New research reveals humanity's roles in ecosystems

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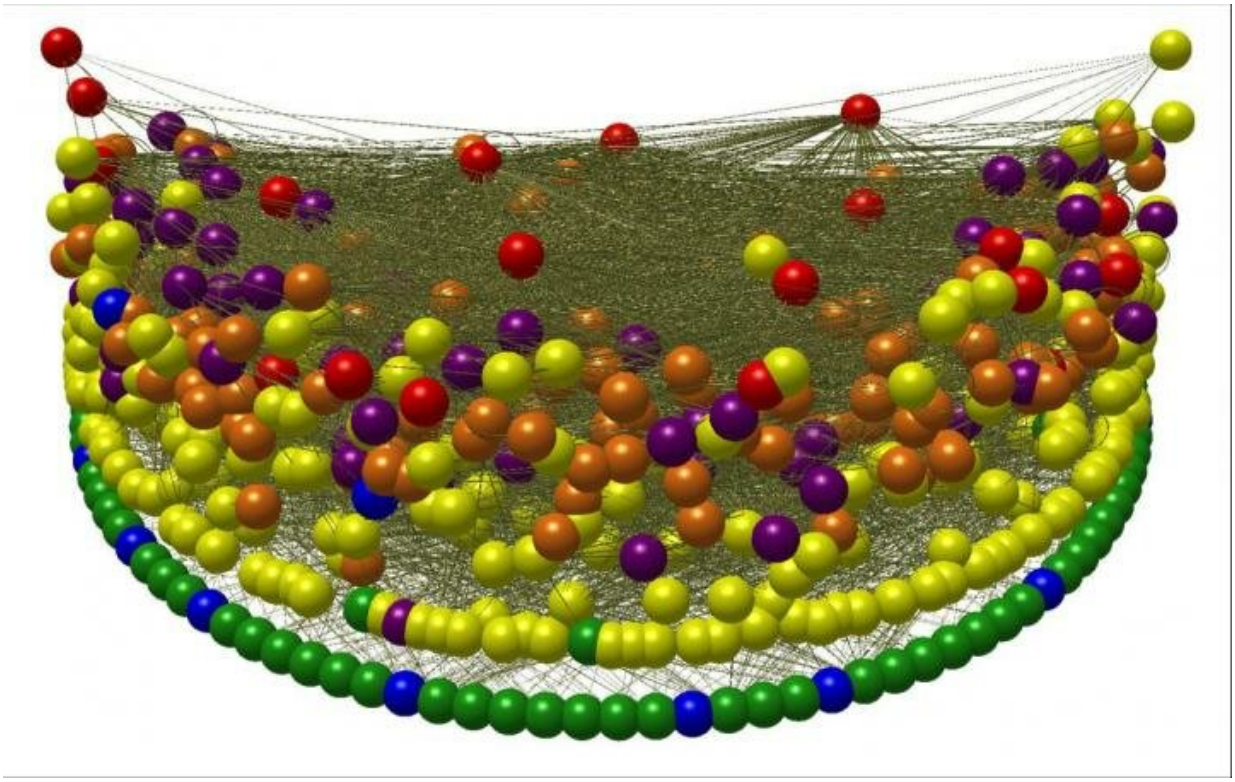

In this depiction of the nearshore food web of Sanak Island, Alaska, spheres represent species or groups of species, and the links between them show feeding relationships. The colors of the spheres indicate types of taxa: green shows algae; blue shows seagrass, lichen, protozoa, bacteria, and detritus; yellow shows invertebrates such as snails, crabs, mussels, and octopus; orange shows fishes; purple shows birds; and red shows mammals such as sea otters. The red node near the center top of the image represents human hunter-gatherers (Aleut). It is the first comprehensive food web to include Homo sapiens. Credit: J.A. Dunne

In two back-to-back symposia at the annual meeting of the American Association for the Advancement of Science in Washington, D.C., on Sunday, Feb. 17, a cross-disciplinary cohort of scientists presented the first comprehensive investigations of how humans interacted with plant and animal species in different cultures worldwide through time. By compiling and comparing detailed data from pre-industrial and modern societies, the researchers are sketching a picture of humans' roles and impacts in sustainable and unsustainable socio-ecological systems.

"Almost all food webs that have been compiled and studied have been put together without including humans," says Jennifer Dunne (Santa Fe Institute), an ecologist and complex systems scientist who is leading the project with archaeologist Stefani Crabtree (Santa Fe Institute and Center for Research and Interdisciplinarity). "It takes a lot of time and effort to put these kinds of detailed data together. So even though ecologists have been studying food webs for decades, we're only now in a position where we can start to rigorously compare human roles and impacts across different systems to understand sustainability in new kinds of ways," says Dunne.

What do we learn when we do include humans?

As part of her presentation during the second symposium, Dunne will reveal initial results from a comparison of food webs that explicitly include humans across several socioecological systems. Three are pre-industrial systems—the Aleutian Islands of Alaska, the Pueblo U.S. Southwest, and the Western Desert of Australia, and one is modern—the Tagus Estuary of Portugal. Given the diversity of cultures, ecologies, climates, and time periods represented in the data, Dunne suggests that we can start to learn "something more general about human roles in, and impacts on, ecosystems" by comparing these systems. For example, humans are often super-generalists compared to other predators—they feed on a huge variety of different species.

In some systems, humans as super-generalist predators can fit into ecosystems without causing extinctions or major environmental degradation. For example, according to Dunne's pioneering analysis published in *Scientific Reports* in 2016, the Sanak Island (Alaska) Aleut fed on a whopping 122 of 513 taxa in the nearshore marine ecosystem. However, like other predators, they switched from their favorite prey—sea lions—to shellfish, kelp, or whatever was readily available when the weather did not allow them to hunt in open water. "Prey-switching is very stabilizing for food webs," Dunne explains, "because it allows prey taxa populations to recover from exploitation, as the predator's focus shifts to other prey that are easier to forage or hunt given current conditions." That, plus limited use of hunting technology and other factors helped to minimize potential negative impacts of humans on the Sanak ecosystem—during approximately 7,000 years of human habitation, there is no evidence for any long-term local extinctions.

Humans also stabilized the desert ecosystem of Western Australia, where Crabtree and Rebecca Bliege Bird (Pennsylvania State University) are examining how the Martu Aboriginal foragers are embedded in their surrounding ecosystems. According to Crabtree, Martu Aboriginal foragers stabilized their ecosystem by providing several ecosystem services such as lighting small brush fires to expose the burrows of small prey. The scorched patches left on the landscape served as natural fire breaks against larger, more devastating wildfires. When the Martu were removed from their homeland in the mid-20th century, wildfires increased dramatically in size, and several small mammals, like the Rufous Hare-wallaby, went extinct.

Bird will present a newly published network analysis for the Aboriginal foragers during the first symposium, following Andrew Dugmore (University of Edinburgh) and George Hambrecht's (University of Maryland) presentation of how Norse people in Iceland and Greenland

used governance to mitigate anthropogenic degradation of the ecosystem.

Just as humans can have a stabilizing effect on their ecosystems, they can also play a destructive role. In the first symposium, archaeologist Jennifer Kahn (College of William and Mary) will present her ongoing historical analysis of the French Polynesian islands, including two cases where human interactions with their surroundings led to markedly different outcomes—both for the ecosystems and the societies embedded within them.

Crabtree, in the second symposium, will present her analysis of the 700-year trajectory of the Ancestral Pueblo people in the Southwest U.S., and the extent to which human interactions with the ecosystem eventually led them to depopulate the region.

Iain McKechnie (University of Victoria and Hakai Institute) will then present anthropological and archaeological data that illustrates the resilience of the indigenous peoples of the North American Northwest Coast as they interacted with both marine and terrestrial species.

In the final talk, Dunne will cross-compare these and other systems and synthesize what we know, so far, about humanity's roles across ecosystems and time periods. In addition to presenting new results about human roles in food webs, she will also discuss new work that moves beyond feeding interactions to consider the myriad ways that humans interact with biodiversity in both simple and complex ways, for example by using species for medicine, shelter, tools, clothing, fuel, ritual purposes, and trade.

"Understanding ecosystems with humans as part of them is essential," Crabtree says. "We're not going anywhere. We are here to stay. We are going to keep impacting ecosystems, and we need to understand the ways

that our impacts can lead to more sustainable and resilient systems."

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