

# GROWING KNOWLEDGE

Series content is coordinated by Dr. Lloyd Nackley, associate professor of nursery production and greenhouse management at Oregon State University in Corvallis, Oregon.



An ongoing series provided by Oregon State University in collaboration with the United States Department of Agriculture and in partnership with the Oregon Association of Nurseries



## Leaping forward

Chris Marble collaborates with a team of Florida growers to evaluate the efficiency and accuracy of various herbicide application techniques, aiming to identify affordable, high-quality options for weed control. PHOTO COURTESY OF CHRIS MARBLE

### How a unique research collaboration is shaping the future of nursery production

BY LLOYD NACKLEY

In the nursery industry, challenges are nothing new, but in recent years, the stakes have risen higher. Labor shortages, rising input costs, unpredictable weather, and increasing customer expectations have converged to create an environment where efficiency, precision, and innovation are more critical than ever.

In response, a unique research col-

laboration is working to give the industry the tools it needs to thrive: the Labor, Efficiency, Automation, and Production (LEAP) Nursery Crops Towards Sustainability project.

LEAP is unique, a one-of-a-kind project funded through the highly competitive Specialty Crop Block Grant Program (SCBGP), a federal initiative administered by the USDA Agricultural Marketing Service (AMS). The SCBGP's core purpose is to enhance the competitiveness of specialty crops, which are legally defined as "fruits and vegetables, tree nuts, dried fruits, and horticulture and nursery crops, including floriculture."

Funded by the U.S. Department of Agriculture's National Institute of Food and Agriculture (NIFA), LEAP brings together researchers, engineers, and industry leaders to rethink how nurseries operate, from potting lines to plant transport to autonomous equipment in the field.

This ambitious multi-year effort focuses not only on developing advanced technologies, but on ensuring those technologies work in the muddy, sloped, or uneven and otherwise variable, real-world conditions nursery growers face every day.

#### Inside the LEAP Approach

LEAP combines engineering



## Growing Knowledge



Karl McKim (left) and Keegan Cole are part of Amy Fulcher's research team at the University of Tennessee, Knoxville. They partner with growers like Holden Nursery to compare fertilizer and irrigation strategies, seeking practical, cost-effective approaches that support plant health and production efficiency. PHOTO BY AMY FULCHER

expertise with nursery production knowledge to develop systems tailored for ornamental crops. The project is led by Anthony LeBude, Ph.D. (North Carolina State University) and the University of Tennessee (Amy Fulcher, Ph.D. and team) with major research partners including Oregon State University, Tennessee State University, University of Florida, Texas A&M, the USDA-ARS, and collaborating nurseries nationwide, spanning states including North Carolina, Tennessee, Florida, Oregon, Ohio and Texas.

The research centers on two threads:

1. Automation and robotics — Machines that can handle pot spacing, pruning, plant transport, and targeted applications, such as precise pesticide delivery, with minimal human intervention.
2. Human-technology collaboration — Tools designed to be intuitive, reliable, and adaptable for diverse nursery layouts, integrating smoothly into crew workflows.

Supporting these are socioeconomic

and behavioral adoption studies, consumer-preference research, and Extension programs to promote successful uptake.

### Why LEAP matters now

Nursery production is one of the most labor-intensive segments of agriculture. Skilled workers are essential for plant quality, but finding and retaining them has become increasingly difficult. Meanwhile, costs for water, fertilizer, fuel, and other inputs continue to rise. Every hour of labor matters.

Automation has made the greatest inroads in row crops, fruits, and vegetables, but nurseries — with their diversity of species, pot sizes, and growth habits — pose unique challenges. For example, nurseries manage thousands of different species grown in myriad container sizes and ages, making it difficult for uniform equipment to handle such variability efficiently.

LEAP addresses this gap with a focus on nursery-specific automation and tools that integrate smoothly into existing production systems. As LeBude, LEAP project

lead at NC State University, explains, “The nursery LEAP forward is about finding ways to help people do their jobs more efficiently, more safely, and with better outcomes for plants and the bottom line.”

A recent report suggests that labor accounts for nearly 35% of nursery production costs, covering tasks such as planting, staking, tying, pruning, fertilizing, weeding, labeling, spacing, and transporting plants. These tasks are highly time sensitive. Many are seasonal, and must be performed exactly when plants require them, like planting, budding, grafting, or harvesting.

Labor cannot be spread evenly. Workers must be shifted to these tasks as the season demands. According to reports the LEAP team and others, U.S. nursery labor costs in 2022 reached 170% of 2007 values.

Historically, nurseries could find enough domestic workers for both seasonal and year-round positions. Today, shortages affect both domestic and migrant labor, with nearly 80% of nurseries in one 2018 survey reporting labor as their larg-

est business challenge.

LEAP surveys suggest that the H-2A program has grown sharply, with certified agricultural jobs more than tripling from 2013 to 2021. However, greenhouse and nursery operations represent only about 9% of firms using the program.

Many growers cite concerns over high wages during training, uncertainty that the same workers will return, and mandated wage increases that ripple through their entire workforce. This means that as wages rise for H-2A workers, all other workers expect comparable raises, increasing overall labor costs.

At the same time, demand for specialty crops is climbing. DIY home improvement trends and housing growth fueled sales increases for 87% of garden centers between 2019 and 2020. However, nurseries struggle to meet this demand due to labor shortages and competition from other industries. Those industries — from retail to construction — offer higher wages and more stable work environments, making recruitment even harder.

Some 40% of growers have responded by raising wages, while 25% have adopted labor-saving technology, and 22% have invested in worker training. Others, constrained by capital or risk concerns, have done little, underscoring the need for solutions like LEAP.

Our grower survey revealed sentiments like this: “Last season, we struggled to find enough hands during peak planting. If LEAP’s tech can ease that crunch, it’ll be a lifeline.”

### Economic and environmental stakes

The USDA reports that the ornamental horticulture industry generates more than \$348 billion annually for the U.S. economy, with nursery stock alone contributing \$4.55 billion in revenue.

Nurseries supply plants that enhance landscapes, provide ecosystem services, and create jobs across rural, suburban, and urban areas. The term “ecosystem services” refers to benefits such as improving air quality, controlling erosion, providing wildlife habitat, and cooling urban heat islands. The suppliers of fertilizers,



From left: LEAP leaders S. Chris Marble (University of Florida), Alicia Rihn (University of Tennessee Knoxville), Di Hu (CEO Moss Ag.), Amy Fulcher (University of Tennessee Knoxville) and Anthony LeBude (North Carolina State University). PHOTO BY ANNA SENTER

equipment, packaging, and transportation support the impact of nurseries.

Yet the economic engine of nurseries relies heavily on labor. Automation and mechanization can help offset this dependency

Automated nursery technologies (ANTs) — a range that includes potting machines, fertilizer dispensers, plant transport systems, and automated pruning equipment — can improve efficiency, reduce worker strain, and enhance crop quality through consistent task execution. Despite their promise, adoption remains limited, signaling the need for targeted outreach and real-world validation.

### Meet the LEAP robots: ANDREW, PIPER, TALI and A-IPM

- ANDREW (Autonomous Nursery Driving Robot for Eliminating Weeds) — Precision navigation and spot spraying for weed control, aimed at commercialization.
- PIPER (Pot-in-Pot Extraction Robot) — Automates harvesting of container-grown trees, using navigation, object recognition, and localization, built on the Farm-ng Amiga platform.



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## Growing Knowledge



Dalyn McCauley, research engineer in the Nackley Lab at Oregon State University, shares the advantages of low-cost, open-source, sensor-based irrigation systems during a field day at NWREC in Aurora, Oregon. PHOTO BY LLOYD NACKLEY

- TALI (Terrestrial Automatic Laser-based Inventory system) — Automates tree inventory, measuring height, canopy dimensions, and caliper to replace manual counting.
- A-IPM (Artificial Intelligence Pest Monitoring) — Uses AI and computer vision for early detection of Japanese maple scale, complementing human scouting.

These prototypes are designed to handle real-world nursery conditions — such as gravel, mud, tight spaces — and not just laboratory conditions. Getting farm-ready robots is the real test: we know they can work on a showcase floor or in a lab, but can they hold up at a farm?

“We build these robots in the lab, but they’ve got to be ready for the real challenge is farm conditions — mud, slopes, obstacles. That’s why we’re excited to get them to Oregon next year and test them in the field,” said Billy Hered, a graduate student from the Carnegie Mellon University robotics team.

### Progress and engineering foundations

LEAP engineers employ tools like Gazebo (a 3D robot simulation environment) and Robot Operating System (ROS, an open-

source robotics middleware) to simulate nursery environments before field testing.

The Farm-ng Amiga electric tractor serves as a shared mobile base for integrating different payloads. Navigation relies on SLAM (Simultaneous Localization and Mapping) mapping — which helps robots build maps and track their location — and Voronoi-based path planning, which helps robots navigate safe and efficient paths around obstacles.

The A-IPM system has already trained preliminary detection models for Japanese maple scale with encouraging results, research that was presented this year at the American Society for Horticultural Science Annual meeting in New Orleans. Multi-state field partners have completed baseline trials and helped refine workflows for evaluating application uniformity and labor savings.

### Shifting demographics: Why labor tech can’t wait

The average age of U.S. farmworkers now exceeds 40, with more than one-third over 55. Replacing experienced workers is harder than ever, making labor-saving technologies essential to sustain production and protect worker health.

Repetitive nursery tasks, such as pruning and tying, place physical strain on workers that increases with age and can lead to injuries. This strain not only affects workers’ health but also makes these jobs harder to fill as younger workers avoid physically demanding roles. Over time, worker fatigue can also reduce the consistency of plant care and quality.

Feedback from growers suggest that “After years on the job, repetitive work takes a toll on your body. Tech that can ease that burden is not just welcome, it’s necessary.”

### Technology for people

LEAP prioritizes usability:

- Simple interfaces to minimize training needs.
- Adaptability for varied crops, pot sizes, and layouts.
- Durability in dust, rain, heat, and cold.
- Growers provide feedback at every stage, ensuring designs meet real operational needs.

As one of our advisory board members said: “What we need are controls mean my crew can use with minimal training. And we’re gonna need to be able to fix minor problems if they come up. We

don't want to have to wait for two weeks for tech support to return our phone call.”

### Engaging the industry

Outreach has been a cornerstone, with meetings and workshops across the country in this first year and to continue throughout. For example, LEAP team was at Cultivate'25 in Ohio, Container Crop Production and Pest Management Workshops in Tennessee, and Sensor-Based Irrigation Field Days in Oregon.

A grower advisor considering adopting robots stressed that field demonstrations — not just trade-show displays — build true confidence. “Watching the robots in action at field demos are key for adoption. Trade shows just don't show you what these machines can really do in the dirt.”

### Early results and lessons learned

Although still in its first year of five, LEAP has already identified key themes:

- Labor reallocation can be as valuable as outright reduction.
- Field validation in realistic conditions is critical.
- Adaptability boosts adoption potential.
- Socioeconomic research informs more effective outreach.

### What's next

LEAP will expand multi-state trials of ANDREW, PIPER, TALI, and A-IPM, refine decision-making algorithms, and advance ROI analysis. Extension teams will continue producing demonstrations, videos, and grower interviews to accelerate adoption.

Growers interested in updates can contact me to join the quarterly mailing list.

This work is supported by the Labor, Efficiency, Automation, and Production: LEAP Nursery Crops Towards Sustainability, project award no. 2024-51181-43291, from the USDA National Institute of Food and Agriculture. ©

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