

Coconut palms bring ecological change to tropics, researchers say

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A variety of seabirds, including terns, prefer to nest in the native trees.

(PhysOrg.com) -- Those graceful coconut palms swaying in tropical breezes are lowering nutrient levels in the soils and the plants around them, thereby altering the eating habits of animals. Researchers say it's one example of how a change in a plant community can disrupt an entire ecosystem.

Coconut palms, the epitome of South Seas tranquility, turn out to be doing more than just soothing vacationers and inspiring aloha shirts. As they continue to spread to new areas, they are also changing the very

landscapes they grace, according to Stanford researchers. Seabirds are shunning the palms as nesting sites, favoring other tree species instead, sending a ripple through island [ecosystems](#).

With the birds has gone the rich cargo of guano that they normally dispense so freely to the earth under their abodes. The absence of that precious input has caused the [soil](#) around the palms to become nutritionally deficient.

That, in turn, is lowering the nutritional content of plant species growing around the palms and is causing the creatures that feed on those plants, such as crabs and grasshoppers, to forage elsewhere.

"We found that you can get a five- to twelvefold decline in important soil nutrients such as nitrate and phosphate when coconut palms are present, mainly because the birds aren't there depositing nutrients to that system," said Hillary Young, a doctoral candidate in biology and member of the research team that conducted a study on Palmyra Atoll in the South Pacific. Palmyra lies roughly midway between Hawaii and Tahiti.

"This is an unusual example of an introduced or spreading plant that causes wide nutrient declines in ecosystems," Young said. Typically, introduced plants enrich the nutrient content of the ecosystems, she said. Young is first author of a paper describing the study, published online this week in the [Proceedings of the National Academy of Sciences](#).

Just how long the palms have been growing on Palmyra, or how they arrived, isn't clear. Most researchers agree that coconut palms originated in Asia. Coconuts can travel long distances by floating on the ocean currents, but the palm was probably introduced in much of its current range, including areas like Hawaii and the Americas, by early human travelers a few thousand years ago.

The arrival of these early voyagers was often accompanied by introduction of non-native species - such as rats and pigs - but also agricultural plant species. Whether coconuts were brought to Palmyra by oceans or by people, they have clearly proliferated in modern times, and now seem to be causing widespread changes to surrounding plant and animal communities, and the ecosystem as a whole.

Architectural features driving seabirds away?

Young said the seabirds are most likely bypassing the palms on architectural grounds. "The palms have relatively small canopies with spiky, sharp leaves, so I don't think they make particularly good nesting habitat for these birds," she said. The long branchless trunks of the palms also lack the crooks and crannies - features crucial to accommodating nests - that are abundant on most other branching native trees. It is also possible that rats, which climb the palms to feed on young coconuts, may contribute to the seabirds' bypassing of the palms.

Red-footed boobies form the largest contingent of forest-dwelling seabirds on Palmyra, but black and brown noddies, terns and frigate birds also nest in the atoll's forests.

"Most of these birds are also colonial species, so they like to nest in large groups," she said. "If you think about it, the coconut palm only has space for maybe one or two nests."

Young and her colleagues, including senior author Rodolfo Dirzo, professor of biology, compared the nutrient content of several species of native trees favored by the seabirds, as well as the coconut palms, on some of the different islets that make up the atoll. The islets are typically dominated either by the palms or by native trees, with relatively few mixed species forests.

"Being able to conduct our studies on multiple islets sharing the same general ecological conditions, but with different forest types, was an ideal experimental setup to investigate the cascading ecological consequences of invasive or spreading plants - currently a serious global environmental problem," said Dirzo, the Bing Professor in Environmental Science.

"All of the [tree species](#) we analyzed showed these nutrient changes," Young said. "Whenever coconuts are present, the nutrient levels decline in the leaves of each species." Even the palms themselves had lower nutrient levels when growing in a palm forest than when they grew in mixed or native-dominated forests. "Coconut palms don't increase nutrient levels of anything," she said.

But the nutrient levels of the tree leaves themselves were not as dramatically different as the levels in the soils. That made the researchers wonder how much effect even a small difference in nutrients in the leaves might have on the creatures that dine on them. In search of an answer, the researchers conducted a taste test.



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Taste testing the leaves

For tasters they chose some strawberry hermit crabs and longhorned grasshoppers, species that are widely distributed across the atoll.

"We would put a crab in a bucket and offer it two different leaves," Young said. In each test, the researchers used two leaves from the same plant species, but one leaf was from a specimen growing in a coconut palm forest, the other from a tree in a forest dominated by native trees favored by the seabirds. They used the same approach with the grasshopper tasters, but placed them in yogurt containers rather than buckets.

"You couldn't tell anything was different between these two leaves; we had to mark them as to what type of forest they came from," Young said. After leaving the taster alone with both leaves for 24 hours, the researchers would measure the change in the size of each leaf.

"I was shocked at the results," Young said. "There was dramatically higher consumption of leaves that came from plants in native forests, even though they were the same species from the same atoll."

That was true even for leaves where the difference in nutrient levels only differed by 10 percent, she said. "Nutrient levels are so important to these herbivores that they can detect that and select for only those leaves that have high nutrient levels. It was really impressive."

The researchers also assessed differences in leaf consumption in the field, using two different methods, each of which also indicated herbivores on the atoll had a profound preference for leaves of trees growing in forests dominated by the native trees. The field findings were consistent with the results of the taste tests, all of which showed that levels of leaf consumption by herbivores is reduced in coconut-dominated forests and that nutrient depletion driven by the spread of coconut palms ripples through the ecosystem's food chain.

"Seabirds can move a large amount of nutrients to land ecosystems and those movements, if you disrupt them, can have a lot of impacts on the ecosystem where the seabirds live," Young said.

Beloved icon or omen of environmental issues?

"The coconut palm is this iconic tree that is everywhere in the tropical world and we all love it, but this study suggests they are actually having deleterious effects on ecosystems where they become dominant," Young said, noting this could have serious ramifications for managing areas similar to Palmyra.

The atoll hasn't seen much impact from humans since 1961, when the United States military ended the occupation it began during World War II, and Palmyra is now part of a National Wildlife Refuge. But elsewhere, she said, coconut palms are still being planted as a crop to spur development, because they are such a useful resource, providing food, drink and raw material for uses ranging from making rope to roofing.

"I'm just suggesting that maybe we want to step back and think a little bit about what ecological impacts coconut palms might have," Young said.

Broader implications beyond the atolls

But Young said the broader implication from the study is that changes in plant communities change connections among ecosystems. "Since humans are changing plant communities the world over in a myriad of ways - invasive species, land use change, resource extractions - it is critical to realize that changes to these plant communities are not isolated," she said. "An apparently innocuous change to these plant communities can disrupt invisible connections among ecosystems and potentially trigger a cascade of change that can fundamentally alter those ecosystems."

Once these changes have happened, it can be difficult or even impossible to repair the damage, she said. "The emphasis needs to be on protecting native plant communities and preventing damaging disruptions from happening in the first place."

Rob Dunbar, the W. M. Keck Professor in Environmental Earth System Science and senior fellow at the Woods Institute for the Environment, and Douglas McCauley, doctoral candidate at Stanford's Hopkins Marine Station, are also authors of the *PNAS* paper.

Provided by Stanford University

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