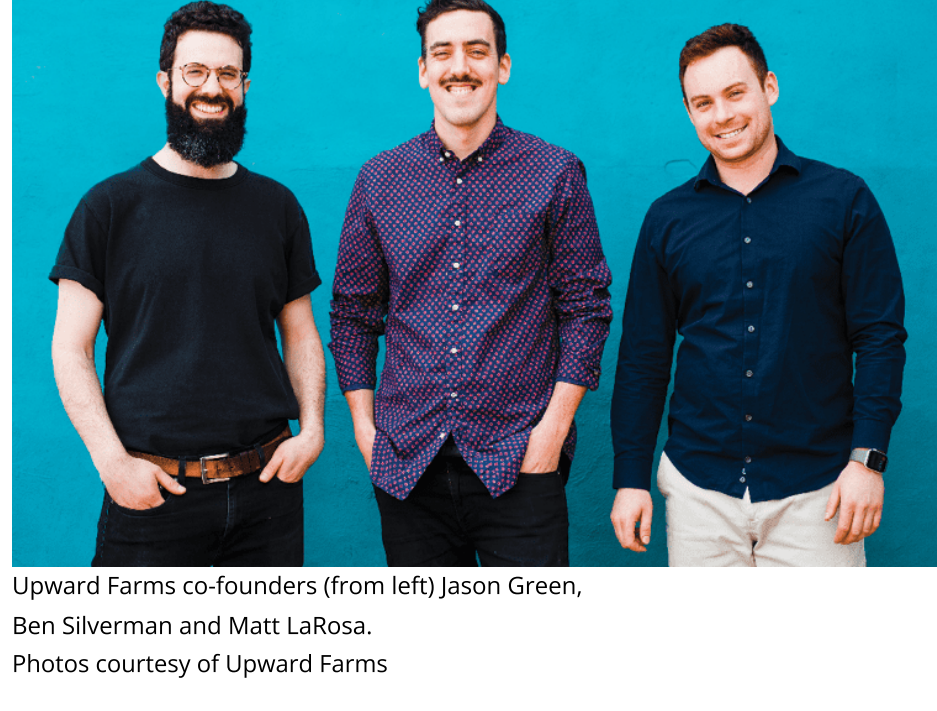


## Onward & upward

With plans for the world's largest vertical farm now in motion, Brooklyn, New York-based Upward Farms has its sights — and its standards — set high.

Jolene Hansen

Until recently, Pennsylvania's Luzerne County was best known for its industrial and coal mining past. But that's changing: cutting-edge agriculture is being added to that list. The shell of a new building is under construction, destined to hold what stands to be the world's largest vertical farm as its first tenant in early 2023. With a footprint of 250,000 square feet, the farm will be the third for Brooklyn, New York-based Upward Farms. An aquaponic USDA Certified Organic microgreens and hybrid striped bass producer, the company's size isn't the only element for consideration. As the next chapter in a journey where upward is a direction, not a destination, this may be one of the world's most ecologically minded vertical farms, as well.



Upward Farms co-founders (from left) Jason Green, Ben Silverman and Matt LaRosa.

Photos courtesy of Upward Farms

### From brains to microbiomes

The backstory of the massive farm planned in Pennsylvania traces back to an improbable start.

CEO and co-founder Jason Green is a computational biologist by training and began his career as a researcher creating controlled environments for human patients rather than plants. Eventually disenchanted with academia's constrictions, Green was fueled by a desire for greater impact — the type that demands a bold, sometimes risky, stance.

Green transferred his attention and energies toward entrepreneurial opportunities involving controlled environments and biology. Drawn to controlled environment agriculture (CEA), which he notes uses a lot of the same language as computational biology, his vision for CEA environments built around whole microbial ecosystems took form.

Given the unique lens garnered through his experience, Green saw an opportunity to understand and harness the power of the hidden layer that separates measurable agricultural inputs and outputs. "What's happening in between, that's where the magic is," he says.

Through a deliberate six-month-long search, Green met his co-founders: Matt La Rosa, now engineering director, and Ben Silverman, chief technology officer.

"I was very fortunate to find two co-founders who both shared my vision, but also offered alternative perspectives and skillsets," Green shares. The company now known as Upward Farms launched in August 2013.

### Taking care of the microbes

At the heart of Upward Farms' success is a proprietary microbiome technology that puts projects like the world's largest vertical farm within reach. Pegged "Ecological Intelligence," this technology unveils the potential in agriculture's hidden layer and enables cultivation of specific microbial cultures to drive crop results.

Genetic sequencing technology, which Silverman says has undergone an "exponential reduction in costs" that makes microbiome-based agriculture commercially viable, is at its core. This technology reveals what microbes are present, where they are and in what proportions, and the genes they carry.

"This allows us to gain insight into the microbial communities that drive key outcomes such as yields, flavor, nutrition and disease reduction," Silverman explains. "We're moving past just controlling the temperature and humidity of the grow room and focusing on the cultivation of an ecosystem from the microbes to the plants that work in tandem to deliver the results our operators are looking for."

The result is complete soil food webs and communities of soil microbes with the genetic capacity to spur plants to their full potential — all in a technically soilless aquaponic environment, in concert with fish and plants.

The result, the company reports, are yields twice the average of the vertical farm industry, next-generation R&D yielding four to five times that of high-performing technology companies within the sector, plus greater stability and predictability and 99% elimination of plant disease.

"We also grow a more delicious and robust product as a result, and that higher turgidity is what enables post-harvest washing of our product. We think microbes first — if we take care of the microbes, the microbes will take care of the plants," Silverman says.



Upward's products are featured in Whole Foods retail locations.

### Scaling production and standards

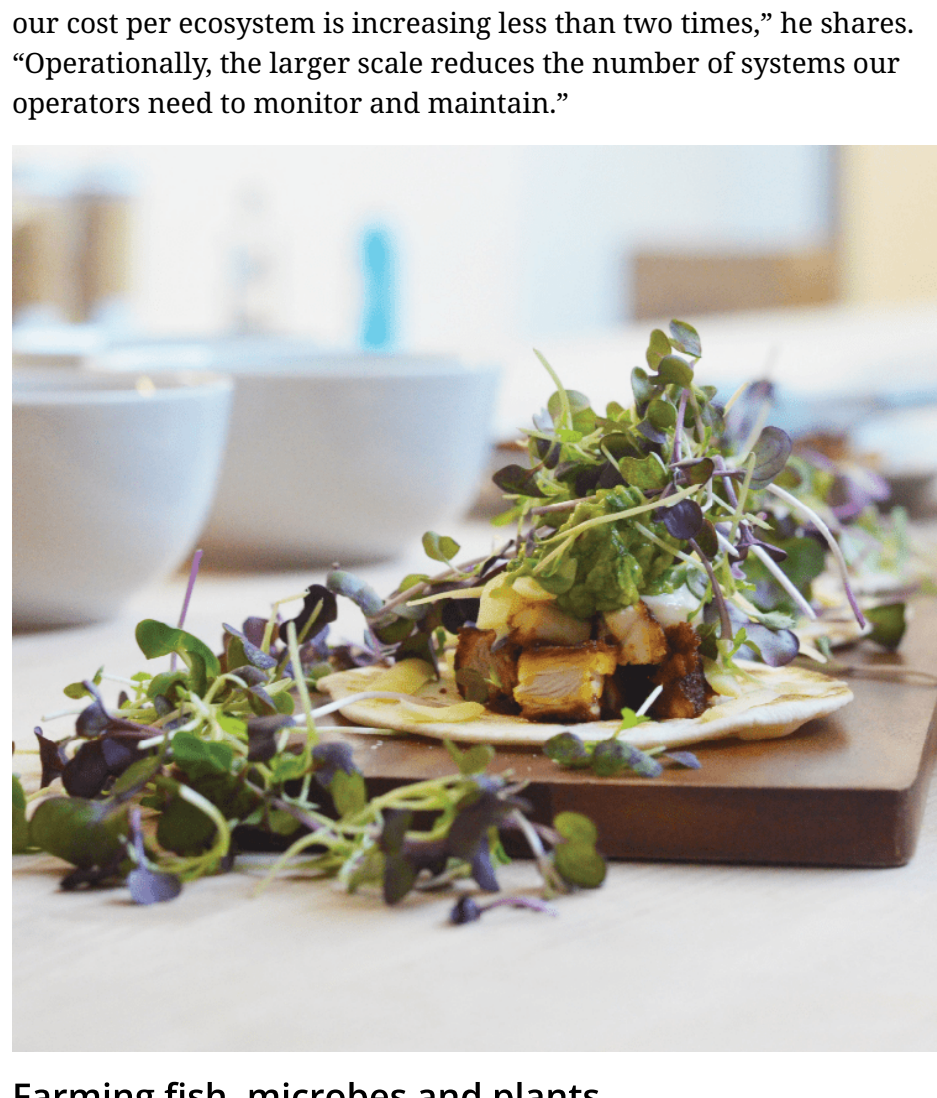
John Perkins, Upward Farms' chief financial officer, says that the goal of building the world's largest vertical farm pre-dated the company's \$134 million Series B funding round in March 2021. Executed shortly before the second Brooklyn farm's launch, the raise dwarfed the company's \$20 million Seed and Series A rounds. Unsurprisingly, Upward Farms' growing technologies and processes were designed for maximum scalability as the company continues its upward trek.

Silverman explains that biological production — what he calls the balance of fish, plants and a healthy microbiome — will stay largely unchanged at the Pennsylvania farm, though fish tanks will get larger and microgreen stacks will get taller. The company's highly automated production processes will continue their refinement.

"We automate all of the rote tasks to allow our operators to focus on the fish, plants, microbiology, and food safety of our product," Silverman says of the "no touch" production process. At the Pennsylvania farm, this will translate to tens of thousands of square feet seeded and harvested daily using state-of-the-art equipment, including robotics.

With expansion in mind, work has focused on automating each production step — from seeding and harvesting through washing to drying, packaging and labeling. "In some cases, we oversized key pieces of equipment so that we could not only test and improve the overall process, but the exact piece of equipment that we're deploying into the Regional Farm," Silverman shares. Next up is automating handling between production steps.

Silverman says scaling for expansion, while challenging, will lower capital and operational costs per pound of yield. "At our next facility, our individual ecosystems are increasing in scale by six times while our cost per ecosystem is increasing less than two times," he shares. "Operationally, the larger scale reduces the number of systems our operators need to monitor and maintain."



### Farming fish, microbes and plants

The ecosystem that undergirds plans for the world's largest vertical farm builds on the same aquaponic technologies Upward Farms now uses. Silverman explains the process starts with a Recirculating Aquaculture System (RAS), where hybrid striped bass and colonies of bacteria and other microbes grow separate from the farm's leafy greens.

Water from the RAS passes through a biological filter, where cultivated microbial communities convert it into organic fertilizer.

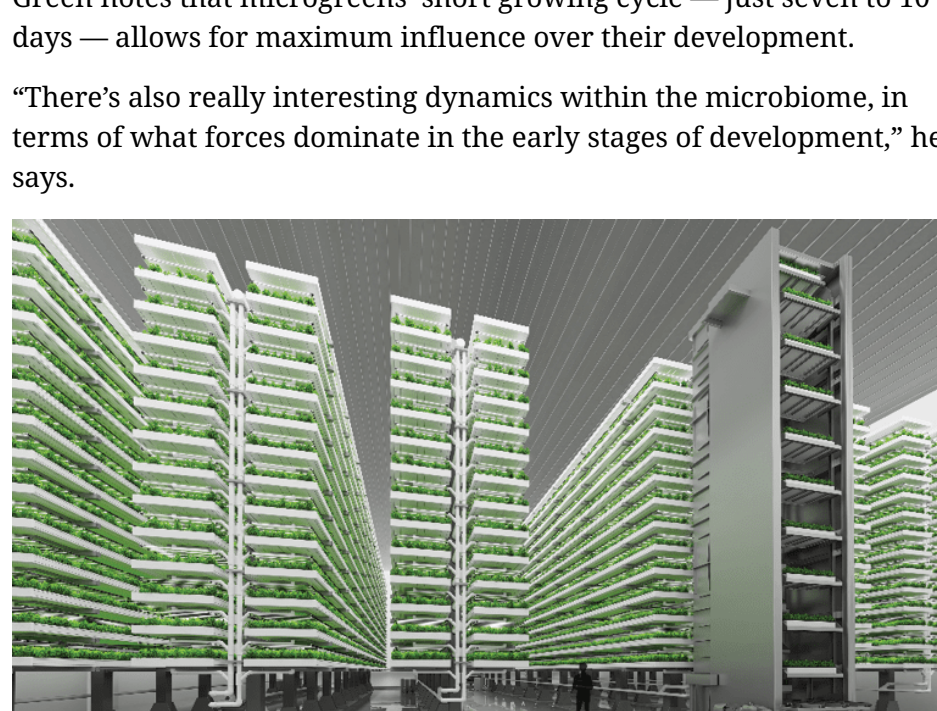
"The fertilizer and microbes produced in the RAS system are then pumped into our leafy greens vertical farm, where the water and fertilizer is absorbed and the microbes form the complex relationships and cascades indicative of healthy soils," Silverman says.

Microgreen crops grow in a very shallow version of floating raft culture — deep water culture without the deep — that allows shallow shelves to stack with the vertical beds. Plants grow in a proprietary coconut coir-based growing media designed to support healthy microbiome development. LED lighting lowers electrical requirements and reduces lighting heat load, which lowers HVAC cooling loads in turn.

"Our system is designed to go as high as the real estate allows for," Silverman says. At the new facility, densely stacked newly seeded crops may reach 44 levels high. By finishing time, respacing will bring crops down to 13 levels.

Green notes that microgreens' short growing cycle — just seven to 10 days — allows for maximum influence over their development.

"There's also really interesting dynamics within the microbiome, in terms of what forces dominate in the early stages of development," he says.



An architectural rendering of Upward's proposed vertical farming stacks and automation in Luzerne County.

### Riding the rising tide

Talking with Green instills a sense that being the world's largest vertical farm isn't the only goal for Upward Farms. He reflects on the company's growth from nine people in one room — just two years ago — to the attention now on the team and its Pennsylvania plans.

As progress on the farm unfolds, Green welcomes the spotlight on what the team believes may be the world's most ecologically focused farm, as well.

"That's really exciting that we are setting a new standard using an approach that is built on ecosystems and not on words and chemicals you can't pronounce," he says.

Citing the company's decision to be USDA Certified Organic with their greens and certified Best Aquaculture Practices with their fish — inviting more third-party oversight and transparency — Green says, "What I hope we're doing is setting a new standard, setting a higher bar."

The Upward Farms team doesn't believe one system, even vertical farming, constitutes the sole future of farming. But knowledge being obtained through stable, precise, reliable controlled environments can benefit the whole. "Our view is all things that we're learning about the interaction of plants, microbes and climate are really valuable to growers on the broadacre," Green says.

As the spotlight intensifies, Green senses opportunity — not burden. He's optimistic about what's ahead: "I think there's a tremendous amount of fear and pessimism and negativity and worry about the future of food systems. That's probably a good thing. It's lighting a fire. It's creating stakes and the stakes are high."

"At the same time, I am a devout believer in the power of human ingenuity. And, with all the work that we've seen from peers — we take a different approach — but a rising tide is absolutely at play here. I think you are seeing success across the board. Different platforms, different approaches, different customers getting involved in the vertical farming space. All of that leaves me incredibly optimistic."

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