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Under the Lunch Tree

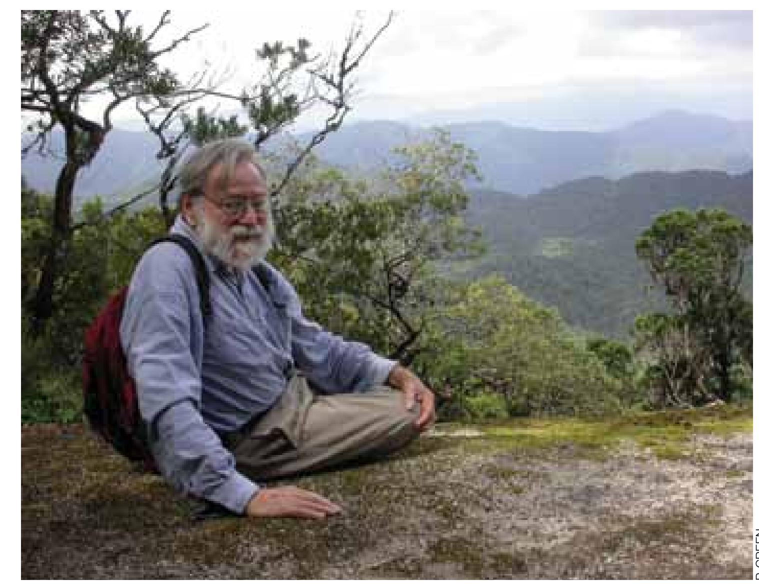
FIFTY YEARS OF RAINFOREST DYNAMICS IN QUEENSLAND, AUSTRALIA

BY KYLE E. HARMS & PETER T. GREEN

"Tag number 3473, one point nine feet," calls the measurer from his contorted position kneeling on the rainforest floor. After scanning the data sheet on her clipboard for the tag number, the recorder answers, "Another one that's barely grown! It was one point six feet in 1965." The recorder writes the new measurement next to the original record on the data sheet, and nonchalantly flicks away the leech that has inched up her leg.

Our field team repeated a similar version of that call-and-response for almost 20,000 plants last year, during the fiftieth-anniversary census of one of the world's longest-running rainforest dynamics projects. We worked at two plots in Australia: one just south of Brisbane, in Lamington National Park, and the other at Davies Creek National Park, southwest of Cairns. Both plots were set up—and the first large trees were tagged—in 1963 by Joseph H. Connell, now Professor Emeritus at the University of California, Santa Barbara (UCSB). About ten members of our team spent two weeks at each plot, extending Connell's legacy to five decades of research. With each new round of field observations we better understand these forests' diversity and dynamics.

The way Connell tells it, once UCSB gave him tenure he was keen to spread his wings and explore. Australia was irresistible as a research destination in the early 1960s—biologically a bit exotic, English-speaking, and unlike several tropical countries at the time, politically stable. Connell's initial research had been in marine ecosystems, and he spent a year in Australia in 1962 setting up permanent monitoring quadrats (small sampling areas) on Heron Island, determined to study the processes that maintain the diverse community of corals that occurs there. It wasn't long, however, before the parallels with rainforests became obvious: like corals, rainforest plant communities contain a high diversity of sessile organisms, so the fates of individuals can be tracked over time. Connell returned to Australia in 1963, and with the help of colleagues John G. "Geoff" Tracey and Leonard "Len" J. Webb (from Australia's Commonwealth Scientific and Industrial Research Organisation, or CSIRO), he laid out what is now known as the Connell Plots Rainforest Network.



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Ecologist Joseph H. Connell (above) presciently established long-term forest plots of Australian rainforest in 1963, in Lamington National Park south of Brisbane and in Davies Creek National Park southwest of Cairns, to study rainforest dynamics. Fifty years later scientists enjoy their noontime break at Davies Creek under the Lunch Tree (far left), a northern brush mahogany, as they work to track the forests' changes.

Connell [*see photograph on this page*] wanted to better understand the processes that maintain species diversity in natural communities. Do ecological mechanisms prevent common species from monopolizing all available resources? Do rare species sometimes have an advantage over the common ones, so that the balance among species shifts over time?

Connell, Tracey, and Webb chose the roughly four-acre tropical site at Davies Creek because it had never been logged; instead, the Queensland Forestry Department set it aside in 1951 as a reference site against which the effects of silvicultural treatments at other rainforest sites nearby could be compared. Logging was still widespread in north Queensland at the time, and Connell remembers hearing the buzz of chainsaws when he first visited the site. The grounds for choosing the other site, the subtropical location near O'Reilly's Rainforest Retreat (an inholding, or privately owned enclave, within Lamington National Park), might have been a bit more prosaic: apparently Mrs. O'Reilly's roast lamb at lunch convinced Connell this was an ideal site for long-term research.

Both the Davies Creek and O'Reilly's plots have been closely monitored ever since. Every few years, teams of hardy field workers brave the stinging trees, ticks, leeches, and biting flies to record the fates of thousands of tagged plants. The value of these long-term demographic data sets—records of birth, growth and mortality—increases with age. When those data are collected at multiple time points ("censuses"), they reveal the temporal patterns of population change. Accordingly, a collection of demographic data sets for the various species that inhabit a natural community provide valuable insights into the patterns of change for the whole community. We've accumulated a lot of information over

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Strangler fig twining around its freestanding host tree in the Davies Creek plot.

repeated censuses in five decades of research: for the plots combined, our databases contain records for about 100,000 individual plants in about 300 species.

Many plots exist throughout the tropics that follow the fates of individual trees. Most of those plots are smaller than the Connell Plots at Davies Creek and O'Reilly's (one-quarter of an acre and two-and-a-half acres are standard sizes), and a few plots are substantially larger (a few dozen sixty-plus-acre plots exist, including a relatively new one at Robson Creek, about six miles away from the Davies Creek plot). Whereas multiple small plots scattered across a landscape are useful for understanding geographic patterns of distribution, large plots are invaluable for understanding a forest's internal dynamics (births, deaths, and growth of individual stems). Within this mix, the unique value of the Davies Creek plot is its age and inclusion of the smallest tree size classes right from the beginning.

For a variety of logistical reasons, more effort has been put into the Davies Creek plot than the O'Reilly's plot. The initial plot census yielded 550 individual trees larger than four inches in diameter in nearly 160 species. A few species were common, but most species were rare. Some species are only represented on the plot by one or two individuals. For example, the Lunch Tree—the tree that serves as the team's assembly point for beginning a day's work, having lunch, or preparing to walk back to the vehicles—is the only individual of its species on the plot. This magnificent specimen is a 115-foot-tall northern brush mahogany (*Geissois biagiana*), with large buttresses and sinuous roots that extend several yards in all directions from its base. Not all species were well known to science, and in fact the most common species on the plot, a member of the genus *Niemeyera*, in the plant family Sapotaceae, remains undescribed by taxonomists.

In 1965 Connell and his colleagues laid out several transects across the research plot to facilitate a census of the seedlings and small saplings. This early addition to the project added another fifty species to the plot's species list, and has proven especially valuable now that nearly five decades of records have accrued for seedling and small-sapling dynamics. The forest is sharing its otherwise well-kept secrets through patterns revealed by statistically analyzing the long-term data set. For example, the data clearly show that recruitment—

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Measurements made of modest growth in the forests (Davies Creek, top; O'Reilly's, bottom). The measuring tapes held side by side (bottom) show the heights of "Tag 3403" (a steelwood tree, Sarcopteryx stipata) in 1965 (left) and in 2013 (right).

the production and germination of seeds, and the establishment of seedlings—is localized and sporadic for most species. At one extreme lies satin sycamore (*Ceratopetalum succirubrum*), one of the largest canopy species at Davies Creek. Individuals of this species have flowered, seeded, and produced carpets of seedling recruits near the parent trees only three times in almost a half century, at roughly decadal intervals. Similarly, the dozen or so mature Queensland kauri pines (*Agathis atropurpurea*)—magnificent, flaky-barked coniferous canopy trees—have produced only about two dozen new seedlings. The long-term data yield many stories like this, and in an effort to understand this

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Research team assembled under the Lunch Tree at Davies Creek on the final day of the fiftieth-anniversary census of the Connell Plots Rainforest Network.

temporal variation in recruitment, a monitoring program was set up in the 1990s to investigate the reproductive patterns of species on the plot. Several years later we concluded that most species at Davies Creek display "masting" behavior, in which populations of trees in the same species all flower more or less synchronously, but only every several years or so, with satin sycamore at one extreme end of the spectrum. However, unlike the community-wide masting events of Asian and Neotropical forests (which are linked to El Niño–Southern Oscillation climatological cycles), the species at Davies Creek seem to follow their own idiosyncratic schedules and do not flower together.

Another insight revealed by decades of detailed monitoring of the Davies Creek plot is the extremely slow pace of the dynamics of this forest. The growth and mortality rates of the large trees are among the slowest known anywhere in the tropics. The vast majority of the plants tagged in the understory in 1965 are still in the understory, suppressed by the extremely low levels of light that penetrate to ground level at most locations in the forest. Many plants that were one or two feet tall in 1965 are only a few feet taller now, and age estimates using these growth data indicate that seven-foot-tall saplings of many species could be eighty to one hundred years old. It seems that light is so limiting that rates of photosynthesis are barely greater than rates of respiration. The canopy giants of these shade-tolerant species must be truly ancient. On the other hand, there is a smaller group of light-demanding species whose seeds are able to reach light gaps created by the death and toppling of large trees. Over the decades we have tracked the recruitment of seedlings and their transitions into reproductively mature adults of the white basswood, or pencil cedar (*Polyscias murrayi*), in a large gap near the center of the plot. Unlike the "slow and steady" persistence of the shade-tolerating species, these white basswoods have lived comparatively fast and died comparatively young, having enjoyed several good years of reproduction through the 1990s and early 2000s. The infamous gympie stinger (*Dendrocnide moroides*) is another fast-growing but short-lived species at Davies Creek, and the very large light gaps it requires to establish have been uncommon on the plot. As a consequence, plants of this species have been comparatively rare—fortunately for us, since to slip and be stung while tagging one can be excruciatingly painful!

Elsewhere in north Queensland, cyclones are recognized as a key driver of rainforest dynamics, but one feature of the Davies Creek plot has been its relative lack of disturbance. The death of large trees sometimes creates canopy gaps, but the plot has survived unscathed by powerful cyclones that have otherwise created large disturbances in rainforests up and down the Australian Wet Tropics over recent decades, notably Cyclones Winifred in 1986, Justin in 1997, Rona in 1999, Larry in 2006, and Yasi in 2011.

The monitoring tools and methodology used on the Connell Plots Rainforest Network have barely changed in fifty years. One curious feature of the Network is the units used for measuring distance, sapling heights, and tree girths. Because the original Queensland Forestry plot at Davies Creek had been set up using the Imperial system of measurement (inches, feet, and chains), Connell decided to maintain this system when he established his plot on top of it in 1963—with one wrinkle. Instead of feet and inches, or inches and eighths of inches, Connell used a hybrid of the Imperial and metric systems in which decimal fractions were applied to Imperial units—feet and tenths of feet, inches and tenths of inches. We maintain this system today, using tape measures specially imported from the U.S. because they are unavailable in metric Australia.

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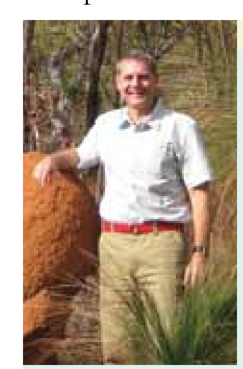
*Southern cassowary (*Casuarius casuarius*) dines on blue quandong fruit (*Elaeocarpus angustifolius*) in Queensland, Australia. Several dozen species of trees rely nearly exclusively on the endangered bird to disperse their seeds.*

Like Connell, we still label plants using tags made from soft aluminum, inscribed with a handwritten number and attached to the plant with a piece of insulated copper. Once the layer of dirt and lichen is rubbed off, these tags are still legible many decades later. Even the data recording is the same: we use paper data sheets, clipboards, and pencils, because, unlike computers, they don't succumb to tropical heat and humidity, nor do they run out of batteries! In one nod to modernity, we have upgraded to waterproof paper.

Long-term data sets are invaluable for understanding consequences of global change, as reference conditions for restoration targets, and as resources for students. Although fifty years of ecological research is a substantial achievement, there's a long way to go for the seedlings that were tagged in 1965 to turn into large canopy giants. Passing on this project to the next generation of young ecologists will be crucial if we are to uncover more of the secrets of these UNESCO World Heritage forests. (Financing is always a challenge, though the U.S. National Science Foundation supported the Connell Plots Network over a forty-year period, and more recently the Australian federal government has taken over support for the research through the creation of the Long Term Ecological Research Network).

The future of the project looks bright. During our final noontime break at the Lunch Tree last year, young members of the field team envisioned themselves participating in future censuses, and one even said he counts on contributing to the 100th-anniversary census. This kind of enthusiasm for field research and continued discovery through long-term efforts bodes very well for the future of tropical forest ecology!



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