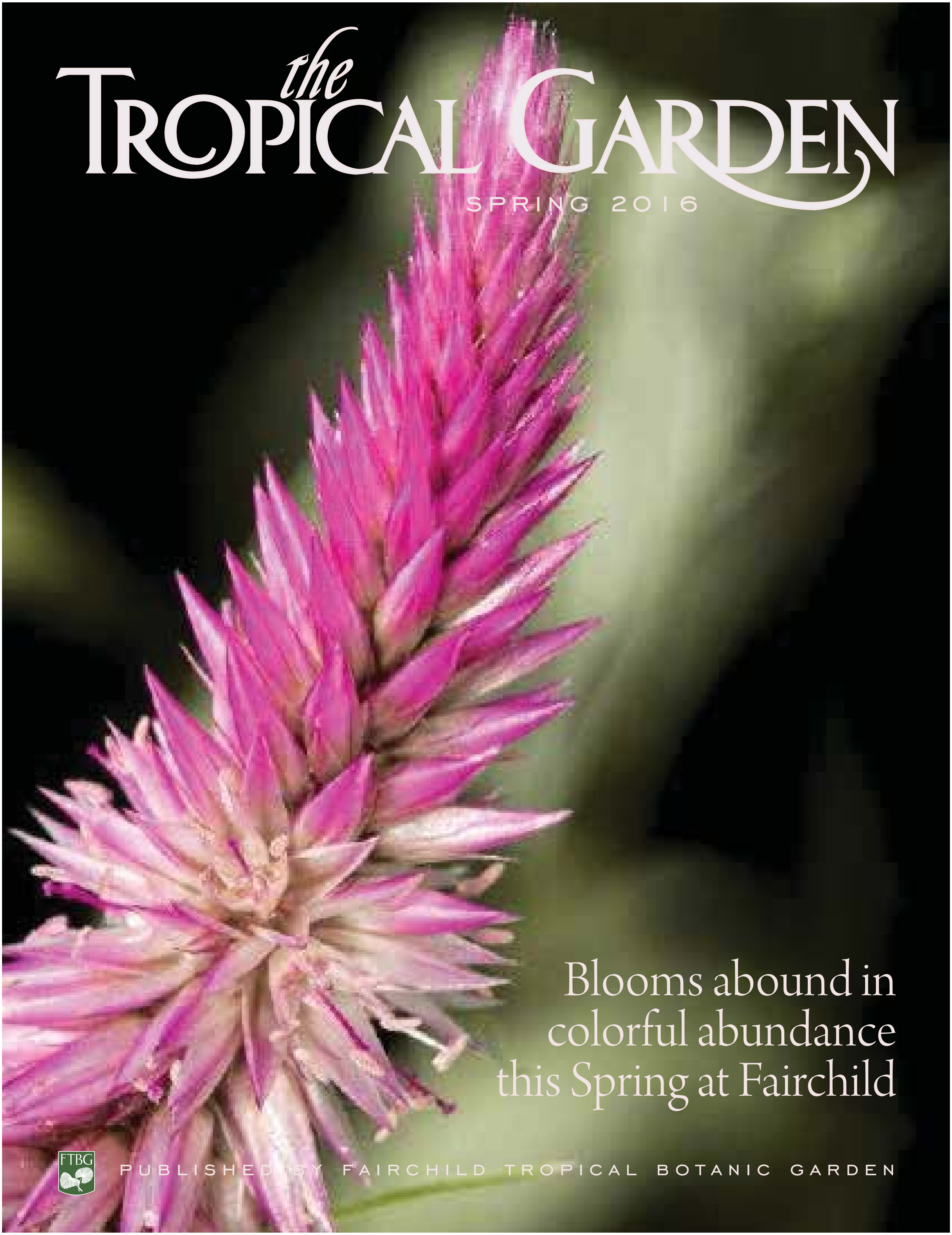

the Tropical Garden

SPRING 2016

Blooms abound in colorful abundance this Spring at Fairchild

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In warmer months, tiny lacy green and pink-margined floating plants fringe the shorelines of Fairchild's lakes. They form mats of an aquatic fern, *Azolla*, which has had quite an influence on Earth's thermostat. It may also play a large part in our planet's future.

THE AMAZING *Azolla* Fern

A thumbnail-sized plant changed the world. Can it help save it?

By Kenneth Setzer @KennethSetzer

PREVIOUS PAGE
Azolla mat along the shore of Fairchild's Glade Lake.
Photo by Kenneth Setzer/FTBG

RIGHT
Azolla at 6x magnification. Note the tiny hitchhikers on the leaves.
Photo by Jack Hahn

Earth's Climate Roller Coaster

Southeast England may not make you think of torrid, sultry tropical beaches and swamps, but during the Eocene Epoch about 50 million years ago, the area's climate closely resembled that of modern coastal tropical Asia. Subtropical nypa palm seeds have been found on the Isle of Sheppey, barely 50 miles east of London, along with turtle, crocodile and alligator remains. Palm tree fossils have been unearthed in areas like Wyoming and Antarctica. It's clear there have been many periods of extremely warm conditions, as well as extreme cold, on Earth.

During the Eocene, the northern continents encircled the North Pole much more so than today, effectively isolating the polar sea. This scenario, along with very warm global temperatures, allowed freshwater runoff from local landmasses to flow via rivers into the polar sea. As it was less dense, the freshwater remained closer to the surface than did saltwater. These conditions were favorable for plants such as the quickly reproducing, aquatic, *Azolla* fern.

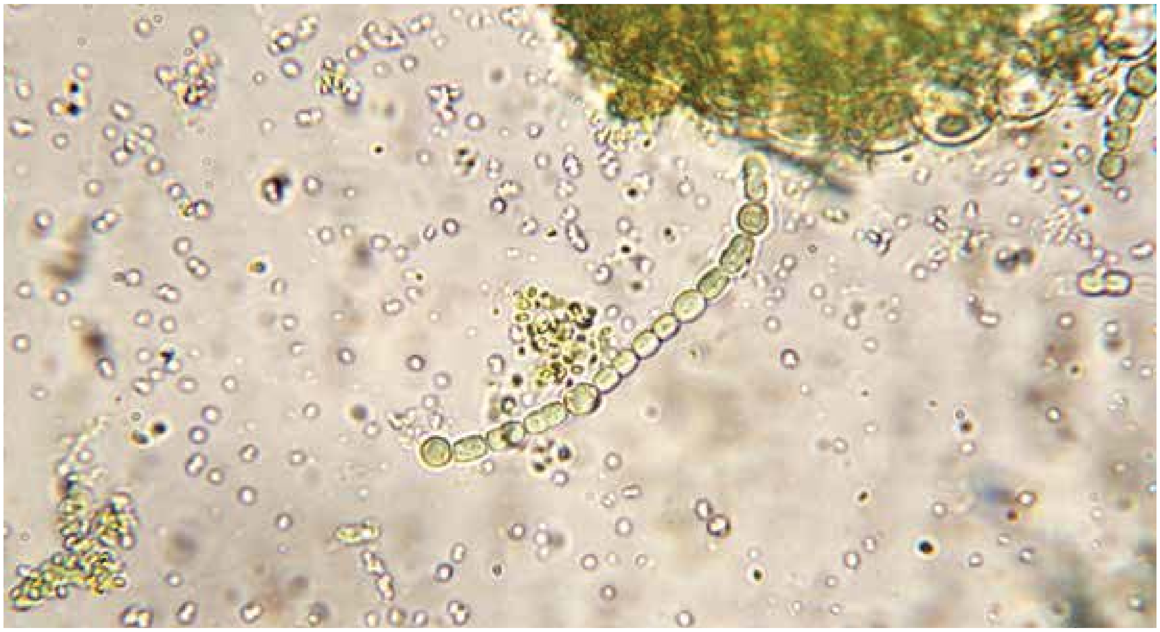
From Hothouse to Icehouse

In 2004, the Arctic Coring Expedition (undertaken by Ecord Science Operator, a consortium of European scientific institutions) collected core samples from deep under the Arctic Ocean floor for scientific research. These samples revealed thick deposits of the remains of *Azolla* ferns dating from the mid-Eocene. During the hothouse conditions of the time, *Azolla* apparently flourished in the arctic waters. During about 800,000 years, layers of it lived, died and consequently drew huge amounts of the greenhouse gas carbon dioxide from the atmosphere. Low oxygen levels at the bottom of the polar waters (known as the benthic zone and including the bottom, the sediment surface and some sub-surface layers) meant the *Azolla* did not decay, but rather fossilized and sequestered carbon.

Indeed, the transition from the Eocene to the Oligocene Epoch—which occurred about 33.9 million years ago—was marked by an abrupt (in geological terms) global cooling. Dense expanses of *Azolla* across the then-polar sea may have been a major contributing factor to the climate change, the effects of which we still experience. This has been dubbed the Arctic *Azolla* Event. Think of it as global warming in reverse.

An Ancient Pairing

I brought a few samples of *Azolla* into Fairchild's imaging lab and asked our imaging volunteer, Jack Hahn, if he had time to capture microscopic images of it for me. By the time I returned, he and Dr. Brett Jestrow, the Garden's herbarium curator, had extracted



Cyanobacteria extracted from *Azolla*, 400x magnification. Note the larger, rounder cells called heterocysts; these are where nitrogen fixation takes place.
Photo by Jack Hahn, FTBG

cyanobacteria, aka blue-green algae, from the *Azolla*'s tiny leaves. I was amazed as the pale-green cells responsible for life as we know it stared me in the face in Fairchild's imaging lab. I had read that the cyanobacteria *Anabaena azollae* is housed symbiotically within *Azolla*, but hadn't thought to ask if we could extract and see it.

Cyanobacteria may have been among the first organisms to figure out photosynthesis; they also contributed to Earth's earliest plants doing so. Chloroplasts—plant cell organelles (specialized subunits within cells) involved in photosynthesis—most likely originated as cyanobacteria that developed an endosymbiotic relationship (when one organism lives inside another in a symbiotic relationship) with, and eventually within, plant cells. I could hardly believe I was staring at such an important player in the formation of life as we know it—a simple chain of green bubbles.

A Nitrogen Fixation

Anabaena cyanobacterium forms another symbiotic relationship with *Azolla*. The fern houses a nitrogen-fixing cyanobacterium in its leaves. The cyanobacterium, in turn, converts atmospheric nitrogen into a form the fern can utilize. When the plant dies, the nitrogen is released into the soil to the benefit of other plants, nature's green manure. Because of this nitrogen-fixing ability, *Azolla* is often used in Asia as a companion plant for rice crops. Thus, *Azolla* has been used as a biofertilizer for, possibly, millennia. A dense mat of *Azolla* also helps deprive mosquitoes of breeding grounds—hence its common name, mosquito fern.

Our Ferny Future

This wonder fern has been researched for its ability to accumulate toxic heavy metals like mercury, lead and chromium, thereby removing these pollutants from water. It is also successfully used as animal fodder—it's healthy for the animals, and grows so quickly that it's truly quite a renewable resource. It is even edible for humans, but *Azolla* salads seem a ways off. Besides some potentially invasive qualities (particularly the non-native species), *Azolla* has enormous potential for bioremediation, as natural fertilizer, mosquito deterrent and food. There are quite a few websites and publications of research devoted to its qualities, including one project to map its genome.

If this tiny plant once helped alter the entire global climate, what else can it do? It seems the better question is: What can't it do?