalize on all our human resources in advanced economies as well as to help women in the developing world.

Lean In explores, through the lens of Sandberg's life experiences, the gap between the major advances in women's educational attainment and the stagnant growth of women in leadership roles. She discusses the societal and institutional problems women face, but she also holds up the need for women to recognize how and when our adaptive strategies to social cues influence our behaviors, habits and life choices. All of which, little by little, create our own barriers to achievement.

Jennifer Raymond, neurobiologist, associate professor, and associate dean in the Office of Diversity and Leadership at Stanford University School of Medicine, agrees. In the recent *Nature* special issue on Women in Science, Raymond writes, "I have a bias against women in science. Please don't hold that against me." She goes on to discuss her results on the Implicit Association Test, which measures unconscious associations. Her results revealed that she associates men with "science and career" and women with "liberal arts and family." This is coming from a woman who is a leader in both academic science and on diversity issues and runs a lab at a major university.

Raymond points out that a growing body of literature has demonstrated the biases individuals hold regarding competency based on gender, race and all sorts of other attributes. She notes that despite the real evidence of gender bias and how it manifests in our actions and decisions, we tend to remain in a state of denial. Even her peers in academic science, those folks most attuned to detecting and attacking bias, are unaware of how gender bias may be affecting their decisions and are uncomfortable discussing it. Gender bias is not just a problem in scientific fields; people tend to rate women as less competent than men in leadership capacities.

"Based on the growing, cross-generational evidence on the topic, Raymond concludes that cultural transmission will ensure that unconscious gender bias will be with us for quite some time to come."

"Cultural transmission of bias" is powerful, notes Raymond. Her own young daughter, who has a scientist for a mother and is surrounded by female scientist role models, showed a bias against women in science when she took the Implicit Association Test. Based on the growing, cross-generational evidence on the topic, Raymond concludes that cultural transmission will ensure that unconscious gender bias will be with us for quite some time to come.

What is Raymond's prescription? Suppress the symptoms.

She defines unconscious biases as "mental habits that tend to dominate our gut reactions," and that "one can suppress undesirable mental habits such as gender bias through deliberate, conscious strategies." If we fail to act consciously and redirect these habits, Raymond points out, our brains will craft perfectly rational justifications for our behavior, even when bias is at the root. Social and psychological research tells us we must "retrain our brains."

Raymond identifies several useful ways to identify and suppress gender bias in professional settings. One of those ways is that women should overcome their own internalized gender bias. This internalization of bias is exactly what Sheryl Sandberg asks women to assess for themselves and take decisive action to address. We cannot ignore the subtlety of unconscious habits behind our individual behavior and expect to manifest changes in our circumstances. For example, women may be less likely to self-identify and compete for advanced job roles or assignments due to negative social cues that tell us competition is not expected from women or is even — gasp! — unattractive.

Not all women — or men — aspire to executive level positions. We make conscious decisions based on a myriad of values, including the choice to lead in other capacities. But women especially should be aware of the subtle ways our own bias may affect our decisions at crucial stages in our lives. Helen Shen, in her contribution to the same *Nature* special issue on Women in Science — "Mind the Gender Gap" — shows how the series of adaptive choices women make from the beginning of their educations through their professional training can undermine their capacity to reach leadership roles. Shen quotes Shirley Tilghman, president of Princeton University, regarding the need for multi-faceted solutions: "I don't think there's a single obstacle. I think there's a whole series of phenomena that add up."

"This internalization of bias is exactly what Sheryl Sandberg asks women to assess for themselves and take decisive action to address."

I recognized patterns in my own decision-making over the years similar to those identified in Shen's analysis. Those patterns are a little too close for comfort. For example, I made what I thought at the time were fairly explicit choices about graduate school and my professional trajectory. Looking back, I can see how those decisions were also influenced by some heavily implicit assumptions about whether or not I could excel in work settings and still thrive in other aspects of life that have great value to me. How might I be allowing internalized bias to affect me still today? Institutional and social support systems buttressed by sound governmental policies are absolutely critical to affect change and help women develop as leaders. But as Sandberg concludes, "Anyone lucky enough to have options should keep them open." SC

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Special Issue: Water Quality
The Elephant in the Room: Nitrogen Pollution

By Marci Bortman, director of conservation programs, The Nature Conservancy in Long Island

Image: Elephant in the room. Image credit: Flickr user retiredinwasaga via a Creative Commons license.

"How about we initiate a 'poop at work' campaign?"

My colleague Carl was kidding about how to improve water quality on Long Island, but his joke went right to the heart of the problem. Many Long Island residents commute to New York City for work every day. Carl's idea would solve the problem that we are grappling with on Long Island, as are many estuaries around the world: There is too much nitrogen in coastal waters and much of it is coming from inadequately treated human waste.

Social science research we carried out tells us that the average person living on Long Island cares deeply about clean water, whether it is to swim or fish in, or live near, or it is clean, freshwater we drink. Our social science research also tells us that the average Long Islander does not know:

- Where their drinking water comes from (answer: groundwater);
- Where their waste goes when they flush the toilet (answer: mostly septic systems, which are not designed to remove nitrogen, or sewage treatment plants in the more urbanized areas); and
- That nitrogen from human waste, fertilizer and burning fossil fuels are polluting Long Island bays and harbors.

Issues of water quality including nitrogen pollution are as old as people living in communities. While the Conservancy has engaged in important conservation like returning flow to dammed rivers, acquiring remaining wild lands, restoring and protecting riparian and coastal habitats and species like bivalve mollusks that provide water filtering ecosystem services, focusing on water quality improvements have been largely secondary to biodiversity goals.

But this is a misstep. If we can find ways to reduce nitrogen loading to freshwater and marine systems, many of the outcomes we care about — biodiversity, species protection, habitat health, and human well-being — can be addressed. For many of the places we work, if we do not tackle nitrogen and nutrient pollution, our work could fail.

That may sound extreme but take The Nature Conservancy's work on Long Island as an example. We have a long-standing marine program focused on estuarine restoration and coastal climate change resilience and adaptation. And by many counts we have been successful. We re-directed land acquisition to better protect estuaries. We acquired 13,500 acres of underwater land and transplanted over 7 million clams in over 100 sanctuaries. We supported science and policy to protect and restore seagrass, and we developed a network of monitoring sites to determine whether salt marshes are keeping pace with sea level rise.

Yet the ultimate success of all these projects hinges on nitrogen: Excessive nitrogen loading will impede our efforts over the long-term. Why? Because regardless of the millions of hard clams returned to Great South Bay, it suffers from harmful algal blooms hampering the growth and adequate recruitment of bivalves. Regardless of the availability of land to which salt marsh can migrate, excessive nitrogen loading is a key driver of marsh loss. Regardless of successful passage of legislation we crafted to protect seagrass, TNC-supported science has found that impacts from excessive nitrogen and warming sea temperatures together inhibit seagrass growth and expansion even when physical impacts are limited.

"If we can find ways to reduce nitrogen loading to freshwater and marine systems, many of the outcomes we care about —biodiversity, species protection, habitat health, and human well-being — can be addressed."

None of these findings are unique to Long Island. Howarth and Marino (2006) contend, "Today there is a scientific consensus, which has emerged from research at several spatial and temporal scales, that nitrogen represents the largest pollution problem in the nation's coastal waters and one of the greatest threats to the ecological functioning of these ecosystems."

There is also scientific consensus that harmful algal blooms (HABs) are fueled by nutrient pollution and improved management of inputs can lead to significant reductions. These HABs are expanding globally, are lasting longer, and have increasingly higher toxicity. There have been reported deaths from eating shellfish tainted from red tide HABs — not only are finfish and manatees dying, but people too are at risk from paralytic shellfish poisoning and other serious illnesses related to ingesting and sometimes even breathing in the toxins. Excessive nitrogen is also linked to acidification in freshwater and marine surface waters. In the groundwater — which is the sole source of drinking water on Long Island, and the primary source of freshwater to Long Island estuaries — nitrogen levels in some areas are the same as levels correlated with colon cancer, bladder cancer and non-Hodgkins lymphoma. Yet levels are below the federal safe drinking water standard.

I believe that to be truly successful in most of the estuaries in which the Conservancy works, we need to directly address nitrogen pollution and its underlying causes. This is arguably one of the biggest challenges The Nature Conservancy has ever faced on Long Island, largely because of the magnitude of the problem and the public expense of the solutions. For example, in Suffolk County (approximately half of the Long Island population), there are over 400,000 cesspools and septic systems in place — waste treatment technology that is not designed to reduce nitrogen from the waste stream. Rather, nitrogen steadily seeps into groundwater and surface water. A proposal being considered to expand and build new sewage treatment plants to serve only six small areas on Long Island is estimated to cost over $2 billion.

Like other coastal communities, Long Island is also facing the problem that as sea levels rise, there is a corresponding rise in the water table. Current estimates indicate that along the coast, over 15,000 septic systems are currently in areas where the water table is less than five feet deep. Future scenarios predict higher than average sea level rise. And, super storm Sandy, which may or may not be a harbinger of more frequent, extreme storms, resulted in the devastation of a sewage treatment plant that serves over half a million people on Long Island. For months over 50 million gallons per day of raw and partially treated sewage discharged into a bay already suffering from eutrophication.

The Conservancy's Southern New England/Long Island Whole System Program and Chesapeake Bay Program have identified reducing nitrogen to coastal ecosystems as a priority strategy. And our North America Integrated Ocean Management Plan recognizes that in some cases improving water quality is necessary for successful species and habitat restoration. One could argue that in most of the coastal areas where we work, there are likely ecological problems associated with excessive nitrogen. Problems with nutrient loading are not limited to these coastal locations; they present serious threats to freshwater and marine ecosystems throughout the world.

"In the groundwater — which is the sole source of drinking water on Long Island, and the primary source of freshwater to Long Island estuaries — nitrogen levels in some areas are the same as levels correlated with colon cancer, bladder cancer and non-Hodgkins lymphoma."

As we invest more in abating this threat, we need to become experts (or seek expertise) in the Clean Water Act and pursue ways to amend state and local laws to strengthen groundwater and surface water protection. We must investigate new and innovative technologies to better treat human waste. As importantly, we must find creative financing strategies to bring sufficient public funds to lower the cost of replacing antiquated waste treatment infrastructure with 21st century solutions. We must find ways to use social science to communicate the problem and sense of urgency, and understand costs and benefits to compel action by decision makers. All of these actions should be done with partners by building coalitions with other environmental non-governmental organizations, health advocates, businesses, and opinion leaders.

Across the globe, scientists are documenting widespread hypoxia and anoxia, habitat degradation, alteration of food-web structure, loss of biodiversity, and increased frequency, spatial extent, and duration of harmful algal blooms in coastal systems. Unlike Long Island, much of the nitrogen that causes these problems throughout the world is transported via rivers. In some areas like the Gulf of Mexico, 70% of nitrogen and other nutrients are from agricultural runoff into the Mississippi River. In other areas, such as the Massachusetts Islands, nitrogen sources impacting seagrass are primarily from atmospheric deposition. In the coastal waters of South America, Asia and Africa, urban wastewater is the primary source of nutrients.

The problem is varied and complex and the solutions are, too — while we are trying to think in terms of whole systems, the solutions will be at various levels including local. This is a call to arms for The Nature Conservancy to take up this pressing, global problem. **SC**

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"Across the globe, scientists are documenting widespread hypoxia and anoxia, habitat degradation, alteration of food-web structure, loss of biodiversity, and increased frequency, spatial extent, and duration of harmful algal blooms in coastal systems."

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"As we invest more in abating this threat, we need to become experts (or seek expertise) in the Clean Water Act and pursue ways to amend state and local laws to strengthen groundwater and surface water protection."

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Special Issue: Water Quality
Increased Nitrogen Loads: A Global-Scale Problem with Local Impacts on Estuaries

By Ivan Valiela, senior research scientist, The Ecosystems Center

Image: In 2008 a massive algal bloom in Qingdao Bay, China, threatened to derail an Olympic sailing event. Credit: Flickr user eutrophication&hypoxia via a Creative Commons license.

Press reports have widely covered the undeniable global changes such as climate warming, rise of sea level, increased intensity of storms, ocean acidification and more. These major perturbations of the world's surface indeed merit our concerted concerns, and demand social, political and management responses.

Less press and popular attention has been given to the slow, progressive, less rampant, increase of nutrients, particularly of nitrogen, in many environments. Human intervention, technological progress, and activities have, across decadal time scales, led to substantial changes in the global nitrogen cycle (Table 1).

The inputs of nitrogen from human causes — chemical fertilizers, agriculture, fossil fuels, and atmospheric nitrogen — are accelerating rapidly. We have shifted the net balance of biologically active nitrogen and now have to deal with environments significantly enriched in forms of nitrogen — ammonium, nitrate, dissolved organic nitrogen — that can prompt considerable change in natural food webs, increasing production of organic matter, and resulting in a complex set of changes, referred to as eutrophication.

Although eutrophication, with its gradual trajectories across decades, may be less apparent than floods and storms, it is taking place at global scales and makes for much environmental change.

Table 1. Approximate estimates of changes in nitrogen balance processes, in teragrams (or 10^9 kilograms) per year, for the world. Numbers condensed and somewhat altered from Galloway et al. (2004)

	Process	1860	1990s	2050
Inputs:	Lightning	5.4	5.4	5.4
	Natural nitrogen fixation	241	228	219
	Chemical fertilizers	0	100	165
	Agricultural nitrogen fixation	15	31.5	50
	Fossil fuel combustion	0.3	24.5	52.2
	Atmospheric deposition	31.6	103	195
	Total inputs:	293.3	492.4	686.6
Losses:	Denitrification	399	437	495
Net balance:		-105.7	55.7	191.6

A Case Study: Waquoit Bay in Cape Cod, Massachusetts

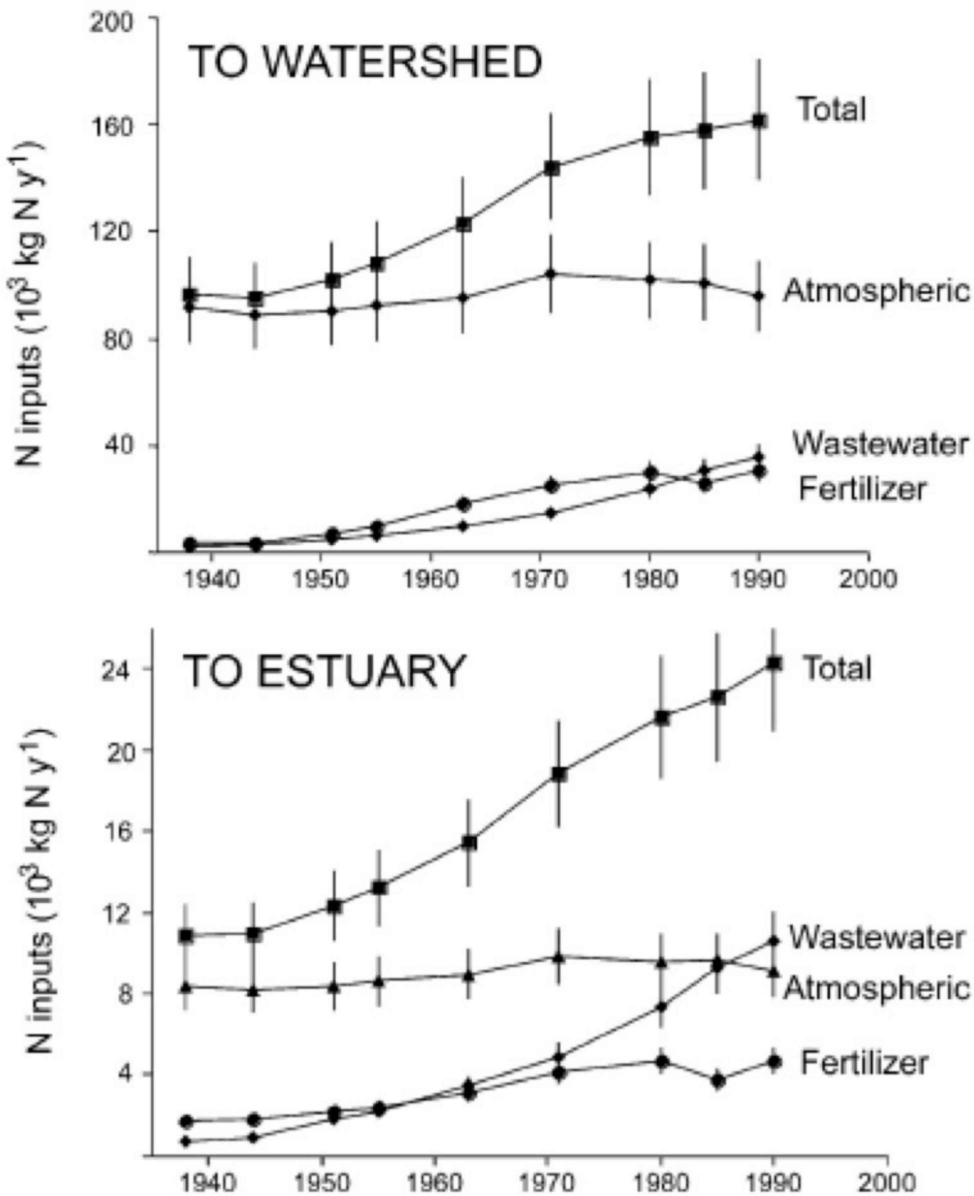
To assess local effects of increased supply of biologically available nitrogen, we can focus on Waquoit Bay in Cape Cod, a region in transition from rural to urbanized land covers. My colleagues and I have reconstructed decadal trajectory of nitrogen loads to the surface of the Waquoit Bay watershed, which increased by about 2x between the 1940s and the 1990s (Fig. 1). Through most of these decades, atmospheric deposition added the largest amount of nitrogen, with smaller increases by fertilizers and wastewater disposal (Fig. 1 top). Probably more relevant to the matter of eutrophication is the delivery of nitrogen to receiving estuarine waters (Fig. 1 bottom). The difference in magnitude in the "y" axes illustrates the impressive interception of nitrogen provided by watersheds. There is an order-of-magnitude retention of nitrogen within the watershed, a subsidy to water quality that has been under-appreciated.

"There is an order-of-magnitude retention of nitrogen within the watershed, a subsidy to water quality that has been under-appreciated."

Nonetheless, in spite of the remarkable interception within watersheds, enough nitrogen is discharged to the receiving estuary as to increase delivery of nitrogen to estuaries significantly, about 2x again, across these decades. Because nitrogen from wastewater is intercepted to a lesser degree than nitrogen from atmospheric or fertilizer sources, wastewater became more prominent across the decades, and the increase on total nitrogen inputs, in fact, parallels the increase in wastewater nitrogen (Fig. 1 bottom).

Note that the inputs discussed here differ from those in Table 1; what we refer to here as "wastewater" inputs is largely a re-conversion of the nitrogen added to soils as fertilizers and atmospheric deposition, for the Earth. To make the inputs more relevant to a local region, such as Waquoit Bay, and to identify nitrogen sources more specifically, we re-define the sources, one of which is the nitrogen that was eaten and excreted by people, and released to the watershed as wastewater.

Figure 1. Modeled historical nitrogen loads to the watershed (top) and the receiving Waquoit Bay estuarine system (bottom). The nitrogen loads are broken down into the contributions by wastewater, atmospheric deposition, and fertilizer use. Taken from Valiela and Bowen (2002).



"Because nitrogen from wastewater is intercepted to a lesser degree than nitrogen from atmospheric or fertilizer sources, wastewater became more prominent across the decades, and the increase on total nitrogen inputs, in fact, parallels the increase in wastewater nitrogen (Fig. 1 bottom)."

This data treatment makes it clear exactly what magnitudes of nitrogen inputs might be contributed by the three major sources — atmospheric deposition, fertilizer use and wastewater. This distinction is important because knowledge of their relative magnitude might suggest where to implement management of wastewater or fertilizer uses at a local scale. Atmospheric sources are harder to manage locally, as the airsheds contributing to atmospheric nitrogen load are much, much larger. Atmospheric loads might be managed locally only by conserving or adding green covers and wetlands.

So, we have a local region — the Waquoit Bay watershed on Cape Cod — that has increasingly received nitrogen inputs across several decades. What have been the consequences? Increased nitrogen inputs have been linked in Waquoit Bay to:

- increased nutrients in water,
- more phytoplankton,
- greatly increased macroalgal biomass,
- much reduced eelgrass cover,
- lower scallop harvests,
- more frequent low oxygen events,
- more fish kills,
- lower diversity of benthic species.

In short, Waquoit Bay is a much perturbed version of its earlier self, with significant impacts to the habitat and to people who use the Bay for seafood and recreation.

Note that Cape Cod is a rural to urban landscape; in places where agriculture is a far more dominant land use, the balance of the inputs swings far to the dominance of fertilizer uses. Such inputs have led to the well-reported anoxic areas on the Gulf of Mexico and Chesapeake Bay, waters receiving nitrogen inputs from agricultural-dominated watersheds. Globally, the problem is the same, with inputs depending on landscape use , but leading to degraded habitats, and a diversity of impacts on people living in these watersheds and coasts. The overall effect is a slow but significant degradation of estuaries around the world, particularly those draining more urbanized or agricultural regions.

"The overall effect is a slow but significant degradation of estuaries around the world, particularly those draining more urbanized or agricultural regions."

Taking Action

What can be done? Breaking down inputs as to wastewater, fertilizers and atmospheric deposition, as in Fig. 1, is a useful first step. Further modeling can provide ways to assess what management options might be brought to bear on the higher priority inputs. In the watershed of Great South Bay, NY, Kinney and Valiela (2011), with Nature Conservancy support, calculated nitrogen loads and provided detailed assessments of loads and prospects on a per sub-watershed basis. Similar estimates allowed Bowen and Valiela (2004) to further evaluate relative effectiveness and feasibility of ten different management initiatives and ranked the options for the Waquoit Bay region. For that particular watershed-estuary region, decreasing wastewater inputs, altering zoning ordinances, preservation of forest tracts, and protection of wetlands were the management options that seemed most likely to be effective.

Management aims at restoration or maintenance of water conditions, and this returns to the matter of global-driven change. It might not be sufficient to merely curtail nitrogen loads. Duarte et al. (2009) make the point that in four different watershed-ecosystems, reduction of nutrient inputs did not clearly revert the ecosystems to the desired earlier condition. Unlike Peter Pan's Neverland, where things never changed, in our coasts and estuaries shifting baselines of environmental conditions are altered by global change factors, and recovery trajectories were substantially and unpredictably affected. Increased temperatures, for example, re-shuffle and re-schedule biological responses and activities; increase sea level rise shifts water residence times and erosion rates.

Reducing nitrogen loads, nevertheless, does have important benefits. And Duarte et al. (2009) point out that the goal should not be to return ecosystems to a particular past state — which is unlikely in a world of shifting baselines — but rather to targets that ensure key ecosystem functions and ecosystem services.

Setting reliable targets for restoration efforts may therefore require action at local scales that is informed by local- as well as the global-scale variables: it may be insufficient to simply set management targets based on return to previous conditions. Understanding and managing our watersheds and estuaries has just become somewhat more challenging. **SC**

"Understanding and managing our watersheds and estuaries has just become somewhat more challenging."

Ivan Valiela is a Senior Research Scientist at The Ecosystems Center, MBL, Woods Hole. He has written over 300 papers about coastal ecosystems and is the author of "Marine Ecological Processes," "Doing Science," and "Global Coastal Change." He has worked in many temperate and tropical environments, and advised and consulted for many agencies in the U.S. and abroad.

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Special Issue: Water Quality
Improving Water Quality on the Chesapeake Bay: Yes, We Do That

By Mark Bryer, director of The Nature Conservancy's Chesapeake Bay Program

Image: Aerial view of the Chesapeake. Image credit: Alan Eckert.

North America's largest estuary isn't what it used to be. Sure, 400 hundred years after it was "discovered" by an explorer from England, it still produces 500 million pounds of seafood a year. It still has a coastline longer than the entire continental U.S. West Coast. Yet, with 17 million people living in its watershed and a 64,000-square mile watershed that has been transformed numerous times to accommodate industrial forestry, intensive agricultural production, cities and towns, and fossil energy development, it has real problems. Two-thirds of the Chesapeake's tidal waters don't have enough oxygen to support life stages for key species. Coastal fishing communities, which once attested to the Bay's reputation as "an immense protein factory," struggle to persist in the global marketplace given greatly reduced populations of fish and shellfish.

To understand what happened to the Chesapeake is to understand the impact of cumulative actions — how little by little, bit by bit, a large body of water is unable to provide what it once could to people. While direct habitat destruction of Bay habitats (like tidal wetlands) and unsustainable fishing practices (like mining oyster reefs) have much to do with the transformation over the last four centuries, there is no better touchstone for the Bay's decline than its water quality. The factors which contributed to the Chesapeake's incredible productivity — its shallowness, its reliance on inputs from streams and rivers, its narrow connection to the ocean — also made it remarkably susceptible to water quality degradation.

In essence, we have too much of a good thing in the Chesapeake. Excess nutrients cause algal blooms frequently in the Chesapeake, and some are harmful to humans (a study from 2000 to 2006 indicated that 31% of cyanobacterial blooms contained enough toxins to make swimming unsafe for children). These algal blooms — along with excess sediment — block sunlight and eventually create large areas of low or no oxygen, robbing the Bay of habitats that are crucial for blue crabs, oysters and other fisheries and those that depend on them. The problems are so well known that Hollywood is now making movies about water-borne mutant parasites in the Chesapeake. Seriously.

Broadly speaking, this excess pollution comes from three main sources: identifiable pipes (think sewage treatment plants and other industrial sources); runoff from the land (think a corn field or your lawn or street); and the air (think fossil fuel based power plants and cars). The largest source by far is polluted runoff from agricultural lands, and the only sector that is not shrinking is polluted runoff from urban/suburban lands. In fact, during the 1990s, suburban area growth led to a 41% increase in impervious surface in the Bay watershed, while population only grew 8%.

Progress has been made. During the past three decades, voluntary agreements on agricultural lands and major upgrades to wastewater treatment plants have helped reduce pollution entering the Chesapeake, achieving more than 51% of the needed improvements. Yet, with something as fundamental to estuarine health as water quality, it hasn't been enough. Many scientists believe these improvements, while crucial, haven't succeeded in lifting the Bay past a key ecological threshold — dead zones persist, beaches are still closed routinely, fisheries still suffer.

Enter the Clean Water Act. With numerous missed deadlines for pollution reduction, the U.S. EPA issued in 2010 its most complex and controversial Total Maximum Daily Load (TMDL) in the country's history. Basically a regulatory "pollution diet" for the Bay, the Chesapeake TMDL sets an amount — essentially a cap — for nitrogen, phosphorus and sediment flowing into the Bay. States with land draining to the Chesapeake have been given 15 years to reduce current pollution levels to that cap. To develop the cap, decades of data collection and tens of millions of dollars were invested in modeling and have resulted in what is likely the most sophisticated approach ever in the world to estimate pollution inputs and their impacts in a water body.

"Many scientists believe these improvements, while crucial, haven't succeeded in lifting the Bay past a key ecological threshold — dead zones persist, beaches are still closed routinely, fisheries still suffer."

Critically, this "cap setting" process began with a simple, yet fundamental question: How much pollution reduction is enough? Using biologically-based outcomes in the Bay — blue crab habitat, fish spawning requirements, etc. — scientists and policymakers developed acceptable and feasible (given 17 million people flushing toilets and driving cars) "loads" of pollution, and distributed them across the watershed states. It is an approach that many across the U.S. and worldwide are eyeing to replicate, and TNC is in a great position to help make that happen.

Even with this new regulatory mechanism and all of the great science in place, real challenges still make the possibility of reversing the Bay's poor water quality questionable. First and foremost is that control of major sources of pollution — runoff from agriculture and new urban development — is largely outside of the EPA's regulatory authority, and instead in the purview of state and local decision makers. Will a largely voluntary approach for controlling these sources achieve the scale needed? While there are good examples of small improvements (like fencing cattle out of streams or building rain gardens or green roofs), the last 30 years suggest a healthy dose of uncertainty in assessing whether we'll achieve system-wide, cumulative improvement.

So, this is where TNC is putting the bulk of our effort for the future: We're building on 50+ years of terrific land protection in this watershed — essentially protecting the "green" areas where people don't live — by increasing our focus on agriculture and development — the "brown" areas. These are the areas that were excluded in all our ecoregional analyses: little natural vegetation, poor stream health, etc. But if you're interested in improving water quality in the continent's largest estuary (and most other coastal areas), these are exactly the places you *have* to work. Of course, you can't lose the healthy places at the same time…so that means ensuring that "green" areas stay that way at the same time. No problem, right?

Can we make a contribution to large-scale pollution reduction in the agricultural sector, especially as it intensifies to meet increasing food demand? Working in partnership with many colleagues inside and outside the Conservancy and learning with other places like Long Island Sound, the Great Lakes, Upper Mississippi, and Puget Sound, we think we have a shot. Using field-scale science (like LIDAR modeling to pinpoint where to intercept pollution) in combination with regional and national policy incentives, we are working to squeeze every possible pound of pollution reduction per dollar spent, driving down costs and increasing outcomes. We are also using private funding to leverage public dollars to show the way, particularly when it comes to monitoring and creating a culture of "outcome-based" investments in non-point source pollution reduction.

"Each of these approaches holds promise, but we have a long way to go organizationally to build the capacity and expertise that can re-shape something (i.e., suburban growth) so fundamentally part of the 'American dream.'"

Can we avoid, minimize, and/or mitigate the pollution impacts of continued urban and suburban growth, especially with 3 million new watershed residents expected by 2030? We believe we can through innovative finance (like public-private partnerships that help generate the dramatically large sums needed to address storm-water pollution), smart science-based investments (that target where pollution reduction can be most effective), and nutrient trading (to drive down costs by allowing other sectors to meet some reduction requirements). Each of these approaches holds promise, but we have a long way to go organizationally to build the capacity and expertise that can re-shape something (i.e., suburban growth) so fundamentally part of the "American dream." And then there's the question of how climate change might alter temperatures, precipitation and storms, all of which influence how pollution impacts the Bay.

When it comes to improving water quality, we've gotten past the phase of "we don't do that." What we're facing now is "how do we do it at a scale that matters?" And while we don't have examples anywhere on the planet of an answer, at least there is some comfort in knowing that we have a lot of company with other whole system projects asking exactly the same question. **SC**

Special Issue: Water Quality
The Air-Water Connection and the Consequences of Putting Nature in a Bag

By Tim Tear, director of conservation science, The Nature Conservancy in New York and Africa

Image: Chimney smoke. Image credit: Flickr user guilherme cecilio via a Creative Commons license.

The articles in this issue of *Science Chronicles* argue that we must pay attention to water quality. They also raise an even larger issue about our role as conservationists in the Anthropocene. Water quality is inextricably linked to air quality, and together they pose vexing problems for society. To understand this problem and how we might be able to get ourselves out of it, we have to first step back and look at how we got into this mess in the first place.

History Matters. Chemistry Too.

Since 1960, the flow of available nitrogen has doubled, and the rate it is added to the environment continues to increase. This accumulation is altering the nitrogen cycle at local and global scales. In our lifetimes nitrogen has gone from being a limiting factor to being overabundant in some ecosystems, causing a host of problems, including:

- acidification of water and soils leading to decreased forest productivity and increased vulnerability to pests and pathogens;

- degraded air quality, in particular ground-level ozone that decreases agricultural productivity and increases asthma for people; and
- over-enrichment of soil and surface waters that lead to eutrophication in our bays and estuaries.

How did this happen?

To understand, try for a minute to embrace your inner chemist. In order for nitrogen to become available to living organisms, atmospheric nitrogen must be converted from its molecular form (N_2) as the most abundant element on the planet, to its reactive form (Nr), which is mostly a limiting factor. Atmospheric nitrogen is bonded or "fixed" to hydrogen or oxygen to form biologically available compounds, such as ammonium (NH_4^+) or nitrate (NO_3^-). In nature, this nitrogen fixation occurs via specialized organisms and bacteria, lightning and decomposition. That is how nature does it, and historically it didn't happen a lot.

A big breakthrough occurred in 1909 when chemists Fritz Haber and Carl Bosch figured out how to "fix" nitrogen from the air and turn it into a solid. What is now known as the Haber-Bosch process, this was the key to getting the nitrogen genie into a bottle. As James McWilliams (2013) described it, the combination of nitrogen and hydrogen ultimately produced nitric acid "which gives munitions an explosive lift." And humans used this great breakthrough to create bombs, "nitrogen bombs."

The next big breakthrough was to get nature's nitrogen into a bag. As Michael Pollan (2006) pointed out, after World War II when bomb production declined, a significant transition was made to using Nr to produce industrial fertilizer. Once nitrogen was easily captured in a bag as fertilizer, our world has never been the same. Massive production of industrial fertilizer gave way to the next bomb, the population bomb. Increased agricultural productivity from industrial fertilizer use is a major factor that enabled the global human population to more than triple since the Haber-Bosch process was discovered.

"Once nitrogen was easily captured in a bag as fertilizer, our world has never been the same. Massive production of industrial fertilizer gave way to the next bomb, the population bomb."

Nitrogen from Above

People are responsible for doubling the rate of Nr entering the nitrogen cycle over the last half century, primarily through the production of synthetic nitrogen fertilizer, expansion of land under nitrogen-fixing crops, and fossil fuel combustion. The consumption of nitrogen-containing foods by humans and livestock also leads to the production of nitrogen-rich waste, which finds its way into rivers, lakes and estuaries.

Fertilizer and runoff from agriculture generally get all the attention. But how big a problem is nitrogen from air pollution? It contributes to acid rain (remember that problem?) and ground-level ozone, which affects human health. When it comes to waterways, a recent U.S. General Accounting Office report found that across the continental U.S., air pollution is a factor in 20% of impaired rivers and streams, 37% of impaired lakes and reservoirs, and 36% of impaired bays and estuaries.

If we narrow the air pollution question to nitrogen, and narrow our scope to only the watersheds that supply freshwater to the coastlines of the Northeastern U.S., recent research shows that all of them exceed "critical loads" (i.e., the amount of nitrogen above which sensitive ecosystems are harmed) for multiple ecosystem indicators. Driscoll et al. (2003) showed that for all eight watersheds they modeled in the Northeast U.S., nitrogen inputs from air pollution ranked second behind the N imported for food, ranging from 11- 36% of the total. And if you wonder if it matters to people, air pollution contributed more than a third of total anthropogenic nitrogen inputs to the highly populated watersheds of Long Island Sound, Casco Bay, and Great Bay.

Yet after all this research, the full impact of air pollution on water quality is not clear, primarily due to the fact that in the U.S., many states either don't assess this problem and/or aren't required to document sources of pollution. But if the Great Lakes are any barometer, all of the 53,000 square miles that fail to meet Clean Water Act standards can be linked, at least partially, to air pollution.

The Search for Solutions

As a society, we have known about and acted on this problem already. In fact, air pollution concerns in the U.S. gave rise to one of the most powerful and effective environmental laws the world has ever seen, the Clean Air Act, followed closely by the Clean Water Act. This year marks the 50^{th} anniversary of the first Clean Air Act, and since its inception we have learned a lot. The more we learn, the more we realize the impacts of air pollution to people and nature are far greater than we first suspected.

So what can be done? We must find ways to reduce the rate of increase in Nr. And there's evidence that we know how to do this. Consider the following summary information from the 2010 multi-agency Report to Congress on progress from the Acid Rain Program (NAPAP 2012):

- In 2009, nitrogen oxide emissions in the U.S. were 67% lower than 1995 emissions, substantially exceeding the emissions goal set in 1990;
- Nitrogen (measured as average annual wet inorganic nitrogen deposition) in 2007–2009 was 16% lower in the Midwest and 27% lower in the eastern U.S. than in 1989–1991.

"Yet after all this research, the full impact of air pollution on water quality is not clear, primarily due to the fact that in the U.S., many states either don't assess this problem and/or aren't required to document sources of pollution."

This data show that we can reduce nitrogen from air pollution if we want to. But it is hard and expensive. These reductions have been achieved largely through technological advances. Our renewed interest in the U.S. on improving air quality to reduce greenhouse gasses presents a new opportunity to continue the reduction of other associated air pollutants like nitrogen, sulfur and mercury. But without a focus on the response of ecosystems to new regulations, we will not know if these regulations achieve the net benefits for society that are needed.

Conservation in the Anthropocene

There is a lot of discussion about the resilience of nature in the new epoch of the Anthropocene. But critical to the concept of resilience is the ability to bounce back. Ecosystems need a break if we want them to bounce back. Accepting high nitrogen loads as the new Anthropogenic normal is a cop out and could result in worse consequences in the future.

To solve these challenges will require societal agreement that these are problems worth solving. Consider this: The human health benefits of improved air quality from the Acid Rain Program alone were estimated at $170-$430 billion in 2010. That's arguably worth it.

Sustained support for critical federal and state long-term monitoring programs of air pollution becomes even more important as we search to better understand the true impacts of climate change. Yet these programs continue to be cut. More research is needed to provide the tools to make better decisions about air pollution regulations, such as the continual improvement of critical loads. Yet these efforts are at risk. Even our federal agencies — like the EPA, who were empowered half a century ago to protect the air and water essential for all life — are severely challenged to carry out what were clearly visionary environmental acts.

The Conservancy has a role to play — to be the voice of why such programs matter — to protect the air and water and land upon which all life depends. **SC**

"Consider this: the human health benefits of improved air quality from the Acid Rain Program alone were estimated at $170-$430 billion in 2010. That's arguably worth it."

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Special Issue: Water Quality
Flushing Out the Truth About Sewage and Coral Reefs

By Stephanie Wear, director of coral reef conservation, The Nature Conservancy's Global Marine Program

Image: Underwater toilet. Image credit: Flickr user Abizem via a Creative Commons license.

I never expected to be so intrigued and excited about poop, until a paper in *PloS ONE* came out in 2011 that demonstrated that a common human pathogen found in human wastewater, *Serratia marcescens* strain PDR60, caused white pox disease in elkhorn coral (*Acropora palmata*), the foundation species in Caribbean coral reefs.

Caribbean reefs have been plagued by disease in recent years and figuring out the source of the pathogens has been a challenge. Human sewage has long been a suspect, but the science behind this suspicion was always tenuous. I think most people would assume that exposing reefs to partially treated or untreated sewage couldn't be a good thing, but there were no clear data that made the connection of human sewage to the degradation of corals so clearly until this paper.

Unfortunately, there is plenty of untreated sewage making its way into tropical seas. In the Caribbean, most sewage isn't actually treated, rather it is put into containers that sit in the ground — the ground being comprised of porous calcium carbonate rock (limestone) that is characteristically leaky. In many places in the Pacific, the ocean IS the toilet. Human fecal contamination in near-shore and off-shore coral reefs has been well documented and has also been linked to causing human disease. We knew that humans were getting sick from their own waste, but what is so remarkable about this suite of disease-host interactions is that not only were vertebrates (us) transferring their disease to invertebrates (coral), but that this transmission took place across distinct realms, from the terrestrial to the marine — crazy stuff!

The offender wasn't the nutrients in the sewage as some have argued, in places like the Florida Keys, but the human pathogens in that sewage. To give you a little background perspective on these ideas, there have been assertions by some scientists that an increase in nutrients in coral reef systems (which by definition are nutrient poor) has been a key driver in the conversion of coral reefs to algal reefs (especially in the Caribbean). However, the experimental science has shown us that in most cases the primary driving factor in the coral vs. algal dominance situation is the number and type of herbivores present. Herbivores play an important role in suppressing algal growth and are thus allies of corals when it comes to the battle for space with algae. This idea that healthy grazer populations are the key for sustaining healthy coral reefs has confused and distracted many whose intuition and observations tell them that runoff from land is a primary threat facing sensitive reef habitats.

The linkage between human sewage and coral disease helps to validate such intuitions and better clarify the contribution that terrestrial activities make in coral reef degradation. But it doesn't stop there — there is evidence that nutrient additions (from things like agricultural runoff) may facilitate coral disease and coral predator outbreaks (such as crown of thorns starfish on the Great Barrier Reef). So nitrogen is likely to have an effect, but perhaps not the one originally thought. One can see why the situation can be confusing and identifying priorities for threat abatement can be a challenge.

The 2011 paper gives us a better understanding of the potential for human sewage to wreak havoc on a reef and the research continues to better understand the linkage. The papers are trickling in and I suspect the relationship will become pretty solid and well accepted over time.

"What happens if we invest in solving this problem and then we learn that it isn't such a big deal for reef health?"

The question for me right now is: When do we do something about it? In a recent conversation with a well-respected academic scientist, who believes that sewage is a problem for reef health, I was cautioned to not jump the gun and go out and start a crusade against poop. He argued that we needed more science. But isn't that often the mantra of scientists?

What happens if we invest in solving this problem and then we learn that it isn't such a big deal for reef health? (Warning: This is where we get into some mission-drift territory.) I would argue that we have still done some serious good for the communities we focus on because sewage treatment and good sanitation systems are good for everyone. The worst-case scenario is that we help address a public health problem (i.e., reducing exposure to fecal pathogens that cause life-threatening diseases). That sounds like a reasonable gamble to me. The best-case scenario is that we solve a problem for reef health and public health.

What bothers me about the environmental movement is we have failed (or perhaps never really tried) to connect environmental health to public health — when the two are intimately intertwined. Giving this sewage problem some attention has become more intriguing to me of late — sewage is something we can actually do something about. We know how to manage it, treat it, and even turn it into useful things — yet wastewater seems to be an afterthought when it comes to reef conservation strategies. Working side-by-side with municipal planners and public health organizations to elevate sewage treatment and implementation of sanitation systems as a local or national priority could lead to some very productive partnerships and help us each achieve our respective goals (i.e., public health and coral reef health).

So many problems in marine conservation are so big that people can't figure out how to possibly solve them — the systems are so complex, the contributing factors are diverse. Figuring out that point of influence in which we can change the impacts is extremely challenging and sometimes would take superhuman effort to make happen. So what we do is focus on what we CAN do — well, most of the time. There are definitely things that have a shut-off valve — things that I don't think we are paying enough attention to. And I would argue that the problem of untreated sewage literally has a shut-off valve and is something worth exploring as a focal strategy in our coral reef conservation.

What do you think? **SC**

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"The best-case scenario is that we solve a problem for reef health and public health."

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Peter Kareiva
Vanishing Soils: The World's Dirty Secret

By Peter Kareiva, chief scientist, The Nature Conservancy

Image: Permaculture farm. Credit: Flickr user e pants via a Creative Commons license.

We talk a lot about the biodiversity crisis, the energy crisis, the water crisis, the climate crisis, the food crisis, deforestation and so on. But what about the soil crisis?

Today, around the world the mean rate of soil loss is roughly ten times the rate at which soil is replenished. In some countries such as China, the rate of soil loss can be as high as 50 times greater than replenishment. It is hard to imagine a better indicator of our failure to achieve sustainability. What could be more fundamental than the soil that grows the plants from which 99% of humankind's calorie intake is derived? From a biodiversity and conservation perspective, this soil loss also impinges on many of our more traditional concerns. It represents nutrient and sediment flow into our rivers and estuaries, to the detriment of fisheries.

Conservation has many narratives of profligate humanity soiling their nest and creating some sort of eco-catastrophe. Often those narratives are overstated and excessive. But in the case of soil, the doom-and-gloom has some merit. Some historians have examined the arc of human history as a series of civilizations bankrupting their soils. And it is not just data and science. If you have gardened and felt the comfort and seduction of warm, fertile soil in your hands, you know how primal is the link between people and soil. When someone back in the recesses of time coined the term "Mother Earth," I have to believe she or he was thinking of warm soil.

The soil crisis also intersects our attention to the hundreds, maybe thousands, of newly emerging cities. In much of the world we have built our cities on the most fertile soils, thereby squandering a valuable resource when buildings and settlements could be much more wisely placed on unproductive soils. It is now routine to inform plans for infrastructure or development with maps of where biodiversity is concentrated and especially valuable. We need to adopt a similar approach for our world's soils.

Unless we fundamentally change our agriculture practices, current rates of soil loss and erosion will pose severe challenges for agricultural productivity, as well as the need for massive clearing of lands as yet undisturbed. The United Nations Environment Programme (UNEP), the Food and Agriculture Organization (FAO), and the World Bank have all recognized how crucial soil is to their mission of sustainable development. And in 2009, the globalsoilmap.net project was initiated with support from the Bill and Melinda Gates Foundation.

But we still lack global- and national-level soil monitoring. We lack clear site-specific indicators that can give us an early warning signal that we might be on the brink of irreversible soil loss. And we have not developed policy incentives to reward land owners, farmers or local communities who treat their soils well.

The loss of any species is tragic and sad. But the loss of one's fertile soil is catastrophic. The conservation community, the environmental community, the agricultural community, and the development community need to unite around the issue of protecting and restoring our soils. SC

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"Unless we fundamentally change our agriculture practices, current rates of soil loss and erosion will pose severe challenges for agricultural productivity, as well as the need for massive clearing of lands as yet undisturbed."

15 Seconds of Fame
Tomás Walschburger

He's helped create new indigenous lands and parks, protect habitat for the giant river turtle, and recently change the entire compensation scheme for development projects in Colombia. Meet the Conservancy's science coordinator in the Northern Tropical Andes.

Image: Science coordinator Tomas Walschburger.

FARMER TOM: I have a small farm where we grow organic coffee, bananas, oranges, and raise cattle with innovative silvopastoral systems. It's more of a hobby. Our farm is about 2 hours from Bogota, we go on the weekends. My wife and I take care of it, with our 3 children. We built a natural swimming pool — no chlorine — which is not so easy to maintain in tropical conditions.

There are a lot of challenges to farming, and it takes a lot of time. I thought it would be relatively easy, but it's not so easy to make a small farm sustainable economically. It's difficult to survive as a small farmer.

ROOTS: I was born and raised in Colombia, but my parents are German. I'm something of a hybrid, but I feel more Colombian than German. My wife is Colombian, she's always saying, "Why don't you speak German to the children more?" My eldest son is in Germany now, learning the language.

DANGEROUS TIMES: I think we are in a strange moment in Colombia. We have always been a country with lots of struggles. Only in the last few years have we been in a recovery, with economic growth. Development is coming in — mining for oil and gas, and agro-industry such as palm oil, soya and rice.

This is a country with a lot of poverty still. We have to give people new opportunities, and there's so much money coming in for these industries. But we conservationists are not organized enough yet. I think the environmental sector is not really prepared to achieve a more balanced development process.

For example, the Orinoco/Llanos Grasslands — they are the most extensive tropical grasslands in the world. But the Colombian government says it's not an economically productive area, we must develop it. There's lots of oil and gas in the Llanos, and palm is planted mostly on grasslands. We are trying to see how we can influence these sectors toward conservation planning.

PROUDEST MOMENT: We changed the country's whole compensation scheme for development sectors asking for environmental licenses. Starting in January 2013, if you impact any ecosystem — like forests, grasslands, desert, etc. — you have to compensate in the same ecosystem with multiplier factors, varying from 2 to 10, which are determined according to the rarity, remanence, representation and rate of loss of these ecosystems. Formerly you just paid for impacts by planting trees anywhere. They're trying now to replicate this methodology in Peru and in Chile. It's very good because new development plans need environmental licenses, so we can influence that.

The licensing system covers mining, oil and gas and big infrastructure developments but not agriculture. Of course agriculture impacts huge land areas, so we need to get to that, too.

Now we will include in Colombia all terrestrial, freshwater, marine and environmental services impacts in the licensing process. If we could do this, we would be the first country in the world to achieve a fully integrated compensation system.

SPARE CHANGE: When I joined TNC our private fundraising depended on U.S. donors. Now we are supposed to be more independent — we have to raise our own money. The 'go-as-you-pay' model. I think it's been successful, but I invest a lot of time in fundraising, in writing proposals.

Fundraising locally is not easy. Philanthropy is a U.S. mentality. In our country, people give mostly for social causes. We're trying to survive in a new scheme. So you have to be opportunistic. But then are you really doing the conservation work you think is best? So you try not to be too opportunistic, to maintain a balance.

READING: I'm reading *The Greatest Show on Earth: the Evidence for Evolution* by Richard Dawkins. It's great, discusses creationism and evolution. Dawkins thinks it's incredible that people still believe in creation, with all the evidence there is for evolution. He's so Darwinist. A lot of people don't like him, but I do. I haven't finished it yet. We get so busy, I only read on vacation. **SC**

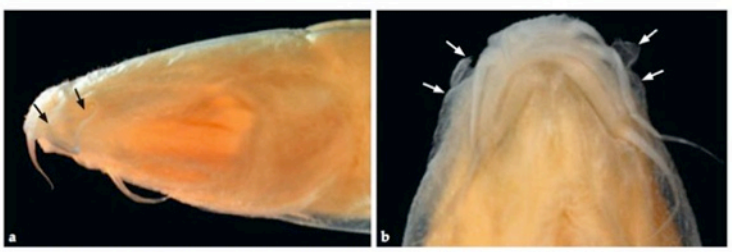
Interview by Darci Palmquist. Know someone we should feature in this column? Please email her with comments or suggestions.

Blog Reel

Voices from the Conservancy's science blog, *Cool Green Science*. Interested in contributing? Contact Matt Miller.

"Even fisheries managers in the early part of the 20th century wanted to eliminate alligator gar. They encouraged people to net them, shoot them, dynamite them. Gar died by the thousands…Today, conservationists, anglers and naturalists have found a new and growing appreciation for the fish: a gar renaissance, if you will." — **Matt Miller** in *Big Fish: Return of the Alligator Gar*

Schistura mobbsi, MHNG 2732.044, holotype, 31.3 mm SL; Vietnam: inside Phuong Hoang cave.



Schistura mobbsi, MHNG 2732.044, holotype, 31.3 mm SL; **a**, lateral view of head; **b**, ventral view of mouth. Arrows indicate anterior and posterior nostrils. Note: retouched to enhance outline of nostrils and lips.

Image: New cave fish, *Schistura mobbsi*

"Deep inside a remote cave in northern Vietnam, Craig Leisher aimed his headlamp at the water. Several small, strange-looking fish flashed by. He readied his butterfly net and quickly tried to scoop one up but missed. He tried again." — **Darci Palmquist** in *Discovery: New Cave Fish Species Sees 'Light of Day'*

"Most of the threats, and of the rich wealth of benefits we take from the ocean, are found concentrated close to people — we are the users, but we are also the polluters. So to look after the ocean we can't just look out beyond the horizon." — **Mark Spalding** in *Marine Protected Areas: Tokens or Treasures?*

"These desert denizens provide us with valuable insight into biological and physical adaptations that allow for survival on a hotter, drier planet that is subject to extreme events." — **Sophie Parker** in *Keep It Cool: What Desert Plants Can Teach Us About Climate Change*

"If a community protects a portion of its fishing grounds, will it actually benefit them? Or will the young fish produced in protected areas just move hundreds of miles away and benefit communities that played no role in protecting the resource?" — **Matt Miller** in *Marine Fisheries: Does Local Protection Mean Local Benefits*

Science Short
Why Climate Change Denial May Not Be As Common As You Think

Leviston, Z., Walker, I., & Morwinski, S. 2012. Your opinion on climate change might not be as common as you think. *Nature Climate Change* doi:10.1038/ nclimate1743

Scientists are such bad communicators, which is why the majority of the public doesn't believe in climate change despite scientific consensus.

Does this drum beat sound familiar? I can almost hear science communicators Randy Olson and Nancy Baron whispering it in my ear.

Well, Zoe Leviston of Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and other researchers offer at least some relief. In work published recently in *Nature Climate Change*, Leviston and her coauthors report evidence of a strong "false consensus effect" around climate change belief in Australia.

Essentially, people who believed that climate change was "not happening" grossly overestimated how prevalent that same opinion was in society, whereas those who did believe in climate change (the vast majority) underestimated how common their views were. Just 7.2% of the roughly 10,000 people surveyed rejected the occurrence of climate change, but on average, these same people believed that over 42% of the population held the same view as them.

The explanation for belief in the commonness of climate rejection predictably includes media bias in coverage of community attitudes. Believing in climate change certainly doesn't imply that someone would choose action if it requires making trade-offs, but it' s certainly a better base to work from then denial.

If this study suggests our communication around climate change might not be as bad as we think, it also highlights a key piece of communication we're missing — that most people are in our camp! **SC**

— **Eddie Game,** conservation planning specialist, The Nature Conservancy

Announcements

Seeking Examples of Conservation Conflicts for New Book

Do you have an example from TNC's recent work (last 15 years) where there was a potential or actual conflict over conservation of a natural area that TNC worked to resolve or at least mitigate? Your examples are needed for a new book about approaches, theory and "big picture" issues with respect to conservation conflicts. The book, Conservation Conflicts, will be published by Cambridge University Press. The editors are particularly interested in conflicts over natural areas from South/Latin America and Asia; however, examples of conflicts from other locations are welcome. If you have a suggestion, please email Dr. Rocky Gutiérrez, Gordon Gullion Endowed Chair in the Department of Fisheries, Wildlife, and Conservation Biology at the University of Minnesota. SC

Prizes for Your Innovative Green Infrastructure Ideas

Calling on all ecologists and biologists to put your engineer hats on and think creatively!

Please send your innovative ideas for "green infrastructure" — broadly defined as how nature or natural systems can play a role that usually would require an engineered solution.

Think outside the box. These could be ideas you've heard about, implemented, or just think might be possible. Feel free to draw on news items, papers, or just your knowledge of ecological systems.

Two randomly-selected entrants will receive free registration to the All-Science conference in December 2013.

We will share the compiled list in a future issue of *Science Chronicles*. This is related to work we are doing in the TNC-Dow Collaboration, where we will be further investigating a short list for feasibility of implementation by industry.

Please send your responses to Jen Molnar. **SC**

Your 250-Word Book Reviews Needed

Read any good books lately? Send in a 250-word review and we'll publish it in our upcoming summer reading issue. Any genre – fiction, non-fiction, textbook, children's literature, self-help, etc. If you enjoyed it, someone else might, too. Submit your review by May 15 to Darci Palmquist. (Please also give me a heads-up of what you'd like to review before that, so I can make sure there aren't any duplicates.) **SC**

April 21 at 2PM ET: North America Region Science Spotlight Webinar

The North America Region is hosting a webinar series to highlight some of the most exciting new TNC science happening in the U.S., Canada and Caribbean. In the wake of Hurricane Sandy, the April 21 webinar will focus on science in support of building Coastal Resilience. Get the call-in info here.

Know of science projects going on in our region that your colleagues should hear about? Please send your suggestions to Brad McRae and learn more about upcoming webinars. **SC**

December 9-13, 2013: TNC All-Science Meeting

The Hayes Mansion in sunny San Jose, CA, will host this powerhouse gathering of Conservancy scientists, staff and external experts from all over the world. Agenda details will follow in the coming months — expect diverse sessions on research, strategies, tools, techniques and much more. If you have questions, please contact Lynne Eder, director of operations for Central Science. **SC**

New Conservancy Publications

Conservancy-affiliated authors highlighted in bold.

Please send new citations and the PDF (when possible) to: pkareiva@tnc.org and rlalasz@tnc.org. Please include "Chronicles Citation" in your subject line so we don't miss it.

Some references also contain a link to the paper's abstract and/or a downloadable PDF of the paper. When open source or permitted by journal publisher, these PDFs are being stored on the Conservation Gateway, which also is keeping a running list of Conservancy authored science publications since 2009.

Ahlering, M.A., J.E. Maldonado, R.C. Fleischer, D. Western and L.S. Eggert. 2012. Fine-scale group structure and demography of African savanna elephants recolonizing lands outside protected areas. *Diversity and Distributions* 18:952-961.

Ahlering, M.A., L.S. Eggert, D. Western, A. Estes, L. Munishi, R.C. Fleischer, M. Roberts and J.E. Maldonado. 2012. Identifying source populations and genetic structure for savannah elephants in human-dominated landscapes and protected areas in the Kenya-Tanzania borderlands. *PLOS ONE* 7:e52288.

Ahlering, M.A., J.E. Maldonado, L.S. Eggert, R.C. Fleischer, D. Western and J.L. Brown. In press. Conservation outside of protected areas and the effect of human-dominated landscapes on stress hormones in savannah elephants. *Conservation Biology*.

Bearer, S., E. Nicholas, **T. Gagnolet**, **M. DePhilip**, **T. Moberg** and **N. Johnson**. 2012. Evaluating the scientific support of conservation best management practices for shale gas extraction in the Appalachian Basin. *Environmental Practice* 14(4):308-319. http://dx.doi.org/10.1017/S1466046612000385

Collie, J., V. Adamowicz, **M.W. Beck**, B. Craig, T. Essington, D. Fluharty, J. Rice and J. Sanchirico. 2013. Marine spatial planning in practice. *Estuarine, Coastal and Shelf Science*.

Halpern, B., C.J. Klein, C.J. Brown, M. Beger, H.S. Grantham, **S. Mangubhai**, **M. Ruckelshaus**, V.J. Tulloch, M. Watts, C. White and H.P. Possingham. 2013. Achieving the triple bottom line in the face of inherent trade-offs among social equity, economic return, and conservation. *Proceedings of the National Academy of Sciences* doi: 10.1073/pnas.1217689110.

Kottelat, M., and **C. Leisher.** 2012. Fishes from Phuong Hoang cave, northern Vietnam, with description of a new species of loach (Teleostei: Nemacheilidae). *Ichthyological Exploration of Freshwaters*, *23*(3), 237.

Leisher, C., L.H. Samberg, P. Van Buekering, and **Sanjayan, M**. 2013. Focal areas for measuring the human well-being impacts of a conservation initiative." *Sustainability* 5, no. 3: 997-1010. http://www.mdpi.com/2071-1050/5/3/997