Smithsonian Environmental Research Center

ON THE EDGE

News from the Smithsonian Environmental Research Center

Fall 2022

America's Marine Protected Areas Need More Diversity

ALSO INSIDE:

Voices from Woodlawn and SERC's Ancestors

As Ocean Heats Up, Predators Get Hungrier



THE DIRECTOR'S LETTER:

Sittin' On the Docks of the Bays

This June, I was pleased to return to San Francisco Bay after three years of COVID shutdowns and travel restrictions. The occasion sparkled with face-to-face reunions with our hardworking "SERC-West" biologists. This reunion also afforded the opportunity for the first in-person meeting of SERC's Advisory Board since 2019.

The Smithsonian Environmental Research Center (SERC) has had a branch on San Francisco Bay for over 20 years. Affectionately called "SERC-West," it's based at the Estuary & Ocean Science Center in Tiburon and part of San Francisco State University.

During the meeting, we also were able to welcome the Smithsonian's Under Secretary for Science and Research, Ellen Stofan, and hold a reception for the San Francisco "regional committee" of Smithsonian-wide advisors and supporters. The meeting was filled with field trips that showed firsthand SERC's nearly 25 years of work on San Francisco Bay, which complements our nearly 60 years of work on Chesapeake Bay.

A cargo ship passes beneath the Golden Gate Bridge (Credit: Monaca Noble/SERC)

As another "urbanized estuary," San Francisco Bay has inherited many of the same blessings and struggles as the Chesapeake. A major commercial shipping port, it encompasses several big cities connected by extensive suburban sprawl. It's surrounded by extensive agricultural lands and a large watershed that drains 40 percent of the state. But with all that development comes a great deal of environmental pressure.

Commercial ships entering the Bay have brought in hundreds of invasive species. Cities, suburbs and farmlands continue to pollute the Bay with toxins and nutrients despite past environmental reforms. Extensive water diversion, dams and dikes have greatly restricted passage of migrating fish and severely reduced spawning runs of salmon and other fishery species. Shoreline development has caused San Francisco's native oyster—the Olympia oyster—to dwindle even more than the Chesapeake's eastern oyster, and infill of tidal marshes greatly reduced crucial foraging habitat for once-abundant migrating shorebirds.

Extreme weather and climate change pose additional threats. Despite long-term drought, major rainstorms create episodic purges of runoff from the Sierra instead of gradual runoff from months of snowmelt. Sea level rise remains an ever-looming threat, with king tides and storm surges encroaching on roads, waterfront homes, businesses and even the airport runways.

If this litany sounds familiar to the Chesapeake, the good news is that our SERC-West ecologists are working intensively for solutions to stop the influx of invasive species, testing new ways to rebuild Olympia oyster reefs, advancing wetland conservation, and restoring shoreline resilience and biodiversity. In the process, they've built enduring local partnerships. Teams of citizen scientists have joined green crab removals and Olympia oyster studies over the years. We advance wetland and seagrass restoration with colleagues from neighboring universities and the San Francisco National Estuarine Research Reserve. And this fall, we're teaming up with the Port of San Francisco to launch the city's first "living seawall" pilot project. We mentor students and interns to become the next generation of scientists, resource managers and conservationists.

As one of our Advisory Board members put it, "SERC folks are working in two giant estuarine systems on both coasts of the U.S., using science and volunteers, partner colleagues, grant funders and donors to drive new answers to tough problems."

I went to high school in Palo Alto and earned my doctorate at the University of California, Berkeley, so San Francisco Bay already feels like a second home to me. I'm proud that SERC can also call that bay its second home. So when I think of the old Otis Redding song, I think of sitting on the docks of two amazing bays.

- ANSON "TUCK" HINES, SERC DIRECTOR

Top, L-R: Alison Haigh, the SERC-West science writing intern in 2019. (Credit: SERC); SERC-West intern Jessenia Suarez and teacher extern Jason Thomas in front of the Tiburon shoreline in San Francisco Bay. (Credit: SERC); SERC biologist Ruth DiMaria on a plankton survey in California in 2017. (Credit: SERC); Bottom, L-R: SERC-West biologist Chela Zabin (right), with Jason Thomas, Evie Mason Borchard and Julia Kelly. (Credit: Richardson Bay Audubon Center & Sanctuary); SERC-West biologist Clinton Arriola on a plankton survey in California's Humboldt Bay. (Credit: SERC)

Front Cover: Palmyra Atoll, a national wildlife refuge in the Pacific Ocean, is dependent on local ecosystems in the area to continue to thrive. (Credit: Sara Maxwell)

Diver Nestor Ortiz of CONICET beside an experiment in Puerto Madryn, Argentina. Ortiz is adjacent to a panel open to predators. Panels contained within cages to exclude predators hang suspended in the background. (Credit: Nicolas Battini, CONICET)

AS THE OCEAN HEATS UP, HUNGRIER PREDATORS TAKE CONTROL

BY KRISTEN GOODHUE

A hotter ocean is a hungrier ocean—at least as far as fish predators are concerned. In a new study published this summer in *Science*, Smithsonian scientists discovered predator impacts in the Atlantic and Pacific peak at higher temperatures. The effects cascade to transform other ocean life, potentially disrupting balances that have existed for millennia.

"It's taken thousands of years to get to this state, and then suddenly we're ramping up the temperature at a much higher rate," said Gail Ashton, lead author and marine biologist with the Smithsonian Environmental Research Center (SERC). "And we don't really know the implications of that."

Past research has hinted that predators are more active in the tropics, since higher temperatures tend to increase animals' metabolism. But empirical evidence from smaller studies was conflicting. And few studies tried to nail down how prey communities respond to the increased pressure.

"Warmer waters tend to favor animals high in the food chain, which become more active and need more food," said co-author Emmett Duffy, director of the Smithsonian's Marine Global Earth Observatory. "And it's their prey who pay."

TRACKING PREDATORS FROM POLE TO POLE

The new study took one of the largest views to date. An international team led by the Smithsonian and Temple University coordinated partners at 36 sites, running along the Atlantic and Pacific coasts of the Americas. The sites spanned from Alaska in the north to Tierra del Fuego at the tip of South America.

First, the team used "squid pops" to track predator activity. Squid pops resemble cake pops at coffee shops. Scientists attach dried squid to a stake and leave it underwater to attract hungry fish. At warmer sites, more squid pops got devoured. But a tipping point emerged around 68 degrees Fahrenheit. In waters colder than that, squid pop predation dropped to near zero.

"With climate change, more coastal waters will exceed this tipping point, or warm even further, fundamentally changing how these ecosystems function," said Amy Freestone, co-author with Temple University.

LIFE IN A RAVENOUS SEA

But this did not answer the more pressing question: What will a hotter, hungrier ocean mean for other life in the food web? For that, the team looked at stationary prey—invertebrates—that colonized underwater plastic panels. Some panels had cages to protect them from predators. Others were left exposed.

Lead author, Gail Ashton, inspects marine invertebrates attached to a panel that had been submerged in San Francisco for three months. (Credit: Smithsonian Institution)

A triggerfish—a member of a fish group known to be voracious predators—swims in front of a panel previously caged for 10 weeks and recently exposed to predators in Arraial do Cabo, Brazil. (Credit: Smithsonian Institution)

As expected, prey biomass plunged in the tropics when prey remained unprotected. But in the coldest zones, leaving prey exposed or protected made almost no difference—suggesting predators didn't pose much threat there.

"We knew from previous work in Panama that predation in the neotropics can be intense," said Mark Torchin, co-author with the Smithsonian Tropical Research Institute in Panama. "However, working with our colleagues across the Americas allowed us to test the generality of this."

The kinds of prey that flourished changed as well. Predators liked eating solitary, bottle-shaped tunicates ("sea squirts"), so those prey suffered major losses in the tropics when left unprotected. Meanwhile, encrusting bryozoans ("moss animals") thrived in the newly free space as fish largely left them alone.

Solitary tunicates filter the water and offer nooks and crannies for other organisms to settle—two important functions that bryozoans don't do as well. But that's just one example of how a rise in predation could alter ecosystems as cooler zones heat up.

"As predation changes, some species will be winners and some will be losers," said co-author Greg Ruiz, head of SERC's Marine Invasions Lab. "Some will be defended; others will be vulnerable. But we don't know exactly how that will play out."

Meanwhile, what will happen at the equator—where temperatures may rise even higher than today—remains even more mysterious.

"We don't really know what might happen in the tropics, because we don't have data from those warmer temperatures," Ashton said.

LINK TO RESEARCH PAPER:

https://www.science.org/doi/10.1126/science.abc4916

Stories from the *Woodlawn History Center*

BY KRISTEN GOODHUE

This July, Woodlawn House—the oldest building in the Smithsonian still in its original spot—opened to the public for the first time. Built in 1735 by the Sellman family, it's now received a new name: the Woodlawn History Center. Visitors can walk through the first floor, encounter centuries-old artifacts and learn about the lives of enslaved and free people who lived on the land. For this feature, we collected a few stories from the exhibit and the people who helped create it.

The Woodlawn History Center is open Fridays and Saturdays, from 10 a.m. to 12:30 p.m. It's located just past the brick security kiosk when visitors first enter the SERC campus.

Left to Right: Victoria Sellman, born in 1904, was one of the last Sellmans born at Woodlawn. (Credit: Nancy Taylor); The Smithsonian's Woodlawn History Center, originally built in 1735. (Credit: Michael Barnes/Smithsonian)

Dennis Simms: The Enslaved Testifier

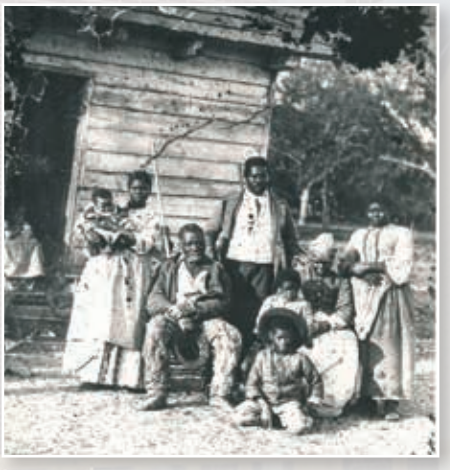
Born in 1841, Dennis Simms worked as an enslaved laborer on the Java Farm, a plantation next to Woodlawn run by the Contee family. There are no photographs or illustrations of him. Other than the color of his skin, we have no idea what he looked like. But in 1937 he left a detailed oral history of slavery at Java. Below are a few excerpts.

"We lived in rudely constructed log houses, one story in height, with huge stone chimneys, and slept on beds of straw."

"Our food consisted of bread, hominy, black strap molasses and a red herring a day. Sometimes, by special permission from our master or overseer, we would go hunting and catch a coon or possum and a pot pie would be a real treat."

"We had to toe the mark or be flogged with a rawhide whip, and almost every day there was from two to ten thrashings given on the plantations to disobedient Negro slaves....We all hated what they called the 'nine ninety-nine,' usually a flogging until [we] fell over unconscious or begged for mercy."

"We were never allowed to congregate after work, never went to church, and could not read or write....Sometimes we would, unbeknown to our master, assemble in a cabin and sing songs and spirituals. Our favorite spirituals were—Bringin' in de sheaves, De Stars am shinin' for us all, Hear de Angels callin', and The Debil has no place here. The singing was usually to the accompaniment of a Jew's [mouth] harp and fiddle, or banjo."



The full oral history of Dennis Simms is in the Library of Congress. SERC owes a great debt of gratitude to Phyllis Jackson, who first brought his testimony to our attention.

Left: Cover featured in Woodlawn exhibit, with excerpts from the oral history of Dennis Simms. (Credit: Kristen Goodhue/SERC); Center: Enslaved farmers work in sweet potato fields in South Carolina in 1862. (Credit: Henry Moore, from the Library of Congress); Right: A Black family of five generations on Smith's Plantation in South Carolina in 1862. (Credit: Timothy H. O'Sullivan, from the Library of Congress)

Background: The Woodlawn History Center, formerly known as the Woodlawn House, originally built in 1735. (Credit: Christine Dunham/SERC)

Lyndra Marshall: The Genealogist

Lyndra Marshall has been studying Black history in Maryland since 1968, when she first began exploring her family roots. When SERC's director, Tuck Hines, and program manager Christine Dunham approached her in 2019 about helping with the Woodlawn exhibit, the family connection immediately sparked her interest.

Marshall's mother bears the Sellman name. Her husband, Roger, also has ties to the neighboring Contee family. "How do I say no? I don't think I can do that," she recalled thinking.

But as Marshall knows from experience, piecing together Black history in America is an uphill battle. Written records from the enslaved—even straightforward items like birthdays, full names and family trees—rarely exist.

"They couldn't tell their story, because they were forbidden to read and write," she said. Most scholars of pre-Civil War Black history need to rely on records from slaveholders: manumission documents, wills and the occasional want ad for a fugitive. For post-Civil War America, obituaries, military records and church records also provide useful intel. Marshall depends heavily on the Maryland Historical Society and the Maryland State Archives for these documents.

Marshall's own connection to the Sellmans runs through her mother, Elsie Alverta Sellman Pratt, whose picture appears in the exhibit. She can trace the Sellman side of her family tree to her great-great-great grandfather William Sellman, born in 1825. But there, the trail vanishes. She's not sure if her family are directly descended from the white Sellmans who lived at Woodlawn or not. However, Marshall is not giving up.

"The main obstacle right now is making that connection from the white Sellmans to the Black Sellmans," Marshall said. "And I believe if I can go back further than 1825, I can make that connection."

Left: Elsie Alverta Sellman Pratt, mother of Lyndra Marshall. Her portrait appears in the Woodlawn exhibit, as one of the Black Sellmans who may have descended from the white Sellmans. (Credit: Lyndra Marshall (née Pratt) Archival Collection); Right: Portrait of Lyndra Marshall in 2008. (Credit: Lyndra Marshall (née Pratt) Archival Collection)

Virginia Arndt and Betsy Kirkpatrick-Howat: The Descendants

The Sellmans remained at Woodlawn from 1735 until about 1908. By then, their descendants had dispersed across the country—some to other parts of Maryland, and some to Ohio and beyond. Virginia Arndt is the last living descendant of the Sellmans who stayed at Woodlawn the longest.

Arndt's mother, also named Virginia, was born right after Wesley Witwright Sellman moved his family away.

"I think my grandfather really wanted to stay on the farm," Arndt said. "When he left to go to Baltimore, I think it was the economics of it. Big family, and he needed a source of income....But he always wanted to farm, and eventually in retirement, after he retired from the insurance business, he bought a small farm out in Sykesville."

After the Sellmans left, the Kirkpatrick-Howat family took over the property. During the Great Depression, the enterprising Elizabeth Kirkpatrick-Howat managed both Woodlawn and the neighboring Contee land, where Dennis Simms and other enslaved laborers had toiled nearly a century earlier. She raised cattle for dairy and grew hay for the livestock.

"She was quite a businesswoman," said her granddaughter, Betsy Kirkpatrick-Howat. Eventually, during Betsy's childhood, the family transitioned to raising cattle for beef.

Arndt and Kirkpatrick-Howat both made substantial contributions to the Woodlawn exhibit, in the form of photos, family history notes and monetary funds. But as their involvement deepened, the two women made a remarkable discovery: They're related. Arndt and Kirkpatrick-Howat are distant cousins through their great-great-great-great grandfather, Robert Carr.

So perhaps, on some level, Woodlawn House stayed in the family after all.

Left to Right: Portrait of Elizabeth Gordon Kirkpatrick-Howat. (Credit: the Kirkpatrick-Howat family); Elizabeth Gordon (later Elizabeth Kirkpatrick-Howat) stands with farmhands on the Howat-Contee Farm. (Credit: the Kirkpatrick-Howat family); Virginia Arndt (left) and Betsy Kirkpatrick-Howat (right) in front of the Woodlawn History Center. (Credit: Kristen Goodhue/SERC)

Marine Protected Areas Need More Diversity To Reap Full Benefits

BY NATHANIEL HUMPAL

In 2021, President Joe Biden launched the America the Beautiful initiative, which included an ambitious "30 by 30 initiative." The plan aims to conserve at least 30% of U.S. land and waters by 2030. It relies heavily on marine protected areas (MPAs)—spaces protected by local, state or federal governments so both people and nature can benefit.

However, according to a new paper in *Frontiers in Marine Science*, roughly 96% of America's MPAs sit in the central Pacific. Outside that region, less than 2% of U.S. ocean waters have any protection at all. The few bodies that do are usually "minimally" or "lightly" protected.

"The U.S. has more than 1,700 MPAs of one sort or another," said co-author Emmett Duffy, biologist with the Smithsonian Environmental Research Center. "But most are quite small and many have very little protection."

Furthermore, the differences between minimally and fully protected MPAs are immense.

"Minimally protected MPAs have activities happening in them that have high impacts on biodiversity—for example, large-scale infrastructure," said Jenna Sullivan-Stack, lead author and research associate at Oregon State University. Fishing still occurs in those MPAs. When fishers use impactful gears at large scale, they can cause further damage.

RAISING THE BAR FOR INCLUSIVITY

Ecosystems most at risk include the Caribbean Sea, the Arctic and Atlantic Oceans. Losses here could snowball into lost benefits for nearby communities. These include the dwindling of bigger fishes and more species and habitats at risk.

On the flipside, increasing the number and strength of MPAs can preserve ecosystems and biodiversity, which helps with climate resilience. It will also help communities' food security as fishes can get bigger and more plentiful.

"Paradoxically, many MPAs can actually benefit fisheries as fish that grow up within their protection are exported ('spill over') to outside areas where they can be caught," Duffy said.

However, historically some vital local stakeholders have been excluded from MPA discussions, despite marine resources being central to their livelihoods and cultures. Native Americans have generations of expertise helpful to MPAs and protection of nature in general.

Emmett Duffy samples water inside a marine protected area in the Arctic archipelago of Svalbard. (Credit: Peter Carey)

"The knowledge and wisdom they hold are incredibly important for charting a path forward," Sullivan-Stack said. Without their help, the U.S. wouldn't have managed to achieve even this much protection of MPAs.

"Local fishing communities also have important insights to contribute, and including them can lead to improved MPA design and increased buy-in," said Matthew Ogburn, head of SERC's Fisheries Conservation Lab, who was not an author on the paper. Indigenous leaders, local stakeholders and other stewards of marine resources all need a place at the table to achieve equitable ocean protections.

CHARTING A BRIGHTER COURSE

The paper highlighted several suggestions for how the U.S. could improve its MPAs, in addition to raising diversity.

Improve its commitments to all current and future MPAs. Some have already been damaged by human actions like overfishing, despite protections that range from local to federal levels.

Create a network of MPAs, enabling authorities to communicate with each other and reinforce MPAs needing extra protection. The best approaches would build upon already-existing programs, saving both money and time.

Reexamine existing MPAs. The U.S. needs to ensure its current MPAs deliver benefits, which is the primary reason for their protection in the first place. This way managers can redirect resources to places that need them most.

It's a fact that some communities have more access to MPAs than others, such as coastal cities. This is also an important factor in determining which areas need to be protected most.

"I've learned from my social scientist and other colleagues, such as Dr. Ana Spalding and Angelo Villagomez, among others, how important it is to take into account the who and the how of MPAs, not just the what and where," said Sullivan-Stack. "And this not only is important for social outcomes of MPAs, but for ecological outcomes as well. MPAs just don't work if you don't pay attention to the people."

LINK TO FULL RESEARCH PAPER:

https://www.frontiersin.org/articles/10.3389/fmars.2022.849927/full

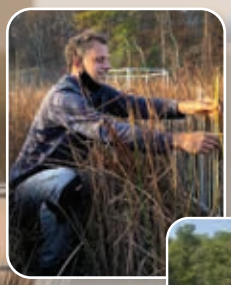
Top, L-R: Ashkhabad, a shipwreck in the Monitor National Marine Sanctuary in the Atlantic Ocean. Despite the wrecked ship, the ecosystem has adapted to continue thriving. (Credit: NOAA); Baker Island in the Pacific Ocean. The marine ecosystem here survives thanks to its being a National Wildlife Refuge and a marine protected area. (Credit: Jim Maragos/US Fish & Wildlife Service)

For Wetland Plants, Sea Level Rise Stamps Out Benefits of Higher CO_2

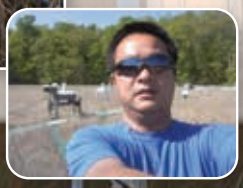
BY KRISTEN GOODHUE

Wetlands worldwide are in danger of drowning from rising seas. But for decades, scientists hoped another aspect of climate change—rising carbon dioxide (CO_2)—could boost plant growth, enabling wetlands to outpace sea level rise. That helpful side effect is disappearing.

"Too much water is a stress, an environmental stress, for plant response to high CO_2," said Chunwu Zhu, lead author of a new *Science Advances* study. Zhu, a biologist with the Chinese Academy of Sciences, conducted the study during a fellowship with the Smithsonian Environmental Research Center (SERC).



Conserving wetlands is critical both to fight and adapt to climate change. Besides providing habitat, wetlands sequester carbon and protect people from hurricanes and typhoons.



"Although they occupy just a fraction of the Earth's surface, they provide outsized ecosystem services, which are basically benefits to people," said co-author Pat Megonigal, a SERC biogeochemist.

The study took place at SERC's Global Change Research Wetland, a research site Megonigal runs with several futuristic experiments. For this study, the researchers relied on an experiment begun in 1987. Inside open-top chambers, scientists raised CO_2 concentrations by 340 parts per million, roughly doubling atmospheric CO_2 levels of 1987.

For about the first two decades, plant growth in high-CO_2 chambers flourished. They grew on average 25% more aboveground and 35% more underground than plants without extra CO_2. Underground root growth is especially critical, as roots build soil and keep wetlands growing *upward*. But after 2005, the effect declined and vanished. For the past 14 years of data in the study, there was no average difference between high-CO_2 and normal chambers.

The team examined several possible explanations. Only sea level rise showed any link to plant growth. Once sea levels at the wetland rose 15 centimeters above where they began in 1987, the benefits of higher CO_2 disappeared.

"In some ways, this is a race," said co-author Lewis Ziska of Columbia University. "A race between what CO_2 can do and what sea level can do."

If wetlands can't rise higher, they may find salvation by migrating inland. However, that can only happen if they have enough space. In the meantime, Earth's climate accountants will need to rethink Earth's carbon budget. Now that scientists know extra CO_2 does not always stimulate wetland growth, how much carbon wetlands can absorb remains more uncertain.

LINK TO STUDY: https://www.science.org/doi/10.1126/sciadv.abn0054

Left to Right: Adam Langley, a co-author and Villanova ecologist, measures soil elevation at the Global Change Research Wetland. (Credit: Mikayla Manyin); Chunwu Zhu, lead author of a study on how sea level rise stifles wetland growth, at SERC's Global Change Research Wetland. (Credit: Chunwu Zhu); Pat Megonigal, head of the Smithsonian's Global Change Research Wetland, on a research expedition to the salt marshes of Virginia's Goodwin Islands. (Credit: Alice Stearns); Background: Sunrise at SERC's Global Change Research Wetland. These chambers have been growing plants with extra CO_2 since 1987. (Credit: Tom Mozdzer)

DONOR SPOTLIGHT: THE SELLMAN FAMILY

BY SARAH WADE

*The exhibits within the Woodlawn History Center were made possible by several generous donors, including three descendants of the Sellman family who built the house in 1735: **Steven DeVience, Sally Sellman** and **Jean Sellman Graf.** We reached out to them to learn more about their ties to the property.*

What is your connection to Woodlawn?

"My 8x great-grandfather was William Sellman, who built the original house," said Sally Sellman. She helped SERC go through Woodlawn artifacts when the renovation began. "My cousin told me that she and her husband were working at the center, going through the 'Sellman trash' and asked if we wanted to join them. My sister and I did, and spent some time cleaning and separating the pieces of artifacts."

Jean Sellman Graf is a 10th-generation Sellman descendant. She and her husband, Bernard Graf, have studied Sellman history for decades.

"We were shocked when we learned we lived only a few miles from Jean's ancestors' home," said Bernard. When SERC acquired the property, they jumped in to provide genealogy records.

What inspired you to contribute to Woodlawn?

"It is really a microcosm of American history: colonization, piracy, slavery, the American Revolution and the Civil War," said Steven DeVience, a descendant of a Sellman branch that went west. He added that family history and a desire to preserve the home inspired him.

What did you like most about the exhibit?

"There was a wonderful crowd of Sellmans on the ribbon cutting day!" said Sally Sellman. "Meeting and talking with 'family members' previously unknown took some time away from seeing everything….I do plan on going back and am hoping to take my granddaughters."

Bernard and Jean Graf were glad to see the artifacts on display, which they helped collect with SERC's Environmental Archaeology Lab. DeVience is interested in how the house and land use transformed over the centuries.

Left to Right: Portrait of General Jonathan Sellman, a Revolutionary War veteran who lived at Woodlawn. (Portrait by Jonathan Beale Bordley, courtesy of the Sellman family); Thomas M. Sellman, a Civil War soldier who fought for the Union, from a Sellman branch in the Midwest. (Credit: Public Domain); John Poole Sellman, a Maryland Sellman who fought for the Confederacy. (Credit: Public Domain)

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Tuesday, October 18 • 7-8:30pm Eastern

with Ellen R. Stofan, Ph.D., Smithsonian Under Secretary for Science and Research

In our finale Earth Optimism webinar of 2022, find out how going to space has helped improve life on Earth! Ellen Stofan will explore how satellite observations and other space technologies are transforming our view of Earth, and yielding new insights for keeping our home planet sustainable. Stofan is a planetary geologist who served as the first female director of the Smithsonian's National Air and Space Museum and the former Chief Scientist for NASA. She now serves as the Smithsonian's Under Secretary for Science and Research.

Photo of Ellen Stofan by Jim Preston, Smithsonian National Air and Space Museum (NASM2018-01471). Photo of Earth by NASA.

This webinar will be recorded. Closed captions and Spanish translation will be available. **Sign up online at https://serc.si.edu/visit/eveninglectures**.

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ON THE EDGE
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