

SPRING/SUMMER 2018

# ReVista

HARVARD REVIEW OF LATIN AMERICA

**CLIMATE CHANGE**



## Chocolate, Parrots and Melting Snowmen

My colleague burst into my office, declaring, "Do you know climate change is going to wipe out chocolate?" Somewhere between joking and broken-hearted, she added, "We better stock up."

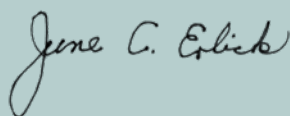
A few minutes later, being the excellent researcher she is, my colleague—who asked to be called "Anastasia" because she didn't want to reveal her chocolate addiction in public—sent me an e-mail with many sources. One of the headlines read, "Chocolate to Go Extinct in Forty Years" (*Business Insider*, Dec. 31, 2017). The article warned that cacao plants might die out because of rising temperatures and lessening humidity around the equator. In an attempt to save chocolate, scientists at the University of California are teaming with candy industry giant Mars to change the genes of the plant, the article noted. The scientists observed in a later statement that they were working on making cacao more disease resistant, and that—even if climate change affected some production—chocolate was not about to disappear. Chocolate lovers, relax.

But climate change is already affecting many aspects of our lives and other areas that do not affect us directly, so we don't think about them. Lisa Paravisini-Gebert tells us how some parrot species are on the verge of extinction partly because of the increased frequency and strength of hurricanes, attributed by scientists to climate change. John Waldron writes about a novel by Puerto Rican writer Mayra Montero in which a frog species is disappearing in Haiti. Jai Chowdhry Beeman—who was a long-time *ReVista* intern before he began his doctoral work on glaciers—examines how mountain water systems in Peru and Bolivia will respond to climate change.

Yet what struck me as I edited this magazine is that it is not all doom and gloom. As Harvard Center for the Environment director Daniel Schrag notes in his First Take, climate change is already happening, and we have to figure out ways to manage it. Most of the authors in this issue are looking at solutions, whether through local action or philanthropy or scientific studies. Some point out meliorative steps already taken or envisaged (for example, in Chile); some of the authors put climate change in the context of other types of environmental degradation caused by humans. Some take a regional view; others look at a specific community. Some use the study of art and literature as a way to make the complex science accessible to a broad audience.

As I interacted with the assigned authors, another pattern became visible—an immense emphasis on North-South collaboration, not just citing works, but co-authoring articles and building bridges. For instance, Karl Zimmerer brought in his collaborators from Peru, and Krister Andersson his Chilean collaborator Patricio Valdivieso. You'll see the pattern yourself as you read this issue of *ReVista*.

Scientists, architects, literary critics, archaeologists, geographers, political scientists and economists have come together in these pages to think about the problems and challenges of climate change. The process can't be reversed perhaps, but hopefully it can be slowed and managed. Here's to parrots in the jungles of Puerto Rico, slower melting glaciers in Peru and Bolivia, and, yes, Anastasia, to chocolate in 2050.



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**Director**

Brian Farrell

**Executive Director**

Andrew Elrick

**ReVista**

**Editor-in-Chief**

June Carolyn Erlick

**Copy Editor**

Anita Safran

**Publication Interns**

Isabel Espinosa

Sylvie Stoloff

Isaac Ochoa

**Design**

Jane Simon Design

**Printer**

P+R Publications

**Contact Us**

1730 Cambridge Street

Cambridge, MA 02138

Telephone: 617-495-5428

**Subscriptions, Back Copies and Comments**

jerlick@fas.harvard.edu

**Website**

revista.drclas.harvard.edu

**Facebook**

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VOLUME XIII NO. 3

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### ON THE COVER

Ice sculpture "Minimum Monument" by Brazilian artist Néle Azevedo melts on the steps of Berlin's Concert Hall at the Gendarmenmarkt on September 2, 2009.

PHOTO BY MICHAEL GOTTSCHALK/AFP/GETTY IMAGES.

# The Timescales of Climate Change

By DANIEL P. SCHRAG

**THE ENERGY CHOICES WE MAKE TODAY ARE** resulting in changes in the amount of carbon dioxide emitted to the atmosphere that will be seen in the composition of the atmosphere for hundreds of thousands of years. Climate change is here; it's happening and going to be with us for thousands of years.

Of all environmental consequences from human activities, the perturbation in carbon dioxide released from burning fossil fuels may be most significant because of the scale of the disruption and the longevity of its impacts. The

famous Keeling curve, a record of carbon dioxide (CO<sub>2</sub>) measured in mid-twentieth century at Mauna Loa, Hawaii, documents how the entire atmosphere is affected by human activities, rising from 315 parts per million (ppm) in 1958 to more than 407 ppm today.

But this famous graph understates the extraordinary rate for this interference in the natural world. Placing the Keeling curve alongside longer records of atmospheric CO<sub>2</sub> measured in air bubbles from ice cores from Antarctica shows

that even the beginning of the Keeling curve is higher than any CO<sub>2</sub> level in the last 800,000 years. Over this time interval, CO<sub>2</sub> reached a minimum of 180 ppm during glacial maxima and peaked around 280 ppm during the interglacial periods, roughly every 100,000 years—with the largest change occurring over 10,000 years. Through a variety of geochemical measurements, atmospheric CO<sub>2</sub> concentration can be estimated over much longer time scales, suggesting that current values above



400 ppm are higher than the Earth has experienced for several million years, and rising more than 100 times faster than any previous time we have measured.

The rise in atmospheric CO<sub>2</sub> is unlikely to recover to pre-industrial levels anytime soon. The ocean takes up about twenty percent of the carbon dioxide we emit each year, helping to cushion the response to human activities. That rate of uptake is limited not by chemical exchange with the atmosphere, which happens across the sea surface relatively quickly, but rather by the mixing of the surface ocean into greater depths. It is impossible to speed up the mixing of the oceans, as that is driven by the rotation of the Earth, and by the tidal forces of the moon and other planets.

Over the next several thousand years, the mixing of the oceans will take up roughly 70 percent to 80 percent of the carbon dioxide that humans have produced from fossil fuels. But the residual CO<sub>2</sub> will stay in the atmosphere for a very long time. Over the next 100,000 to 200,000 years, a slight increase in the chemical reaction rate between water, CO<sub>2</sub> and rock will slowly convert the CO<sub>2</sub> to calcium carbonate, mostly as shells on the sea floor, and the climate impacts of human activities will subside.

There are many other long timescales in the climate system, although none quite as long as the carbon cycle. For example, it remains uncertain exactly how long warming will continue even after CO<sub>2</sub> levels stabilize, mostly because we don't fully understand critical feedbacks in the climate system that can amplify the direct effects of higher greenhouse gas concentrations, as well as feedbacks in the carbon cycle that can add additional carbon dioxide to the atmosphere.

But another uncertainty in our ability to predict how climate will respond to higher CO<sub>2</sub> levels comes from the timescales of heat mixing into the ocean. If the Earth were only land, with no oceans and no ice, and we doubled the atmospheric CO<sub>2</sub> concentration (and managed to keep it there), the Earth



**Dzilam Bravo Wind Farm currently has 28 330-foot tall wind turbines under construction and will provide renewable energy to approximately 32,000 homes in the area.**

would reach a new stable temperature relatively quickly, in less than a decade or so. Two major factors slow down the response of the real Earth system, making it challenging to know how much climate change lies ahead, even if we were able to stabilize atmospheric CO<sub>2</sub>.

The first factor is heat uptake by the ocean. Of all the solar energy trapped in the Earth by greenhouse gases, more than 90 percent goes into heating the oceans. Indeed, one can think of the oceans as a vast reservoir of coolant, helping to slow down the climate change that is happening over the land. Heat uptake by the oceans tempers the impacts of climate change on the surface, but it only buys us time.

Over the next few hundred years, temperatures in the upper third of the ocean will slowly rise, and this will drive additional warming of the surface, even if atmospheric CO<sub>2</sub> levels are no longer rising. This is both good and bad. It is good that ocean heat uptake is slowing down the climate response, giving us more time to adapt to the changes. But it is bad because this means that even after we stop emitting CO<sub>2</sub> (i.e., stop burning fossil fuels in our current manner), the Earth's surface will keep warming for centuries, leaving future generations the obligation to manage the environmental consequences of our energy choices.

The second factor that contributes to slowing down the rate of warming at the surface is the ice sheets in Greenland and Antarctica. These ice sheets are massive parts of our surface water budget; the ice sheet on Greenland contains the equivalent of more than seven meters of sea level (i.e., if Greenland melted, sea level would rise more than seven meters on average); West Antarctic ice sheets contain roughly six meters of sea level equivalent; and the massive terrain of East Antarctica stores more than fifty meters of sea level equivalent. Although far smaller than heat uptake by the oceans, the melting of ice sheets is also important in the Earth's energy budget, and is particularly important in Antarctica, where the presence of such massive ice




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**Over the next few hundred years, temperatures in the upper third of the ocean will slowly rise, and this will drive additional warming of the surface, even if atmospheric CO<sub>2</sub> levels are no longer rising.**

sheets helps to resist the warming that is happening in other parts of the world.

As far as timescale, we do not know how quickly the melting of these ice sheets could occur: neither observations nor models provide enough information. The timescale for the Greenland and West Antarctic ice-sheets could be hundreds of years, or thousands of years. The timescale for parts of the East Antarctic ice-sheet is likely to be longer because it is so cold and also less vulnerable to rapid collapse due to topography and glacial structure. Paleoclimate data suggests that the Greenland ice sheet probably cannot survive in a world where atmospheric carbon concentrations are above 400 ppm (their current level). The same is probably true for the West Antarctic ice-sheet, and for small parts of the East Antarctic ice-sheet. This implies that we may already be

committed to some 10 to 15 meters of sea level rise in the long-term future.

Even if this process occurs over a thousand years, remaining relatively minor for any single generation, it is a sobering thought that the actions of humans over a relatively short span of history will impact the planet in such a profound way and for such a long time. One thing is certain—however long it takes for these ice sheets to melt or slide into the ocean, it will take much, much longer for them to grow again, driven by the slow accumulation of snow on glaciers over tens of thousands of years, once (if?) the overall climate returns to its pre-industrial state.

Another critical timescale of climate change is the timescale for building new energy systems. Unlike some technological revolutions like telecommunications or



information technology, creating new energy systems requires building massive amounts of infrastructure— including huge amounts of cement and steel. And a new, non-fossil system spearheaded by wind and solar power will likely require building even more infrastructure than our current one, due to the intermittency of renewable resources. First, solar and wind power have lower capacity factors than coal or natural gas generating plants—meaning that they produce a relatively small amount of electricity annually relative to their nameplate capacity, simply because the sun doesn't always shine and the wind doesn't always blow. This means that we have to build more capacity to get the same amount of total electricity. Second, because solar and wind energy are intermittent, it is very likely that we will need to maintain

backup generating capacity, which also adds to the need for more infrastructure. A final factor involves the issue of how electric grids will manage the intermittent power from solar and wind. One proposal is to install additional wind and solar capacity spread in different places, connected by a much better transmission network, increasing the likelihood that sufficient sun and wind will be available from somewhere. The problem is that this requires even more capacity—and so more infrastructure and a longer time to build it. Overall, the electricity system alone (ignoring other energy sectors, such as liquid fuels) is likely to be at least five times larger than it is today, even if we are able to manage the intermittency of solar and wind with cheap batteries and flexible demand. For the United States,

at current rates of installation of wind and solar, which set a record in 2017, this would take more than 300 years. Can this be accelerated? Yes—but only with massive political will that does not currently exist.

Another example of the long timescale for turnover of energy technology is in the area of biofuels. Brazil has led the world in building ethanol refineries, using sugar cane as the primary feedstock. Biofuel refineries typically measure their output in units of gallons per year (as opposed to barrels per day for the oil industry); when one uses common units, the comparison to oil is sobering. For example, the world's largest ethanol refinery is currently being developed in Brazil and will have a peak output of 12,000 barrels per day. The largest oil refinery, the Jamnagar refinery



Child at pig farm Fundo Oquendo, Callao (Chancheria), 1992.

in India, has a capacity 100 times larger, and took nearly 10 years to build. If biofuels will someday replace petroleum fuels, at least for applications like jetfuel and diesel that are difficult to replace with electrification, then the timescale to build the necessary refining capacity is very long.

And even more challenging than the timescale for building systems with mature technology, we must also face the reality that eliminating fossil fuels from our energy system is likely to require new technological innovation far beyond our current energy systems. Non-fossil energy systems, from electric vehicles to concentrated solar that allows for flexible generation, to advanced nuclear energy, all must become much, much cheaper if they are going to compete with fossil fuels. And this requires time for research, for development, for demonstration, and ultimately for deployment.

What are the lessons from these long timescales of the carbon cycle, of the climate system, and of energy systems? I believe these timescales show us that climate change is likely to persist for centuries and millennia. Earth will continue to warm as

long as humans continue to emit carbon dioxide from fossil fuel. The first challenge we must confront in working towards a solution to future climate change is that any “solution” will be incomplete. Some amount, perhaps even a substantial amount, of climate change is unavoidable. Some people have argued that we dispense with trying to reduce greenhouse gas emissions and focus all our efforts on preparing for the consequences, trying to avert the impacts of climate change or at least make them less costly. The flaw in this argument is that preparing for climate change becomes more and more difficult—ultimately impossible—if mitigation is not pursued. The consequences of ignoring climate change and allowing atmospheric CO<sub>2</sub> to reach 1000 ppm or higher—quite possible if no mitigation steps are taken—are simply too great to allow adaptation in any meaningful sense.

The nature of the climate experiment means that no one truly knows what a safe level of CO<sub>2</sub> really is, apart from the impossible goal of the pre-industrial level of 280 ppm. Because of the potential for catastrophe, it seems prudent to ask what

societies might do if the rate of climate change were to accelerate over the next few decades, or if the consequences were much worse than anticipated. One approach is the engineering of our climate system by adjusting the incoming solar radiation by injecting aerosols into the stratosphere; indeed, there may be some ways to accomplish a reduction in solar radiation at relatively low cost relative to other strategies of mitigation. Recently, such ideas have gained more prominence, not as a substitute for serious emissions reductions, but in the sober realization that efforts to reduce emissions may not be sufficient to avoid dangerous consequences.

The power to engineer the climate comes with an awesome responsibility. How could we engineer such a system to be failsafe? Which countries would control this effort? Who would decide how much to use, or when? And what would happen if something went wrong, if we discovered some unforeseen consequences that required shutting the effort down once human societies and natural ecosystems depended on it? These scientific, political, and ethical questions will be debated over the next few years and decades. However, it is likely that they will not be hypothetical for long; even with the most urgent efforts over the next decade to take action and pursue mitigation efforts, we should understand that we are heading into a climate state that no human has ever seen. Surprises are inevitable; how we deal with them may be our greatest challenge.

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*Daniel P. Schrag is the director of the Harvard Center for the Environment and the co-director of the Science, Technology and Public Policy Program at the Belfer Center for Science and International Affairs at the Harvard Kennedy School. He is the Sturgis Hooper Professor of environmental science and engineering at Harvard University and teaches an undergraduate course he calls “the climate energy challenge.” Schrag served on former President Barack Obama’s Council of Science and Technology from 2009 to 2016.*



# CONFRONTING CLIMATE CHANGE



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# The Brave New World of the Digital Herbarium

Mobilizing the Past to Understand the Future

By CHARLES C. DAVIS AND AARON M. ELLISON

**HERE IN THE NORTHEAST OF THE UNITED STATES,** spring will soon be upon us, pulling us from the darkness and cold of winter's grip. Spring's exuberance—singing and nesting birds returning from their wintering grounds in more southerly latitudes, flowers bursting from dormant buds, leaves expanding in verdant green—indicate the turning of nature's internal calendar. The timing of these natural events—what biologists call phenology—is deeply tied to climate. And phenological observations are revealing that spring now starts much earlier than it did in the past. Every species responds differently to climate change, but the responses of most species remain unknown.

One of the ways we are beginning to understand the effects of climate change is through the study of botanical collections, whether in the traditional context of museum collections or groundbreaking digital herbaria. These collections represent a new hope of documenting and understanding nature, and how it may be altered irrevocably by climate change. They help us track phenological responses, whether in frosty New England or sweltering Brazil.

## PHENOLOGY AS A TOOL FOR UNDERSTANDING SPECIES RESPONSE TO CLIMATE CHANGE

These phenological responses—or the lack thereof—have tangible effects on an individual's ability to reproduce and even the persistence of its species. Flowering of apple and peach trees, for example, is closely tied to winter chilling and spring temperatures; unseasonably warm spring months can trigger earlier flower production. That may be of relatively little

consequence if temperatures remain steady and bees emerge to pollinate the flowers. But if hard frost returns after unseasonable February warmth, either the bees won't show up at the right time, or the flower's hidden ovaries will be damaged and fail to produce ripe fruit. These phenological effects of climate change matter to us as well; in the Northeast alone, revenues from apples can exceed one billion dollars.

## PHENOLOGY IN THE TROPICS: A MISSING PIECE OF THE CLIMATE-CHANGE PUZZLE

Biologists who study the impacts of climate change have observed consistent changes in phenological events in the lives of many plants, insects and larger animals. But most of these observations have been made only in the last few decades, most frequently for trees, and predominantly in the United States and western Europe. There is much less observational evidence linking phenology and climate change in the tropics, which is home to the lion's share of Earth's biological diversity. For example, there are more than 14,000 species of trees in the rainforests of the Brazilian Amazon, the "lungs" of our planet.

Studying phenology and documenting phenological change in the tropics is remarkably difficult. The extraordinary diversity of tropical forests means that finding enough individuals of a single species can frustrate even the most seasoned field worker. Imagine this: a soccer-field-sized area of the Brazilian rainforest may include more than 650 tree species, which is more than the different kinds of trees than can grow in all of Canada and the United States combined. And in the rainforest, most of those species are likely to be represented by fewer than five individual trees, hardly a large enough



sample size from which to draw robust conclusions.

Although rainforests get most of the attention of scientists and nonscientists alike, they are only one part of the rich diversity of the tropics. Brazil's Atlantic coastal forests are another biodiversity hotspot, as are the *tepuis*, the table-top mountains bordering Venezuela and the Guayanas that were the inspiration for Sir Arthur Conan Doyle's *Lost World*. And then there are the hot, dry grasslands of the *cerrado* and the southern temperate regions dominated by "southern pines," which are not anything like our northern-hemisphere pines, but are trees in their own family, the *Auricariaceae* (which includes the familiar monkey-puzzle tree, *Auricularia araucana*).

The origin of Brazil's remarkable diversity remains an open question, but hypotheses include unique ecological dynamics in climatically benign tropical environments, the ancient age of the tropics that has allowed plenty of time for new species to evolve, and the climatic extremes associated with dramatic topography that have allowed different species to evolve in isolation from one another. Sadly, large-scale agriculture and forestry with nonnative species (Photo C), mining and human population growth are destroying this diversity before much of it can even be described.

Finally, physiological linkages between climate and phenology have been little studied in the tropics. Temperature plays

a large role in regulating phenological responses of both temperate and tropical plants, but in the frostless tropics, small changes or subtle variation in temperatures



**Opposite page, left: The Amazon rainforest at the 1,158 square-mile Caxiuana National Forest in Pará, between the Xingu and Anapu Rivers. Established in 1961 and accessible only by boat, Caxiuana is the oldest National Forest in Brazil, and in addition to its unparalleled biodiversity, it is home to more than 100,000 people. Caxiuana is managed by the Chico Mendes Institute for Biodiversity Conservation. The Ferreira Penna Scientific Station (Estação Científica Ferreira Penna) is located in the middle of the National Forest and hosts a number of international research projects on rainforest biology, ecology and the effects of climate change on tropical biodiversity and ecosystem processes.**

may have unexpectedly dramatic effects on phenology. Some evidence also suggests that temperature, precipitation and solar irradiation may interact in particular ways at certain times of the year, or even during previously uncommon El Niño events, to trigger bursts of flowering or fruiting.

Overcoming these and other challenges requires much more data than are available from individual, idiosyncratic field studies. To bridge this gap, we have partnered with Brazilian colleagues to mine a treasure trove of data that has rarely been explored for this purpose.

## HERBARIUM SPECIMENS AS A SOLUTION

It is estimated that nearly 360 million pressed and dried specimens of plants and fungi are secured behind the closed doors of herbaria around the world (Photo D). For example, at the Harvard University Herbaria—the largest university-affiliated herbarium in the world—we care for about 5.5 million herbarium specimens. Botanists have been collecting specimens for herbaria since before the time of Linnaeus, who established in the mid-1700s our system of naming species. Herbarium specimens,

**This page: Caxiuana is one of the last refuges in Brazil of the majestic tauari tree (*Couratari guianensis*), which has been exploited extensively for its high-quality wood. Like other trees in the Brazil-nut family (*Lecythidaceae*), flowers of the tauari fruits are pollinated by large bees, and its nuts are eaten by parrots, monkeys and many other canopy-dwelling animals. The hyperdiverse Brazilian *cerrado*—one of the world's largest producers of livestock and agricultural products—is increasingly threatened by conversion to forest plantations, which often include the planting of nonnative species, such as *Eucalyptus* (in background). Photograph taken in northern Minas Gerais state (Photo C) The Harvard University Herbaria, with more than 5.5 million specimens, is the largest university-affiliated herbarium in the world. Each of the thousands of compact-shelving cabinets holds thousands of specimens dating back to the early 17th century (Photo D). Charles Davis, Director of the Harvard University Herbaria, uses the herbarium collections to study the evolution of plants and their responses to environmental change. (Photo F) Photograph by Aaron M. Ellison.**

and similar mounted specimens of insects, skins of birds, and skeletons of many animals stored in museums such



as Harvard's Museum of Comparative Zoology, are essential for describing species and characterizing where they live.

These specimens, and the field data associated with them, are the basis not only for the Linnaean categorization of nature, but also for untangling the intricate details of molecular biology in model plant species like *Arabidopsis thaliana* and reconstructing the evolutionary history of humans. When studying these collections (Photo F) it is hard not to appreciate the efforts of the countless individuals who have scaled mountains, forded rivers (Photo G), been stung by ants (Photo H), preyed on by leeches, and spent long days under tropical suns and rainstorms to help these collections grow and thrive.

#### TOWARDS A GLOBAL RESEARCH COMMONS

Just as phenology has been studied more in the global north than in the world's tropics, the geographic distribution of herbaria and zoological collections is uneven. Most large, well-

curated collections are in the United States and Europe, from where, for centuries, scientists have traveled to tropical countries, collected specimens to document their rich biological diversity, and returned with these materials to their home institutions for cataloging and further study. Documenting and analyzing Brazilian plant diversity, for example, has for decades involved traveling to herbaria in Cambridge, St. Louis, New York or London rather than to Brazil itself. This has been true especially for studies of historical collections from the early days of botanical exploration, which include the first-named "type specimens" and that document diversity in years prior to urbanization and large-scale resource extraction.

For centuries, these collections and their associated data have remained largely off-limits, accessible only to small museum staffers who can accommodate academic visitors or send loans to researchers via global post. But all of this is changing rapidly with the emergence of new technologies and synergies between biologists, computer scientists and engineers. Digitization of museum specimens is creating a global, virtual museum, whose millions of specimens are available online for anyone to view and study.

Digitization involves scanning or photographing specimens in a collection and digitally transcribing the "metadata" associated with them. The specimens themselves are useless without these metadata—information about the specimen, including its scientific name (and changes in its name as understanding of its place on nature's family tree has grown), who collected it, when, where, and why it was collected, and other useful natural history information. Herbarium specimens also are a rich source of data about phenology and climate change. The



**Top Photo: An arboreal nest of *Azteca charitifex* at Caxiuanã can contain more than one million aggressive, stinging ants (Photo H). Bottom Photo: Rainforests throughout the world are dissected by rivers and streams, both perennial and seasonal (Photo G).**



**A specimen of *Scirpus subterminalis* collected on September 15, 1858, at Walden Pond in Concord, Massachusetts, by Henry David Thoreau. Thoreau's Herbarium is part of the Harvard University Herbaria. (Photo 1)**

specimens often include the different life stages of plants—buds, flowers, fruits—which, when linked with local climatic data can reveal how species have been affected by past changes in climate.

Because the past is the key to understanding the future, institutions throughout the world are digitizing their collections and mobilizing them online. In northern countries, federal governments are supporting this effort, often in partnership with private donors. In the United States, for example, the Mellon Foundation was instrumental in funding the digitization of type specimens in major herbaria, including those at Harvard. In Brazil, where federal funding for scientific research has been slashed in recent years, the petroleum giant Petrobras and the multinational cosmetics firm L'Oréal, among others, have supported these efforts.

For Brazil, digitization also effectively repatriates its plant biodiversity. Since the early 2000s, the Rio Botanic Garden and its director, Rafaela Forzza, have spearheaded *Reflora*, a global effort, centered in Brazil, to digitize Brazil's botanical biodiversity.

*Reflora* began with European and American herbaria and was later expanded to Brazilian herbaria, each digitizing and aggregating their own collections. Like many partnering non-Brazilian institutions, the Harvard University Herbaria has virtually repatriated all its Brazilian plant specimens.

#### **NEW TOOLS, NEW DIRECTIONS, NEW UNDERSTANDING**

As it nears completion, *Reflora* now includes more than three million images and associated metadata. As an open-access virtual herbarium

developed and supported by more than 400 Brazilian botanists and biodiversity specialists, *Reflora* is fast becoming the go-to resource for studying Brazilian plant diversity and its relationship to climate. Our own work has demonstrated that herbarium specimens collected in Massachusetts faithfully capture phenology and its association with climate stretching back nearly 150 years (Photo 1). We have also worked with computer scientists to develop *CrowdCurio*, a software platform to engage citizen-scientists in the identification of critical phenological stages on specimens. This large-scale crowd-sourcing of phenological data-collection has demonstrated that non-expert citizen scientists can contribute to scientific research efforts alongside highly trained botanists; the result is datasets

on phenology and climate change of incomparable size and global reach.

Just as the 15th- and 16th-century explorers mobilized sailing ships and the resources of kings to document the world's biodiversity, we are mobilizing the virtual resources of *Reflora* and other digital herbaria around the world with Big Data analytical tools to embark on a grand experiment aimed at understanding phenology and phenological change in the tropics. Our first effort is a multi-institutional one, spanning three institutions besides Harvard (Universidade Federal da Bahia, Universidade Estadual de Santa Cruz, and the Jardim Botânico do Rio de Janeiro) and a number of faculty with expertise in computer science, ecology, evolution, and education. And just as the early explorers made new discoveries in the "New World," so too are today's virtual explorers discovering the new patterns and processes of our rapidly changing world.

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**Charles C. Davis** (<http://www.people.fas.harvard.edu/~ccdavis/>) is Professor of Organismic and Evolutionary Biology at Harvard University and Director of the Harvard University Herbaria. He is an expert on phylogenetic applications to questions of plant evolution, including climate change, biogeography, and molecular biology. This spring he is teaching a course on plant diversity and evolution that includes sending the students on a research trip to Brazil as part of the course.

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**Aaron M. Ellison** (<http://harvardforest.fas.harvard.edu/aaron-ellison>) is the Senior Research Fellow in Ecology at Harvard University and the author of *A Primer of Ecological Statistics*, *A Field Guide to the Ants of New England*, and *Vanishing Point*. He studies the disassembly and reassembly of ecological systems in New England and abroad, and explores the contribution of ants in the Brazilian Amazon to the global carbon cycle.



**Above: Exploring the reef in Belize; Opposite page top: Growing juvenile staghorn on nursery in Belize. School of juvenile parrot fish, Belize.**

# Fragments of Hope Nursery

Protecting the Coastline in Belize By JENNA CHAPLIN AND EMILY BLAIR



**THE DRIVE TO PROTECT THE COASTLINE IN BELIZE** doesn't end at the water's edge: the most important need for protection can be out of sight, under the crashing surf. Reefs play a critical role in the reduction of wave energy. The Mesoamerican barrier reef off the coast of Belize is also dotted with cayes, atolls and mangrove islands that rise above the sea. We traveled to Placencia, Belize, and saw what a positive difference these reefs made along Belize's Caribbean coast.

Different strategies have been tried around the world to protect the corals that make up the reefs. Lisa Carne's Fragments

of Hope coral nursery is a good example of these efforts. Based in Placencia, seven coral nurseries extend throughout the barrier reef and within the lagoon. We visited the nursery at Laughing Bird Caye, a six-year-old project. Fragments of Hope grows Staghorn (*Acropora cervicornis*), Elkhorn (*Acropora palmata*), and their hybrid (*Acropora prolifera*) coral species in its nursery, transplanting them later onto the reef.

Although the main goal of Fragments of Hope is to increase biodiversity on the reef, this research has also driven home the importance of looking below the water to reframe the coastal strategies that could be employed in the face of dynamic weather and rising sea levels.

The name Fragments of Hope comes from the coral fragments cultivated in the nursery. Initial fragments, two to three inches long, that are particularly resistant to coral bleaching and disease, come from nearby reefs. The coral genotypes are pinpointed at the University of Miami in order to identify what makes them disease and stress resistant. The nursery, located on the protected, leeward side of the Caye at a depth of -15ft, makes use of metal frames, concrete "cookies" and ropes to support the variety of corals as they grow. After growing for three years, the corals will reach six inches and be ready to plant on the reef in one of five study locations around Laughing Bird Caye. Researchers come from around the world to study these plots.

The reef is in an ideal location inside the Laughing Bird Caye National Park. The coral nursery is home to some of the healthiest stands of *Acropora* corals in the area, if not the region. This effort draws many tourists to the reef and encourages locals to respect the habitat. When we visited the caye after Hurricane Earl, we could see hurricane wave damage. Some corals were broken off and others rolled upside down. Carne reassured us that when she began the nursery five years ago, she too was distressed at overturned or broken coral fragments, but the corals are adapted to this experience and many fragments resprout asexually, and form new stands. Literally, Fragments of Hope.

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*Emily Blair and Jenna Chaplin are graduates of the Masters of Landscape Architecture program at the Graduate School of Design. Emily is originally from Vancouver, Canada and has a background in Biology and Jenna is from the Bahamas with a background in Fine Arts. Both Emily and Jenna have returned to their hometowns after graduating in 2017, and Jenna is now planning on getting her Coral Nursery Dive certification in order to be involved in local reef restoration programs.*

Contact info: Jenna Chaplin - [chaplinjenna@gmail.com](mailto:chaplinjenna@gmail.com) Emily Blair - [emilyaablair@gmail.com](mailto:emilyaablair@gmail.com)

# Fleeing the Weather

## Migration in the Time of Climate Change

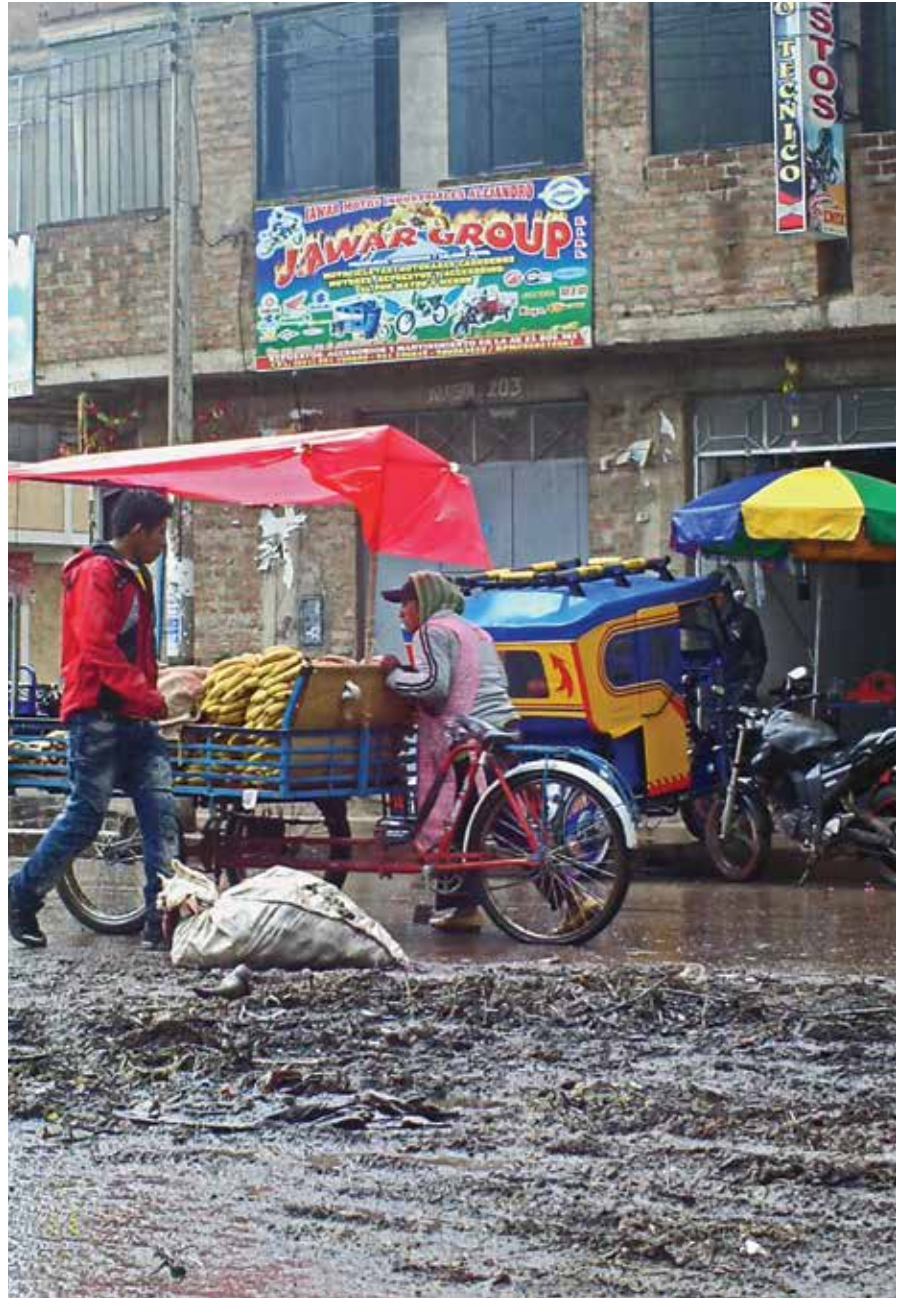
By ELIZABETH DONGER

**THE STREETS OF SANTIAGO K ARE QUIET.** THIS village in the highlands of southwestern Bolivia bustled throughout centuries of conquest and expansion, but the mayor is now one of the few remaining residents. He says most of the young have migrated across the border to Chile in search of work, some to other towns in Bolivia. Eighty percent of families have left since 2015. Multiple seasons of drought have decimated the area's quinoa crops and dried up the river. For these farming families, there was simply no way to make ends meet.

The term "climate migrant," bringing together two of today's most timely and fear-ridden debates, typically conjures images of people forcibly displaced by hurricanes, floods or rising sea levels. These issues have increasing political, academic and social visibility across Latin America.

People like the residents of Santiago K have used migration to adapt to changing climate for centuries. A study in the January 2011 issue of *Science* connected periods of low temperature in the early 17th and 19th centuries to "sustained settlement abandonment during the Thirty Years' War and the modern migrations from Europe to America." But today climate change is impacting migration patterns across Latin America and the Caribbean in accelerated and diverse ways.

International law does not guarantee a "right to migrate" for these people fleeing the weather. States can choose to provide short term humanitarian visas but are obliged to provide safe haven only to certain categories of vulnerable

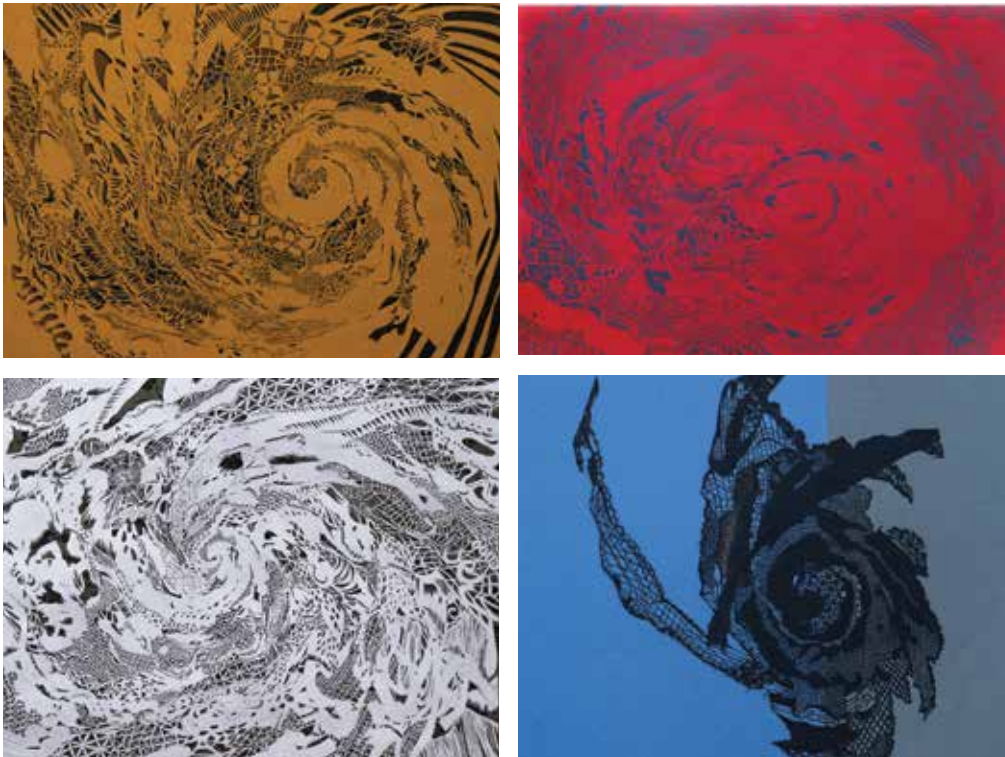


individuals, most significantly, refugees. And refugee law, designed for the displacement challenges of the 1950s, does not apply. It guarantees refuge to those fleeing individual persecution on the basis of their race, religion, nationality, political opinion or membership in a particular social group.

Latin America's existing frameworks for regional free-movement lay the groundwork for an effective and humane

alternative response, allowing some citizens to legally emigrate and work with minimal requirements. These frameworks can be useful more broadly, but stand to be tested in the coming years. The most visible examples of climate change's impact on migration are sudden-onset disasters leading to large collective evacuations. In 2016 alone, an estimated 1.8 million people were displaced across Latin America and the Caribbean





(Hurricane series), 2011, 19.5 in x 25.5 in, cut paper, collage. Clockwise from upper left; Carmela\_Gallardo, Luis\_Gallardo, Carmen\_Gallardo, Cynthia\_Gallardo.

by hurricanes, floods or mudslides. Evacuations due to rising sea levels are another high profile example: in Panama, plans are underway for the exodus of the Guna indigenous people from the San Blas archipelago, as the water begins to swallow their homes.

At the same time, the long-term effects of climate change on migration patterns, as witnessed in Santiago K, remain poorly understood and under-addressed. Less visibly, the slow-onset impacts of climate change both directly and indirectly drive decisions to uproot. Land and forest degradation, loss of biodiversity, and drought are widespread examples. A recent World Food Program survey of migrants from El Salvador, Guatemala and Honduras found that of six main reasons to emigrate, the highest percentage of respondents reported “no food” as being most important: a multi-year drought and 2015-2016 El Niño in the so-called “Dry Corridor” of these countries has left 3.2 million without enough to eat.

Climate change restricts and disrupts

access to water, land, and employment. The poor and marginalized carry this burden disproportionately. Resource scarcity and inequality also have well-documented links to violence of all kinds. Examples include civil unrest over fresh water scarcity in Peru and Bolivia; the murder of environmental activists in Brazil; and spikes in intimate partner violence in Nicaragua in the aftermath of Hurricane Mitch. All these complex factors impact individual migration decisions. As environmental law expert Benoit Mayer has written, “the physical effects of climate change produce series of social effects which...extend ad infinitum and ad absurdum in time and space.”

Brazilian law professor Lilian Yamamoto and colleagues, reviewing available literature on environmental change and migration in Latin America, found that most displacements occur internally, towards urban centers, and usually last a short time. This truth is often omitted from current migration debates: most people prefer to stay in their

home country if possible. But, as opportunities diminish in a country for safety, education, health and well-being, it is deeply human to look for these things further afield.

How should all these people be classified at the border? It is difficult to attribute any one event to climate change, and difficult to attribute migration to any one cause. Santiago K’s residents left Bolivia because of the drought, but also to find ways to meet their mounting debts: the quinoa industry has suffered from the fluctuating tastes of U.S. markets and competing production from Peru. So are they climate migrants, or something else? This label is subjective.

This complexity makes it difficult to predict the scale of the problem, and think about long-term, practical policy responses beyond disaster

management.

Across the continent, a number of regional and sub-regional platforms, working groups and coalitions have begun to address the effects of climate change on migration. Although inevitably somewhat disjointed, these efforts are remarkable in bringing together players across multiple sectors—climate change, disaster risk reduction, environmental protection, human rights, humanitarian response, migration and security. Their focus to date has largely been on short-onset climate disasters, both on risk reduction and response.

In November 2016, the Regional Conference on Migration (RCM) convened eleven countries from across the Americas to adopt a best practice guide on this issue. The guide provides non-binding direction to member countries on how existing law, policy and practice in the Americas can address the needs of persons displaced across borders in the context of disasters. It advocates for flexible application of existing migration categories, granting



Thirteen-year-old Luis Lulo Granados took this photo of a Peruvian neighborhood.



Proyecto Reserva Biosfera Huascaran, Minera Antamina, in Chile.

of humanitarian visas, and temporary suspension of return to disaster-affected countries. The effects on regional responsibility-sharing and cooperation have already been positive. The South American Conference of Migration is now developing a similar document.

But what about those displaced by the slow-onset effects of climate change? In a review of the RCM Guide, Walter Kälin and David Cantor write that there is “little State practice” on this front in Latin America. Some political and academic actors are advocating for the creation of new migration laws that specifically protect “climate migrants.” Without consensus around whom exactly the term encompasses, this is a Sisyphean task. Even if the terms were clear, questions

## Evacuations due to rising sea levels are another high profile example: in Panama, plans are underway for the exodus of the Guna indigenous people from the San Blas archipelago, as the water begins to swallow their homes.

arise about prioritizing categories of migrants, thus creating more meaningless hierarchies between categories of “deserving” and “undeserving” migrants.

Latin America’s existing free-movement frameworks position the region well to respond to the migration effects of slow-onset climate change. The 2002 MERCOSUR (Mercado Común del Sur) Residence Agreement permits nationals of Member and Associate States—including Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, and Suriname, with Venezuela temporarily suspended—to reside and work in any of these places for a period of two years. There are no economic requirements, only proof of citizenship and a clean criminal record for the previous five years. The permit offers the right to equal working conditions, family reunification, and access to education for children. After two years, the permit can be transformed into permanent residency, contingent on meeting requirements for financial sufficiency.

The Andean Community (CAN) has also adopted a migration instrument to facilitate free movement of select workers from member states Bolivia, Colombia, Ecuador and Peru. Both of these blocs participate in the sub-continental process of the Union of South American Nations (UNASUR), a forum with the explicit aim of facilitating “cooperation on issues of migration” and ultimately developing a South American citizenship.

These frameworks allow people to use migration as an adaptation tool. Residents of Santiago K who moved across the border from Bolivia to Chile could get access to legal residence, work and basic services. This approach respects the rights

of migrants: they do not languish in detention centers or suffer needlessly from the inability to meet their family’s basic needs. This approach also allows migrants to help fill key labor market shortages, send back remittances and bring newly acquired skills, knowledge, networks and links to new markets.

Forecasts for the number of people displaced globally by climate-related events by the year 2050 range from 25 million to one billion. Unsurprisingly, experts have questioned the accuracy of these projections for a phenomenon without a clear definition. But it is reasonable to expect that numbers will be large. According to the International Organization for Migration (IOM), intra-regional migration just in South America went up 11 percent between 2010 and 2015.

Latin America’s remarkable commitment to the principles of open borders and freedom of movement dates back to the 19th century, when most countries gained independence. Yet, as is evident all over the world, increasing numbers of new arrivals are often met with popular backlash and heavily secured borders. An influx of Haitian immigrants to Chile is fuelling a debate there over racism and xenophobia. In January 2017, Argentina’s President Macri issued a decree making it easier to deport immigrants and restrict their entry.

These free-movement agreements are also currently inconsistently applied by each state, as per their political and social climate; for example, more progressively than required in Uruguay, but more restrictively in Chile. Unlike in the European Union, the power held by the MERCOSUR and CAN is intergovernmental, not supranational.

As migration lawyer Diego Acosta points out, “South America is now at a crucial crossroads on regional mobility” and must “take further action to solidify a free mobility scheme in the near future.”

Mayer writes in *The Concept of Climate Migration* that “despite its essential flaws, the concept of climate migration has...a particularly strong political currency.” This currency should be used to advocate for humane policy for people using migration to adapt to the slow-onset effects of climate change, as well as for people fleeing sudden climate disasters. In some quarters, it is already being used to stir up anxiety around floods of newcomers and to militarize borders, as documented in Todd Miller’s book *Storming the Wall*.

Latin America’s crucial experiment in free movement needs further study. How many Bolivians from Santiago K were able to take advantage of the opportunity to move to Chile? How did it impact their opportunities and decisions, and those of the families they left behind? Did the Chilean state and economy benefit?

Firm evidence about this group and locality would have implications for migration policy outside this regional bloc. No one is taking bets that the United States will adopt a similar open-doors policy for Central Americans fleeing the Dry Corridor. Latin America’s free-movement regime is premised in large part on shared identity, as in Europe. Nevertheless, evidence of the benefits of this approach—giving people the right to legal residence, work, and access to basic services—could be used to advocate for increased labor mobility pathways.

Despite efforts to mitigate and prepare for climate change, emigration from places like Santiago K will become an increasingly familiar reality. This model of response deserves our full attention.

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*Elizabeth Donger is a Research Associate at the Harvard FXB Center for Health and Human Rights. She works on issues of distress migration, child protection and climate change with a focus on Latin America and Asia.*

# Preparing Students to Lead Social Change

## Advancing The UN Sustainable Development Goals

By RAMÓN SÁNCHEZ, ERIKA EITLAND, JIE YIN AND JOHN SPENGLER



Students huddled in their favorite coffee shop powered by caffeine and reliable wifi.

**FAR FROM BOSTON'S WINDOWLESS LECTURE** halls and projector screens, the small Yucatecan town of Santa Elena became a dirt-paved classroom rooted in culture and global change. As the students of the Harvard T.H. Chan School of Public Health course, Social and Sustainable Innovation Driven by The Sustainable Development Goals (EH210), walked the narrow streets lined by indigenous and colonial architecture, the complex history of the Yucatan was quickly illustrated to all of us.

Our “*abuelita*” for the afternoon, weathered yet ever-smiling, told us the future would also feature great environmental and social changes, which had already shaped the livelihoods of her children. As her hands methodically shaped the perfect corn tortilla and placed it on a three-stone fire, her small hut filled with a distinctive smoke. At Harvard, we had learned that three billion people in the

world use solid fuels for domestic energy needs, however alternative energy sources also have important cultural, historical, and health implications. During a two-week course, this single afternoon with the Mayan community provided a living example of why we need to understand and find solutions to the social, economic, educational and environmental inequities of our world as they relate to natural disasters and climate change.

In 2015, more than 150 countries committed to the 2030 Agenda for Sustainable Development, which includes the 17 Sustainable Development Goals (SDGs) aimed at ending poverty, hunger and inequality, and building strong institutions and partnerships that lead to environmental action to improve access to health and education. The 2017 UN report showed promising progress with a 17% reduction in extreme poverty since 1999.

Yet economic losses from natural hazards have increased to as much as \$300 billion each year, with disproportionate burdens on the poorest and most vulnerable communities. Water stress is among these challenges and requires efficient ways of protecting and using water, especially for food production.

For this generation of young socially conscious students, the SDGs are becoming a “north star” to break with the shibboleth of the status quo. They see themselves as citizens of the world anxious to have relevant professional careers. Ramón Sánchez and Jack Spengler at the Center for Health and Global Environment, T.H. Chan School of Public Health, recognizing the need for immersive educational experiences, collaborated with Professor Carlos Vinajera of Universidad Autónoma de Yucatán (UADY) to craft a winter session course in Mérida, Mexico. Through this living case study students experienced firsthand the immediate impacts of changing environmental and social conditions as well as the consequences of inaction.

### THE SETTING

As one of the largest cities in Mexico and the capital of the state of Yucatán, Mérida is vibrant and notably diverse with more than 60% of the population of indigenous Mayan descent. Mérida is an education hub with 16 universities and some of the best performing public schools in the nation—well placed to develop innovative solutions. As a public health course, EH210 took advantage of this intellectual base to find socially just and health-promoting business ventures.

Beyond its human capital, the city and surrounding regions provided

many examples of sustainable solutions and leadership. For example, heading eastward, we learned that the Dzilam Bravo Wind Farm currently has twenty-eight 330-foot tall wind turbines under construction and will provide renewable energy to approximately 32,000 homes in the area. Forty minutes north, the port manager of Progreso explained the key challenges of receiving up to 18,000 tons of products along the world's second longest pier. To the west, the ancient Mayan city of Uxmal and Santa Elena highlighted the local efforts to not only preserve but

restore culture, ancient architecture and indigenous communities. To the east, the Chichén Itzá showed us a great example of how climate change played an important role in the Maya's downfall.

Within Mérida itself, students walked the streets in search of examples of biophilic design, which incorporates natural elements into the built environment in an urban milieu to better understand how design contributes to climate change adaptation and sustainability. Lastly, with the support of UADY and Fundación Plan Estratégico de Yucatán (a non-profit championing sustainable development in Merida for twenty years), skill-driven, discussion-based classroom sessions became possible. Their partnership ensured our students received a holistic toolkit to design and implement timely, relevant solutions.

### THE PROGRAM

During a period of ten days, students turned creative ideas into robust business plans. The course set the stage with observational and informed experiences not pedagogically available in Boston. Determined to illustrate the deep connection between human health and global environmental change, Sánchez and Spengler decided to go back 1,100 years

to the end of the Mayan civilization. Local archaeologists discussed how prolonged drought, overpopulation and deforestation led to the collapse of the scientifically advanced Mayan civilization, despite attempts to adapt to these new conditions.

While the experiences we examined spanned centuries, classroom-based teaching highlighted 21st-century techniques and methodologies necessary for practical product/service development and implementation. Students got firsthand experience searching for patents for pre-existing technologies and performing assessments of community vulnerability and climate change resiliency. To become effective entrepreneurs, students were also exposed to advanced market intelligence techniques, methods of harnessing creativity when developing solutions for local problems, intellectual property and technology frameworks, risk-benefit analysis and risk management techniques. The rigorous agenda culminated with students, powered by caffeine and reliable wifi, huddling in their favorite coffee shop on Paseo de Montejo, a colonial home transformed into a Starbucks—another sign of the changing times. Their ideation and collaboration often sparked critical discussion. How do we have the greatest environmental impact? Is there a more sustainable alternative than what we are proposing? What are the local economic and policy challenges we need to overcome?

Additionally, we started some research to evaluate the health and efficiency of the local innovation ecosystem in the Yucatan Peninsula (Mexican States of Quintana Roo, Yucatan and Campeche) to try to enhance educational, financial and legislative frameworks so social and sustainable entrepreneurs in the area may eventually have similar innovation support systems and investors like the ones found in major innovation hubs like Boston, New York and Silicon Valley.

### THE STUDENTS

The magic of the course was the students themselves. Multidisciplinary, enthusiastic, collaborative and solution-



Above: A dog in Mérida; Bottom: Limestone Carvers.

driven, they were not just academics but problem-solvers. The Boston graduate student contingent included three from the Tufts University Fletcher School of International Affairs, four from the Harvard T.H. Chan School of Public Health, one from the Harvard Kennedy School and two from the Harvard Graduate School of Design. Our Mexico-based students included architects, engineers, social workers, lawyers, economists, archaeologists and directors of business incubators from several local universities such as the Universidad Autónoma de Yucatán, Universidad Anáhuac-Mayab, Instituto Tecnológico de Mérida and Universidad Modelo en Mérida. From the beginning of the course, students joined forces and formed multidisciplinary and multinational groups to develop a business plan that targeted one or several SDGs.

The Mexican students provided profound understanding of the local context, whether it was through the non-profits they led or a practical understanding of the occupational hazards faced by small communities of limestone carvers. We recognized that deep-learning could be best achieved through a co-creation process of shared discovery and knowledge. Therefore, it was no surprise to the teaching staff that collaboration became an iterative process. By week two, students had begun to restructure their groups to reflect their interests, expertise and heightened understanding of the local context. Ideation amongst team members would result in multilingual animated discussions that challenged each group member to think about feasibility, metrics of success and impact of their proposal.

## THE RESPONSE

The goal of EH210 was to provide students with the necessary tools to create a socially equitable, environmentally conscious and health-oriented business plan that would be ready to pitch to potential investors. However, the response of the students was more profound. The transformative and investigative power of students was captured in the class blog ([socialsustainableinnovation.wordpress.com](http://socialsustainableinnovation.wordpress.com)) featuring more than eighty critical analyses focused on the intersection of the SDGs, climate action and innovative solutions. The diversity of the student body is reflected in the topics discussed, which makes the blog a useful resource and engaging read for anyone interested in sustainable development.

Ultimately, six technical business plans were submitted covering issues related to sustainable tourism, recycling, urban forest preservation, occupational hazards in local stone carving communities and coastal protection and revitalization. Within these documents, students described their business models, how they would reach early customers, who would make up their management team, outline expected revenue streams and establish how their venture would overcome current inefficiencies and challenges. On the last day of class, students gave 15-minute pitches of their venture illustrating how deeply they had considered the ramifications of their work.

Arguably, the real metric of success for EH210 is the profound relationship formed among our students. Collectively, the students deepened their understanding of the environmental determinants of health, recognized the shared expertise of their colleagues and left empowered to tackle social and environmental challenges that will shape their careers as they work to achieve the 2030 Agenda for Sustainable Development.

Written into each sidewalk tile is “Merida para todos” or “Merida for everybody,” a constant reminder why courses like these are not only important but necessary to foster global leaders. It is not about finding the solutions for the lucky few, but challenging our methods of learning to be more inclusive and addressing key disparities impacting communities globally. The path towards a healthy, more equitable planet may appear a formidable task, but if we have a shared commitment to promote innovative knowledge generation amongst our students, professors and universities, the solutions are within our grasp.

*Ramón Sánchez, Erika Eitland, Jie Yin and John Spengler* are at the Department of Environmental Health, Harvard T.H. Chan School of Public Health.

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*Ramón Sánchez* is a certified professional in sustainability, renewable energies, green manufacturing techniques and technology innovation. He is director of the Sustainable Technologies and Health Program in the Center for Health and the Global Environment at the Harvard T.H. Chan School of Public Health (HSPH).

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*Erika Eitland* is a doctoral candidate in the Department of Environmental Health at Harvard T.H. Chan School of Public Health and received her MPH at Columbia University. Her research focuses on the health impacts of climate change as well as the adaptive and protective role of the built environment, specifically in elementary and secondary schools.

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*Jie Yin* is a doctoral student at the Department of Environmental Health, Harvard T.H. Chan School of Public Health (HSPH). He holds a Master of Science degree in Environmental Health from HSPH and a Master of Urban Planning and Design from Tongji University. His research interests lie in the cross-disciplinary field of urban planning and public health, including assessing the health impacts of biophilic design and environmental health risk factors shaped by urban planning and policy.

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*John Spengler* is the Akira Yamaguchi Professor of Environmental Health and Human Habitation at the Harvard T.H. Chan School of Public Health. His research assesses population exposures to contaminants that occur in homes, offices, schools and during transit, as well as in the outdoor environment.

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(For more information about EH210 please contact Dr. Sanchez at [rsanchez@hsph.harvard.edu](mailto:rsanchez@hsph.harvard.edu))



Merida for everybody.



Sewage is an environmental problem that has direct impacts on ecosystems.

# Beyond Climate Change

## The Latin American Sewage Crisis and Environmental Injustice

By **VERONICA HERRERA**

**CARMEN OFFERED TO SHOW US AROUND THE** neighborhood. We turned onto unpaved streets that housed surprisingly dissimilar buildings. Homes made of brick and mortar with finished lawns and paved entryways sat next to corrugated tin houses with plastic bags for windows. Yet they all shared something in common: they were surrounded by lagoons full of garbage and human waste. In Villa

Inflamable, a shantytown in Buenos Aires, Argentina, enterprising residents had improvised a solution to the lack of sewers in their neighborhood by running hoses underground to take wastewater from their bathrooms to open lagoons a few meters away. The result was green lagoons composed of raw sewage and strewn with plastic bottles, car parts and bags full of kitchen scraps. Carmen told

us that last year her two children had been diagnosed with lead poisoning. Her house sat adjacent to the Matanza-Riachuelo River, a waterway that traverses the capital city and has made the top ten list of the most contaminated places in the world.

Carmen has never heard of climate change. The environmental problems she faces are not directly linked to



greenhouse emissions, yet they are shared by millions. According to the World Health Organization, one out of four people dies every year from living or working near toxic pollution. Ninety-two percent of these deaths occur in middle or low-income countries, where the majority of the global population lives. A 2017 Lancet Commission report estimated that pollution causes losses of US\$4.6 trillion per year—6.2 percent of global economic output. While some forms of pollution, such as air pollution, are closely aligned with determinants of greenhouse emissions and share common solutions, other forms, such as water pollution, are not.

The largest contributor of water pollution is untreated wastewater, a fast growing, global problem that has been neglected by the international community because its determinants are largely local and not linked to the drivers of climate change. Yet environmental degradation from wastewater pollution is global in reach, impacting most of the world's population and ecosystems. Less than 20 percent of global wastewater—including residential, industrial and agricultural water—receives any form of treatment; this figure is only eight percent in low-income countries. In Latin America, approximately 22 percent of wastewater receives treatment, but some studies show that the total percentage of wastewater being managed sustainably may be as low as 11 percent.

The spread of the global climate change agenda has coincided with the upsurge in the urban sewage crises in Latin America. Unplanned urbanization has skyrocketed in the region; eight out of every 10 people in Latin America now live in cities, a migration accompanied by unregulated industrialization. Environmental organization leaders I interviewed in Colombia and Argentina stressed the difficult access to international financing for sewage contamination because of international environmental foundations' singular focus on transborder climate change initiatives. Indeed, wastewater management has little appeal to international foundations,

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## **The largest contributor of water pollution is untreated wastewater, a fast growing, global problem that has been neglected by the international community because its determinants are largely local and not linked to the drivers of climate change.**

policymakers and even academics who work on environmental issues.

But sewage pollution, even without climate change, is a pressing environmental policy problem. The United Nations reports that severe pathogen pollution (from fecal contamination) affects one third of all rivers globally and presents health risks from drinking contaminated water, bathing, laundering and other household activities. Severe organic pollution from herbicides, pesticides and industrial compounds also pour into many rivers. In Latin America, about one out of every three rivers is polluted by wastewater and solid waste (the region produces 160 million tons of waste annually, or 12 percent of the world's waste).

Sewage as an environmental problem has direct impacts on ecosystems. The Millennium Ecosystem Assessment reports that 60 percent of global ecosystem services, on which many social and economic activities depend, are being degraded. Agricultural practices, population growth and industrialization are creating excessive nitrogen and phosphorus dumping into waterways. The result is toxic algal blooms, or eutrophication, which is the dramatic growth of plant biomass, an alarming development visible in Villa Inflammable's green lagoons.

There is an inextricable relationship between ecosystem degradation and human health. Unmanaged wastewater is a vector for disease, including typhoid, paratyphoid, dysentery, gastroenteritis and cholera. More than half of the hospitalized global population suffers from water-related diseases, and

diarrheal diseases make up more than four percent of the global disease burden. The World Health Organization estimates that approximately 58 percent of all cases of diarrhea in low and middle-income countries are attributable to the environment, and they account for 20 percent of global deaths for children under the age of five.

These figures do not include, however, exposure to toxic contamination that many low-income urban communities face from manufacturing firms' release of heavy metals, chemicals and other nonbiodegradable pollutants into waterways. Villa Inflammable is one extreme example—it surrounds a Shell petrochemical processing plant that transmits soil, air and water toxins. It is not uncommon for manufacturing firms to be located near residential communities in Latin American cities. Residents and activists I interviewed in Buenos Aires and Bogotá recounted cases marked by various health problems, such as gastrointestinal illness, lead poisoning, skin lesions and cancers. As health crises mount, many government officials suppress information about the link between industrial pollution and human health, hoping to deflect responsibility and avoid blame.

Climate change will exacerbate environmental degradation and toxic exposure from the wastewater sector, but the factors that contribute to wastewater contamination are not a result of climate change. Non-climate change factors such as aging infrastructure, industrialization and population growth will have similar levels of negative environmental impact in the short term even outside of climate

change scenarios. Better understanding the unequal distributive impacts of environmental harms associated with wastewater pollution will surely underscore political, regulatory and social conflicts related to rapid industrialization and urbanization in Latin America. As Victor Hugo noted in *Les Misérables* (1862), “A sewer is a cynic. It tells everything.”

We need to do a better job of distinguishing between drivers of climate change and other environmental problems that may have distinct causes and consequences. Climate change is often discussed with respect to its distributional over-time tradeoffs—the need for current generations to reduce greenhouse emissions for the good of future

generations. Yet pollution abatement presents different distributional tradeoffs. Environmental degradation associated with wastewater, solid waste and toxic dumping disproportionately affects low-income residents who are most likely to live near pollution and most directly suffer its health and economic impacts. Those interested in social justice issues would do well to focus on the global wastewater crisis. More attention is urgently needed to attend to growing pollution in developing countries, which currently account for a large, and growing, percentage of global human deaths and the alarming rate of debilitating ecosystem health. Climate change mitigation is critical, but we do not need to wait decades to experience

the worst of the environmental problems that are headed our way. For the majority of low-income residents like Carmen in Latin America and beyond, that future is already here.

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**Veronica Herrera** is Assistant Professor of Political Science at the University of Connecticut and Visiting Scholar at DRCLAS at Harvard University. She is author of *Water and Politics: Clientelism and Reform in Urban Mexico* (University of Michigan Press, 2017), and researches and teaches on environmental politics, development, and cities, with a focus on Latin America. Find her on twitter @veromsherrera or email [veronica.herrera@uconn.edu](mailto:veronica.herrera@uconn.edu).



Above: polluted waters; Opposite page: *Osteopilus dominicensis*, in Macaya Biosphere Reserve, Massif de la Hotte, Haiti.

# THROUGH THE LENS OF LITERATURE



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# The Melting of Humankind

## How Art Deepens our Dialogue about Climate Change

By **MARIA ALESSANDRA WOOLSON**

**IMAGINE ONE THOUSAND ICE-FIGURINES** covering the steps of Berlin's Gendarmenmarkt Square Concert Hall on a warm September day. Similar scenes had emerged before in cities such as São Paulo, Florence, Havana, Belfast, Tokyo, Paris, Brasilia, Kyoto and Salvador. This artistic installation-cum-urban action titled *Monumento Mínimo* (Minimum Monument) was the work of Brazilian artist Néle Azevedo. On this occasion, the 73 degrees Fahrenheit temperature turned the melting-men into traceable water marks within thirty minutes and, shortly thereafter, they were gone, leaving no trace of their existence (Azevedo Néle, 2014).

It was the year 2009; the same year that Chacaltaya, the Bolivian glacier that had once housed the world's most elevated ski resort at 17,785 ft., melted away into nothing but a thin stream of water, a full six years before initially predicted. Chacaltaya also represented a precious fresh water resource for the population of La Paz that, in a matter of months, vanished and dramatically hastened the expected gradual decrease of the mountainous water source. No one had predicted the accelerating effects of rising temperatures or the early disappearance of the glacier that forced Bolivia to declare a state of emergency in January 2016 for the country's third most populous city (The *Guardian*, November 28, 2016).

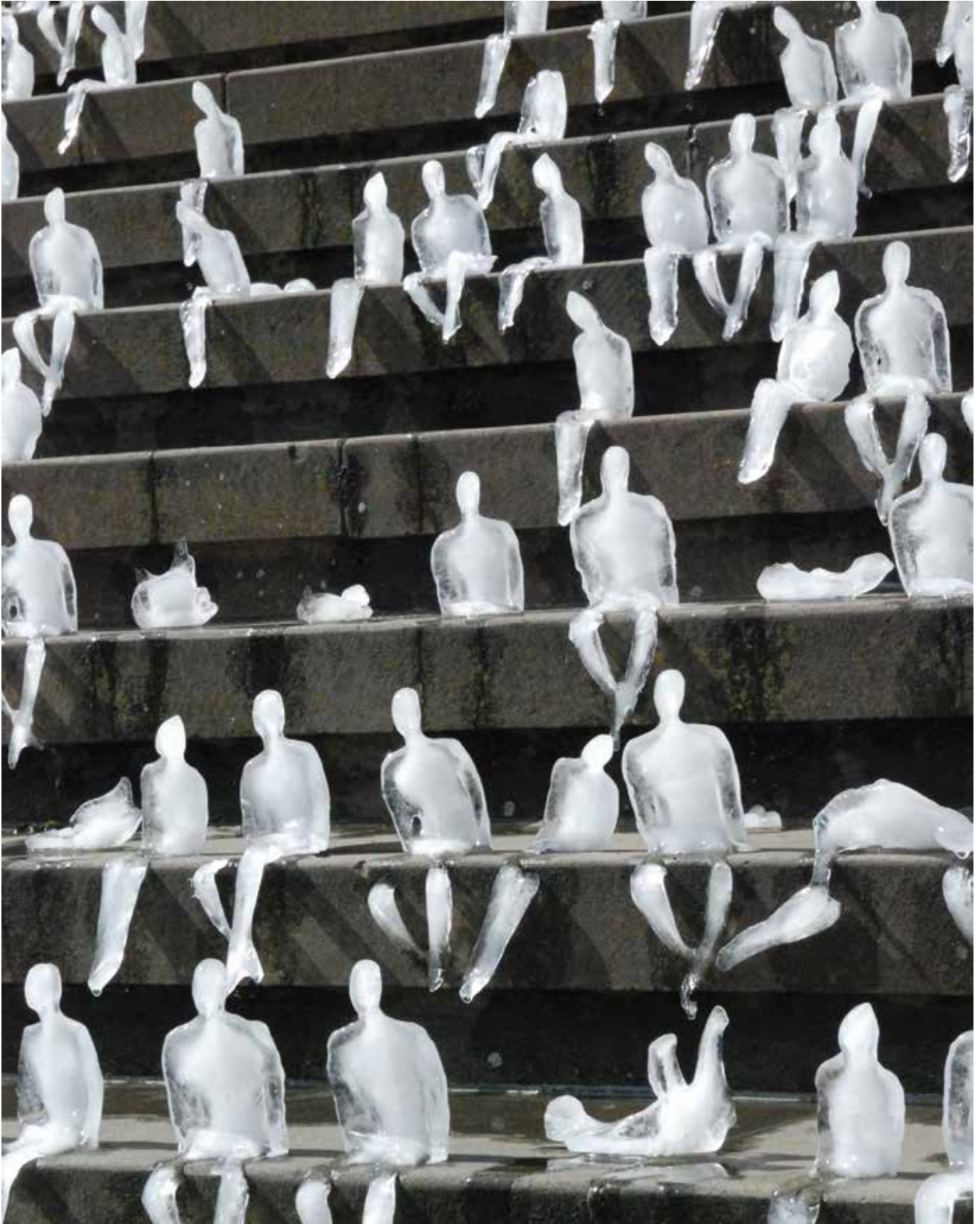
Chacaltaya is but one example of events that drive the international community of experts' urgency to develop new collaborative research models that respond to the Special Report on Global Warming of 1.5°C (IPCC 2017). The special report was commissioned by the Intergovernmental Panel on Climate Change (IPCC), following the 2015 United Nations Conference on Climate Change



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(COP21) or Paris Climate meeting, to establish a basis for understanding the difference of projected impacts and costs between an increase of 1.5°C and 2°C warming. At the same time, the outcome of the glacier's untimely disappearance is proof that an ethical perspective is necessary, as it can reveal the central role of culture for building the systemic capacity required to adapt to changing conditions.

A powerful environmental thinking flows from the often-paradoxical experience of Latin America, a region rich in diverse forms of practical and adaptive knowledge embedded in traditional cultures, one that is still attuned to the deeply-rooted wisdom of its many identities, and yet cannot escape its indexes of poverty and inequality, or its colonial legacy. The region's contemporary artistic representation, such as that of



Néle Azevedo, is equally powerful; it is as diverse as its peoples and comprises a plurality of aesthetic expressions and cultural relations. Reading these artistic and literary 21st-century works through the lens of ecocriticism, which adopts a humanities perspective to examine paradoxical aspects of human-environment interactions, opens a window onto the complexity of present-day socio-ecological problems. The resulting perspective can facilitate a reevaluation of environmental problems that reveals their fundamentally ethical nature in and far beyond Latin America.

The world's changing climate and the need to respond to the outcomes of the Paris Climate meeting of 2015 was also raised from the outset at a summer meeting of the U.S. National Council on Science and the Environment that I attended in June 2017. One of the meeting's primary aims was to highlight current goals and trends regarding the future of environmental and sustainability work in higher education, including what it means to engage this topic in anticipation of future adaptations. The challenge was not just to establish understanding of complex differences between magnitudes of warming, but to do so within the context of the 2015 Sustainable Development Goals (SDGs) that underpin the UN 2030 Sustainable Development Agenda (UN Sustainable Development Goals, 2015). This discourse exuded an urgency to engage with United Nations work, and to creatively and collectively identify the kind of research and collaboration necessary, given a paucity of peer-reviewed literature upon which to evaluate the difference of impacts and costs between 1.5°C and 2°C warming (Liverman, Diana, NCSE summer meeting, 2017).

Here we were, in 2017, looking at a set of Sustainable Development Goals that were agreed to in 2015 and delineated an agenda for the world in ways that seemed to usher in a new rhetoric, but notably shared the underlying rationale of the objectives delivered at the seventh meeting of Ministers of

the Environment of Latin America and the Caribbean, held in São Paulo, Brazil, in 2002 (Manifesto). These objectives would coalesce into a manifesto, a Latin American manifesto of Latin American environmental thinking that represented the collective will to understand and respond to the challenges that would later be put forth in the SDGs. This was the MANIFESTO FOR LIFE in Favor of an Ethic for Sustainability (UNEP Latin America 2003), or a manifesto of an ethic in favor of life.

In this light, one could argue that the so-called environmental crisis which afflicts the world today is symptomatic of another major crisis: a crisis of modern knowledge. What are the singular challenges that climate change poses to that knowledge and to our global modernity? What are the unique ways in which Latin American thinking makes sense of those challenges? How do these ways of knowing and making meaning contribute to international conversations about climate and global change? These questions define an endeavor that is both practical and epistemological. Responses to that challenge must equally involve perspectives from the ecological sciences and the arts and humanities, an assertion that directly aligns with the International Council for Science's recent assessment of the 2015 United Nations Sustainable Development Goals, which underscores the necessity of an integrated approach for dealing with our changing climate (ICS Report, May 2017).

Here, the humanities provide vital insights of culture, human institutions and practical wisdom. In other words, the humanities provide deep readings of texts and signs that enable the interrogation of human values and actions, which in turn deepen our understanding of the range and diversity of human knowledge available to us, enabling us to respond to these critical issues. For example, an approach to water and food access that focused exclusively on management and agro-technical aspects, without addressing the fact that women, worldwide, provide approximately eighty percent of the world's food supply and

at the same time are the majority of the world's poor, would fail to understand that this is as much a gender issue as it is a socio-economic and technical one. And this is where art and the humanities have the special ability to establish a perspective that encompasses the full complexity of socio-ecological challenges.

The thousands of faceless tiny men and women sculpted in ice by Néle Azevedo, that wandered between the public stairways of cities, states and countries, and intervened in both their physical and discursive urban landscapes, have continued to spark conversations about climate change. Since 2001, the presence of these works has suspended daily routines, transforming the public space in unique ways and altering culturally contoured norms and behavior that we naturalize in our daily life. Azevedo's arranging of her 500, 1,000 or 5,000 sculptures is always a community event. She invites the public to partake in assembling the installation, but surprises the observer with a kind of social happening. The miniature icy bodies are placed in position by volunteers, often casual passersby, turning each sculpture's placement into something very personal—a personal moment of contact with an icy-cold reflection of ourselves that will soon become part of a sea of anonymity.

Her sculptures and installations, by their very nature as objects, reconfigure and re-functionalize the space where they are placed. But space is hardly neutral. To intervene in public space is to challenge the limits of that space, and of what is public and of the subjective knowledge stored in it. Part of that subjective knowledge that is naturalized in our modern urban daily life manifests in an often-indifferent behavior toward public spaces that has become deeply ingrained within society, consciously or otherwise. Azevedo is aware of this social performance when she situates her melting-men on an urban monument and metaphorically intercepts the site and its memory with a sensory experience involving ice. For the viewer, the faceless bodies and ephemeral ice figures soon become a confrontation of

our modern indifference and the fragility of our existence, at the same time. They are also an honest representation of the beauty of the ordinary, which interrogates the ethics of a contemporary experience that is constantly choreographed in relation to consumer images, slogans and individualistic practices. Azevedo's Minimum monument reminds us of the forgotten bodies that surround us in a shared planet, common to us all.

The dynamic experience with this art installation begins as the figurines melt. The once collective presence of the thousand turns into the daunting disappearance of fallen bodies, as ghostly figures melt under a watchful audience, much like Chacaltaya did under eyes of the Bolivian population. Although originally intended to examine the role of monuments in the contemporary city, Azevedo's ice sculptures now speak of global warming as a threat to life:

the ice gave poetic support to what I was looking for. I wanted to break the characteristics of the monument. Curiously, monuments in antiquity were made to remember that people die. As today in the capitalist system the "dead" do not produce wealth, the dead do not enter into the "account." But we are still mortals. By affinity, I was invited to work on environmental issues. My work was considered by many as an alert to global warming and I accepted that affinity, because it is our life that is threatened. The planet will continue to exist, but our life that is threatened. I do not know if we still have time to reverse it, but I hope we have time. (Azevedo 2014, my translation)

Indeed, global change is increasingly understood as a systemic, eco-social challenge that requires a deeper capacity to foster leadership and responses to both local and regional problems for working across boundaries and differences, from diverse disciplines and methods, to identities and cultures, and other ways of knowing the world. The 2002 Manifesto for Life issued by Latin



America and the Caribbean's Ministers of Environment defined these needs and centered discussion of climate and environmental change around ethics: "an ethic of knowledge and dialogue among fields of knowledge, an ethic for global citizenship, an ethic of global governance and participatory democracy, of peace and dialogue for resolving problems, of rights, justice and democracy for the commons and the common good" (Manifesto). It explained our current climate and environmental crisis from an ethical perspective, revealing the central role played by culture as a tool for building the systemic capacity to evolve with changing conditions. Not only is the manifesto a clear sign of the contributions that a uniquely Latin American environmental thinking can make to international conversations about climate and global change, it also functions as a road map for engaging the topics enunciated through the SDGs from multiple viewpoints, including the arts, the humanities and the traditional knowledge that embeds much of the regions' own ecological potential (Leff, E. "Latin American Environmental Thinking: A Heritage of Knowledge for the Humanities," 2012).

As an aesthetic experience that is both social and emotional, Minimum Monument fosters a kind of dialogue that is still infrequent in discussions about climate change. The transformational and disquieting aesthetic of a melting humankind forces the observer, even if only for an instant, to ask the why of the installation. It is here that its ephemeral quality creates a visual image capable of confronting the ethics (or the lack of ethics) sustained by the many abstractions

of today's globalized world, including those leading to frequent inaction to engage in climate action. The installation functions as a cultural mirror, or a collective cultural reflection of ethics and values. Moreover, the melting men's success at making visible issues of temporality serves as a reminder of what Rob Nixon has called the "slow violence" of environmental change.

This is a violence that confronts the fast-paced, detached worldview perpetuated by mainstream media, with its discardable facts once their news value has been extracted. It is the violence of "disasters that are slow-moving and long in the making, anonymous, starring nobody, attritional and of indifferent interest to our image driven world" (Nixon, R. *Slow Violence and the Environmentalism of the Poor*, 2011). When overwhelming evidence of the ecological disruptions, climate change, resource depletion, and urban growth causes a devastating alarm that leaves the public's imagination with a sense of powerlessness, experiences such as that of Azevedo's art work stimulate a powerful discourse that is necessary, both consciously and subconsciously. Her installations are situated in dialogue with the environment and the community. Her aesthetic language personalizes experience of place and adds a humane dimension to the global conflict of a warming planet. She brings visibility to important issues and, while the dialogue may have a beginning and an end, the meaning that is produced lives on.

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*Maria Alessandra Woolson teaches at the University of Vermont for the College of Arts and Sciences and the Honors College, and is an affiliate of its GUND Institute for Environment. Her teaching and scholarship bring together the worldviews of science and humanities, framed by sustainability as a paradigm for interdisciplinary studies in the context of Latin America. Her research interests and publications include transcultural perspectives in Ecocriticism, the culture of water and water governance, digital humanities, and biocultural diversity as an empirical approach to the study of identity and conservation.*



Hispaniola Crowned Frog

# Writing at the End of the World

Mayra Montero's *In the Palm of Darkness* By JOHN WALDRON

**MAYRA MONTERO'S *IN THE PALM OF DARKNESS*** (*Tú, la oscuridad*, 1995) takes us on an in-depth journey that allows us to understand relationships between the crises caused by climate change and coloniality (a term coined by Aníbal Quijano to describe the hierarchies left by colonialism).

In the novel, the author deals with frog extinctions and ecological devastation but only as a backdrop to the main narrative. Montero tells the story of the herpetologist Victor Grigg, accompanied by his Haitian guide Thierry Ariene, in search of what is possibly the last specimen of the red frog or grenouille de sang. The novel is set in Haiti during the tumultuous political times when former president Jean-Bertrand Aristides was in exile and the paramilitary TonTon

Macoute fought for control over the nation through intimidation and violence. Victor is oblivious to the fact that he is in danger throughout the narrative. He feels that his status as a scientist and a Westerner will protect him from the environmental and political chaos that surrounds him. At one point, Thierry senses that a gang wants them to leave a mountain where they search for the frog. Focused on his objective, and thinking he is protected due to his status, Victor insists they stay. Thierry eventually convinces him, and as they are running down the mountain, Victor stops when he sees a journal containing his article left by the group that had destroyed his and Thierry's camp. Seeing his name in print confirms his usual sense of self-importance, but the

drug lords let him know what they think of his special status, "The most recent issue of *Froglog*, a monthly bulletin of data concerning the decline in amphibians, lay on a stone covered in a pile of shit" (45).

Thierry, on the other hand, is highly aware of all that is going on. Unlike Victor, Thierry is able to read the signs all around them because he learned about frogs from an eminent herpetologist, is a practitioner of Voodoo, and his brother is a Macoute. He is sensitive to elements that are unimportant to Victor and that form a background to their quest. The background comes to the foreground no matter how much Victor or we may wish to ignore it. In one instance Victor unwittingly witnesses a "necklacing" — a Macoute technique in which the victim



is burned to death by tying him or her to a tire and setting it on fire. Oblivious to the danger he is in, he gets hit on the head and falls down unconscious. If we choose to discount the background, as Victor does when he unwittingly observes a necklacing, then we too may end up clubbed on the head.

Montero structures her novel in the form of Russian literary critic Mikhail Bakhtin's "polyphonic" narrative. Some chapters are narrated by one or the other of the main characters, some by a cold, objective scientific voice frequently quoting from scientific journals about the extinction of frog species throughout the globe. Along with the Macoute's violence and fear tactics, the chapters about frog extinctions provide a global perspective and apocalyptic backdrop to the narrative. Like the lynched and dismembered bodies that seem to accumulate at an accelerated pace as the novel nears its end, the disembodied voice comes to haunt the reader through sheer repetition. What also creates the sense of horror with these sections is that Montero provides no clear relation between them and the events confronting Victor and Thierry that, on the surface at least, seem to be the central narrative. Victor, Thierry and the last frog are finally united in death in the last section, told by the objective voice. Readers learn that, "The bodies of the scientist and his Haitian assistant, Thierry Adrien, were never found. The last, carefully preserved specimen of the grenouille de sang was lost with them at sea" (183).

Even more unsettling perhaps than their deaths and the ecological devastation—the dismemberments, necklacing and lynching—is the fact that the novel itself is about its own failure. It is about the inability of Victor to interpret the signs given to him and to make the connections that would save his, the frog's and Thierry's life. That failure suggests the inability of narrative and art in general to imagine a way out

of what ecologist Elizabeth Kolbert calls "the sixth extinction," our own demise as a species. If narratives can sometimes help us reimagine our relations to each other and our environment, thus allowing us to create a better world, Montero's novel is about our own failure to imagine or create alternative possibilities. The reason we cannot conceive of other options is due to our own blindness caused by coloniality. Like Victor, we are entirely oblivious to our connection to the devastation all around us. Living lives of relative luxury, we may travel to a place like Haiti and ignore the problems because we think they do not affect us, that they are just part of a place, people and culture that are eternally troubled, confirming perhaps racial biases that form part of coloniality. Montero shows the relation between inequities and environmental devastation, between the background and foreground of her narrative. However, through Victor, she also shows our own failure to recognize the connections.

Although we are all suffering the effects of climate change, the results of climatic devastation are not felt equally. The slow, ineffective and racially biased response to Hurricane Katrina in New Orleans and now Maria in Puerto Rico shows how hierarchies created by colonialism create the ideological structure in which these inequities continue. Given a similar connection to coloniality and its limits, it is

thus appropriate that Montero places the novel in Haiti because, as Lisa Paravasini-Gebert argues, "the ghost of Haiti haunts the Caribbean imaginary."

Thierry, Victor and maybe even the frog could have been saved had Victor decided to pay attention to the Haitian herpetologist Emile Boukaka instead of discounting his knowledge. When Victor first meets Boukaka

he tells us that he had an image of him as a mulatto . . . less chubby and tropical than he actually was. . . he was absolutely black, intensely black, the skin on his arms gleamed as if he had been born in Africa . . . There, in the fat circle of that face, his nose, his bulging eyes, his thick half-smiling lips seemed to be dancing. (93)

As literary critic Laura Gillman observes regarding this scene, "Grigg's taxonomy is not an innocent description but rather an ideological codification of racial difference that naturalizes relations of superiority and inferiority between the colonizers and the colonized" ("Inter-American Encounters in the Travel and Migration Narratives of Mayra Montero and Cristina García: Toward a Decolonial Hemispheric Feminism." *Signs: Journal of Women in Culture and Society*. vol. 39, no. 2, 2014, 518). Victor's interaction with Boukaka is the product of the ideological framework created by coloniality, a framework founded on racism, misogyny and capitalism, which prevents him from accepting what Boukaka has to say as knowledge.

Victor's thought, limited as it is by coloniality, leads to his and Thierry's demise. Boukaka says that, "when Damballah desires it, the great flight will begin . . . The great flight has begun . . . You people invent excuses: acid rain, herbicides, deforestation. But the frogs are disappearing from places where none of that



Hurricane damage in the Caribbean affects wildlife, including frogs.

happened” (96). Victor’s response is astounding. He says, “I wondered who he meant by, ‘you people’” (96). He does not question Boukaka’s premise or his argument. It is almost as if he does not hear a word Boukaka says excepting “you people.” It is unfortunate that he did not probe the reference to Damballah in Boukaka’s warning. If the frogs are being called back to the ocean, the last thing you would want to do is get on a boat with a frog. Yet that is what Victor does, leading to his and Thierry’s death. Victor cannot consider what Boukaka says as “knowledge” because of the divide produced by coloniality that shapes the ideological limits creating Victor’s and our worldview.

Victor’s ignorance and bigotry frame all of his interactions. When he first meets his future guide, he says, “he looked too old, even sickly. . . I concluded that in the field at midnight, setting out on the difficult treks of an expedition, this man would not be of much use to me” (19). Victor then draws the frog he is looking for, and Thierry takes the pencil to correct the drawing. Victor is momentarily shaken, his worldview unsettled. He says, upon seeing the perfected drawing, “now I was the one trying to gain a few moments” (19). As Gillman argues, Thierry, “creates cracks in this ideological system” (518). The “cracks” however unsettling they might be, are not enough to transform Victor in time to save him. His demise leads to the realization that he and we must listen to the stories and knowledges of other people and integrate them into our own if the planet and we are to survive. However, Montero’s novel shows the failure of any transcultural communication limited as it is by coloniality.

Critic Marcus Embry argues that Montero’s novel rehearses the demise of transculturation—often expressed through the literary genre of magical realism—and of the novel itself. Embry contends that *In the Palm of Darkness*, “we have a novel that is remarkably flat in terms of narrative spaces to which we can assign a politics of resignification, because the narrative

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## He is incapable of seeing the interconnection between the decaying nature and the anarchic political situation surrounding him.

spaces are about extinction. There is no salvation in any death in this text, and there is no significance in death. Death opens no narrative possibilities” (“Mapping a New Literary Century in the Caribbean.” *Body Signs: The Latino/a Body in Cultural Production*, 2011, 144). Further driving the nail in the novel’s coffin, Embry connects the death in this novel with the death of magical realism as a possible imaginative tool that might create the possibility for planetary salvation.

Montero also shows how his emphasis on reason and objectivity leads to Victor’s inability to see what may be more important and eventually to his death. Victor is emblematic of the mind/body split, which is foundational to modernity, the scientific method and ultimately colonialism/coloniality. His imbrication in coloniality is evident in his dismissal of other knowledges. On the first page of the novel Victor says of Thierry, “I let him talk a while. It’s impossible to keep a man like Thierry quiet for long” (1). At the beginning of the next chapter Victor narrates, chapter three, he says, “I began taping my conversations with Thierry when I realized that between stories he was inserting important information about the frog” (18). Victor first shows his authority over Thierry’s right to speak and then separates stories to look for what he considers important while Thierry sees everything as connected. Thierry tells us, “That’s a defect of mine when people tell me something: I always keep track of the ones in the background, the ones who disappear for no reason. The forgotten ones” (12). With this statement both Thierry and Montero invite us to look at the different, perhaps forgotten narrative threads running through this novel as well as to keep track of the “forgotten ones” something that Victor might see as a “defect.” Nevertheless, as Embry points out, the novel emphasizes our failure to do so.

Thierry, the person whom Victor would rather silence, becomes the locus for a possible narrative of resignification. Contrary to the scientific vision that tries to place the rational observer standing in a superior position to the observed, Thierry is both the observed and the observer. Thierry like Boukaka is highly erudite in both herpetology as well as local knowledge. It is in the non-hierarchical intersection of these two types of understanding where narratives can be reshaped and new worlds can be imagined.

Such possibilities prove very troubling to Victor. He is incapable of seeing the interconnection between the decaying nature and the anarchic political situation surrounding him. Though he does learn quite a bit from Thierry, he does not learn enough to save his, Thierry’s and the frog’s life. Montero’s narrative becomes a warning to what happens when we forget stories because they are unsettling.

*In the Palm of Darkness* is about many things, ecological devastation, the political chaos in Haiti caused by a history of colonialism/coloniality, failed relationships, the extinction of species and the failure of magical realism among others. Ultimately it confirms what Elizabeth Kolbert argues in *The Sixth Extinction*, humans have a special proclivity for destruction even when it means they are destroying themselves. However, rather than just a journey to the apocalypse, the events allow us to become aware of the atrocities we have committed and that have led us to where we are now. New possibilities, new imaginings will make us feel unsettled. However, if we choose to ignore what unsettles us, we risk ending like Victor, a victim of our own blindness and false sense of security.

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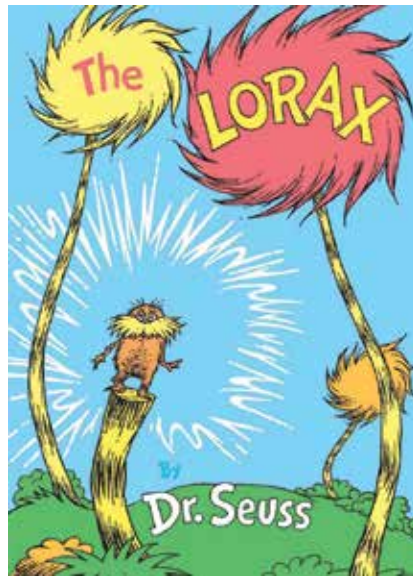
*John Waldron is an Associate Professor of Spanish at the University of Vermont.*

# Words That Matter

## Imagining Climate (and) Change By GISELA HEFFES

THOSE OF US WITH LITTLE CHILDREN OFTEN read *The Lorax* by Dr. Seuss to them at bedtime. The story points toward the past, because the Lorax is a ruin, with only residues remaining of something that once existed. The narrator character, Once-ler, tells the story of why the Lorax “was lifted away” from a land where once upon a time “the grass was still green/and the pond was still wet/and the clouds were still clean/and the song of the Swomee-Swans rang out in space...” On arriving to this “glorious place,” the first thing Once-ler saw were “the Truffula Trees,” the “bright-colored tufts of the Truffula Trees.” Motivated by greed and the relentless desire to get rich, Once-ler chopped down tree after tree to take off their tops to make “Thneeds,” despite the warnings of Lorax, a small orange figure who “speaks for the trees, for the trees have no tongues.” The rest of the story is well known: the trees are chopped down until they are gone; the “Brown Bar-baloots” leave because there’s no fruit to eat; the swans can’t sing because their throats have been contaminated by smog; the fish can’t swim in the lake and the sky turns gray from the pollution of the factories. The bright and colored space populated by Truffula Trees is transformed into a somber and inanimate wasteland. Fortunately, the story ends by telling us about a surviving seed. Perhaps one day the forest will return and, with it, all its living friends.

After reading the story again and again to my daughter Sarah and my son Nathaniel, I realized that this is not exactly a book children enjoy. On the contrary, it is a story that fills them with anxiety and uncertainty. Perhaps, if more of a distance existed between the imaginary circumstances of the story and the very real present day, children might perceive this tale as a true fiction, something



dystopic—although also open to a possible utopia—a story produced from the author’s imagination, emphasizing the “unless” of the story’s ending.

Just like Once-ler, the Portuguese historian Pero de Magalhães Gandavo was dazzled by a landscape—this time in Brazil. In 1576, he wrote about his visit: “This land is the best of all for the life of man: the air is exceptionally healthful, and the soil is extremely fertile; all that is before you is delightful and pleasing to the human eye to a great degree” (1995). A similar impression has been attributed to Alexander von Humboldt, when, in 1804, he referred to the Anáhuac Valley and Mexico City with the well-known phrase: “Traveler: you have reached *the region where the air is clearest*.” In 1917, Alfonso Reyes used this phrase as an epigraph for his book *Visión de Anáhuac (1519)*, and in 1958, Carlos Fuentes titled his first novel *La región más transparente (Where the Air Is Clear)*: “Fall with me on our moon-scar city, city scratched by sewers, crystal city of vapor and alkali frost, city witness to all we forget, city of carnivorous walls,

city of motionless pain, city of immense brevities, city of fixed sun, ashing city of slow fire, city to its neck in water, city of merry lethargy, city of twisted stinks, city rigid between air and worms, city ancient in light, old city cradled among birds of omen, city new upon sculptured dust, city in the true image of gigantic heaven, city of dark varnish and cut stone, city beneath glistening mud, city of entrails and tendons, city of the violated outrage, city of resigned market plazas, city of anxious failures, city tempested by domes, city woven by amnesias, bitch city, hungry city, sumptuous villa, leper city. Here we bide. And what are we going to do about it? Where the air is clear” (1995, 4-5). Without a doubt, the metamorphosis that this space has suffered cannot just be attributed to the changing modes of thinking and conceiving the relationship between man and the natural world, but also to the mechanisms and devices for the continual exploitation and destruction of the environment.

When Homero Aridjis, also a Mexican author, published his novel *¿En quien piensas cuando haces el amor?* in 1995, he revisited this same trope in order to put forth, in the words of one of his characters, the following itinerary: “Before returning home, wander along Gladiolas Street. There is a hill there from which one can observe the twilight over the Anáhuac Valley, a twilight made up of confused lights, dirty colors, dripping shadows and stinking odors” (34). This description demonstrates how, with the passage of time, the reference to a particular space can serve simultaneously as a symbol of environmental decomposition. We could elaborate a genealogy for this one point in space and focus on its amplifications and repercussions—rather like a kaleidoscope—although, unlike the kaleidoscope, where you once saw green,

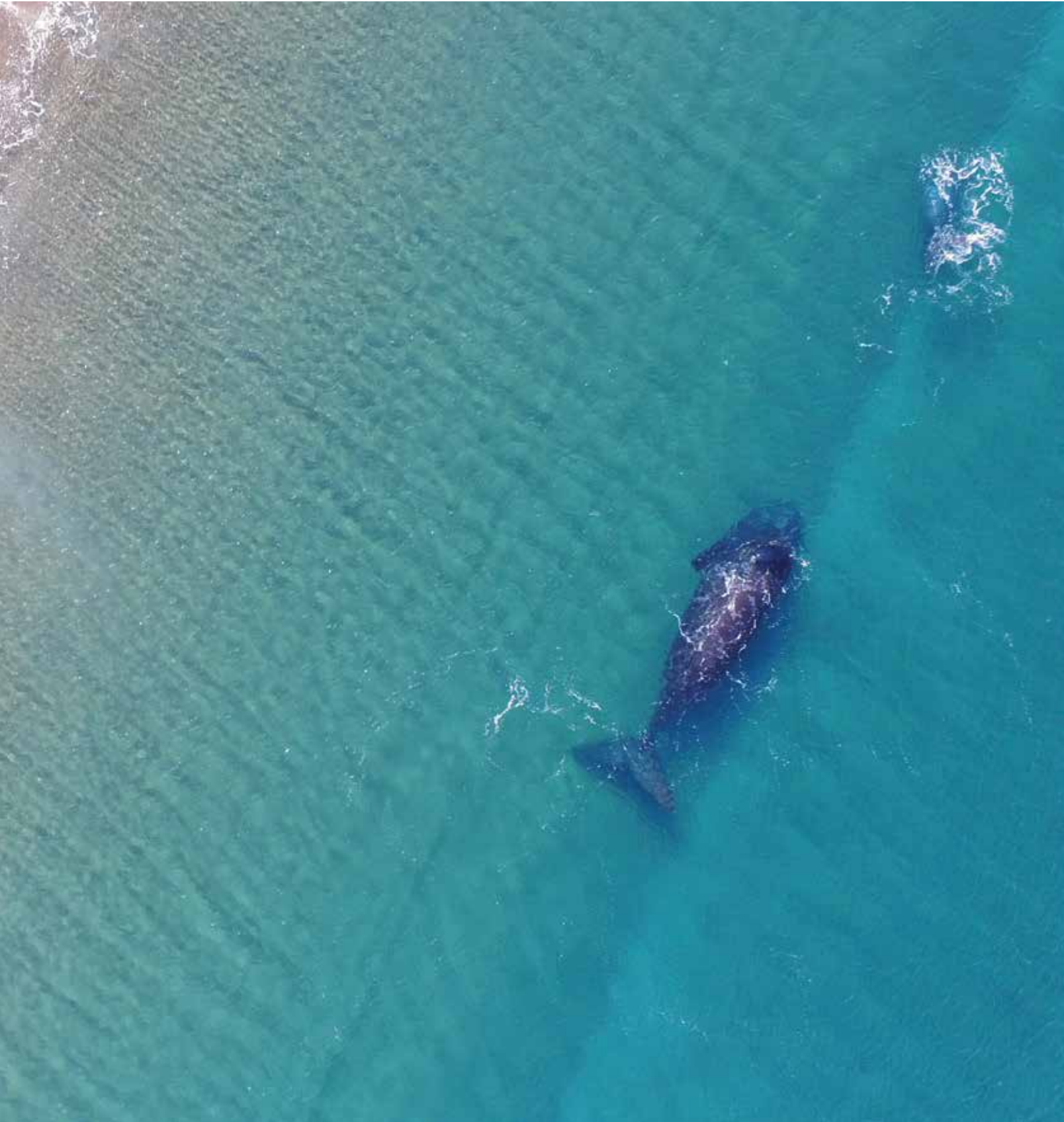
you now see brown, where you once saw forests, you now see concrete, and where you once witnessed a sustainable demographic population, you now see a demographic explosion that can hardly be sustained.

In Latin America, an enormous and varied quantity of literary and artistic works register the fragility of our ecosystems. This breakdown is happening everywhere, as global warming and climate change do not distinguish between rural or urban spaces nor among races, ethnic groups or social classes, although it's important to point out that the rich can more easily resist the impact of climate change; they live in communities less prone—but not immune—to disaster (as the recent mudslides in California illustrated). In general, the rich live along tree-lined streets in areas high enough to avoid flooding and in neighborhoods far from the contamination of factories and industrial waste.

While we lose species at a dizzying speed, while we deforest our woods, make deserts out of our fertile earth, dynamite our mountains to look for precious minerals, while we suffer from extreme drought, fires, heavy rainfall and floods, and severe snowstorms, literature takes stock of these changes and transforms them into aesthetic objects to propose ethical approaches in explicit or implicit ways. Literature in Latin America has become a sounding board for a problem that has pursued us from the very arrival of the Europeans. Namely, this very land of abundance that Magalhães Gandavo described so well is, at the same time, a land of gold: "... there is much gold in those regions, according to the signs and samples which they found, and if people properly prepared should return thither with all necessary equipment, taking with them experts in this line, they would discover in that land great mines" (182).

The natural world of the Americas, that is, the cornucopia of the "New World," is catalogued and measured, studied, examined, and analyzed in terms of its potential for exploiting its resources: the gold to get rich, the pure air to get well and live fully, the fertile earth to work and cultivate, and the natural beauty to please the eyes and senses. The promise for the future,







Climate change and environmental degradation caused by humans threatens marine mammals. Dominican photographer Eladio Fernández, who is also a conservationist, documents whale life in the region. According to the World Wildlife Foundation, climate change may affect the areas of the oceans in which whales live, including migration patterns. Climate change, depletion in the ozone layer and the related rise in UV radiation may also lead to a fall in the population of krill, a primary food source for many marine species, the organization notes.

Like Pacheco, the Chilean writer Luis Sepúlveda also narrates the massacre and extinction of the marine mammals on the other end of the continent, in the extreme south. *Mundo del fin del mundo* (1989), one of his best-known novels, refers to this catastrophe or “ecological disaster” in the “Gulf of Sorrows,” where every spring people used to watch “the mating of the pilot whales” (100-1). This magnificent spectacle, nevertheless, has ended because of the “boat factories” that sweep up the ocean, turning it into “a dark cauldron of dead waters” (101-2). The discourse of abundance and cornucopia is posed against that of scarcity and shortages. The earlier spectacle has become invalid because it does not correspond to reality.

However, not all the narratives opt for elegy. During the 19th century and—with some exceptions—until the 1950s, Latin American literature has incorporated the role of climate as protagonist, although not necessarily as climate change caused by humans. From Argentine writer Domingo F. Sarmiento’s novel *Facundo* in 1845 to *María* (1867) by Colombia’s Jorge Isaacs, *Os Sertões* (1902), by Brazilian Euclides da Cunha, *La vorágine* by Eustasio Rivera (1924), *Don Segundo Sombra* (1926) by Ricardo Güiraldes and *Doña Bárbara* (1929) by Rómulo Gallegos, among many others, all feature a ubiquitous and constant role of climate and narrate how its varied characteristics influence not only the personalities of the novels’ characters, but also the cultural and economic aspects of reality depicted in these tales. More recent climate change, however, consists of the acceleration of these effects, because it is a problem of scale: both in terms of size and frequency.

If literature captures processes in the making—*in status nasquendi*—it also moves them forward, playing a role in their formation that goes beyond mere representations. According to Antonia Mehnert, the author of *Climate Change Fictions*, culture texts not only create a narrative but also mediate and shape our own reality (3). Climate change is a phenomenon without precedent, hard to pin down and to grasp, whether because



it is a slow violence, as Princeton’s Rob Nixon defines it, or whether because it is an entity of such vast temporal and spatial dimensions—a hyperobject—that it becomes inconceivable, as Rice University’s Tim Morton theorizes. Literature, cultural texts and art examine the social and ethical implications of this unprecedented crisis, but also propose concrete interventions in the current debate about environmental policies, tackling the material risks faced by society as a whole and seeking to mold our conceptions about these changes. In short,

imagine climate (and) change. Because it is in the imagination that one also finds the key to innovate, communicate, visualize and transform: the last seed, as it were, of Dr. Seuss’ Truffula Trees. And at the end of the day it will all depend on the “unless” that is waiting for us at *The Lorax*’s conclusion.

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*Gisela Heffes is a fiction writer and an Associate Professor of Latin American Literature and Culture at Rice University.*



# Who More Cli-Fi than Us?

The Climate-Change Lessons of Andean Literature **By PATRICIA VALDERRAMA**

**WHEN I TELL PEOPLE THAT I RESEARCH CLIMATE** change and literature, they usually start asking me about novelists like Kim Stanley Robinson, Claire Vaye Watkins or Jeff VanderMeer. It makes sense. Climate fiction—or cli-fi—that depicts the earth after some kind of future weather-induced apocalypse seems like a natural starting point for a literary study of climate change. In response, I could explain that I don't work on an English-language corpus, but there are Latin American equivalents to those Anglophone bestsellers, like Edmundo Paz Soldán (*Iris*, 2014), Pedro Mairal (*El año del desierto*, 2005) and Roberta Spindler (“Sol no Coração,” 2013), to name a few. But I don't study these authors either.

The narrator of *The Brief Wondrous Life of Oscar Wao*, Yunior de las Casas, asks a question that reveals how Latin American fiction is relevant to climate change: “Who more sci-fi than us?” Colonial trauma, its aftermath and the radical shifts of the



immigrant experience all motivate Yunior's question. Because colonial genocide went hand in hand with ecocide, the devastation of ecosystems on which indigenous American ways of life relied, I like to rephrase Yunior's question to include our environmental past. So, I ask, who more cli-fi than us?

Indigenous peoples and their mixed-race (mestiz@) descendants across the two American continents and the Caribbean have lived through more than one ecological apocalypse—first in the colonial period and then in the different stages of 20th- and 21st-century industrialization. By examining the ecological histories intertwined with human ones, we open up new possibilities for the interpretation of Latin American cultures and their

literary representations in discussions about climate change. In addition to documenting a brutal history of violence against indigenous and mestiz@ peoples and ecosystems, natural-cultural histories of Latin America demonstrate how to grieve and build resilience in the face of personal, cultural and ecological loss.

By way of example, I will turn to Andean literature. The mountains themselves, a shared colonial history as part of a major Spanish viceroyalty, ongoing extractive mining operations in places like Potosí and multiple vibrant indigenous cultures unite this region as a category for academic study. One of those indigenous cultures is that of the Quechua people, or *runa*, and one *runa* story is *Montacérdos* (*Pigrider*), a novella written in Spanish and Quechua and first published in 1981 by the Peruvian author Cronwell Jara.

In Jara's novella, a young mestiza child recalls the events following the journey she undertook with her older brother,



Yococo, and their mother, Griselda, from an unknown location in the Andes to a fictional shantytown outside of a major Peruvian city, based on the Rímac district in Lima. *Montaceros* begins when Yococo, Griselda and Maruja arrive at the outskirts of the city and assemble their home made of cardboard and rags. As Maruja puts it, in the forbearing tone that characterizes her voice, “Traíamos nuestra casa en hombros” (We were carrying our house on our shoulders). The residents of the neighborhood, also recent arrivals to the metropolis, shun Maruja and her family because of their poverty, extreme even for the shantytown, and because migration to Lima occurred over the course of decades, which created hierarchies of belonging even among the disenfranchised squatters.

Eventually, a woman named Doña Juana invites them to live in a corner of her adobe house, where the protagonists fare better for a short time. Then Juana’s husband repeatedly rapes Griselda while her nephew plays sadistic games with Yococo and forces Maruja to watch. Yococo dies after being trampled by the hooves of policemen’s horses and, shortly afterwards, Griselda dies after miscarrying the fetus that was the product of rape. The novella concludes with Maruja’s expulsion from Juana’s house, because she is coughing up blood, and Maruja ends up living alone on the street.

That this would be an apocalyptic experience for any child is only partially the point. It is equally important that children like Maruja regularly live through this kind of tragedy. How they do it renders their stories especially meaningful within the context of climate change, because what we are losing now—homes, forests, entire species, ways of life—portends a vaster series of losses in the future. The story of this migrant mestiza child holds lessons for how to acknowledge loss and get on with living.

*Montaceros* could be summarized—equally accurately—as a novella about the family’s loving and tender friendship with a large-eared pig named Celedunio. In this alternative summary, Yococo encounters an underfed pig who nuzzles him out

of curiosity. They immediately become friends and play around the neighborhood together until, one day, a starving Griselda threatens to eat Celedunio. He and Yococo run away, only returning after Griselda accepts Celedunio as her child and promises never to threaten him again. From then on, Celedunio accompanies the family, especially Yococo, as they pull pranks, play music and eke out a living.

This alternative interpretative focus underscores that resilience can be built on interspecies kinship. In placing a pig in the position that traditionally belongs to canine companions, Jara points out the way Peruvian society equates poor Quechua-speaking mestiz@s with trash and simultaneously repudiates that racist colonial inheritance by imbuing the interspecies kinship with tremendously moving affect and vitality. This authorial choice not only denounces racial, economic, cultural, linguistic and gendered injustice and oppression, but also suggests that joy and endurance can be found in unexpected places. Because of Celedunio, the family lives happier than they otherwise would, and, because of the family, Celedunio does too. That this relationship does not save Yococo or Griselda from their deaths does not diminish its power to bring happiness and love into their lives as they struggle through rending poverty. Indeed, after other children see Yococo riding on Celedunio around the neighborhood, they begin to ride pigs too. (Wonderfully, Jara himself engaged in this activity as a boy.) Pig-riding is the hobby that eventually gives the town and the novella their name. In the end, the interspecies alliance is the primary way in which the family makes their presence felt in a city that otherwise devalues and brutalizes them.

Jara knows much of the maltreatment and happiness that are parts of daily life in Lima’s peripheries. Born in 1950 in Piura, a northwestern province of Peru, like his characters, Jara moved to Rímac with his family at the age of five and grew up speaking Spanish and Quechua. He recalls witnessing child abuse, murder, gang rape, the premature deaths of teenagers and adults due to preventable or easily

cured diseases, suicide, drug trafficking, alcoholism, the effects of protracted hunger and exposure during his childhood and adolescence—all among moments of solidarity, ordinary chores and play.

In moving to Lima, Jara and his family were participating in a demographic shift that reshaped Peruvian society in the second half of the 20th century, whose cascading effects the author would later portray in much of his fiction. Although in *Montaceros* the migration itself takes place off-page, as it were, it is the reason Maruja and her family find themselves in an urban setting, and the causes and conditions of Peru’s mass migration impact every facet of the family’s experience once they arrive.

The seminal work on Peru’s demographic upheaval, José Matos Mar’s *Desborde popular (Popular Flood)*, identifies the country’s colonial legacy as a significant underlying basis of the mass migration of mostly indigenous and mestiz@ Peruvians from rural Amazonian and Andean regions to coastal cities. The economic policies implemented by the military dictatorship of President Manuel A. Odría (1948-1956) concentrated the economic and political capital generated by industrialization along the coast, the historical site of colonial power. Staying in the Andes, meanwhile, often entailed laboring under a centuries-old servitude on land that always belonged to someone else. Matos Mar links these conditions to the internal domination of the urban-coastal-criollo over the rural-Andean-indigenous that the colonial regime—and, later, the new republic—imposed.

Economic and racist policies, along with governmental neglect, were not the only factors that influenced the outcome of Peru’s internal migration, however. Nature does not vanish at city limits, in spite of the common tendency to associate it with the rural. An earthquake in 1940 demolished much of the available housing in Lima, creating a large number of homeless families and a housing shortage just as migration from the provinces began. Those displaced Lima residents and recent migrants found their housing options together dictated as much by ecology as by the market. Families



Caption: Pigs forage in Playa Rimac, Callao, Lima (above, 1999-2000; below, 1980s)



like Jara's and Maruja's could find room to settle primarily on the city's outskirts, which were uninhabited precisely because they were not environmentally suitable for construction or agriculture. In contrast, the long-settled regions of Lima are built on a literal oasis. The economic and emotional precariousness of Maruja's childhood extends down to the sandy, arid soil where her family tries to build a home. Ecology, industrialization and colonial legacies mutually determine each other in the natural-cultural history of Peru's internal migration and the world Jara imagines in *Montaceros*.

The economic forces that sparked Peru's rural-to-urban demographic shift and the environmental forces that directed the resulting urban sprawl also have direct parallels with the way climate change

is currently changing societies around the world. Simply put, climate change means more humans will be temporary or permanent migrants. According to a 2015 report published by the International Displacement Monitoring Centre and the Norwegian Refugee Council (IDMC-NRC), between 2008 and 2014 "an average of 26.4 million people have been displaced from their homes each year by disasters brought on by natural hazards—equivalent to one person displaced each second. [...] 17.5 million people were displaced by disasters brought on by weather-related hazards in 2014" alone, sometimes permanently. Additionally, the probability of being impacted by an environmental disaster has been growing over the past 40 years. The IDMC-NRC report links this increased probability to higher levels of exposure and vulnerability, which have, in turn, been driven by the exponential rate and unplanned form of urban population growth in cities like Lima.

The fact that displacement of an economic kind often instigated this worldwide rural exodus and concomitant unplanned urban growth adds a note of bitter irony, for climate change only compounds the spatial, social and economic marginalization of urban inhabitants like Jara's characters, in countries developing or otherwise. For these reasons, the effects of unplanned urbanization so carefully

depicted in *Montaceros* and actually lived by Jara cannot be clearly separated from climate-related displacement. The causes and consequences of economic and environmental displacement have merged so thoroughly over the past decades as to become nearly indistinguishable, leading both environmental philosophers and advocacy groups to begin to question the utility of the distinction.

When I read *Montaceros*, I keep the contemporary blurriness of these categories in mind. Embracing that blurriness allows me to see Maruja's, Yococo's and Griselda's migration and marginalization as inseparable from biophysical and geological processes, like earthquakes and soil quality, rather than viewing them as exclusively human phenomena cut off from natural history. It also allows me to see the stories of these slums as part of the story of climate change: why it manifests itself the way it does, who it disproportionately impacts and why, and why it is happening in the first place. The history of coloniality, industrialization and the environment overlap and converge in a way that allows Jara's tale of a migrant mestiz@ family in mid-century Peru, moving due to economic forces far beyond their control or possible realm of agency, to read as a parable for our current experience of climate change. What a novella like *Montaceros* offers is an alternative, one option among many that we will need, for how to endure with precarious multispecies joy during the struggles and migrations to come.

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**Patricia Valderrama** is a Ph.D.

Candidate in Comparative Literature at Stanford University. She researches 20th-century German, French and Latin American literatures and philosophies with a focus on representations of humans' interactions with the more-than-human world, also known as nature. After completing her Ph.D., she hopes to share the solution-oriented storytelling she has developed to help build more sustainable societies. She is happiest when she is in the forest, and can otherwise be reached at [patricia.i.valderrama@gmail.com](mailto:patricia.i.valderrama@gmail.com).

# CLIMATE CONSEQUENCES

GLACIERS, FLOODS AND PRETTY PARROTS



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# Understanding Global Climate Change from Andean Glaciers

## Perspectives from Ecuador and Bolivia

By JAI C. BEEMAN AND JEAN CARLOS RUIZ HERNÁNDEZ

**IN THE SUMMER OF 2007, A SMALL GLACIER** disappeared north of La Paz, Bolivia.

At 17,000 feet above sea level, the small mountain Chacaltaya is a mere foothill of its giant, glaciated brothers Huayna Potosi and Illimani. Accessible by taxi on a dirt road from the city of El Alto, its small glacier had been used as a marked ski run long ago.

The Chacaltaya glacier became a local symbol of changing climate: a mountain stripped of its ice by temperatures rising at unprecedented rates as we emit greenhouse gases into the atmosphere. And similar changes are happening across the Andes.

Here, we tell two stories, from the perspective of scientists training to understand glaciers and how they change in response to climate. The first, from Ecuador, is a look into why, and more importantly, how we study glaciers and their responses to modern climate change. The second, from Bolivia, takes a journey from the Altiplano, up a glacial valley, and into the past.

*Jean Carlos Ruiz Hernández, Ecuador*

Glaciers are like animals: they move, change, grunt and are always angry, notes Bear Grylls in his popular TV series *Man vs. Wild*. This colorful description captures why we feel so attracted to these colossi, and why some of us spend our lives exploring and studying them.

People tend to have questions for glaciologists. Some of the most common: how long will we have glaciers? What will be the socioeconomic impact of changes in freshwater availability for populations that depend, in part, on the water stored in glaciers?

The responses to these questions are not so simple. For a glacier to survive, it needs to receive at least the same mass in precipitation that it loses by melt. When melt dominates, the glacier begins to recede. As a result of anthropogenic global warming, the interior tropical Andes are experiencing an increase in temperature and higher precipitation variability. Glaciers in this part of the world are retreating as a result.

Tropical glaciers are highly sensitive to temperature changes, even on the hourly scale. In the tropical Andes, small streams can form as the sun warms the front of a glacier in the morning, only to disappear at night. Over longer periods of time, they testify to oceano-atmospheric phenomena, like the El Niño Southern Oscillation, itself well referenced in popular culture. In El Niño years in Ecuador, snow amounts are reduced and temperature increases, an ideal combination for glacier mass loss. La Niña years, on the other hand, tend to induce small losses or even slight increases in mass.

The Antisana massif, a colossus rising to 19,000 feet above sea level, is home to the most observed glacier in Ecuador. Located 25 miles outside of the capital, Quito, its ice cap covers around seven square miles, just a bit less than the land area of Cambridge, Massachusetts (for our Boston-area *ReVista* readers). In the Antisana massif, a complex network of water catchments has been installed, which supplies some of the water to the 2.5 million inhabitants of Quito.

Quito counts on glacial sources for five to ten percent of the city's water supply and will suffer less from glacier retreat than a city like La Paz, for example, where

glaciers provide up to 30 percent of the dry season water source.

These conclusions are obtained through long campaigns of observation and measurement. We make regular trips to the Antisana massif and other mountains to place instruments: meteorological stations, weirs to measure streamflow, stakes and pits to measure glacier mass. We add information from satellites that allow us to estimate precipitation, snow cover and topography. In Ecuador, public and private institutions together with international cooperation allow us to continue this work.

Antisana is a laboratory for glaciologists, ecologists, biologists and hydrologists. Here, numerous Ecuadoran and international students have trained at the undergraduate and postgraduate levels. And from Antisana, we will be able to answer the urgent questions about how mountain water systems will respond to the climate change that we are exposed to. It's in our hands to generate and study the data to provide the answers.

*Jai Chowdhry Beeman, United States*

The changes on Antisana in Ecuador and the disappearance of the Chacaltaya glacier in Bolivia are part of a much longer story. Earth's changing orbit and climate, through glaciers, have left their traces in the mountains.

I was introduced to this record of changes during the year that I worked as an intern at the Instituto de Hidráulica e Hidrología/Institut de Recherche pour le Développement in La Paz. For a couple days every two weeks or so, I would travel with other technicians and students, both from Bolivia and abroad, to the glaciers



Engineer Marco Solis transports material (above) and checks accumulation (below).



in the Charquini and Huayna Potosi massifs to download meteorological data and measure glacier mass. Usually, I was drawn to parts of the mountains further afield for the weekends as well to explore.

Leaving El Alto, on the edge of the Altiplano, we would head towards the Cordillera Real. The foothills of the cordillera are cut by wide, u-shaped valleys, where streams connect the high mountains to the altiplano.

These u-shaped valleys during the last glaciation were filled with ice. During the glaciation, responding to lower solar radiation amounts, ice sheets had formed over much of North America and northern Europe. Smaller caps covered high mountain regions as well: huge glaciers carved out the valleys that now surround the Alps, the Himalayas and the Andes. Rises known as terminal moraines,

formed by debris forced downslope by flowing ice, cross the outlets of these valleys and mark the past extent of these glaciers.

The road out of El Alto crosses a terminal moraine to enter the Milluni Valley on its way to the Huayna Potosi and Charquini massifs. Using cosmogenic isotopes, whose concentrations vary slowly over time, Smith et al. (2005, *Science*) date these moraines to between 34,000 and 23,000 years old. During this period, huge glaciers would have loomed over the plateau where El Alto now reigns.

After 23,000 years ago, the glaciers began to retreat. And this age is probably not a coincidence. Earth's orbit constantly undergoes change. Around 24,000 years ago, the Earth began to receive more sunlight. As temperatures rose, the massive glaciers that had spread out of the Andes would likely have begun to lose ice. Their fronts would have melted more rapidly than they could be replenished by ice flowing down from the mountains.

The changes in the amount of solar radiation associated with glaciations and deglaciations, though, are small, and the climate system does not respond quickly to these changes. Rather, feedbacks in the climate system: greenhouse gases, which re-emit radiation in the form of heat, and ice loss at the polar caps, which increases the amount of radiation the Earth system can retain, for example, can accelerate warming over thousands of years. Then, mechanisms in the ocean and the atmosphere, like the ENSO variations that determine each year's variations on Antisana, transport this heat across the globe.

These mechanisms are likely responsible for variations as the glaciers retreated to higher altitudes. Jomelli et al (2014, *Nature*) indicate that another advance likely occurred here around 14,500 years ago, during the period known as the Antarctic Cold Reversal. The glacier advance during this period in the Andes coincided, remarkably, with lower temperatures recorded in archives across the Southern Hemisphere and a pause in the deglacial CO<sub>2</sub> increase.

Moving up into the mountains, a much more recent sequence of terminal moraines, dated by Rabatel et al. (2008, *Quaternary Research*) to the 17th to 19th centuries, crosses the increasingly narrow, steep valleys. These moraines testify to a more recent period of glacial advance, known as the Little Ice Age.

At the end of the road winding up Milluni valley, we arrive at a parking lot. Here, there is a refuge for mountaineers and a seismic station. Continuing along a path, we arrive at the tongue of Zongo glacier.

This current position of Zongo glacier, which has retreated significantly even over the last few decades, is indicative of a new period of climate, called the Anthropocene: the epoch of pronounced human influence. The story is well known: the Industrial Revolution introduced greenhouse gas emissions into the climate system, provoking rising temperatures and a corresponding change in weather patterns. Chacaltaya's south-facing glacier that may have once been a tributary of the ice field flowing to the Altiplano, would vanish. Its neighbor Charquini Sur, one of the glaciers I would visit every two weeks, loses mass from almost all of its surface most years.

These modern changes are reflective of changes in climate that are rapid and complex. But we have a reference with which to understand how they will proceed. In paleoclimate archives across the globe, we have a record, albeit an imperfect one, of a true-scale experiment in climate change. These archives range from moraines; ice cores like that recently drilled on Illimani, Bolivia's highest peak, by the IceMemory project; tree rings; lake and ocean sediments; speleothems; and many others, each recording different components of Earth's climate. The climate changes that occurred during the past, like those that caused glaciers to retreat above La Paz, might be indicative of what we should expect for the future.

The continued development of a network of paleoclimate records in the Andes will be imperative for this century, as we attempt to understand how climate

will change and how we might adapt. These records allow us to constrain the behavior of climate mechanisms in the past. In turn, we can attempt to understand how these mechanisms will operate under changing climate in the future.

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**Jai Chowdhry Beeman** is a Ph.D. candidate at the Université Grenoble Alpes, where his most recent work is on the last deglaciation as recorded in Antarctic ice cores. He worked as a publications intern for ReVista during his time as an undergraduate at Harvard. His time at ReVista took him to Bolivia and the glaciers of the high Andes.

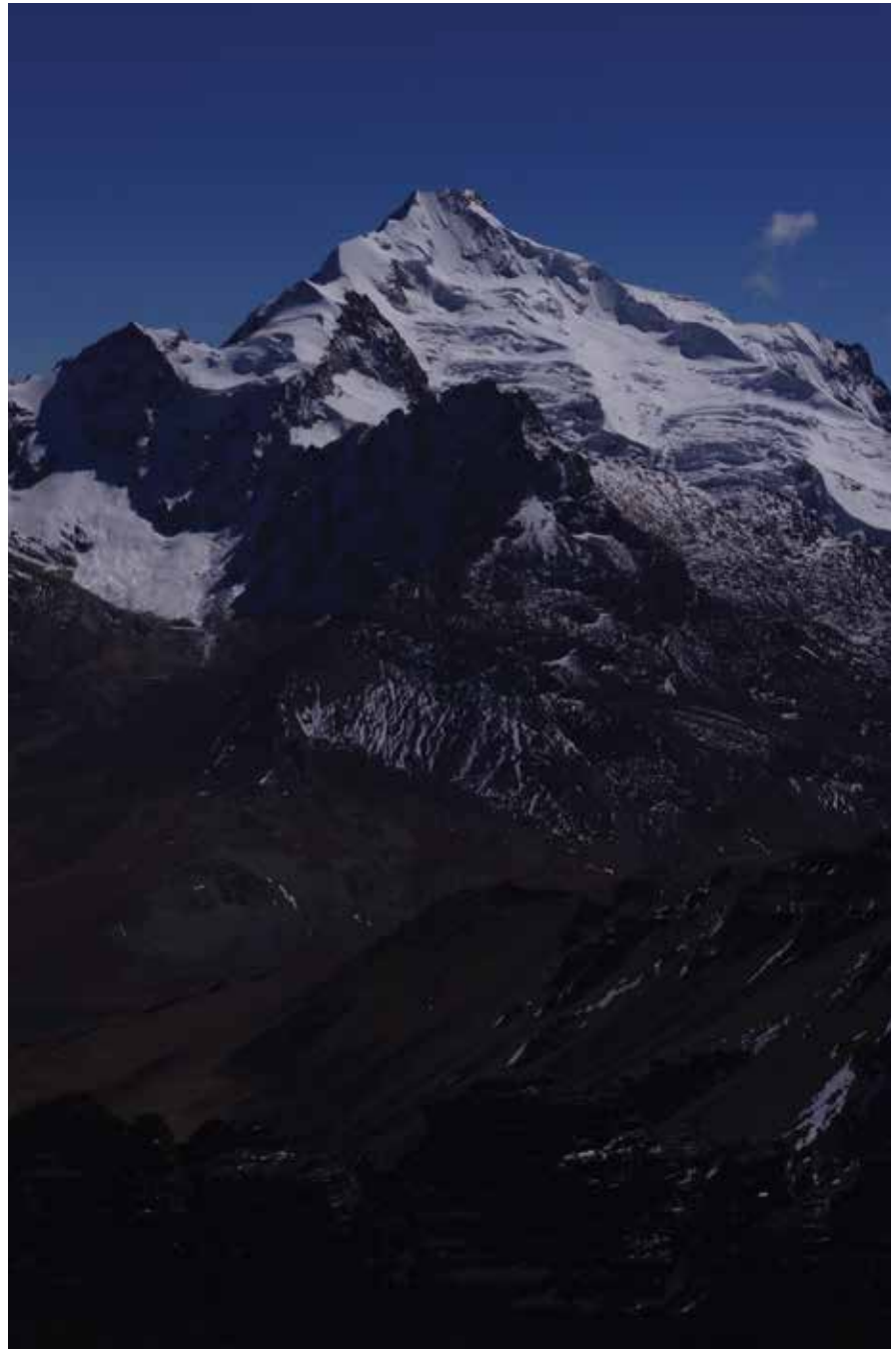
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**Jean C. Ruiz Hernández** is an Assistant Professor of Physics at the Transportation Management career of the Chimborazo Polytechnic School in Riobamba-Ecuador. His research work focuses on the impacts of climate variability on partial glacierized catchments and water management. He will begin a Ph.D. at the Université Pierre et Marie Curie this spring.



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**Quito counts on glacial sources for five to ten percent of the city's water supply and will suffer less from glacier retreat than a city like La Paz, for example, where glaciers provide up to 30 percent of the dry season water source.**



Engineer Marco Solís, taking samples of solid precipitation 5300 msnm, left. The glaciated south face of Huayna Potosi, Cordillera Real, Bolivia, right.

# The Parrots of the Caribbean

Facing the Uncertainties of Climate Change By LISA PARAVISINI-GEBERT

I ASK YOU, FOR A FEW MOMENTS, TO IMAGINE A Caribbean region where you can suddenly be rendered breathless by the sight of a flock of a thousand *Amazona* parrots flying overhead, darkening the skies like a gaily colored, deafeningly squaking eclipse of joy. Columbus, sailing past the Bahamas, described such flocks of parrots “obscuring the sun.”

The dazzling display—unimaginable today—occasionally met European explorers sailing between Vieques and Puerto Rico before the ecological revolution unleashed by colonization pushed most Caribbean parrots and macaws onto their slow but inexorable path towards extinction. Climate change—manifested through warming trends, decline in food availability and the intensification of extreme weather events, as we saw through the devastation caused by Hurricanes Irma and Maria in September 2017—may signal the end of parrot species that have lived in the region for millions of years, long before human inhabitants were recorded in the area. The threat to parrot populations posed by tropical storms has deepened due to changes in the climate caused by increased levels of carbon dioxide in the atmosphere from the burning of fossil fuels. Parrot extinctions have taken place throughout the Caribbean region, where there only remain 14 of as many as 20-25 species recorded in the first centuries after the European encounter.

At the time of Columbus’ encounter with the “Indies,” there were twenty-some parrots species in the Caribbean. They belonged to the *psittacine* subfamily of birds, as did the region’s macaws, about eight or nine endemic species of the *Ara* genus, now all extinct. Together, they took center stage in his account of the first encounter with the native peoples of the region, as one of the salient items



Puerto Rican parrot (*Amazona vittata*), critically endangered.

offered in this historic first exchange. As Columbus describes it in the diary of his first voyage, “they came swimming to the ship’s boats, where we were, and brought us parrots and cotton threads in balls, and spears and many other things, and we exchanged for them other things, such as small glass beads and hawks’ bells, which we gave to them.” Native Caribbean peoples were known to have kept and traded live parrots and macaws, but this familiar gesture of exchange was going to forever change the scale of such trades, endangering numerous species in the process.

*Amazona* parrots and *Ara* macaw specimens were exhibited at the royal court in Barcelona as Columbus, upon his return from his first voyage, presented a procession of naked Native Americans adorned with gold and bearing multicolored parrots. A year later, upon Columbus’s return from his second voyage, masses of Sevillians rushed to the docks to watch a Palm Sunday parade of Indians in gold masks carrying New World parrots and macaws. Specimens

of various *psittacidae* were given away to European kings as tokens of Spain’s feat of discovery. From the earliest moments of the colonization process these *psittacidae* specimens became emblems of a wondrous spectacle that embodied the marvels of the newly discovered Caribbean territories, lands of exotic abundance and green tropical forests vibrant with sparkling parrots glimpsed as flashes of red, emerald and turquoise.

The parrots’ symbolic and very public display before the old world marked, ironically, the beginning of processes that would lead to most of them being now extinct or listed by the International Union for the Conservation of Nature as extremely threatened or endangered—some of them among the most endangered birds in the world. The steady decline of the Caribbean’s *Amazona* and *Ara* populations can be measured from the first century of the colonization process, caused by rapid deforestation to open millions of acres for agriculture (including sugar production), cattle raising, widespread logging, introduction

of exotic plants and animals (among them parrot predators), and poaching to supply birds for Europe's growing exotic-pet market. Island bird species, given their particular vulnerability to anthropogenic extinction (extinctions caused directly by humans), represent roughly 90 percent of bird extinctions since European colonizers targeted islands as prime possessions. Most of the birds currently on the world's endangered list, not surprisingly, live on islands, and many of them belong to the Caribbean's psittacidae family, whose need for reasonably large expanses of forest made them particularly vulnerable to the type of ecological revolution that European colonizers brought to the region. Their vulnerability has led some experts to conclude that they are "doomed in the wild."

The impact of climate change on Caribbean avian populations can be measured already through changes in population distribution, increased temperatures on breeding grounds and changes in rainfall that affect patterns of migration for wintering birds. But by far the greatest menace comes from the increases in hurricane intensity—frequency, size, duration, levels of rainfall, and wind speeds—that scientists expect as global temperatures shift upwards—and which have been linked to the loss of life and extensive damage to nature and property throughout the Caribbean in the wake of Category 5 Hurricanes Irma and Maria in 2017.

Parrot species are especially vulnerable to hurricane damage because they are dependent on forests and their thick vegetation for food and protection from predators. Direct hurricane hits on their habitats can bring species to the verge of extinction. As storms strip their forest habitats bare, surviving the hurricane itself is only the first step in survival, as they must then struggle in deeply compromised environments with limited food supplies, often competing with predators for food and shelter. This was the case with the damage inflicted by Hurricane David (1979) on the island of Dominica, when the populations of

the island's two endemic parrots, the Sisserou (*Amazona imperialis*) and the Jaco (*Amazona arausiaca* or red-necked parrot), already endangered, saw their numbers reduced to catastrophically low levels. Their condition prompted the forestry service to engage in a highly successful project to increase the number of specimens and bring the species out of the IUCN's endangered list.

Puerto Rico's own endemic species (*Amazona vittata*), with a population of about 2000 in the 1930s, had sustained an ongoing population decline that reduced it to 47 parrots by 1975. The impact of Hurricane Hugo (1989), brought that number down to a critically endangered low of 22 birds, a number impacted negatively again in 1998 by Hurricane George. Before the rainforest at El Yunque, the last stronghold of the relict wild population of Puerto Rican parrots, sustained a direct hit from Hurricane Maria in September 2017, the number of individuals had been reduced to thirteen. Tom White, chief biologist of the U.S. Fish and Wildlife Service's Puerto Rican Parrot Recovery Program, expressed his deep concern in a 2016 conversation. He feared that the fragile remaining population, a tiny group "on life support," "could not survive another hurricane."

Sadly, the endemic parrot populations of Puerto Rico and Dominica were the hardest hit by Hurricanes Irma and Maria. The impact of the hurricanes on the two islands best known for their assertive efforts to conserve their parrot species illustrates the extreme vulnerability of threatened and endangered parrot populations to expected climate change. In an interview in July 2017, Steve Durand of Dominica's Forestry, Wildlife and Parks Division, cautioned that despite the Sisserou and Jaco's slow but steady recovery—which had made it possible for the two species to reach numbers close to five times their pre-Hurricane David population (250-350 for the Sisserou, 1,200-1,500 for the Jaco)—climate change, with its potential for intensive hurricanes, reminded us that "the species' future was far from secure."



Jaco (*Amazona arausiaca*)

The Sisserou, the largest of the Caribbean's *Amazona* parrots—a remarkably beautiful bird whose distinctive colors (purple head and underpants, dark maroon wing-speculum and red carpal edge) justify its "imperial" name—sustained heavy losses following the obliteration of its mountain canopy habitat by Hurricane Maria. Shy and elusive at the best of times, the bird had not been sighted for nearly six weeks following the hurricane despite television and radio appeals to the population, and it was feared that the species had been driven to extinction by the storm. On November 8, Durand confirmed the first sighting of a single individual south of the capital, Roseau, away from its usual habitat, where it had been driven in search of food. Other sightings have followed, but these have not been numerous, and we await an official count by the Forestry Office to determine the extent of the surviving population and gauge the steps needed to aid its recovery. It is a disheartening predicament for a group of dedicated forestry officers who have been working on the saving of the species for close to four decades, since the launching of "Project Sisserou," a national effort to



acquire the large parcel of privately-owned land to consolidate the parrot's habitat, the expansion of environmental awareness programs, the support of scientific studies aimed at the preservation of the "shy and secretive" Sisserou and the more abundant "noisy and gregarious" Jaco (Dominica's "second" parrot). The Jaco, always more numerous than the Sisserou, has been recorded in healthy numbers since Hurricane Maria, and there are no present fears for its survival, although it remains on the IUCN's "threatened" list.

The survival status of the Puerto Rican parrot in the face of hurricanes and climate change is complex—as there are two distinct populations—and fraught with colonial entanglements and cultural dislocations. The Puerto Rican parrot—a vibrant green, 12-inch tall bird, with blue-feathered primary wings, a characteristic red stripe over the beak and striking white-ringed eyes—is listed by the IUCN as one of the ten most vulnerable birds in the world. Two subspecies of the Puerto Rican parrot have already gone extinct, including the *Amazona vittata gracilipes*, which disappeared from its range in Culebra, off Puerto Rico's eastern coast, in the late 1890s, a victim of deforestation, hunting, and San Ciriaco, a devastating August 1899 hurricane that holds the record as the longest-lived Atlantic hurricane in history. Before Hurricane Maria struck, the 13 parrots left in the extant wild population lived in a range of a little over six square miles, 0.2 percent of its pre-colonial range, an area increasingly encroached by tourism and vacation homes. These developments had not only restricted the wild population to its smallest range and lowest numbers ever, but have increased the presence of its natural predators, particularly of the *guaragao* hawk (the red-tailed hawk or *Buteo jamaicensis*), pushed away from its habitat by continued construction of hotels and shopping malls into the parrots' range.

The area of El Yunque where this extant wild population struggled is in a "national" forest under federal protection and supported by federal funds since

it belongs to the U.S. National Park Service. The irony of the island's extant wild parrot population living in an U.S.-controlled habitat was not lost on Puerto Rican ecologists, who in the early 1990s demanded (and received, after tense negotiations), half of the captive population (around eighty birds born and raised in captivity) to set up a new breeding aviary in Río Abajo—the José L. Vivaldi Aviary—on a "state" forest controlled by the Puerto Rican forestry commission. This aviary, where Puerto Rican scientists have continued to breed parrots in close cooperation with the U.S. Fish and Wildlife team at El Yunque, is in the island's karst area, a once densely populated area with numerous small agricultural holdings abandoned in the 1940s. This allowed the secondary forest to recover to become the largest contiguously forested area on the island, harboring the richest biodiversity, with more than 1,300 species of flora and fauna, among them the native and endemic species that include thirty federally listed as threatened or endangered.

The Río Abajo aviary began an enormously successful captive parrot release program in 2004. When Hurricanes Irma and Maria swept through Puerto Rico, some 140 released Puerto Rican parrots were living and (most importantly) breeding in the wild in the new recovered forests of the northwest. They fared relatively well after Hurricane Maria, despite significant damage to the forest, with a survival rate of about 73 percent. This new population, born and bred in captivity, is creating its own "culture" and language without access to the extant wild population in El Yunque, the only population that knows the characteristic vocalizations that marked the "culture" of the Puerto Rican parrot at the time when the species began to be studied by scientists. It is the threatened repository of acquired, not genetic, vocalizations and behaviors on the verge of extinction.

The wild population in El Yunque did not fare well in the wake of Hurricanes Irma and Maria, both of which hit

their precarious habitat. Realizing the precarious situation of the extant wild population under their care, White and his forestry team were planning the capture and re-release in the karst region of one of their wild breeding pairs, hoping that they could breed again in their new habitat and teach their own young about vocalizations about to go extinct, thereby preserving a cultural component of the parrots' development in the wild that can go extinct even if the species survives genetically. They were praying for time, enough perhaps to gradually move the remaining wild population to the new habitat, perhaps to join the small flocks of Puerto Rican parrots that can now be seen again over the Puerto Rican forest.

It was not meant to be. The wild flock of parrots at El Yunque—the relict wild population and a flock of released captive-bred individuals—has not been located in its former range. It has been either scattered or decimated. Twenty-two recently-released parrots at El Yunque wore radio transmitters; the seventeen that have been recovered were from dead birds. A dwindling hope rests with the five missing transmitters that they have survived and the next breeding season will bring them back home, with the handful of wild birds that have been seen or heard in the recovering forest, and with the captive population that survived the storm under special protection in the aviary. White has not dwelled on the disillusionment and frustration, but in every interview speaks of his hope.

White keeps the faith. His resistance to the possible loss of the remaining parrots is an act of defiance, an effort to preserve what remains of the sacred in their natural habitats, in their contributions to biodiversity, their specific roles in island ecologies, their quirks and idiosyncrasies, their particular beauty, their capacity to make us marvel.

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**Lisa Paravisini-Gebert**, the 2016-17 Wilbur Marvin Visiting Scholar at DRCLAS, is a Professor of Caribbean culture and literature in the Department of Hispanic Studies at Vassar College.



# Resilience and Resistance in the Peruvian Deserts

A PHOTOESSAY BY ARI CARAMANICA

**JUST A FEW DECADES AFTER FRANCISCO** Pizarro conquered Peru and the Inca Empire, a natural disaster struck the Peruvian coast, threatening to put an end to the colonial project. Locals described putrefied farmland, locusts and the destruction of entire settlements caused by massive El Niño floods. El Niño Southern Oscillation (ENSO) is a climatic phenomenon that arises due to changes in normal sea surface temperatures and winds over the Pacific Ocean. As a result, El Niño brings heavy rains to the

otherwise desert coast of Peru, causing floods and related effects: plagues, disease, water and food shortages. While the first written records describing these events are dated to the colonial period, El Niño flooding has been occurring on the coasts of Peru and Ecuador since the beginning of the Holocene. Today, climate change has led to a change in the pattern of events: El Niños are more frequent, unpredictable and intense.

February 2017 witnessed just this kind of El Niño: the El Niño costero.

This event went undetected by both the U.S. and Peruvian climate monitoring institutions until it was too late—it was the most destructive event in recent memory, leading to 158 flood-related deaths, 1,372,260 people displaced, and 3.124 billion dollars in damage.

These massive events push the limits of the modern state; however, the prehistoric cultures of Peru not only survived, but flourished for almost five times as long, until the Conquest in 1532. This past summer, my team and I decided to explore



**Opposite page: Arid desert lands on Peru's southern coast have been affected by flooding due to El Niño costero (b); Top of page: the team looks over a cornfield affected by the floods; bottom left: the team uses remote sensing techniques and paleobotanical analysis to reconstruct agricultural landscapes from pre-hispanic coastal Peru (a); bottom right: blooming flowers in the desert; next page: a view of the desert.**



the ancient landscapes of the remote Peruvian deserts to ask how prehispanic societies managed El Niño without the help of modern-day technology.

In normal years, the Pampa de Mocan—characterized by active dune fields and wind-eroded surfaces—receives less than half an inch of precipitation each year. And although this environment is inhospitable to any kind of life, we found densely concentrated archaeological remains, including a vast ancient irrigation

system. The system included both opportunistic features, such as check-dams to divert or capture floodwaters dating to around 900 BC, and man-made, large-scale infrastructure, such as aqueducts and irrigation canals dating to 1100 AD. It was only after the 2017 El Niño costero that we came to understand how large-scale and long-term agriculture could take place in this desert: El Niño floodwaters turned the Pampa de Mocan into a veritable oasis.

Thanks to drone photography, we can

compare images of the Pampa de Mocan in 2016 (a) and in 2017, after the El Niño costero (b). With a team of Peruvian biologists and support from the David Rockefeller Center for Latin American Studies (DRCLAS), I set out to collect and record the plant growth across the Pampa de Mocan. We recorded more than 45 plant species, approximately 70 percent of which bloomed thanks to the 2017 El Niño event.

The El Niño-related plants included wild tomatoes, flowering herbs, gourds



and legumes, along with sturdy shrubs and young trees such as Capparis (also known as sapote or caper bush) and Prosopis (the mesquite or carob tree in the United States).

Incredibly, while the floodwaters caused widespread destruction to the modern-day farmland, local farmers used the ancient agricultural landscape in their backyards as an emergency resource. An aqueduct dating to around 1100 AD acted as a dam during the 2017 floods, protecting the nearby town but also forming a reservoir. As the waters receded, moisture and rich sediments were left behind. There, in these hidden pockets of soils just behind the aqueduct, modern farmers tapped the near-surface moisture to plant corn, beans and squash. The ancient agricultural remains provided a refuge for today's opportunistic farmers

and helped to defray crop loss in the aftermath of disaster.

The Pampa de Mocan archaeological evidence and the response of plant life in this desert to the 2017 El Niño suggests that ancient agriculturalists practiced a fundamentally different kind of disaster-response strategy than what is used today. Prehispanic societies were flexible and willing to adapt to the opportunities presented by El Niño flooding, and some modern-day farmers continue that tradition. One of the lessons of the El Niño Costero is that resilience to major climatic events is in practice today and can be traced back to prehistory. Future management of flood events might include the strategic use of otherwise marginal areas of the coastal landscape—places such as the Pampa de Mocan, which, although it has already returned

to its desert state, is waiting for the next opportunity to bloom.

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*Ari Caramanica is a Ph.D. candidate in the Harvard Anthropology Department. Her research focuses on the sociopolitical impacts of borderland occupation and the reconstruction of agricultural landscapes of pre-hispanic coastal Peru using remote sensing techniques and paleobotanical analysis. She is currently a Dumbarton Oaks William R. Tyler Fellow. She received a DRCLAS grant to travel to Peru.*

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*Collaborators: Universidad Peruana Cayetano Heredia Laboratorio de Palinología y Paleobotánica, Claudia R. Morales, Fiorella Villanueva, Roxana Tornero, Prof. Luis Huaman Mesia, and Dr. Luis Jaime Castillo Butters.*

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# Extreme Hydraulic Urbanism

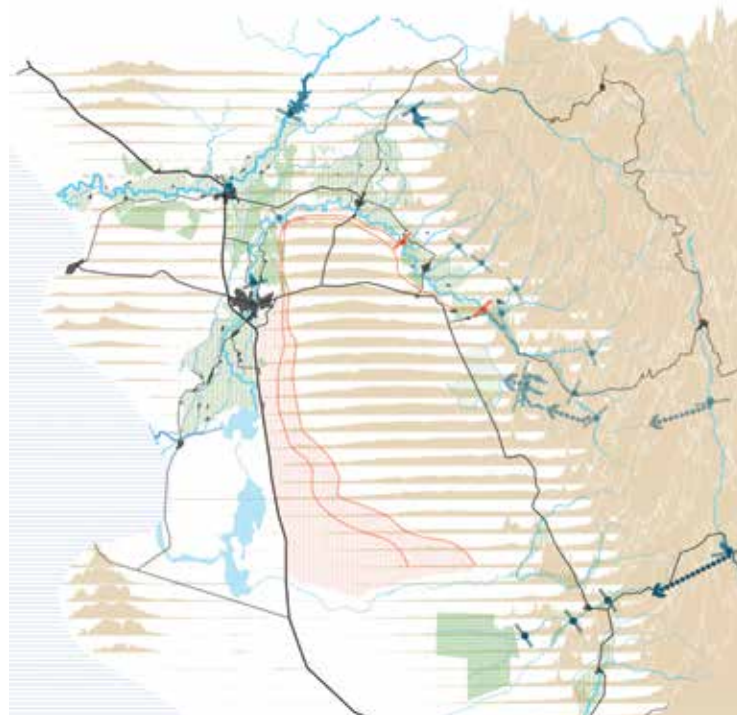
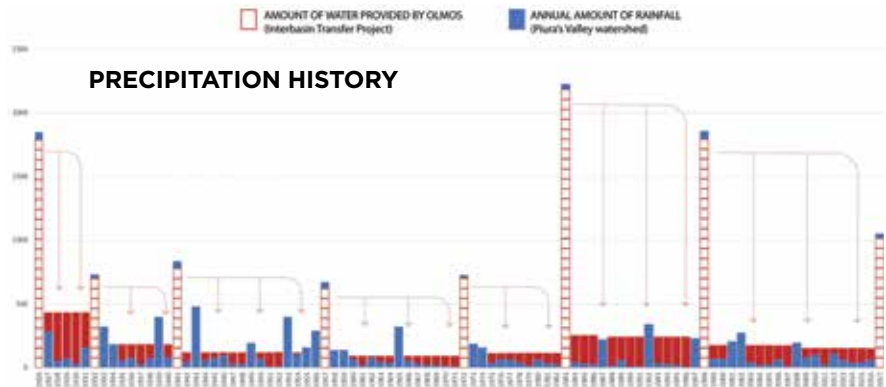
Reframing Water Management on the Peruvian Coast By GUSTAVO DIAZ PAZ

**GROWING UP ON PERU'S COAST, WE ARE ALWAYS** told as children that we don't have enough water and that we shouldn't waste it. But we also learn to get used to disasters, especially El Niño, which brings large amounts of water that cause floods and arrive every decade—at least once in the early life of every Peruvian child. And one out of two Peruvians live on its extensive coast, which has a desert climate. Scarcity and overabundance of water exist for us at the same time.

Most of our coastal regions bring water from the Andean valleys or the Amazon basin for agriculture and urban consumption by using costly infrastructure. But should we consider the possibility that our public policies to manage water and prevent disasters are ill-fitted to our territory's requirements?

Certainly, in Peru, a postcolonial country, our concepts of urbanism and management of territory derive from the legacy of the western approach which was inevitably influenced by the western territory. In terms of water and weather, western patterns of seasons and rainfalls periods are very different. Peru and other nations within the tropics do not have four seasons or periods of stable rainfall.

The ancient societies in Peru, as well as the other greatest ancient societies in the world, had to adapt to their territory. Historian Karl Wittfogel asserts that effective management of water was a key to the flourishing of the greatest societies in the ancient world, what he called Hydraulic Societies—civilizations in Egypt, China, India, Mexico, Mesopotamia and Peru. These societies experienced different weather conditions from those of colonizing nations. Many factors influenced these so-called hydraulic societies such as their tropical location and/or ENSO (El Niño South Oscillation). El Niño, for example,



**Map and precipitation history of Piura's territory contrasting the potential of rainfall's storage capacity of El Niño cycles and government's current or future projects of flood defense and interbasin transfer.**

is one of the greatest influencers in the weather of the Pacific Ocean basin, as well as conditions in Western Africa (drought periods) and India (monsoons), which make up a large area of the world. ENSO causes their weather variations so that it can produce a diverse intensity of either droughts or floods in the same place in different years. Our territories do not have extreme changing scenarios, but our

scenarios are extreme; our nature is the constant change.

Presumably, ancient societies considered their weather conditions normal, not unstable, and events like monsoons or El Niño were not considered disturbances or disasters but part of their territorial cycle. They knew how to deal with their local assets and limitations. They faced droughts by taking

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## The objective is to propose an alternative plan that could not only increase water availability and result in benefits to the regional economy, but also accomplish flood defense necessities through a project that would be more economically efficient and ecologically sustainable.

advantage of sustainable measures such as aquifers, creating filtration galleries or qanats in Jordan or Peruvian desert civilizations; they dealt with floods by creating agricultural patterns of ridged fields in Colombian valleys; they developed agriculture with dynamics that anticipated weather extremes such as floating agriculture in Bangladesh or chinampas in Mexico. They dealt with shifting rainfall scenarios by creating storage devices which would be useful in dry years such as dams and percolation grounds coupled with wells; the best examples are the stepwells and dams in India. Could you imagine how a territory conquered by Aztecs or Mesopotamians in Europe would have looked? What would the management of territory have been like? Water bodies filled with chinampas and rivers' flood plains converted into ridged fields.

The western approach embedded many mismatches of water management in our territories because the colonizers had base concepts informed by a different context. Harvard professor of economy and history David Landes asserted, "Tropical areas generally average enough rainfall, but the timing is often irregular and unpredictable, the downpours are anything but gentle. The averages mean nothing when one goes from one extreme to the other, from one year or one day to the next." Yet most of the decision-makers in our regions based their policies on the average annual rainfall, as was the western approach. Instead, we ought to break down the annual historical precipitation to look for opportunities and manage our limitations. We must reframe our mindsets about our territories. What if our

mindset realizes our extreme conditions are normal? Then, what would be done? What are the opportunities and the mismatches?

My ongoing thesis seeks to reframe the approach to the water in Piura's valley, the most damaged Peruvian region in the 2017 El Niño. The National Government proposed a flood protection plan which focuses on short-term solutions: taking out new sediments from the river channel that would quickly divert the river flow to the sea. This sounds paradoxical in an arid area needing to increase water availability, throwing away blue gold to the sea. In the next severe El Niño, Piura's river will continue to carry large amounts of sediments, raising the bed of the river channel and increasing flood vulnerabilities again.

On the other hand, Piura is also struggling with expanding its agricultural frontier since the current capacity is not enough. The Peruvian government has sought to increase the productive land area interbasin transfer projects, such as Olmos Irrigation Project, which brings water from the Amazon basin by a tunnel that cuts across the Andes, the Olmos project provides 20,000 jobs and 100,000 acres for agriculture; however, this type of project is highly expensive and takes long time. Here is again the paradox of current strategies: dealing with the abundance and scarcity of water.

By understanding the local dynamics of precipitation in Piura's watershed through history, my thesis project envisions a proposal that tackle at the same time flood protection and water supply. Given the extremely variable amount of annual rainfall, many questions arise: What

would have happened if we would have stored all the drops in wet years? Can we use as much water to avoid interbasin transfer projects that are costly and ecologically harmful? Can the collection of rainfall be useful for flood protection? Water storage is the key to finding answers to all these questions. Ancient societies deployed an array of systems by managing superficial water (dams) and aquifers (which are considered "naturally built dams").

My thesis uses as a point of reference the new amount of water supply to be produced by the Olmos Interbasin Transfer project, as well as its cost implications. The objective is to propose an alternative plan that could not only increase water availability and result in benefits to the regional economy, but also accomplish flood defense necessities through a project that would be more economically efficient and ecologically sustainable. In addition, it would help to restore the water cycle by the aquifers recharge which will help to recover the local forest whose keystone species such as the Algarrobo tree depend on groundwater. The water infrastructure, such as the percolation basins or ponds, also could be used as temporary agriculture or floating agriculture by villagers, depending on the shift between dry or wet years, as ancient societies did.

Due to climate change, contemporary challenges seem more complicated; dry years or arid regions will be drier and wet years or rainy regions will be wetter. Peruvian coast must face these new contexts appropriately, based on a real understanding of its territory dynamics.

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*Gustavo Diaz Paz is a Master in Urban Design candidate at the Harvard Graduate School of Design. He graduated as an architect from Pontificia Universidad Católica del Perú. His research focuses on water in the interplay of Urbanism, Landscape and Ecology; he has been researching mostly in territories of extreme water dynamics such as India, the Middle East, California and Peru.*



Landscape of Huánuco Valley at height of dry season.

# Climate Change and Food

## Challenges and Opportunities in Tropical Mountains and Agrobiodiversity Hotspots

By **KARL S. ZIMMERER, ANDREW D. JONES, STEF DE HAAN, HILARY CREED-KANASHIRO, MILUSKA CARRASCO, KRISTY MESA, MILKA TELLO, FRANKLIN PLASENCIA AMAYA, GISELA CRUZ GARCÍA AND RAMZI TUBBEH**

**THE RAINS HAD JUST BEGUN IN HUÁNUCO** IN central Peru when we arrived in early February 2016. This time of year is usually midway through the roughly six-month rainy season that stretches from October to May. Instead, the unseasonal heat and months of drought that year were a shock to people in Huánuco—and to us.

Only a week or two earlier, we were told, the landscape of the Huánuco valley had resembled the drab brown of the height of the dry season. We had just begun a project focused on biodiversity (agrobiodiversity) in the food landscapes of indigenous small landholders, as well as on their dietary patterns amid dynamic changes in the

environment and society. We're a diverse team of faculty, scientists, field practitioners and students from multiple institutions. In Peru, we're headquartered at the Instituto de Investigación Nutricional (IIN) in Lima. In Huánuco, we've been able to build on the superb work of local, national and international organizations that include



**Team of faculty, scientists, field practitioners and students comes from multiple institutions.**

agrobiodiversity experts such as Milka Tello and her colleagues and students at the Universidad Nacional Hermilio Valdizán de Huánuco (UNHEVAL). Other members of our team are associated with the International Center for Tropical Agriculture (CIAT) and the Universities of Michigan, Pennsylvania State and Birmingham

Bridging the Andes and the Amazon, Huánuco is widely recognized as a global agrobiodiversity hotspot. This designation means that Huánuco farming and food systems are distinguished by exceptional concentrations of agrobiodiversity currently endangered. This risk emanates from such forces as agricultural, cultural and socioeconomic changes. The double meaning of “hotspot” quickly acquired a third dimension owing to the climate change impacts felt in Huánuco. It is not only the climate that is changing. Closely related to environmental changes are loss of resources and livelihoods, poverty and development changes that often work to undermine the production and consumption of agrobiodiversity.

The mile-deep trench of the Río Huallaga and its tributaries in Huánuco, like many of the major valleys of the Andes Mountains, have quite unusual

environments and unique biodiversity. Although locals are accustomed to the extreme seasonality of weather, this variability has increased. Drought and heat in the Andes often coincide with the El Niño-driven warming of the Pacific Ocean with heavy rains and floods in the coastal lowlands. This time, however, an extended drought was already underway in Huánuco and other Andean regions before the ocean events of the past year.

In 2017, El Niño Costero (coastal El Niño) triggered catastrophic floods in Peru and Ecuador, a continuation of the strong El Niño effect from the two previous years. Global-scale climate change driven by the greenhouse gas emissions of industrial countries has continued to increase the strength and frequency of these events. The Costero demonstrated the regional warming of the Pacific Ocean off the western coast of South America.

Elevated temperatures also accelerated the melting of mountain glaciers. Peru’s glaciers have shrunk by more than forty percent in past decades. Though less publicized, the extremes of droughts, warming and hailstorms have worsened in Huánuco and the major valleys of the Andes from Colombia and Venezuela to

northern Argentina and Chile. Both the people and diverse environments of the Andean valleys have become another leading edge of global climate change impacts.

The major impact of these climate changes falls on the indigenous people, the majority of Huánuco’s population, who produce and consume the highest levels of agrobiodiversity. In the Andes region of Huánuco, most speak the Quechua language intermixed with Spanish. These indigenous people range from agriculturalists residing in rural areas to their family members and migrant counterparts who live as first- and second-generation urbanites. Their role as consumers of agrobiodiversity remains crucial, though food consumption is changing in the Andes with profound consequences for health.

Food and nutritional insecurity are widespread among indigenous people in the Andean countries. Climate change compounds the vulnerability of these indigenous people, especially in drought-prone valley environments such as Huánuco. Rain-fed agriculture in the Andes has also become increasingly prone to out-of-season extreme weather events such as hail and frost (for example the widespread frost of 2007). Mountain and hill areas more generally, which extend widely in Latin America and the Caribbean as well as Asia and Africa, once functioned as indigenous “regions of refuge” though they have become subject to major impacts and spatial integration involving national and global forces.

#### **PRELIMINARY RESULTS OF THE HUÁNUCO AGROBIODIVERSITY-NUTRITION-HEALTH PROJECT (2016-2017)**

Agriculture and food production are greatly affected by climate change. Meanwhile, the individual and the community can use food choice as a pivotal way to exert influence on the environment. To the indigenous small landholders of Huánuco, these climate interactions run directly through their myriad foodways. These foodways are



culturally distinctive, nutritionally vital and always evolving. The use of cultivated, semi-wild and wild foods depends on such factors as skills and knowledge, typically wielded by women. Women's access to resources is therefore critically important.

For the sake of brevity we focus on a few foods that illustrate the interactions with climate change. One is *tocosh*



(spelled *toqush* in the Quechua of Huánuco). It is prepared most often through the anaerobic (without oxygen) fermentation of the local potato landrace known as *walas*, resulting in a favorite low-cost food valued for nutrition, medicinal use and flavor. Quite odorous and resembling aged cheese, *tocosh* is fermented from six to eighteen months. Another food experiencing the effects of climate change is Andean maize. In Huánuco the most important maize-based foods are a hominy-style preparation known as *mote* and kernels parched as *kancha*. Both *tocosh* and maize, easy to include in various food preparations and to transport, can be readily made into flours that contribute to food security. Such foods—popular throughout Huánuco—are central to the issues of agrobiodiversity, nutrition, health and climate change.

Preliminary results of our project make use of surveys of 600 households

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**Top: *Tocosh* (spelled *toqush* in the Quechua) of Huánuco Middle: Such foods—popular throughout Huánuco—are central to the issues of agrobiodiversity, nutrition, health and climate change. Bottom: Maize-based foods are a hominy-style preparation known as *mote* and kernels parched as *kancha*.**



of indigenous small landholders and additional in-depth interviews completed with 37 individuals and households. Most of those interviewed gave us detailed examples of climate change effects on food and agriculture. One example is the preparation of *tocosh*, which is typically undertaken outdoors and requires water at various stages. Several interviewees mentioned how *tocosh*-making is threatened because of diminishing water supplies due to climate change.

Andean maize also offers a number of important examples. Today the production and consumption of distinct Andean maize is very important in mountain valleys from Colombia and Venezuela to points as far south as Argentina and Chile. Huánuco small landholders are recognized as producing and consuming the greatest biodiversity of Andean maize in Peru, which at the national level is second only to Mexico in the diversity of this crop.

Maize foods grown as staples in local diets and nutrition are complemented by the widespread growing and consumption of beans. The suite of cultivated legumes includes Andean common beans, Andean lupines, broad or fava beans, and peas. More than half of the people surveyed in Huánuco cultivated maize in fields with beans and other crops in addition to gathered wild foods. One person remarked that the rich, multi-species biodiversity of a maize field typically resembles a garden.

Certain types of Andean maize are well-suited to the flexible scheduling of planting and harvest that is vital to farmers facing climate change. For this purpose, they select among the local varieties of Andean maize (also known as landraces) that can mature more quickly. The highly varied maturation period makes it far easier to resist the effects of climate change.

Huánuco farmers rely especially on the category of maize landraces known as *wansa* that better withstands heat and drought. Defined as the group of maize landraces best suited for the preparation of *mote* (mentioned above), *wansa* maize



is made up of prominent types such as *morocho*. In short, the farmers' food-based classification of the *wansa* category of Andean maize also guides adaptive capacity in the context of climate change.

Andean maize is also well-suited to another of the major adjustments farmers make to climate change, namely upslope movement. This shift is particularly promising for maize. The interviewees described the idea to move their fields of maize upslope by 250-400 meters of elevation as the result of climate shifts. By contrast, they are being forced to reduce the production of Andean potatoes and tuber crops since the area suitable for planting them at high elevation is shrinking.

As the Huánuco farmers consider moving their fields, they choose among a category of maize landraces known as *gapia*, which has the adaptive capacity for upslope movement. The culinary category of *gapia*, which they define as the maize

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**In sum, these preliminary results demonstrate how the production and consumption of biodiverse foods among Huánuco's indigenous small landholders show both adaptive capacity and vulnerability in relation to climate change and food and nutritional security.**

types suitable for the preparation of parched *kancha* (mentioned above), is comprised of locally valuable landraces such as *chuspillu*. This use of *gapia* maize therefore offers another prominent example whereby the food-based classification of Andean maize offers information that is important to farmers in considering potential adaptations to climate change.

But the vulnerable conditions of Huánuco's indigenous smallholders may eclipse such adaptive capacities. For

now, fewer than half of those interviewed have actually moved their fields of maize upslope. Reasons vary, from lacking access to upslope fields to broader decisions to curtail parts of their agriculture and engage further in non- and off-farm activities. One key interviewee detailed how she and her neighbors had lost access to their upslope fields because of the government's misguided land reform.

Meanwhile in the hotter, lower elevations of maize-growing some farmers have experienced water shortages caused

by climate-change impacts on their important community-wide management of irrigation. In sum, these preliminary results demonstrate how the production and consumption of biodiverse foods among Huánuco's indigenous small landholders show both adaptive capacity and vulnerability in relation to climate change and food and nutritional security.

Unfortunately, this vulnerability is compounded further by the expanding consumption of low-cost, industrially produced food. Such items include rice, wheat noodles, cooking oil and sugar including sugar-containing beverages and low-cost industrialized snack foods. These food choices are driven by ready availability and the rapid changes of livelihoods and lifestyles, as well as poverty.

Preferences for food that is perceived as more "modern" and part of mainstream, national cultural and racial identities also play important roles. The consequences include high rates of food and nutrition insecurity among the indigenous small landholders of Huánuco. Nearly one half of those surveyed in our research had experienced food insecurity while a similar number noted the inadequacy of diversity in their diets. These trends are in sharp contrast to the culinary glamor and cultural celebration of Andean foods in the capital of Lima and elsewhere.

The local decline of agrobiodiversity is being exacerbated by Peru's national policies and several international policies. Although too complicated a theme for this short article, examples extend well beyond the Peruvian agrarian reform mentioned above. The conditional cash transfer program in Peru known as *Juntos*, for example, offers assistance to mothers in conditions of poverty. It does not, however, provide nutritional advice or education that would be culturally appropriate and include locally available fresh foods. Meanwhile the climate change adaptation and risk-alleviation projects favored by the international community have often favored the import of low-quality industrial foods rather than the strengthening of local food systems.

## SUPPORT INSTITUTIONS AND WHAT NEXT?

In light of the challenges described above, several organizations are committed to strengthening the adaptive capacity and resilience of the livelihoods of indigenous people in contexts of climate change. These include government and international agencies as well as non-governmental organizations. Since the beginning of our work, we've been mindful that our project depends on large numbers of extraordinary institutions, collaborators, colleagues and related work undertaken in Peru and elsewhere. These influences include both our current networks and the various outstanding legacies of diverse specialists, both in Huánuco in particular and also more widely.

Many of their climate-related initiatives focus on physical and social infrastructure for improved water resource management. Our research results demonstrate the urgent need for agriculture and food systems to become foundations of these climate projects. Vulnerability and resilience, in addition to adaptive capacity, needs to be addressed. Without such integration, attempts to address climate change may reinforce the trends of food and nutrition insecurity.

Our project is utilizing these research results to offer specific insights and practical, forward-looking solutions integrated across the fields of agrobiodiversity, nutrition and public health. We're committed to creating insights that will be operational in the context of dynamic environmental, sociocultural, and economic circumstances.

In sum, the agrobiodiversity of indigenous smallholders is diminishing in Huánuco at a time when it is most needed. This need is vital for addressing the goals of food and nutritional security in addition to sustainability, not only in Huánuco, but more broadly in Peru and globally. The farmers and workers in food systems with whom we collaborate are showing us that global climate change, in addition to the shifts of urbanization, migration and markets, can potentially be compatible with the use of

agrobiodiversity in their food systems.

But other powerful forces are undermining these goals. In particular, the expansion of cheap food in industrial food systems poses a serious risk. These intersecting challenges have become a major juggernaut confronting the prospect of a sustainable future.

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**Karl Zimmerer**, the 2016 DRCLAS Custer Visiting Scholar, is a professor in the department of geography and the department of agricultural economics, sociology, and education at Pennsylvania State University, where he also directs the GEOSyntheSES lab (<https://zimmerer-geosyntheses.psu.edu/>). Zimmerer's recent publications include "Agrobiodiversity and A Sustainable Food Future" (Nature Plants, 2017, with Stef de Haan) and "Territorial Ordering: A new mode of land use planning for urban-rural integration and next-generation conservation" in *The Urban and the Territorial: Housing in Mérida (2017) edited by Diane E. Davis and her colleagues at the Harvard Graduate School of Design*.

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**Andrew Jones** is with the School of Public Health at the University of Michigan.

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**Stef de Haan and Gisela Cruz García** are with the International Center for Tropical Agriculture (CIAT).

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**Hilary Creed-Kanashiro, Miluska Carrasco and Krysty Mesa** are at the *Investigación Nutricional in Lima*, where **Franklin Plasencia Amaya** is a consultant.

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**Milka Tello** is a faculty member in agricultural sciences at the *Universidad Nacional Hermilio Valdizan de Huánuco (UNHEVAL)*.

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**Ramzi Tubbeh** is a Peruvian Ph.D. student at Pennsylvania State University.

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1. Protester carries a child-sized coffin made of paper in a 2016 demonstration in Bogotá's Plaza de Bolívar protesting the deaths of Wayuu children.

# Climate Change and Resource Pressures

A PHOTOESSAY BY NICOLÓ FILIPPO ROSSO

**DROUGHTS IN ALREADY DRY PLACES** are lasting longer because of climate change and human intervention, but sometimes it's hard to distinguish where climate change leaves off and human exploitation of natural resources begins. A case in point is La Guajira in northernmost Colombia, one of the country's most remote and impoverished regions, home to more than 270,000 indigenous Wayuu.

There, longer droughts have meant that the streams feeding the aquifers and wells supplying water to the community got drier than usual, making any kind of meaningful farming impossible. Because of the lack of water, the region's goat population is dwindling; the Wayuu are running out of their main source of food. "[D]roughts can have different causes depending on the area of the world and other natural factors, [and] the majority

of scientists have started to link more intense droughts to climate change," observes the Washington D.C.-based Climate Reality Project on its website. "That's because as more greenhouse gas emissions are released into the air, causing air temperatures to increase, more moisture evaporates from land and lakes, rivers, and other bodies of water. Warmer temperatures also increase evaporation in plant soils, which affects



The captions are from top to bottom and left to right.

**2.** Francia Epiayu, 19, is pregnant for the third time. One of her children died from malnutrition associated with lack of food and clean water. Francia became blind while pregnant.

**3.** People fill tanks with water from a water truck. Fucai Foundation, a Bogotá-based NGO, brings water daily to more than 32 communities around the municipality of Manaure.

**4.** Patilla Coal Pit- Cerrejon coal mine. The 330-foot deep pit allows the extraction of 400,000 tons of coal every month. Daily explosions damage the structure of neighboring houses, and respiratory diseases are common among local residents. Several cases have been brought against the company, which denies responsibility.

**5.** A bottle of Old Parr whiskey, filled with the traditional Chirrinchi brew, made from fermented sugar, lies on a tomb in a Wayuu cemetery in La Guajira.

6. Community members access water through a windmill built during the Rojas Pinilla dictatorship in the '50s.

7. A young girl Arijuna (not Wayuu, in Wayuunaiki) at Manaure hospital. Malnutrition and respiratory diseases affect many in La Guajira.

8. At the grave of a two-year-old who died from sudden fever. Epidemics of fever have increased among Wayuu children since the rain started to fall again after four years of severe drought.



plant life and can reduce rainfall even more.”

The survival of the Wayuus—Colombia’s largest indigenous group—is increasingly at risk. Climate change’s effects are complicated by the fact that La Guajira is also home to one of the world’s largest open-pit coal mines, Cerrejón, a conglomerate owned by BHP Billington, Glencore and AngloAmerican.

The Cerrejón coal mine broke ground in La Guajira in the 1980s and has since become the world’s tenth largest.

Cerrejón’s huge drilling operations, daily explosions and high demand of water—which taxes a desert region already suffering from droughts—have contributed to the degradation of La Guajira’s environment and the indigenous population’s way of life.

There was, however, hope for change. Initial plans for the construction of the El Cercado dam in 2011 included provisions to service nine municipalities in the department. But the pipes that should have brought water to the region were never connected to anything, as a consequence of unchecked corruption. Instead, water from the Ranchería River—the Wayuu’s main source of



9. A woman sits beside her son at Manaure Hospital. Wayuu women often walk hours through the desert to reach the closest hospital, and when they arrive, they often find that the doctors do not speak their language. 10. A woman walks home with a tank of water. People access water from rudimentary wells with water that is often not potable. 11. A Wayuu woman with her child at hospital of Manaure.



12. Women cook a goat at the funeral of Maricela Uriana Epiayu, 22, who died of malnutrition in August 2016. She was mother of two sons under the age of five. 13. A woman cooks soup in 2016. According to the Wayuu and their advocates, there is no longer enough water for the subsistence crops that once supplemented their poor diets. 14. A Wayuu woman stands in Bogotá's Plaza de Bolívar in 2016 during a demonstration to protest the deaths of Wayuu children. She dresses in a black vest as a sign of mourning.



water—was funneled to the mine and nearby farmers.

Today, the community's sources of water are rudimentary wells often located a several hours' walk from where the families have settled. Years of drought mean the Wayuu must dig deep to find water, and even then it is often undrinkable, causing many to fall ill.

Tracking the number of Wayuu casualties is nearly impossible, as the community does not keep an official count of births or deaths. The lack of hard data makes it difficult to judge the scale of the problem and draw international attention to the humanitarian crisis. The Cerrejón mine is a deadly resource conflict that threatens the survival of the Wayuu, an indigenous

people exposed to extreme poverty, thirst and environmental degradation. Telling their story can contribute to a deeper discussion about the humanitarian consequences of cheap fossil fuel and its true costs in the context of climate change.

*Nicoló Filippo Rosso is an Italian photographer based in Colombia.*



# PUBLIC SPACES, LOCAL SOLUTIONS



Trail steps in the Melimoyu reserve, developed by Patagonia Sur in Chile

Pablo Allard [The Green Leap Forward](#) • Krister Andersson and Patricio Valdivieso [Why Local Governments Matter](#) • Manuel Perló Cohen and Loreta Castro Reguera Mancera [Design With Water](#)



Tsunami shelter and overlook, designed and built by Samuel Bravo and Armando Montero in the Melimoyu reserve.  
PHOTO: ARMANDO MONTERO.

# The Green Leap Forward

## Chile's Innovative Shift in Conservation

By PABLO ALLARD

**CHILEAN ARCHITECT CAZÚ ZEGERS ONCE** stated, “The landscape is for Latin America what the cathedrals are for Europe.” The cultural power of territory has evaded every intention to dominate it for centuries. The Spanish conquerors unsuccessfully tried to impose the grid system mandated in the Law of the Indies, an operating system for territorial domination. And nowadays conventional urban planning has abdicated in the face of the spontaneous adaptation to the landscape of informal slums and architecture in all our cities.

With nearly 4,000 miles of coastline and expanding over more than 2,500 miles along the Andes mountain range, Chile features magnificent basins, fjords and glaciers, vast temperate evergreen rainforests, Patagonian grasslands and forests with some of the highest levels of biodiversity and endemism, as well as the driest desert on the planet and some of the most productive agricultural land in the continent. The Global 200 Initiative, promoted by the World Wildlife Fund (WWF) together with the World Bank, has classified some of these ecosystems such as the Valdivian forest among the priority conservation sites worldwide.

In this context, the Chilean economy is strongly based on the extraction and exploitation of bulk copper, wood cellulose, salmon and fish powder, agricultural produce and most recently lithium. These highly intensive extractive activities produce environmental and social impacts at a regional, even planetary, scale that are challenging the country's development model. The massive wildfires suffered during the Chilean summer of 2017 were in part fueled by massive monocultures of pines and eucalyptus, but also exacerbated by

the deliberate action of radical groups reclaiming land taken from indigenous communities. On the other side of the country, in the arid zones of the Atacama Desert, large-scale mining operations are also challenging traditional villagers over the use of scarce water resources. These tensions have led to unprecedented political conflicts such as the resignation of two ministers from President Michelle Bachelet's economic team in August 2017 because of the president's decision to stop a 2.5 billion-dollar investment for a mining project near one of the main marine sanctuaries of Chile. In a territory stressed by the dynamics of massive extractive economies and the public's awareness of its unique potential for conservation, Chileans begin to internalize the long-term commitments of such dilemmas.

In this context, the emergence of territorial and environmental conservation initiatives in Chile assumes great relevance. So far in the 21st century, the Chilean state has managed to establish national strategies for land conservation and biodiversity, with the ratification of the Convention on Biological Diversity and the approval of the Native Forest Act in 2008. Despite the lack of an appropriate legal framework, groups of philanthropists, individuals, corporations and foundations, as well as NGOs, have been leading initiatives parallel to governmental efforts to create a broad spectrum of private protected areas. This interest in the generation of natural, human and financial capital to generate a structure that allows the protection in perpetuity of private lands—particularly in areas of high environmental value—has been accompanied by remarkable innovations, both in legal and territorial planning areas.

The first efforts to promote private conservation came from wealthy philanthropists such as Douglas Tompkins, founder of the clothing brands The North Face and Esprit, who invested nearly 300 million dollars in the purchase of more than 1.5 million acres of land in the Chilean Patagonia, or even wealthy locals like Chilean President Sebastián Piñera who bought 291,500 acres of native forest on the island of Chiloe in 2004 to create the Tantauco Park. In addition to these philanthropists, several foundations, corporations and individuals began to look for alternative ways to protect private areas in Chile. One of the main challenges was the lack of legally binding instruments such as land trusts to zone private land as conservation areas for perpetuity, as well as the lack of tax incentives to promote private investment in these issues.

In this context, the work carried out by Patagonia Sur, led by Warren Adams (MBA '95), is especially significant. After an early success in the world of digital startups, Adams envisioned one of the first for-profit conservation funds in the world. Founded in 2007, Patagonia Sur purchases and permanently protects scenically remarkable and ecologically valuable ecosystems in Chilean Patagonia.

The Patagonia Sur model aspired to purchase 98,850 acres in territories of high environmental value—either a valley or a basin—for which, after a scrupulous environmental baseline study, a reforestation and conservation plan was developed in order to guarantee the recovery and care of its biodiversity over time. The business model originally created three income streams—an ecotourism venture that works on a vacation club or membership-fee model, a land brokerage and a carbon-offset business that sells credits to schools and corporations. The long-term value of conserving territories as virgin and remote as these would generate the expected returns for investors. The challenge was how to guarantee the resources to finance the conservation plans. This is when innovation converged with sound planning, architectural design, legislation

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**With the help of local consultants in conservation and landscape design, a territorial planning model was defined where at least 85 percent of the land stayed under protection and only a maximum of 15 percent was reserved for profitable low-impact uses, namely eco-tourism and real estate development under strict conditions such as design guides and a co-ownership regulation.**

and entrepreneurship. To consolidate his vision, Adams articulated a profitable conservation model. With the help of local consultants in conservation and landscape design, a territorial planning model was defined where at least 85 percent of the land stayed under protection and only a maximum of 15 percent was reserved for profitable low-impact uses, namely eco-tourism and real estate development under strict conditions such as design guides and a co-ownership regulation.

As an example of the Patagonia Sur model, the “Valle California” project in the remote province of Palena considered a protected area of 8,105 acres and seven Limited Development Areas (ADL), with only 25 lots of approximately 22 acres each. These lots were sold at prices ranging from \$350,000 to three million dollars depending on their attributes. In this way, an investor bought land at a higher value than the market price in nearby properties, but his investment guaranteed perpetual maintenance, access and co-ownership of a natural reserve of more than 7,500 acres. The design of the ADLs, as well as the low impact infrastructure and constructions, had to deal with the climatic and logistical difficulties characteristic of such isolated areas. These difficulties led to the use of vernacular building techniques and an architectural language appropriate to the values embraced by southern Patagonia. Finally, to guarantee that more than 85 percent of the ecosystems could be protected for life, the legal office of Roberto Peralta interpreted and

recycled an existing mechanism in the Chilean legislation called “servidumbre voluntaria,” or voluntary right of use, under which it was possible to register and secure in perpetuity the conservation areas in each of the seven ecosystems recovered by Patagonia Sur, totaling more than 103 square miles of private land.

The Patagonia Sur experience allowed the creation of the first Land Trust in Chile: “Fundación Tierra Austral,” an independent non-profit organization that safeguards strict compliance with the conservation plans committed by the developers. Most consultants, architects and planners who participated in developing conservation plans for Patagonia Sur, have extended the model to other initiatives—in a sort of open source agreement—so other foundations, owners, cooperatives and corporations can participate in the protection of private lands, adding, up to date, more than 116,200 acres (181 square miles) of profitable conservation master plans in Chile.

Some critics like George Holmes, professor at the Sustainability Research Institute at the University of Leeds, call these initiatives “philanthrocapitalism” because they combine intentions as diverse as conservation and for-profit businesses; however, they recognize that—in the absence of resources or governmental mechanisms to promote non-profit conservation—new models such as Patagonia Sur could make conservation more effective in emerging countries like Chile. As Adams once

mentioned in an interview for the Harvard Business School, “We learned that market-based solutions can be effective and efficient tools to augment the work of governments and NGOs on social issues.” In fact, Patagonia Sur nested several nonprofit spin-offs, like the Patagonia Sur Foundation, which helped nearby communities; the Melimoyu Ecosystem Research Institute (MERI), which studies blue whales and other endangered species; and Reforest Patagonia, a public-private campaign to plant a million indigenous trees in Torres del Paine and other national parks in Chile.

In June 2016, and after a decade since Adams established the profitable conservation model of Patagonia Sur, the Chilean Congress passed the first law establishing the “Derecho Real de Conservación” (Real Right of Conservation)—thanks to the work of the NGOs like “The Nature Conservancy,” “Así Conserva Chile” and several other organizations. This law grants every land owner the right to protect the environmental value, certain attributes or functions of a property in perpetuity.

Similar initiatives to Patagonia Sur have been replicated in the last decade in Chile adding more than 300 private protected areas in more than 3.9 million acres (6,093 square miles), equivalent to 2.2 percent of the total area of the country. Along with the enactment of the Real Right of Conservation Law—and after the tragic death of philanthropist Douglas Tompkins in a kayak accident—his widow Kristine McDivitt Tompkins and the foundation that bears his name fulfilled his posthumous desire to donate to the Chilean state about 988 thousand acres (1,543 square miles) of the park Pumalín (an area greater than the state of Rhode Island) in March 2017. Once perceived as a threat to Chilean geopolitical stability by the national government in the mid-90s, the perseverance and legitimacy of Tompkins’ commitment to the sustainable development of Chilean Patagonia found the necessary political ally in President Michelle Bachelet, who enthusiastically endorsed his will and opened the way for

the recognition of his legacy.

The Tompkins’ donation along with the many private conservation projects and the Chilean National Parks Network make up a new protected area of 11 million acres (17,187 square miles), equivalent to the entire surface of Denmark, to which is added the recent expansion of the Marine Protected Areas of Juan Fernández, Cape Horn and Easter Island. With President Bachelet’s approval last February of these marine parks, Chile confirms its new role as a global leader in ocean conservation, protecting 103 million acres (160,937 square miles) of marine ecosystems, with a commitment to reach 395 million acres (617,187 square miles) of Marine Protected Areas in the coming years.

In summary, Chile has established more than 360 million acres (562,500

square miles) of sea and land conservation, which constitutes an increase from five percent to 38 percent of its protected land and sea in just four years. Chile leaves an irreversible legacy of conservation for the country and the world that capitalized the vision, commitment and consciousness of public and private initiatives in an emerging and still-developing country.

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*Pablo Allard is the 2018 Robert F. Kennedy Visiting Professor of Latin American Studies at the Harvard Graduate School of Design. He is also Dean of the Faculty of Architecture and Arts at Universidad del Desarrollo in Chile and principal at Allard & Partners Landscape and Urban Design, where he collaborated in the creation of the Patagonia Sur conservation model.*



**Views of Valle California reserve, the first for-profit conservation initiative developed by Patagonia Sur.**

# Why Local Governments Matter

## Adapting to a Changing Climate in Chile

By KRISTER ANDERSSON AND PATRICIO VALDIVIESO

**WHEN CONFRONTED WITH THE NEED TO** address climate change, we environmentalists often set our hopes on global environmental agreements with strong enforcement capabilities. We look toward the implementation of international treaties such as the Paris Agreement and the Kyoto Protocol. It is a natural reaction: climate change is a global problem and hence we need a strong and coordinated global response.

This is true, especially if we limit our discussion to mitigation activities—that is, interventions that will reduce greenhouse gas emissions. However, once we broaden the discussion to include climate change *adaptation*—the actions we can take to cope with a climate that is already changing—the importance of local political action becomes more apparent. This is because local governments are responsible for much of the public infrastructure that we will need to survive in a world with more frequent and more severe extreme events such as floods, droughts, storms and wildfires.

In many ways, our future quality of life depends on how our local governments are able to plan and invest in infrastructure improvements. Local governments can help save lives during extreme events by anticipating the impacts of these events and investing in prevention measures such as building flood-proof bridges, retaining walls along mountain roads, more efficient irrigation systems, enhanced water recycling capacity, better emergency-response systems and public subsidies to citizens to weather-proof their homes.

Scientists predict that extreme weather events and natural disasters will become more frequent and more serious as a result of global warming. Latin American and Caribbean societies are particularly

vulnerable to these events. An enormous amount of damage has already interrupted normal life and inflicted huge economic losses on the region. For example, in 2008, a severe drought in central and southern Chile caused emergencies in fifty municipalities, and the national government spent about US\$30.5 million just on trucking animal feed and drinking water to affected communities. In 2015, the floods in northern Chile caused an estimated US\$1.5 billion in reported damages to about 8,000 homes and local infrastructure. And most recently, the massive wildfires in 2017 destroyed nearly 1,500 homes and 250,000 acres of forest, costing the government about US\$330 million.

Most national governments in Latin America and the Caribbean recognize the need to strengthen local governments to prepare for such events, but progress has been slow. In our research, we have documented what local governments are currently doing in response to the threat of extreme events. We have conducted a large number of interviews in some 170 local governments in both the United States and Chile. What is quite clear from these interviews is that an enormous amount of variation exists in what local governments are doing to respond to the threat of extreme events. Most of our research is about figuring out why some local governments more than others decide to invest their scarce public resources in infrastructure improvements. In this short essay, we share some of our most surprising results.

First, and perhaps most surprisingly, we have found little evidence in support of commonly held notions about what makes some local governments perform better than others. Conventional wisdom

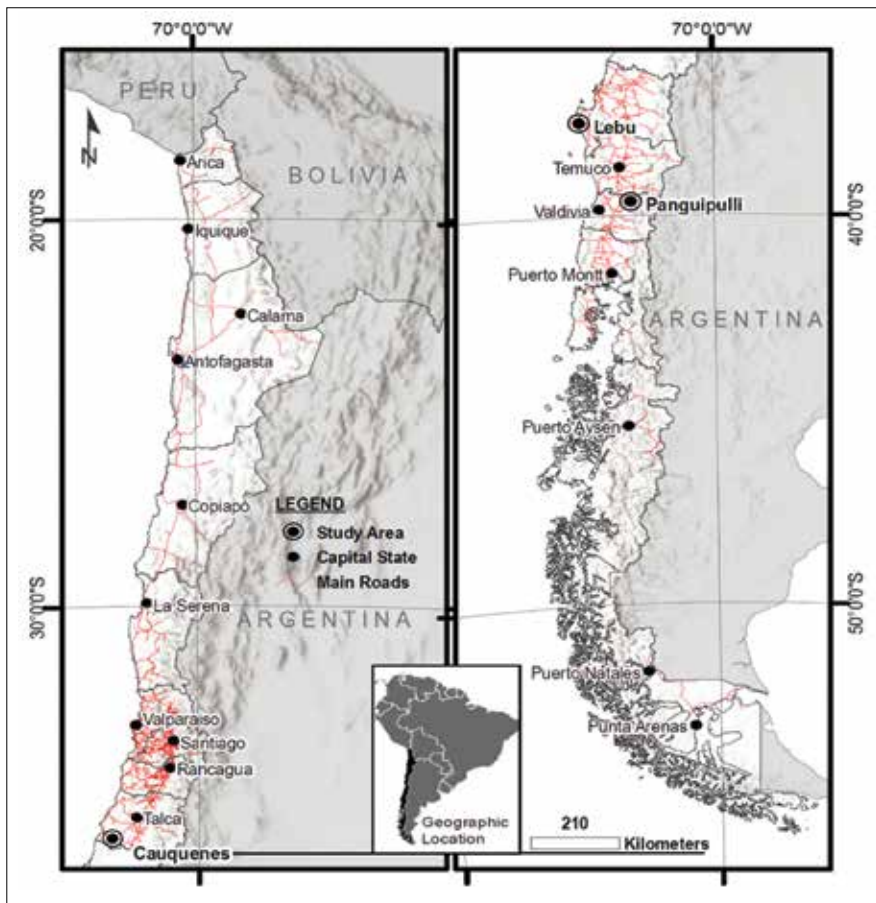
suggests that local governments that are richer and have highly trained technical personnel are the high performers, but our evidence suggests otherwise.

Through the systematic analysis of observations made in hundreds of interviews with local leaders, and by using computer simulations, we've found quite unexpected findings on more than one occasion.

### **SURPRISE #1: MORE MONEY DOES NOT MEAN BETTER ADAPTATION**

Documenting cases of vulnerable Chilean municipalities at risk during the period 2009–2014, we've observed that local governments with similar levels of financial resources and exposure to climate-related risk differ a great deal in their efforts to improve critical infrastructures and maintenance. Our comparative analysis of three municipalities—the agriculture and viticulture municipality of Cauquenes, the fishing and mining municipality of Lebu, and the forestry and tourism municipality of Panguipulli (see map)—showed that Panguipulli stands out for its superior performance in taking action to adapt to extreme climate-related events although all three have very similar levels of financial resources for their municipal administrations.

Our statistical analyses of all Chilean municipalities confirm this lack of relationship, as we find no evidence in support of a correlation between a municipal administration's wealth and its performance in adaptation activities. While more money does not always mean better performance, it is important to recognize that all municipalities do need basic financial stability to be able to make the necessary infrastructure improvements.



Location of Cauquenes, Lebu and Panguipulli

## **SURPRISE #2: HIGHLY TRAINED MUNICIPAL STAFF IS NOT ESSENTIAL.**

Since 2000, Chilean local governments have modernized their municipal structures following guidelines from national legislation and decentralization policies. This has included introducing new internal regulations, managerial procedures, offices of environment and disaster risk reduction, civil protection plans, environmental ordinances, as well as hiring more personnel and providing more training opportunities.

However, these changes in local government structures, procedures, and technical know-how have not uniformly produced better performance when it comes to investing more in critical infrastructure. For example, the local government of Lebu has effectively introduced new managerial

procedures with training given to their personnel. However, Lebu continues to struggle to reduce its vulnerability to extreme events and remains one of the coastal municipalities least prepared to confront such events during the period 2009–2014. Lebu hardly invested in infrastructure and maintenance with its own resources. Our statistical analysis finds that variables that seek to measure the technical capacity of a local government, such as the education of the mayor and the number of personnel per capita, are not correlated to adaptation performance among local governments in Chile. It appears that if local governments are to be successful, they do need some basic technical and administrative capacity, but there are other factors that are more important in producing high-performing local governments.

These findings beg the question: If

these factors don't explain much of the variation, what does?

## **EXPLANATION 1: WELL-DEVELOPED LOCAL INSTITUTIONAL NETWORKS PROVIDE AN ENABLING ENVIRONMENT FOR ADAPTATION WORK**

Through our research, we have come to appreciate the importance of looking beyond single-factor explanations such as money or technical capacity. The reality on the ground is complex: local governments are constrained by central government mandates and rules, and often struggle to respond even to the most pressing problems, not to mention long-term challenges such as preparing to adapt to climate-related events.

To make sense of this complexity it helps to consider a combination of factors to explain why some local governments perform better than others. A step in this direction is our efforts to study local institutional networks—how local governance actors connect and relate to one another on particular issues. For example, by measuring the multiple ways that local governance actors decide to connect to other actors on issues related to the adaptation to extreme events in Chile, our analysis has shown that the density of these networks is systematically linked to local government performance in adaptation activities.

The importance of local institutional networks is perhaps best illustrated by the case of Panguipulli, where the local government has cultivated strong relationships with actors operating at a variety of governance scales (e.g., local, regional, national and international) and these relationships are characterized by high levels of trust and reciprocity. These well-functioning relationships facilitated the access to new knowledge, resources and technical support, which were essential to identify, plan, and implement infrastructure improvements (which are an integral part of adaptation work). And even though Panguipulli isn't richer, doesn't have more and better



Discussion group with social leaders of the communes of Chiloé (Region X Los Lagos) moderated by thesis student Ilcia Nahuelquén (standing)

trained personnel and doesn't operate under special rules, these networks are much more developed than in other municipalities such as Cauquenes and Lebu.

By comparison, Cauquenes' governance network was much smaller, covering fewer issues, and it emphasized external

relationships with the public sector at regional and national scales. Lebu presented a similar network, with a majority of non-reciprocal linkages; Lebu's network also showed a preponderance of public-sector institutions. Panguipulli had the most diverse and largest (and highest-

intensity) network, characterized by reciprocal relationships among a diversity of governance actors, including public, private and civil society members.

**EXPLANATION 2: POLITICAL CHAMPIONS AND LEADERS CAN MAKE A DIFFERENCE FOR ADAPTATION**

In order for the local institutional networks to develop and eventually flourish, we have found that it helps if there is a local political champion—or group of individuals—who lead by example and take the initiative to identify, invite, convoke and connect with others who have compatible (but not always identical) objectives and worldviews. Again, the political leadership in Panhuipulli provides a case in point. Mayor Alejandro Kohler is a political entrepreneur, trained as a journalist, with a strong supportive network—he enjoys strong electoral support and a supportive municipal council. With experience in a successful tourism-related microenterprise and his vision that sustainable tourism

**Discussion Group with social leaders of the communes of Chiloé (Region X Los Lagos. Participants include Pedro Bahamonde (left; Governor of Chiloé during the environmental crisis of the Red Tide, 2016, and currently a member of the council of national monuments ); and Felipe Montiel, renowned historian of Chiloé and director of the Castro Museum (right).**







Research results on risk factors presented in the municipality San Juan de la Costa (Region X Los Lagos)

can open new horizons for the people of Panguipulli, the mayor (who served in 2000–2008) led a process to create a local political consensus to invest in critical infrastructure, tourism and sustainable development. This vision was consistent with a combination of international cooperation agreements, legislative reforms and provisions of budget laws to strengthen the multi-sectorial approach for infrastructure investments in vulnerable municipalities such as Panguipulli (which is relatively rural and remote).

At the municipal level, Mayor Kohler began the institutional change by reforming the internal structure and operational rules of the local government: he obtained council approval of new regulations and ordinances (2004, 2005) and created the Department of Territorial Planning and Environment within the planning office. He introduced more computerized administrative routines, recruited thirty young professionals, strengthened coordination among departments and created more external links for municipal planning. The local government made alliances and collaborative agreements with diverse individuals and organizations in the private, civic and governmental worlds.

Institutional change introduced during Mayor Kohler's term set the stage for new and more inclusive working routines

on how to address adaptation challenges, including support to municipal study commissions. Municipal staff was invited to share its expertise during council meetings; the commissions actively explored new agreements and cooperation with outside organizations. Academics, business owners and citizens at large were all invited to report on physical and environmental conditions; the municipality held open hearings to discuss the mayor's and council's proposals.

This experience suggest that individual or collective leadership may increase the likelihood of local government engagement in risk reduction in places where municipal institutional contexts have high levels of support (internal and external). Leadership may have a key role in initiating institutional change, but leaders can be held back by lack of support, institutional inertia, organizational cultures and political factors. They need trusting relationships and supportive networks.

### SUPPORTING LOCAL LEADERS

Our research has shown us that political action is rarely driven by a single factor or event. Many factors interact or act in combination to produce an enabling environment for action in the face of weather- and climate-related risk. One of the approaches we have found particularly useful to communicate this insight is computer simulations. These tools allow us to model which combination of local conditions among Chilean municipalities would increase their investments in the adaptation of critical infrastructure. What these simulations show is that when a local government enjoys a combination of favorable local conditions—a well-developed local institutional network that spans across multiple governance levels, strong internal administrative efficiency and high levels of civic engagement in

the municipality—then the likelihood of making these investments increases dramatically (more than forty percent increase compared to unfavorable local conditions).

The bad news is that among Chile's 346 municipal governments, only a very few enjoy these favorable conditions. The good news is that there are ways through which external actors may contribute to a more propitious institutional climate—by supporting local leaders and facilitating their efforts to develop local governance networks related to adaptation—which may ultimately improve the adaptive capacities of local governance actors.

*Krister Andersson is a professor of Political Science at University of Colorado at Boulder. He acknowledges financial support for his field research from the National Science Foundation (grants SMA-1328688 and BCS-1115009).*

Contact: [krister@colorado.edu](mailto:krister@colorado.edu)

*Patricio Valdivieso is Professor of Political Science of the Center for Regional Development Studies and Public Policy at Universidad de los Lagos, Chile. He acknowledges financial support from the National Fund for Scientific and Technological Development, FONDECYT, (Grants 1140672 and 1181282) as well as from the Institute for Research in Market Imperfections and Public Policy (ICM IS130002); Ministry of Economy, Development and Tourism. Contact: [patricio.valdivieso@ulagos.cl](mailto:patricio.valdivieso@ulagos.cl)*

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# Design with Water

## Rediscovering Public Spaces in Mexico City

By MANUEL PERLÓ COHEN AND LORETA CASTRO REGUERA MANCERA

**WATER IS A KEY TO THE FOUNDING AND** shaping of cities. The first humans established settlements alongside bodies of water. Whether these populations flourished or not depended largely on smart water strategies. Whenever these failed, cities struggled to guarantee their future.

Mexico City is now a sprawling megalopolis of 22 million people. The city was an excellent example of landscape as infrastructure when it was founded at the center of a 425-square-mile system of lakes, and designed through a system of canals and *chinampas*. As the indigenous city evolved into a colonial one, the original waterscape turned into one of the largest, seemingly endless, and mostly dry urban fabrics. To cope with the results of colonial and subsequent urban development, monumental and sophisticated water management infrastructures have been constructed throughout the last five centuries.

These water management systems help the city survive, but they also have severe consequences: subsidence (the gradual caving in or sinking of an area of land), floods and overexploitation of the aquifer. These outcomes are provoking the collapse of infrastructure, meaning that one out of four Mexico City inhabitants do not have guaranteed access to a daily supply of water. In contemporary Mexico City, water has disappeared from the urban imagination. Its citizens have lost a necessary link with the liquid, one which guarantees the survival of the city.

Moreover, the drastic transformation of Mexico City's natural context can be a decisive aspect to accelerate climate change. In the Basin of Mexico rainfall patterns have been modified as a result

of warmer air holding more water vapor. We are now subject to shorter but more intense rain seasons, leading to an increased risk of flooding. At the same time, warmer air evaporates more quickly water from surfaces, drying out faster areas where it is not precipitating.

The city is subject to a paradox of scarcity of drinking water and excess of rain. It has repeatedly tried to break the unsatisfactory dialogue with the liquid, but the nature of the basin obliges it to constantly deal with this cycle. The relationship between the natural landscape, the form of the city, water and its citizens have spurred our research and projects.

### THE HISTORY OF LANDSCAPE INFRASTRUCTURE IN MEXICO CITY

Mexico's basin doesn't drain anywhere. In more scientific terms, it's endorheic or closed, with no natural exit for its water. Thus, the system of lakes and swamps, nourished by the runoffs of the surrounding mountains, became the channel for water. Although humans first settled in the basin some 10,000 ago, the population significantly increased in the 12th century when the so-called seven Nahuatlacas tribes began to establish themselves on the shores of the lake system. They found excellent living conditions, securing the provision of water, fertile grounds and a temperate climate. Some of the towns founded by the different tribes, specifically those located in the southern areas around the Xochimilco and Chalco lakes, developed one of the most ancient, efficient and still practiced agricultural techniques: the *chinampas*.

The *chinampa* system emerges from a deep understanding of the natural

conditions of the Mexico basin. The changing water levels of the lake or more specifically, the five different wetlands that became a sole water body during the rainy season, provided a hint for how to harness them. Xochimilcans developed a strategy for constructing large-scale, thin and long woven baskets, filled with earth previously excavated from the shallow waters of the lake ground. With the aid of roots from the native *ahuejote* tree, the baskets became grounded to the water body. They were separated from one another by canals, providing transportation access around the area and good communication with the dry land. Along with a continuous exposure to a humid environment, the soil on the *chinampa*, mineralized through ancient volcanic activity, resulted in one of the most efficient and productive agriculture methods worldwide, having as much as five harvesting periods in the course of a year. This ancient agricultural method is undoubtedly one of the most sophisticated examples of landscape design. It was later expanded and turned into an urban design strategy in 1325 when Mexicas came to inhabit Lake Texcoco and founded Great Tenochtitlán (today's Mexico City).

The *chinampa* system is definitely a landscape infrastructure, as it provided urbanized areas in the Basin of Mexico with a system to domesticate the ground, enjoy fertile agricultural lands, foster mobility and transportation, make use of a dynamic medium to negotiate with rising water levels, and devise a site-specific and sustainable strategy to deal with the context. It also meant a continuous exposure of the society to the basin's natural conditions. Water was present always, sometimes flooding the

city, but always an important part of the life of its inhabitants. Each of them knew the benefits and threats of water and was able to understand and learn the abilities to survive in this land.

### WATERSCAPE TO DRY LAND

The Spanish conquest of Tenochtitlan led to a complete transformation of the city's urban form. Through the Laws of the Indies, Spain was able to set a standard regarding regulations to establish or redesign cities in the New World. These were not site-specific and, in the case of Tenochtitlán, their application meant a strong clash with the natural conditions.

European Renaissance cities, planned through a grid of streets that connected a series of squares constructed with massive stone were difficult to implement in a waterscape. The original canal system that structured Tenochtitlan's urban fabric was replaced by roads, displacing water with earth. This substitution meant that, when lake water rose during the rainy season, it would have no place to flow within the

city, causing prejudicial floods. These happened often, forcing the new decision makers to implement an infrastructure strategy.

At the beginning of the 17th century, the city officials decided between two flood control projects. The first proposed the construction of enormous, dike-like infrastructure similar to those used by Aztec rulers to deal with rising levels of water by separating the city area from its adjacent lakes. The second proposal advocated the artificial opening of the basin by drilling a tunnel to drain the lake system on its northern end. The tunnel strategy was chosen and commissioned to Heinrich Mertens, a German engineer.

This choice of strategy defined how Mexico City would deal with its water supply during the following 400 years: drilling, piping and pumping the liquid both in and outside the basin. It also meant the disappearance of an intrinsic and essential element of historical use, which involved either digging or driving

out the water: the new city decided to deny water.

Thus, in modern Mexico City water is no longer present. Of the 425-square-mile water network, fewer than twenty square miles remain. The decision to dry out the water network created empty, dry ground—ultimately soft and inappropriate, but nevertheless ideal to expand Mexico's urban fabric. Mexico City's urbanized ground runs for more than 965 square miles, occupying most of what was a lake. Thousands of deep wells have been dug in order to provide its inhabitants with water, causing disturbing ground subsidence. The city also occupies the permeable hillsides, blocking natural aquifer recharge, and making it hard to substitute the extracted liquid. Moreover, fast runoffs coming down the hills provoke huge volumes of the water to accumulate in the lower parts of the basin, making it impossible for any drainage system to hold and manage these amounts in the desired time. Four hundred years after a decisive action was taken to prevent floods



The purple jacaranda trees adorn public spaces.

in Mexico City, the city is still vulnerable.

### **REDISCOVERING PUBLIC SPACE AS A PARALLEL HYDRAULIC INFRASTRUCTURE**

In 1960, the lake system was almost completely desiccated. The city created extensive infrastructure to import and export water—bringing it from the western adjacent basins, using it, and then sending it away to the east—and assure the city's survival in terms of water access. However, the water is running out. The city is consuming the liquid from its neighbors' basins, evoking a heated reaction from some municipalities. However, at the same time as it suffers from water shortages, the city is unable to manage the enormous amounts of rain and wastewater that inundate it during the storm season.

Several experts have urged decision-makers to implement a management system alongside the current one. The work we have been doing builds upon these efforts, but focuses the solution on grassroots acupunctural projects (hydrouurban acupunctures). Our approach bets on hundreds of small-scale, disseminated interventions instead of large-scale infrastructure solutions. We focus on public spaces and their capability to serve both as soft decentralized infrastructure (meaning less dependent on energy, using the characteristics of the natural context to manage the liquid, such as absorption, retention, treatment through wetlands), as well as social-integration and recreational spaces.

In 2012 we started working for the borough of Iztapalapa, one of the areas most affected by scarcity and drainage of water. We asked the community to present small-scale alternative water management solutions in public spaces. We also demanded a budget of less than US\$500,000.00. Surprisingly, we received more than 200 projects, from which an expert jury selected eight winners. Although these projects received awards, they were not implemented because the moment in which they were presented coincided with changes in

government management. However, the contest demonstrated the community's interest and understanding of diverse possibilities for managing water.

While working on the Iztapalapa project, we stumbled across La Quebradora, a site with ideal characteristics for the first hydrouurban acupunctural project: permeable ground, property of the borough, and surrounded by a dense urban area lacking public spaces. The research team worked on a conceptual design proposal that, after years of hard work, was finally presented to the borough representative. In 2015, the

in September 2018) will host a ten-acre public space with cultural, sports and recreational programs. Structured through a grid of platforms, squares and pathways, the park will triplicate the original tree count and introduces only endemic vegetal species, typical of the volcanic stone context. Moreover, it will provide the surrounding population with a museum, a library, an open-air theatre, an outdoor gym, multi-use courts, children's playgrounds and spaces to develop indoor activities. The park also will have public toilets, an important necessity in an area of the city where the population lacks a

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## **However, at the same time as it suffers from water shortages, the city is unable to manage the enormous amounts of rain and wastewater that inundate it during the storm season.**

project was accepted, and the borough hired a team coordinated by us from the National Autonomous University of Mexico (UNAM) to develop a complete study and construction plans for the Parque Hídrico Quebradora.

Parque Hídrico Quebradora introduces a contemporary waterscape that seeks to attack one of the city's largest problems: water management. The idea is to reconfigure the hydraulic system by capturing intense water runoff and diverting it into an infiltration basin, thus reducing urban floods in the area. In addition, the venue treats wastewater through a joint water treatment plant and wetland system. This liquid will be used for the park's hydric sustainability and redistribution in surrounding areas. Additionally, it harvests and filters rainwater that may be used for drinking. The park will be the first decentralized soft-water infrastructure in the city, setting a standard for any future urban design interventions, in which water management becomes seminal.

Along with its hydric functions, La Quebradora (to be inaugurated

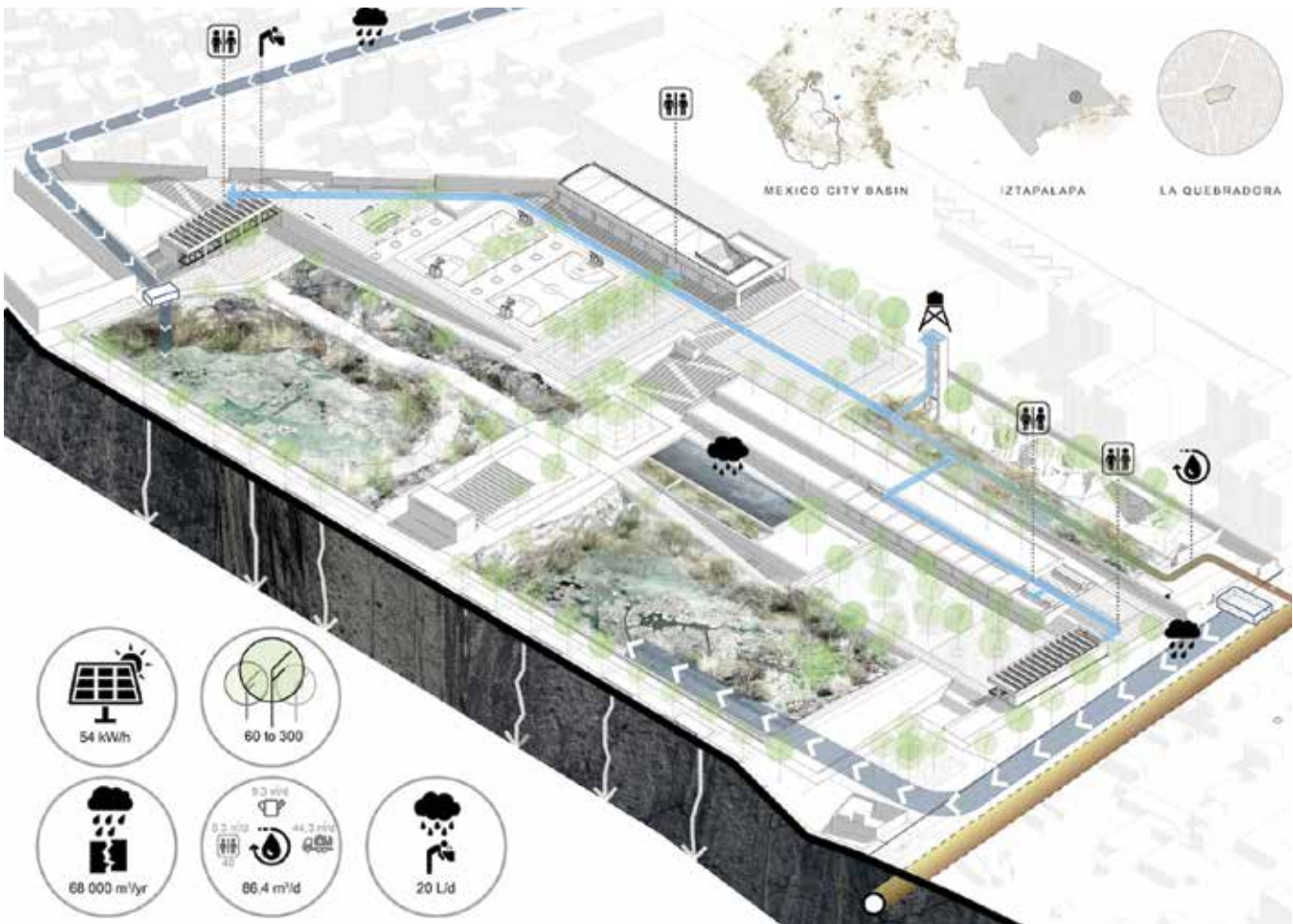
continuous water supply.

La Quebradora will serve an area of 28,000 inhabitants who lack recreational areas and regular access to water. The park's open borders will emphasize pedestrian mobility and aiming to reduce insecurity. It sets a paradigm for a new understanding of public space, where it will not only serve as an aesthetic venue but, more importantly, as an infrastructure managing the most precious resource in the city: water.

La Quebradora, currently under construction, is the first project in a more ambitious strategy, in which public spaces are intended to serve diverse purposes, ranging from decentralized infrastructures to water culture broadcasters. These thousands of sites spread throughout the urban fabric will become the medium through which water will return into the image of the city, not only as an aesthetic element, but more importantly, as a vital resource. Sometimes scarce, sometimes abundant, water will always be in need of an intelligent management through clear strategies provided by the form of the city and the awareness of its inhabitants.

**Manuel Perló Cohen** is a Mexico City-based economist educated at UNAM and a city planner with a degree from UC-Berkeley. He is a tenured researcher at the Instituto de Investigaciones Sociales at UNAM and teaches graduate students in city planning, urban sociology and environmental policies. He combines his academic research with applied projects that can help change the urban water system in Mexico City.

**Loreta Castro Reguera Mancera**, MAUD 2010, is a Mexico City-based architect and urban designer. She teaches at the UNAM School of Architecture and has an architectural design studio: Taller Capital. She focuses on the design of public spaces capable of managing water through soft infrastructure. [www.tallercapital.mx](http://www.tallercapital.mx)



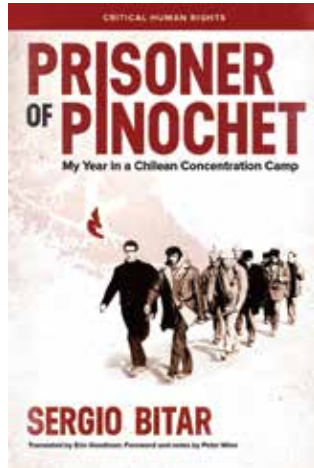
# A Tale of Survival

A REVIEW By MARGUERITE FEITLOWITZ

**Prisoner of Pinochet: My Year in a Chilean Concentration Camp** by Sergio Bitar, translated by Erin Goodman with foreword and notes by Peter Winn (Madison: University of Wisconsin Press, 2017)

On September 11, 1973, at about eight o'clock in the morning, Sergio Bitar, one of Allende's top economic advisers and the Minister of Mining, received a phone call from a colleague: the military was on the move. Downtown Santiago was surrounded by soldiers. It had to be the coup they'd been expecting. Bitar's first thoughts were "diffuse." Since Chile's constitutionalist military had neutralized previous coup attempts, he prepared to head downtown himself for a meeting he had scheduled with CORFO, the agency that managed the public economy and had nationalized the country's major industries. But then, the one radio station still functioning announced that the military was bombing the presidential palace La Moneda. As his middle-class neighbors cheered the fall of the socialist Popular Unity government, Bitar and his wife gathered their children to take them to a place of greater safety.

As the family drove away from their home, news reports confirmed that the coup



was unstoppable.

Bitar recounts his experiences in this 1987 book, translated for the first time into English, in an even tone: from the moment of his capture, he clearly made a pact with himself to stay alert, observant, lucid and mentally organized. He kept track, as best he could, of dates, knowing that timekeeping is especially hard for those in captivity.

But that's getting ahead of the story. That fateful September 11, war planes were bombing radio stations, flying low above the city streets to intensify the terror. Radio Magallanes broadcast Allende's courageous and devastating last words, then went off the air. Bitar had long known that Allende would die by his own hand rather than let himself be slaughtered by the enemies of democracy. The legitimately elected socialist

president wanted, more than anything, to save his country from civil war.

With his regime long under threat, Allende had instructed his Cabinet to secure safe houses in the event of dire emergency. Bitar drove to the modest neighborhood of La Florida where a woman who had worked for his mother and known him as a child would shelter him. A day later, Bitar was ordered via radio broadcast to report to the Ministry of Defense. Although he had offers of asylum from several embassies, Bitar refused to flee; Allende's surviving Cabinet members, congressional representatives and political leaders had all got the same order. Some of these men had, like Bitar, left their safe houses; others had remained at the presidential palace during the bombing and since their capture had been held incommunicado. The reunion (if that's the word) was emotional: they were relieved to see dear comrades alive, but were also anxious and frightened, especially for their families.

From September 12, 1973, until October 28, 1974, Bitar was a political prisoner (renamed *Isla 10* by his captors) in Antarctica. The body of his narrative is preceded by a complete list of the forty-seven Unidad Popular Prisoners held at Dawson

Island—Cabinet members, government ministers, congressional representatives, senators, mayors, party and union leaders, a university president, the director of the national bank, Allende's personal physician and press secretary. Among these men (they were all men), was Orlando Letelier, who served, successively, as Allende's Minister of Foreign Affairs, Interior, and Defense, and who would be assassinated by an agent of Pinochet's secret service in September 1976, in Washington, D.C.

Located in the Strait of Magellan in the Tierra del Fuego archipelago, Dawson Island has a long history as an internment camp. Inhabited for thousands of years by the Selknam and other indigenous tribes, it was seized in the 19th century by European settlers, miners, gold-diggers and bounty hunters who corralled the local Indians after taking their lands, dwellings and animals. After the Selknam genocide, the island was given to Salesian missionaries who were to oversee the "assimilation" of the surviving Selknam and their descendants. Dawson Island again became a site of human rights abuses when within days of the coup, the Chilean armed forces commandeered the island and ran it as a concentration camp for Allende's inner circle and prominent

supporters.

In freezing temperatures, driving rains and deep mud, Bitar and his companions were subjected to forced labor (cutting down trees, sawing logs, sinking fences), insufficient and disgusting rations, inadequate sanitation, and uniforms and bedding grotesquely unsuited to Antarctic conditions. Prisoners got badly injured; several died. Some got so sick they would be ill for the rest of their lives. Torments included ear-splitting sirens and light storms in the middle of the night. Interrogations sometimes included outright torture (though not in Bitar's case). The group could be suddenly moved to other locations—furious roundups, a storm of trucks, unexplained transport to another bare-bones and brutal camp, as he vividly recounts.

Bitar's narrative, though personal, is at its heart communal. He keeps track of the men around him, documenting illnesses and injuries, moods and modes of coping. Not a page goes by without clear descriptions of canny strategies for surviving at the bottom of the world. The mutual generosity of these men may have been their best protection against the daily humiliations and cruelties of their captors. Whenever one of their group gets a letter (though heavily redacted), a package (always previously opened and often pilfered), a visit, or is released, Bitar never fails to say, "Good news for one of us was good news for all." And he recounts how the mood in the barracks would then lift, the pace of

activity pick up.

The prisoners held classes and formed study groups. In their number were international experts in economics, political science, history, the military and a host of other academic disciplines. Smaller groups studied languages. Bitar taught German, and with the skillset of a Harvard-trained economist, he began a rigorous analysis of Allende's government programs, focusing particularly on what they could have done, or explained, better. (Bitar would go on to write a number of important books on Chilean democracy, economy and military.) The group jerry-rigged a radio, but this too could be a source of misery, as when the regime triumphantly broadcast the deaths of comrades ("enemies of the state").

As Bitar makes clear, triumphalism was not universally shared among the captors on Dawson Island. The highest-ranking officers tended to be true believers in the cause to eradicate socialism; the lower ranks were more mixed—a number of soldiers and policemen posted to Dawson Island had been in Allende's Popular Unity party or in other leftist organizations, and had their own apprehensions. Even some of Pinochet's most ardent supporters treated Bitar and his group as Prisoners of War—a misnomer (there was no war, it was an unopposed military coup), but the so-called status granted the prisoners certain rights and gave the captors a cleansing sense of mission. That these attitudes were simultaneously in

play further complicated the prisoners' situation. Speculation and rumor, conflicting statements, attitudes and information intensified the prisoners' anxieties.

Included in this volume are a suite of affecting photographs: Bitar and fellow cabinet member Jorge Tapia reporting to the Escuela Militar two days after the coup; a censored page of a letter from Bitar's wife, Kenny; prisoner portraits and camp drawings by fellow prisoner Miguel Lawner (Director of the Corporation for Urban Improvement); a photo of bundled-up prisoners trudging back to camp after work; Bitar's lovely stone carvings done to pass the time. One of the most moving photographs shows *Las Dawsonianas*, as the prisoners' activist wives called themselves. The picture shows five of these vibrant women sitting close together on a living room sofa with Allende's widow, Hortensia, front and center. Two of these women (Margarita Morel de Letelier and Moy Morales de Toha) would later also lose their husbands.

International pressure was key to the prisoners' survival, liberation and offers of asylum. Sergio Bitar left Chile on November 14, 1973, for Washington, D.C., where he was awaited by the friends who'd won his freedom and who now urged him to "write down everything you're telling [us]." While teaching at Harvard in 1975, Bitar spent time each day systematically dictating his prison story into a tape recorder. His wife, Kenny Hirmas de Bitar,

transcribed every word, archived every page, and kept the manuscript safely hidden away for nine years. In 1984, Bitar was allowed to return to Chile, where the book was published in 1987, while Pinochet was still in power. Printed multiple times in Chile and translated into at least a score of languages, *Prisoner of Pinochet* only now appears in English. That is a whole other cultural story, and a disheartening one, in view of Bitar's distinguished profile as a scholar and political leader in post-Pinochet Chile.

But let us take this publication for the belated triumph that it is. Erin Goodman's translation hews to the grounded, modest tone of Bitar's Spanish. Peter Winn supplied excellent notes, and his foreword is at once personal, surpassingly lucid and eloquent. As a young man in Santiago, Winn found himself in the plaza as the military bombed La Moneda. It was a moment that would change his life, and help produce one of the finest Latin Americanists of his generation.

A final word of praise for Steve Stern and Scott Strauss, who direct the Critical Human Rights series at the UW Press. Theirs is a distinguished list of titles, and Bitar—always one to value good company—is right at home.

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*Marguerite Feitlowitz is the author of A Lexicon of Terror: Argentina and the Legacies of Torture. She teaches at Bennington College in Bennington, Vermont.*

# Latin Roots and Universal Suffering

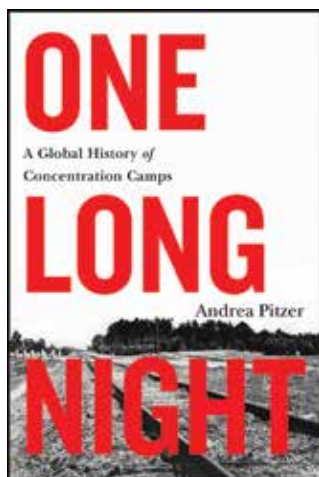
A REVIEW By DALIA WASSNER

## One Long Night: A Global History of Concentration Camps

by Andrea Pitzer (New York: Little, Brown and Company, 2017)

In *One Long Night: A Global History of Concentration Camps*, Andrea Pitzer offers a thoughtful combination of investigative journalism and historical analysis that identifies the roots and commonalities across global iterations of concentration camps throughout the 20th century. The book lends poignant testimony to what it means for private citizens to be corralled time and again into spaces where human rights, legal processes and social relations dissolve. Claiming witness to the multiple—and multiplying—systematized instances of removal of human beings from their homes, and demanding accountability from the nations that have hosted the torturous machinations of the ensuing captivities, Pitzer diagnoses the past century as “the lost century.”

Beginning in 1890s, Cuba and later the U.S. control of the Philippines after the Spanish-American War, extending of course to Nazi Europe and Soviet Russia of World War II, Communist China of the 1960s and '70s, and the Southern Cone of Latin America during the Cold War, the book concludes finally in our current



21st century with a searing condemnation of North Korean prisons alongside ongoing U.S. use of Guantánamo Bay. Invoking Elie Wiesel’s harrowing testimony of the Holocaust, “Never shall I forget that night, the first night in the camp, that turned my life into one long night seven times sealed,” alongside Primo Levi’s assessment that the *Shoah* was not a singular occurrence, “It can happen, and it can happen everywhere,” Andrea Pitzer upholds the moral imperative to remember the Holocaust in its specific manifestations while also remaining aware and responsible to the concentration camp phenomenon writ large.

Through extensive interviews of historians, activists, soldiers and lawyers, as well as accounts by survivors and camp guards alike, Pitzer

demands that her audience reckon with the immoral and often illegal tactics that modern regimes have repeatedly adopted in service of civil wars. These are tactics of inhumanity that steadily exclude “the other” not only from participation in polity or society, but from a collective consciousness. To her study of the emergence and functioning of camps, Pitzer then adds the complicated aftermath whereby survivors and perpetrators again live together in societies once defined by the violent separation and abuse of the former by the latter.

Pitzer’s journalistic fire is balanced by a grounded historical inclination, one that impels her to begin her book by tracing the *reconcentración* of indigenous Americans by Columbus, a pattern continued through the Spanish and Portuguese conquests to the south and the British and French conquests to the north. Subsequently describing the period of post-independence in the United States, Pitzer notes that the Lieber Code of Conduct, which gave Civil War generals the right to remove all suspected sympathizers from their homes, set an important precedent within U.S. and international law courts—including The Hague in 1899 and the Second Geneva Convention in 1906—one that lent the

American Civil War some of its most devastating aspects, and which was instructional for the mass deportations and detentions of Nazi Germany. Pitzer thus demonstrates that as instrumental as bureaucratic efficiencies such as census taking and the invention of barbed wire and automatic weapons were to creating the infamous camps that would mark the 20th century, so too were the historical precedents that paved way for each subsequent iteration.

Providing a clear moral judgment in the context of the first concentration camp studied in the work—the case of Cuba in the wake of its independence from Spain—Pitzer notes: “History is full of moments in which hindsight provides the only clear view. This is not one of them” (20). The author explores the deliberate tactics of cleansing the Cuban countryside of its inhabitants through a policy enunciated on October 21, 1896, summarily accomplished within only two weeks, and describes the Spanish agenda to ensure control of the island as the European country tried desperately to maintain its final foothold in the Americas. The very pursuit of such terrorizing practices influenced U.S. involvement in the war in defense of Cuba—an involvement as much pursued for U.S. political and economic



**On the same landscape of his childhood, Agüero now faced the embodiment of “atomized terror:” “Illegal detention, it turned out, could be tucked away in the every day world, carried out with few people being the wiser” (354).**

interest and popularized at home in defense of human rights. Pitzer then shows how similar concentration camp tactics were imposed by U.S. troops in the Philippines. Thus, the same war that marked the finality of Spain’s overseas empire transformed the United States from a past colony to an imperial power that adopted the repressive policies of its vanquished foe. Pitzer’s global history of concentration camps, from its inception, thereby demands that the United States confront its own checkered past as it consolidated a national identity through “reconcentrations,” civil war and imperial ambitions, all in preparation to become a global power of the 20th century.

While the book traces many important connections across the globe, I would like to focus on the section covering Latin American concentration camps of the military dictatorships of Chile (1973-1990) and Argentina (1976-1983). In the chapter titled “Bastard Children of the Camps,” Pitzer describes how national public spaces such as sports stadiums were converted into concentration camps: “Agüero headed from the gallery to the closest entrance gate and waited for

the guard to let him through. Stepping onto the track he had run as a child, he walked the straightaway and the curve as he circled the soccer field. At his assigned spot he stood waiting for his torturers, taking in the grass, the sky, and tens of thousands of seats, row after empty row” (333). On the same landscape of his childhood, Agüero now faced the embodiment of “atomized terror:” “Illegal detention, it turned out, could be tucked away in the every day world, carried out with few people being the wiser” (354). Through such testimony, the reader witnesses the appropriation of public spaces in service of the dissolution of democracy: “friends pretended to be strangers to protect themselves and each other” (329). These spaces of terror, claims Pitzer, were the “illegitimate offspring of Western democracies,” since the dictatorships of the Southern Cone were supported in secret by the United States as part and parcel of the Cold War within the Global South, including in the case of Latin America, the Guatemalan and Paraguayan coups of 1954, Brazil in the 1960s and Chile and Argentina in the 1970s and ‘80s.

In the example of Felipe Agüero, a victim of Pinochet’s

coup in 1973 Chile, Pitzer observes that he tried as much as possible to maintain a notion of humanity not defined in terms set by his captors. Thus, instead of stealing a glimpse of his torturers when he had a chance, Agüero opted to turn away, “frightened to see the face of someone willing to do these things to him” (336). Pitzer thus lends testimony to the determination of the detained to resist the forces and justifications of inhumanity enacted on them. While describing the historical precedents to these camps, as well as the international coordination that at times was instrumental to their existence, Pitzer additionally notes that victims of concentration camps too carried in their minds global and historical frameworks for understanding their own circumstances. In Agüero’s words: “the prisoners, looking at the ground and covered with blankets, appeared markedly worse than any prisoners he had seen thus far. Their shattered aspects brought to mind images of Nazi camp survivors. He wondered where these people had been and what they had gone through to look like that” (339).

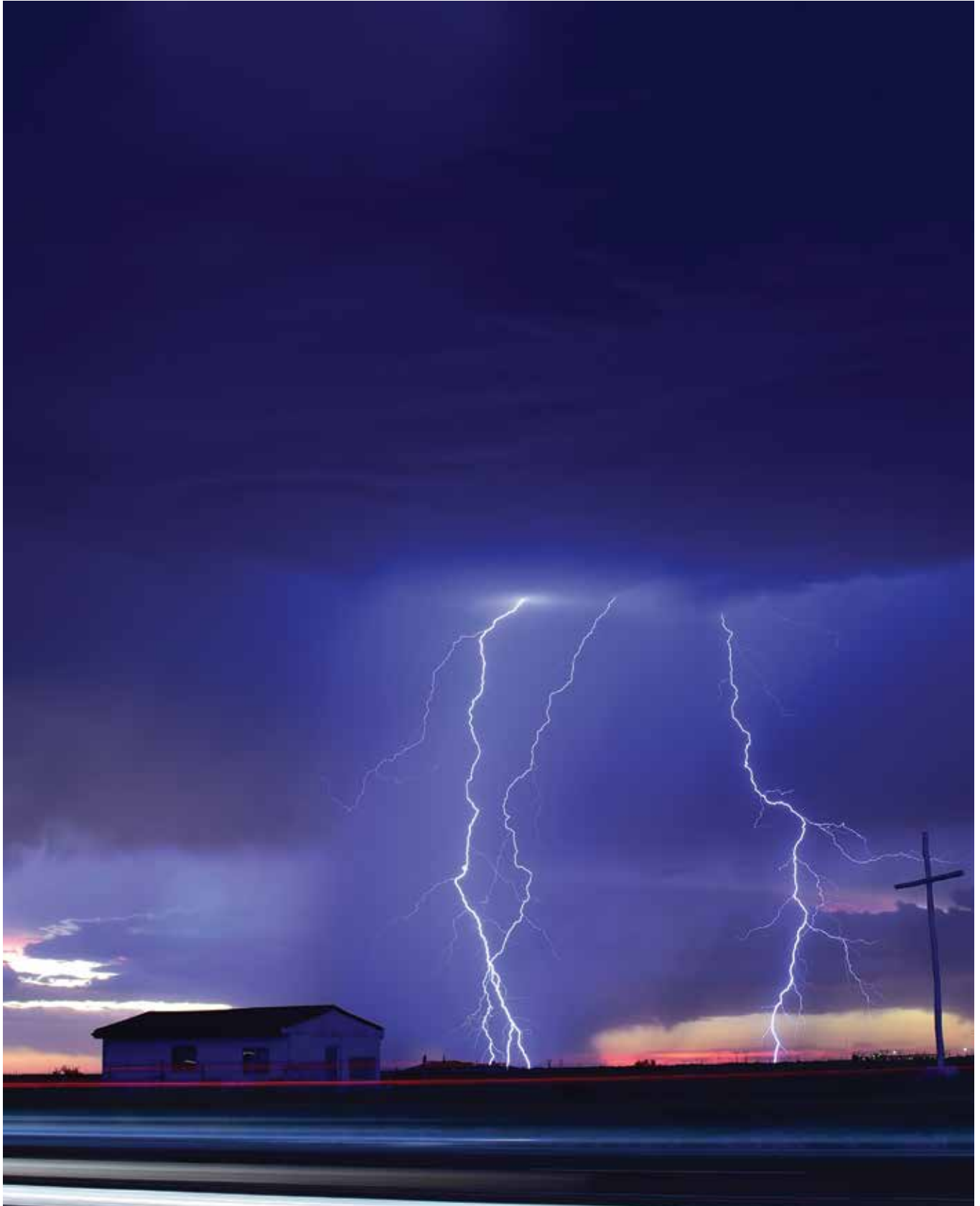
In my own research, I have studied subversive culture created by women of the Southern Cone who have urged the importance of post-Holocaust collective memory in bringing reckoning—if not justice—to the humanitarian abuses enacted in their own lifetimes. Creating subversive journalism and theater, producing novels and poetry, women of Argentina and

Chile have dialogued with the ghosts of the Holocaust to bring truth to the horrors of their own lifetimes, experienced a generation and ocean apart. As Pitzer outlines the multi-generational and international aspects of the camps themselves, so too has a cadre of Latin American feminist figures emerged to emphasize the multi-directionality of culture in bringing an end to the global proliferation of camps and their goals of genocide.

Recalling Hannah Arendt’s now famous phrase “banality of evil,” which emerged in relation to Eichmann’s trial in Jerusalem, Pitzer outlines the repeated instances in which people around the world have been removed from their homes and treated “as if they no longer existed, as if what happened to them were no longer of interest to anybody, as if they were already dead and some evil spirit gone mad were amusing himself by stopping them for a while between life and death” (7). And yet, Pitzer shows that prisoners or detainees of the multiple camps of the last century have fiercely struggled to maintain their own humanity even while experiencing systematized machinations of de-humanization. Pitzer’s work implores of the current generation: How will the 21st century be defined?

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*Dalia Wassner, Ph.D. is a Research Associate and the Director of the Project on Latin American Jewish & Gender Studies at the Hadassah-Brandeis Institute of Brandeis University.*



DAVID ROCKEFELLER CENTER FOR LATIN AMERICAN STUDIES

# VISITING SCHOLARS AND FELLOWS PROGRAM



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Founded in 1994, the David Rockefeller Center for Latin American Studies at Harvard University works to increase knowledge of the cultures, economies, histories, environment, and contemporary affairs of past and present Latin America.

## THE PROGRAM

Each year the Center selects a number of distinguished academics (Visiting Scholars) and professionals (Fellows) who wish to spend one or two semesters at Harvard working on their own research and writing projects. The Center offers nine fellowships that provide support for one semester. Applications from those with their own resources are also welcome.

Visiting Scholars and Fellows are provided shared office space, computers, library privileges, access to University facilities and events, and opportunities to audit classes and attend seminars. The residential fellowships cover round-trip travel expenses, health insurance, and a taxable \$25,000 living stipend while at Harvard. Appointments are typically for one or two semesters. Recipients are expected to be in residence at the University a minimum of twelve weeks during the semester.

**APPLICATIONS DUE FEBRUARY 1<sup>ST</sup>**

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**DAVID ROCKEFELLER  
CENTER FOR LATIN  
AMERICAN STUDIES**

1730 Cambridge Street  
CGIS, South Building  
Cambridge, MA 02138

Phone: 617-496-1588  
[drc\\_vsf@fas.harvard.edu](mailto:drc_vsf@fas.harvard.edu)

David Rockefeller Center for Latin American Studies

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DAVID ROCKEFELLER CENTER  
FOR LATIN AMERICAN STUDIES

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1730 CAMBRIDGE ST., CAMBRIDGE, MA 02138

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## CONTRIBUTORS

**65 Pablo Allard** is the 2018 Robert F. Kennedy Visiting Professor of Latin American Studies at the Harvard Graduate School of Design. **68 Krister Andersson** is a professor of Political Science at University of Colorado at Boulder. **42 Jai Chowdhry Beeman** is a Ph.D. candidate at the Université Grenoble Alpes and a former *ReVista* intern. **13 Emily Blair** is a 2017 graduate of the Masters of Landscape Architecture program at the Harvard Graduate School of Design. **48 Ari Caramanica** is a Ph.D. candidate in the Harvard Anthropology Department. **53 Miluska Carrasco** is at the Investigación Nutricional in Lima. **72 Loreta Castro Reguera Mancera**, a Mexico City-based architect and urban designer, teaches at the UNAM School of Architecture. **13 Jenna Chaplin** is a 2017 graduate of the Masters of Landscape Architecture program at the Harvard Graduate School of Design. **53 Hilary Creed-Kanashiro** is at the Investigación Nutricional in Lima. **53 Gisela Cruz García** is with the International Center for Tropical Agriculture (CIAT). **8 Charles C. Davis** is Professor of Organismic and Evolutionary Biology at Harvard University and Director of the Harvard University Herbaria. **53 Stef de Haan** is with the International Center for Tropical Agriculture (CIAT). **51 Gustavo Diaz Paz** is a Master in Urban Design candidate at the Harvard Graduate School of Design. **14 Elizabeth Donger** is a Research Associate at the Harvard FXB Center for Health and Human Rights. **18 Erika Eitland** is a doctoral candidate in the Department of Environmental Health at Harvard T.H. Chan School of Public Health. **8 Aaron M. Ellison** is the Senior Research Fellow in Ecology at Harvard University. **76 Marguerite Feitlowitz** is the author of *A Lexicon of Terror: Argentina and the Legacies of Torture*. **33 Gisela Heffes** is a fiction writer and an Associate Professor of Latin American Literature and Culture at Rice University. **22 Veronica Herrera** is Assistant Professor of Political Science at the University of Connecticut and DRCLAS Visiting Scholar. **53 Andrew Jones** is with the School of Public Health at the University of Michigan. **53 Krysty Mesa** is at the Investigación Nutricional in Lima. **45 Lisa Paravisini-Gebert**, the 2016-17 Wilbur Marvin Visiting Scholar at DRCLAS, teaches at

Vassar College. **72 Manuel Perló Cohen**, an economist, is a tenured researcher at the Instituto de Investigaciones Sociales at UNAM in Mexico City. **53 Franklin Plasencia Amaya** is a consultant to the Investigación Nutricional in Lima. **58 Nicolás Filippo Rosso** is an Italian photographer based in Colombia. **42 Jean C. Ruiz Hernandez** is an Assistant Professor of Physics at the Transportation Management career of the Chimborazo Polytechnic School in Riobamba-Ecuador. **18 Ramón Sánchez** is director of the Sustainable Technologies and Health Program in the Center for Health and the Global Environment at the Harvard T.H. Chan School of Public Health (HSPH). **2 Daniel Schrag** is the director of the Harvard Center for the Environment. **18 John Spengler** is the Akira Yamaguchi Professor of Environmental Health and Human Habitation at the Harvard T.H. Chan School of Public Health. **53 Milka Tello** is a faculty member in agricultural sciences at the Universidad Nacional Hermilio Valdizan de Huánuco (UNHEVAL). **53 Ramzi Tubbeh** is a Peruvian Ph.D. student at Pennsylvania State University. **38 Patricia Valderrama** is a Ph.D. Candidate in Comparative Literature at Stanford University. **68 Patricio Valdivieso** is Professor of Political Science of the Center for Regional Development Studies and Public Policy at Universidad de los Lagos, Chile. **30 John Waldron** is an Associate Professor of Spanish at the University of Vermont. **78 Dalia Wassner** is the Director of the Project on Latin American Jewish & Gender Studies at the Hadassah-Brandeis Institute of Brandeis University. **26 Maria Alessandra Woolson** teaches at the University of Vermont for the College of Arts and Sciences and the Honors College. **18 Jie Yin** is a doctoral student at the Department of Environmental Health, Harvard T.H. Chan School of Public Health. **53 Karl Zimmerer**, the 2016 DRCLAS Custer Visiting Scholar, is a professor in the department of geography and the department of agricultural economics, sociology, and education at Pennsylvania State University.

FEATURED PHOTOGRAPHERS: **Eladio Fernandez, Maxi Jonas, Robin Moore and Nicolás Filippo Rosso**