A world without mangroves? Effects of climate change on mangrove range contractions in the Anthropocene

Overview

Mangrove ecosystems are one of nature's most unlikely success stories. Approximately 70 species of salt-tolerant coastal plants, many of them unrelated, occupy ~75% of the world's tropical coastlines where they provide protection against storm surges, habitat for thousands of other species, and store 10x more carbon per area than terrestrial forests. A surge of recent research has focused on poleward mangrove migration at the range edges due to fewer mangrove-killing freeze events. However, these slight gains at the margins mask the rapid range contractions occurring in the range core, where whole mangrove islands are being lost due to sea level rise, and entire coastlines have been decimated by drought. Although such losses are potentially the norm going forward and could undermine gains made by the slowing of mangrove deforestation, to date we lack a global projection of mangrove gains and losses due to climate-induced contractions in the core of their range. Here, we propose to recruit a Fellow to synthesize our extensive mangrove data resources and global data sets to leverage our global professional network of colleagues to be used to guide management and conservation resources to help preserve resilient mangrove ecosystems. This could include modeling mangrove range contractions under current and future climate change, and/or develop tools for detecting early-warning signals of stress and degradation of mangrove forests that may precede die-offs.

Importance

Mangrove ecosystems are recognized for a wide array of ecosystem services, especially the buffering of shorelines against storm surges, habitat for commercially and ecologically important fisheries, and blue carbon sequestration. Whilst range expansion (poleward and landward) of mangroves at the edges is increasingly emphasized as a response to climate change, there is limited focus on the survivorship of mangroves within the core of their current range. In fact, one key assumption appears to be that a warming world will generally favor mangroves, which are particularly hardy species that thrive in tropical weather. However, this optimism may be unfounded. Increasingly warmer temperatures, drought, and rising sea-levels are already stressing mangroves beyond their ecological tolerance, as evidenced by extreme diebacks including the drought-induced loss of over 1000km of mangroves in the Australian Gulf of Carpentaria in 2016. Understanding how mangroves respond to combinations of these stresses has important implications for climate mitigation, their future carbon sequestration potential and climate adaptability, and whether coastal communities will continue to receive flood and storm defenses. Mangroves provide these and other ecosystem services, which are inextricably linked to human well-being.

Numerous international collaborations have banded together to recognize and respond to early-warning signals of mangrove degradation, prevent the loss of mangrove cover, increase mangrove management, protection, and restoration, and promote science-based restoration. This culminated in the founding of the Global Mangrove Alliance, of which the Smithsonian is a member. To achieve these common goals, it will be critical to understand the implications of climate change for mangrove ecosystems and to promote climate resilient systems that continue to provide benefits to people and nature. An important component of effective management is the ability to implement proactive, rather than reactive, interventions that can mitigate multiple stressors.

As with other vegetation, mangroves exhibit a range of signals as a response to singular and multiple stressors, which can be detected through satellite imagery. The aim of this collaborative network is to develop tools that can reliably detect these stress signals using known case studies of mangrove ecosystem declines and die-off events to train models. These models can then be tested through detecting other historical events to determine if the models can predict mangrove degradation in other regions. The overarching objective is to detect early-warning signals of stressed mangrove ecosystems and determine if proactive management interventions can prevent the loss of these ecosystems. Such tools can be shared widely within our diverse community of collaborators that includes academics, non-government organizations, management practitioners, and policy makers.

POTENTIAL RESEARCH THEMES

The successful postdoctoral researcher will have an interest in pursuing innovative science to advance the understanding of mangrove ecosystems, and the use of existing and novel biological indicators to detect change. These research themes have direct implications for the management of mangrove ecosystems, through the creation of early warning signals. Potential research themes include, but are not limited to:

- *Assessments of the drivers of mangrove range expansion and contraction* under different climate stress conditions (e.g., drought, sea-level rise) and scenarios over the next 20, 50, and 100-years.
- *Analyses of mangrove vegetation stress* application of existing and the development of novel remote sensing tools that can detect stress in mangroves preceding die-offs.

PROGRAMS AND ASSETS

The Fellow will have access to the scientific expertise, data resources, and professional networks of the scientists from the Marine Conservation, Terrestrial Ecology, and Integrative Spatial Ecology labs at Smithsonian Environmental Research Center, the Conservation Ecology Center at National Zoo and Conservation Biology Institute, and from across the Smithsonian Institution at large. Additionally, the fellow will be connected with our global network of partners and collaborators to advance studies of their own design and interest. We work in close collaboration with a diverse community of scientists, policy makers, and blue carbon ecosystem practitioners, partnering with organizations such as Conservation International, Pew Charitable Trusts, and global programs such as the Global Mangrove Alliance and the IUCN Mangrove Specialist Group. Specific assets include access to baseline global mangrove cover maps, validated national mangrove cover maps throughout Latin America and the Caribbean, access to Planet data – through an existing Smithsonian partnership - and a global network of long-term mangrove fertilization experiments. Additionally, global temperature, precipitation, sea-level rise, and nutrient pollution data sets are available from NOAA and other agencies and academic institutions.

ADVISORS

The following scientists commit to advise fellows, providing datasets and guidance to link their research to broader conservation and restoration goals: Steve Canty, John Parker, Justin Nowakowski, Hannah Morrissette, Candy Feller (SERC), and Grant Connette (NZCBI).