26-241
February 22, 2026

Canopy Systems: Building an R&D Portfolio

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It was Monday, December 1, 2025. Maya Okafor, the recently appointed VP of R&D at Canopy Systems, a Healdsburg-based manufacturer of vineyard automation equipment, looked over the list of possible development projects sitting in front of her and realized that ultimately she was responsible for allocating the resources for product development for the next year. Canopy's growth had been strong—the company had quadrupled revenue since 2018—yet margins had been steadily eroding as competitors closed the technology gap. In the early days of the company it had been easier, since there was only one platform—the SV-100 tractor guidance system—to worry about. As the product line had grown to encompass harvesters, autonomous tractors, cultivation robots, and digital agriculture software, however, the problem of deciding where to allocate scarce R&D resources had become far more difficult.

Adding to Okafor's feeling of unease was the growing morale problem. There had been an increasing number of complaints about her engineering group, from both outside and inside the organization. The sales team complained loudly that new products always shipped late, and that these delays had recently been getting worse. Yet her own engineers complained just as loudly that they were overworked. Indeed, her top harvester system architect had recently taken a medical leave of absence, complaining of burnout, and it was becoming increasingly difficult to find senior engineers willing to lead projects. Canopy already spent over 8% of revenue on R&D—well above the agricultural equipment industry average of 3-4%—so simply adding engineers to tackle these problems wasn't an obvious option. She was beginning to realize why David Ashworth, her predecessor as VP of R&D, had left for a new position at John Deere.

Her thoughts were interrupted by the buzz of her phone. It was James Liu, the CFO. "Are you ready to finalize the product development plan for next year yet?" he asked. "The board meeting is in two weeks,

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and we need to lock in the FY2026 budget before the holidays. I don't think I've seen a year where the strategic choices are so consequential."

The Vineyard Automation Industry

The mechanical grape harvester—a machine that straddles vineyard rows, shakes fruit from vines, and sorts it on the move—can do the work of 30 field hands at two acres per hour or more. One of the transformative inventions of modern viticulture, its adoption in premium wine regions nonetheless remains surprisingly contentious.

Mechanical Harvesting History

In the early 1960s, California's grape growers faced a labor crisis. The Bracero Program—a guest worker arrangement that had brought seasonal agricultural laborers from Mexico since 1942—ended in 1964, and growers were already searching for ways to mechanize the harvest.[1]

Development proceeded across the US. At Cornell University, researchers developed machines that straddled vineyard rows and shook clusters from vines; at UC Davis, agricultural engineers designed equipment adapted to West Coast conditions. By the late 1960s, several manufacturers were producing commercial harvesters, including the Mecca-Nized machine built by a New York grape farmer and John Deere dealer (see **Exhibit 1**).

None of the early machines were gentle. Grape skins broke, vines were damaged by violent pounding, and leaves, sticks, and worse wound up in the bins alongside the fruit. Wine quality from mechanically harvested grapes was noticeably inferior: excessive MOG, broken berries oxidizing in the California heat, and rough handling that extracted harsh tannins from stems and skins. In California, unionized grape pickers initially blocked commercial adoption.[2] But by the 1970s, most Central Valley vineyards were machine-harvested. California's smaller estate wineries, however, continued to hire crews for hand-harvest.[3]

For decades, premium wine regions like Napa Valley dismissed mechanical harvesting as suitable only for industrial-scale production. "You might as well harvest with a bulldozer," one Rutherford winemaker remarked in 1985. But steady improvements in striker design, onboard sorting technology, and gentler fruit handling gradually closed the quality gap. By the 2020s, companies like Braud (New Holland), Pellenc, and Grégoire were producing state-of-the-art machines adjustable for numerous trellising and canopy systems, capable of operating 24 hours a day—with night-harvesting, when temperatures are cooler, a particular advantage. By 2025, a self-propelled mechanical grape harvester costs $300,000-$500,000 depending on capabilities.[4]

The Basic Technology

Mechanical grape harvesters use various combinations of shaking mechanisms, catching systems, and sorting equipment to detach and collect grapes from vines. Generally speaking, the subsystems of a mechanical harvester can be divided into three categories: the *shaking* subsystem, the *collection* subsystem, and the *sorting* subsystem (**Exhibit 2** shows the major components of a modern grape harvester).

The shaking subsystem consists of a series of flexible rods, bow-shaped strikers, or pivoting paddles that contact the vine's fruiting zone. As the harvester straddles a vineyard row and moves forward, these elements vibrate rapidly, transferring energy to the grape clusters and detaching them from their stems.[5] The shaking mechanism represents a fundamental engineering tradeoff: aggressive action removes more fruit but damages vines and ruptures berries, while gentler action leaves fruit on the vine and reduces throughput.

Below the shaking zone, catching plates—sometimes called "fish scales" for their overlapping, pivoting design—swing back to allow vines and trellis wires to pass through while providing a surface to intercept falling grapes. The fruit drops onto a system of conveyor belts that transport it toward the center of the machine. The conveyors are typically rubberized to minimize berry damage.

The sorting subsystem removes MOG (Material Other than Grapes)—the leaves, stems, insects, and other debris that inevitably enter along with the fruit. Most harvesters use a combination of fans and screens: fans blow away lightweight material, while screens allow juice and small debris to drain while retaining whole berries and clusters. More sophisticated machines add optical sorting systems that use cameras and air jets to identify and eject individual damaged berries or foreign objects. The cleaned fruit is then deposited into onboard bins or discharged via a conveyor to a trailing gondola.

The shaking mechanism and catching plates must be engineered for specific vineyard configurations—row spacing, trellis height, canopy density—and represent significant design complexity.[6] (**Exhibit 3** gives the 2024 cost structure of a representative mechanical harvester.)

The level of sophistication of a mechanical harvester can be thought of along two dimensions: the *gentleness* of fruit handling and the *adaptability* of the machine to different vineyard configurations. Gentleness depends on shaking frequency and amplitude, the materials and geometry of catching plates, conveyor belt design, and the sophistication of onboard sorting. Superior designs minimize berry damage, stem inclusion, and juice loss—all factors that directly affect wine quality. A modern harvester with optical sorting can achieve MOG levels below 3%, approaching hand-harvest quality. (Performance claim based on manufacturer specifications; actual field performance varies.)

Adaptability determines how effectively a single machine can work across diverse vineyard conditions. Row spacing in California vineyards ranges from 6 feet (older plantings) to 12 feet (modern mechanical-access configurations). Trellis heights vary from 4 to 7 feet, and canopy management styles range widely.[7] A highly adaptable harvester can adjust its shaking height, catching plate width, and conveyor positioning to accommodate these variations—reducing the need for vineyard owners to purchase multiple machines or forgo mechanical harvesting on certain blocks.

More recently, manufacturers have begun integrating computer vision, GPS guidance, and variable-rate shaking technology. These systems can adjust shaking intensity in real time based on yield maps or visual assessment of fruit load, theoretically optimizing the tradeoff between fruit removal and vine damage on a vine-by-vine basis. Night-vision cameras enable 24-hour harvesting operations, with many premium producers now preferring night harvest when cooler temperatures help preserve grape freshness and reduce oxidation.

The California Premium Wine Market

The Napa-Sonoma wine region represents a $12+ billion industry cultivating over 106,000 acres. Despite producing only 4% of California's wine volume, Napa generates 25% of the state's wine revenue—a reflection of its premium positioning. Red varieties from Napa average $8,200 per ton versus $325 per ton for Central Valley grapes.[8] Land values in prime appellations like Oakville and Rutherford reach $300,000-$500,000 per acre, among the highest-value agricultural land in America.

California's ascent to world-class wine status—cemented by the 1976 "Judgment of Paris" blind tasting, when California wines defeated their French counterparts[9]—came at a cost: an unshakable association between premium wine and hand-harvested grapes. While mechanical harvesters had been working Central Valley vineyards since the 1970s, Napa and Sonoma producers largely refused to adopt them. Less than 10% of Napa grapes are mechanically harvested today, compared with 30-40% in Sonoma and over 80% statewide.[10] The resistance is partly practical—many premium vineyards occupy hillsides too steep for harvesting equipment—but largely cultural. "We're selling a story as much as a bottle," one Rutherford winemaker observed. "The moment you put a machine in that story, you've changed what you're selling."

The labor economics of hand harvesting have grown increasingly precarious. Hand-picking costs $248-$400 per ton versus $27-$50 per ton for mechanical harvesting—an 8- to 15-fold difference.[11] Year-round vineyard workers command $19-$29 per hour; seasonal harvest crews—needed for just three to six weeks—exceed $30 per hour when they can be found at all. The problem is availability, not price. Surveys indicate that 65-87% of Napa vineyard firms report difficulty hiring workers, with over 1,200 positions unfilled during peak harvest season.[12]

The workforce itself is aging out of the fields. The average California farmworker's age has risen from 30 in 1979 to over 40 today; 16% are now over 55. The children of vineyard workers are not replacing their parents—they are going to college or finding work that does not require bending over grapevines in August heat. Two-thirds of year-round vineyard workers live outside Napa County because median home prices exceed $1.5 million.[13] (**Exhibit 4** shows California wine grape economics by market segment.)

For decades, premium producers managed these pressures through a combination of H-2A guest worker visas, established relationships with labor contractors, and sheer willingness to pay whatever the harvest demanded. But by the 2020s, the arithmetic had shifted decisively against hand harvesting.

Quality Perception and the Mechanization Barrier

The technological case for mechanical harvesting has strengthened considerably since the crude shake-and-catch machines of the 1970s. Modern harvesters from manufacturers like Pellenc and Braud feature adjustable shaking frequencies, gentler fruit handling, and sophisticated onboard sorting systems that remove leaves, stems, and damaged berries in real time. Pellenc's Selectiv' Process system, among the most advanced optical sorting platforms available, claims MOG levels approaching hand-harvest quality.[14] Night harvesting, when temperatures drop 15-20°F below daytime highs, preserves grape freshness and reduces oxidation, an advantage that mechanical harvesters can exploit around the clock while human crews cannot.

Yet belief lags technology. Cook-off competitions—where winemakers blind-taste wines made from mechanically and hand-harvested grapes—consistently show that experts cannot reliably distinguish between the two. Academic studies at UC Davis have reached similar conclusions for most grape varieties and wine styles.[15] The problem is not that mechanical harvesting produces inferior wine; it is that consumers and critics believe it does, and belief shapes market value.

This dynamic is not unique to California. Premium wine regions worldwide—from Champagne to Bordeaux—have concluded that the romance of harvest is part of what they sell. Hand harvesting signals quality to collectors, regardless of whether mechanical alternatives could match it. The result is a strategic paradox for equipment manufacturers. The customers who most need labor-saving technology—premium producers facing acute worker shortages—are precisely those most reluctant to adopt it. Convincing a Napa winemaker to buy a mechanical harvester requires more than demonstrating equivalent quality; it requires changing what "premium" means.

Even the best mechanical harvesters, however, remain fundamentally brute-force machines—shaking entire vines and relying on increasingly sophisticated sorting to compensate for the resulting damage. The quality gap has narrowed not because the harvesting itself has become gentler, but because the cleanup has improved.

The Competitive Landscape

The vineyard equipment market serving California's premium producers is dominated by European manufacturers who design primarily for volume production:

Pellenc (France) is the technology leader, with Optimum harvesters priced at $350,000-$440,000 in 2024 and a strong service network operating from its North American headquarters in Santa Rosa—less than 35 minutes from Canopy Systems' Healdsburg facility. Pellenc offers the broadest product line and has invested heavily in sorting technology.

CNH Industrial's **Braud** brand (France) leverages global scale and financing capabilities. With over 15,000 harvesters produced across 50 years, Braud benefits from a massive installed base and parts availability. Premium models are priced between $442,000 and $473,000 (2024).

OXBO (United States/Netherlands) has invested $60.5 million in a new manufacturing facility in Bergen, New York. Strong in the Finger Lakes and Oregon, OXBO is expanding its California presence.

A new category of autonomous vineyard systems has emerged from the Bay Area technology ecosystem. Agtonomy has deployed its TeleFarmer platform at Silver Oak, Caymus, and other premium estates; Monarch Tractor produces fully electric, driver-optional smart tractors; Burro has deployed over 600 harvest-assist robots in wine grape vineyards. Together these startups have raised hundreds of millions in venture funding. A critical distinction separates these systems from the harvesting challenge: they handle cultivation and navigation tasks, not harvesting itself. Autonomous grape harvesting remains the frontier. The company that cracks it will own the category.

Recent Developments

By 2025, autonomous technology had transformed most vineyard operations. John Deere's acquisitions of Blue River Technology ($305 million, 2017) and Bear Flag Robotics ($250 million, 2021) signaled the agricultural giant's intentions; its fully autonomous 8R tractor, announced at CES 2022, demonstrated that driverless cultivation was no longer theoretical. Bay Area startups had followed: Monarch Tractor and Agtonomy deployed driver-optional electric tractors and remote supervision platforms at premium Napa and Sonoma estates, enabling a single operator to supervise multiple machines simultaneously. For driving between rows, mowing cover crops, and applying sprays, autonomy had become routine.

Regulatory barriers had begun to ease as well. In August 2024, California's Division of Occupational Safety and Health (Cal/OSHA) clarified that driverless tractors could operate when no humans were present in the work area—a significant opening for vineyard automation.[16]

Yet for all these advances, one critical vineyard operation remained stubbornly resistant to automation: harvesting grapes with the gentleness required for premium wine production. The technical barriers were formidable. Unlike row crops such as corn and soybeans—where grain heads are exposed and uniform—grape clusters hide within canopy. A Cabernet Sauvignon bunch looks nothing like a

Chardonnay cluster. Detecting clusters across variable trellis systems, lighting conditions, and canopy densities remained what one academic review called "perhaps the most significant unsolved issue" for precision viticulture.[17]

The occlusion problem was particularly acute. In a typical vineyard image, most berries were hidden behind leaves or other clusters. Dense foliage and color similarities between grapes and leaves made segmentation far more challenging than for crops like citrus. Researchers had achieved promising results under controlled conditions, but field performance degraded significantly under variable lighting.

Even if vision systems could reliably locate clusters, the manipulation problem remained. Soft robotics researchers at Washington State University had recently demonstrated a gripper capable of gently harvesting apples—a significant achievement, but one that highlighted the gap remaining for grapes.[18] Apples were far simpler targets than grape clusters: they hung individually, presented a uniform shape, and detached with a predictable twist. Grape clusters varied enormously in shape, weight, and compactness depending on variety, trellis system, and growing conditions. Detaching them without damaging surrounding berries required either the violent shaking of traditional mechanical harvesters or the dexterous manipulation of human hands.

The fundamental challenge was integrating vision, manipulation, and speed at commercial scale. Existing mechanical harvesters processed two or more acres per hour by shaking entire vines—a brute-force approach that worked but damaged fruit. Achieving hand-harvest gentleness at commercial throughput would require autonomous systems that could identify individual clusters within canopy, navigate soft robotic grippers around leaves and trellis wires, detach clusters without rupturing berries, and sort fruit in real time—all while moving through the vineyard at speeds that made economic sense. No company had yet demonstrated this combination of capabilities outside laboratory settings.

The gap was not lost on industry observers. "Whoever solves autonomous harvesting for premium grapes doesn't just win a product category," one Napa vineyard manager remarked. "They solve the labor crisis and the quality tradeoff in one shot. That's a transformational technology—if anyone can actually make it work."

Canopy Systems

The company was founded in 2008 by Elena Rodriguez in Healdsburg, California, at the heart of Sonoma County's premium wine country. Rodriguez was a mechanical engineer who had spent eight years at NASA's Jet Propulsion Laboratory working on Mars rover mobility systems. She had grown up on her family's small vineyard in Dry Creek Valley, and after nearly a decade of engineering Martian terrain navigation, she returned home to help her aging parents with their operation. What she found was a crisis. "My parents were paying $400 a ton for hand-picking—when they could get crews at all," Rodriguez would later explain at a Stanford engineering symposium. “The workers who picked our grapes when I was in high school had aged out. Their kids weren’t replacing them. I watched my parents call contractor after contractor, offering whatever it took, and still we almost lost a quarter of the crop to late harvest. That’s when I realized the same technologies that let rovers navigate boulder fields on Mars could navigate vineyard rows in Sonoma.”[19]

Rodriguez’s first product, the SV-100 tractor guidance system, brought GPS-based autonomous steering to Sonoma’s narrow vineyard rows. The technology was straightforward by JPL standards—centimeter-accurate positioning, obstacle detection, path planning—but revolutionary for an industry still relying on drivers eyeballing row centers. The SV-100 worked. More importantly, it attracted attention from investors and engineers who had never considered agriculture a promising field. Through the 2010s, Rodriguez expanded from guidance systems into a comprehensive vineyard automation platform: autonomous tractors, robotic cultivation tools, and eventually mechanical harvesters with advanced sorting capabilities. The company attracted venture funding and recruited engineers from Tesla’s Autopilot team, Waymo’s perception group, and John Deere’s autonomous systems division.

By 2025, Canopy Systems employed approximately 187 people, having generated $105 million in revenue the previous year. Rodriguez remained CEO. Marcus Chen, who had left Tesla’s powertrain engineering team in 2010 to become her first engineering hire and eventually CTO, had long led the engineering organization. The company operated from an industrial building in Healdsburg, a former winery barrel storage facility converted into a peculiar hybrid: welding bays alongside software development workstations, test harvesters parked next to espresso machines, engineers in boots discussing neural network architectures. One venture capitalist, visiting for the first time, described it as “what would happen if SpaceX and a farm equipment dealer had a baby.”

Canopy Systems remained privately held, having raised $45 million in venture funding led by Hillview Partners between 2010 and 2018. In 2021, Prestige Vineyards Corporation, one of California’s largest wine producers, acquired a 15% stake—providing customer validation but adding a board member whose interests did not always align with the venture investors. By 2025, Hillview had begun pressing for liquidity, either through an IPO or a strategic sale. Rodriguez, who along with early employees held roughly 35% of the company, resisted. “We’re not building this company to sell it,” she had told the board. “We’re building it to transform an industry.” The tension between near-term financial returns and long-term technology bets formed the backdrop to every major resource allocation decision.

Canopy Systems offered four platforms. The Harvest Platform—self-propelled mechanical harvesters with proprietary OptiSort onboard sorting—represented the company’s flagship line, accounting for 45% of revenue. Priced between $320,000 and $475,000 depending on configuration, these machines incorporated optical sensors, air jets, and mechanical separation to remove MOG in real time, achieving what the company claimed was 99.2% whole-berry integrity—better than most mechanical harvesters and approaching hand-pick quality. The Drive Platform—the successor to Rodriguez’s original SV-

100 guidance system, now encompassing GPS-guided tractors ranging from driver-assist to fully driverless operation—represented 30% of revenue. Built on Monarch Tractor's electric platform with Canopy's proprietary control systems, these machines handled the year-round cultivation tasks that consumed most vineyard labor hours. The Tend Platform—autonomous weeding, mowing, and inter-row cultivation equipment—contributed 15% of revenue, including partnership integrations with Burro's harvest-assist robots. Finally, the Sense Platform—NDVI mapping, yield estimation, and vineyard management software—represented 10% of revenue but provided the data infrastructure that enhanced the performance of all other systems. (**Exhibit 5** shows the product mix of the Canopy Systems offering and revenue by platform.)

The company positioned itself as the premium automation partner for California's highest-value wine producers—the estates commanding $50 to $200 per bottle that could not compromise grape quality but increasingly could not find labor at any price. Unlike European competitors who designed primarily for volume production, Canopy Systems emphasized three strategic principles. First, quality parity or better: every system was engineered to match or exceed hand-labor standards, and the company invested heavily in testing to prove it. Second, Silicon Valley integration: equipment designed to work with California's technology ecosystem—Tesla's agricultural batteries, NVIDIA's edge computing, UC Davis's viticultural research. Located less than 90 miles from Silicon Valley, Canopy recruited software talent that Pellenc and Braud could not attract. Third, labor replacement rather than labor displacement: Canopy's customers did not need automation to cut costs; they needed it because workers no longer existed. Premium Napa and Sonoma producers paid $30 or more per hour for skilled harvest labor—when they could find it. Canopy sold solutions to scarcity, not tools for cost reduction. This positioning allowed the company to maintain price premiums of 15-25% over European competitors while delivering technology those competitors lacked.

Company Organization

Canopy Systems had grown organically from Rodriguez's initial garage operation into a 187-person organization, all housed at the Healdsburg headquarters except for a small field service team stationed in Napa during harvest season. The company's structure reflected its dual identity as both a manufacturing business and a technology company. Rodriguez oversaw corporate strategy, investor relations, and customer relationships—she still personally visited major accounts during harvest season. Chen, as CTO, had shifted to a strategic role in 2023, focusing on long-range technology vision. Maya Okafor, promoted to VP of R&D in early September 2025, led the 30-person engineering organization. James Liu, the CFO, managed finance, operations, and the administrative functions that supported growth. (**Exhibit 6** shows Canopy Systems' organization structure.)

The Healdsburg facility combined design, manufacturing, and testing under one roof. The manufacturing organization of 86 staff—including 65 line workers, supervisors, quality control technicians, and materials handlers—assembled harvesters and tractors on two manufacturing lines, producing approximately 330 complete units annually plus several hundred component upgrades and refurbishment kits.[20] Manufacturing was partially automated—welding and painting were robotic, final assembly was manual—reflecting the relatively low volumes and high customization requirements of the premium market.

Canopy distributed its equipment through a combination of direct sales and dealer relationships. A 12-person sales team maintained direct relationships with premium estates throughout California, Oregon, and Washington, providing the consultative selling that $400,000 purchases required. The company's service organization—10 field technicians—provided support year-round, with particular intensity during the harvest season from August through October when equipment failures could cost customers thousands of dollars per hour in delayed picking.

The marketing team of 8 tracked competitive developments, managed customer acceptance testing programs, and coordinated the demonstration events that served as Canopy's primary demand generation. Unlike consumer appliance companies that relied on advertising, Canopy's sales depended on technical credibility established through live demonstrations and customer references. The company maintained a demonstration vineyard adjacent to its facility—10 acres of Chardonnay and Pinot Noir where customers could observe equipment operating under realistic conditions. Winemaker testimonials, published quality data, and case studies formed the core of Canopy's marketing collateral; the company spent virtually nothing on traditional advertising.

The R&D organization consisted of 30 engineers organized into six groups. Mechanical Systems (10 engineers) was the largest group, responsible for harvesting mechanisms, sorting systems, and chassis design. Led by a senior engineer who had joined from John Deere's combine division, this group represented the most critical concentration of expertise and the primary bottleneck for harvester development. Electrical Systems (5 engineers) handled power electronics, motor controllers, and battery integration—capabilities that had grown in importance as the industry shifted from diesel to electric platforms. Perception and AI (5 engineers) developed the computer vision and machine learning capabilities that would eventually enable fully autonomous harvesting. Autonomy and Control (4 engineers) managed GPS integration, path planning, and the real-time vehicle control software that translated perception outputs into machine actions. Software Platform (3 engineers) maintained the Sense platform and data infrastructure that spanned all products. Finally, Test and Validation (3 engineers) conducted field trials, verified performance claims, and ensured regulatory compliance with Cal/OSHA's evolving autonomous vehicle requirements. (**Exhibit 7** shows the R&D team breakdown by engineering group.)

The engineering groups worked across all four platforms, though the Harvest Platform consumed disproportionate attention due to its complexity and revenue importance. Product development followed a stage-gate process that Chen had implemented in 2018. The process worked reasonably well when followed. The challenge, as Maya Okafor was discovering, was that the volume of concurrent projects often made following the process impossible.

During the harvest season—August through October—equipment failures demanded immediate engineering attention. When a harvester went down at Silver Oak or Caymus, engineers from whatever project they were nominally assigned to would drop their work and respond. This seasonal support burden consumed approximately 12% of total engineering time, though the figure varied year to year and was never formally tracked. “It’s just what we do,” one Mechanical Systems engineer explained. “You can’t tell a customer paying $400,000 for a harvester that their call is queued behind our sprint planning.” The support work was essential to customer relationships but created havoc with development schedules. Project plans assumed engineers would be available; the reality was more complicated.

The Harvest Platform

Canopy Systems entered the mechanical harvester market in 2017 with the H-100, a machine that embodied Rodriguez’s conviction that premium wine production required fundamentally different automation than commodity agriculture. The H-100’s core innovation was OptiSort—the first integrated optical sorting system built directly into the harvesting mechanism. Previous mechanical harvesters used a two-stage approach: shake the fruit loose, collect it in bins, then sort later. Canopy built a machine where sorting happened continuously as fruit moved through the system, optical sensors and air jets removing damaged berries and MOG before they ever touched intact fruit. The result was dramatically less handling damage and better preservation of whole berries.

Rodriguez introduced a new quality metric to market the innovation: whole-berry integrity, defined as the percentage of harvested fruit that emerged with skins unruptured. With her JPL precision-measurement background, she argued that existing industry metrics—MOG percentage, throughput rates—missed what winemakers actually cared about. Oxidation and harsh tannin extraction began when berry skins broke.[21] The H-100 achieved 97% whole-berry integrity in field trials, compared with 91-93% for competing Pellenc and Braud units. Premium producers noticed. In its first full year, Canopy sold 47 H-100 units at prices averaging $380,000—a 15% premium over comparable European machines. (**Exhibit 8** presents winemaker quality assessments from a demonstration trial at Silver Oak Cellars.) The innovation earned Canopy a Silver Medal at the 2019 SITEVI trade fair in Montpellier—the first American company to win a harvesting technology award at the prestigious European exhibition.[22]

Success bred demand for variants. Napa’s VSP-trained Cabernet vineyards required different shaking frequencies and canopy management than Sonoma’s head-trained Zinfandel. Hillside benchlands needed different slope tolerances than valley floors. Ultra-premium producers wanted enhanced sorting systems that could inspect individual berries; mid-tier operations wanted faster throughput with standard MOG removal. Each configuration required substantial customization. By 2022, the harvester line had expanded to encompass twenty-one distinct configurations spanning three chassis sizes, four sorting levels, and multiple trellis system optimizations—each requiring distinct software parameters, testing protocols, and manufacturing documentation.

The proliferation created manufacturing challenges. "We're essentially building semi-custom machines on what's supposed to be a production line," one manufacturing supervisor observed. "The documentation for each variant is different, the testing protocols are different, and when engineering changes something mid-stream, we're chasing modifications across a dozen configurations." By 2025, Harvest remained Canopy's flagship product family, representing 45% of revenue. The other platforms—Drive, Tend, and Sense—had followed similar trajectories of derivative expansion. (**Exhibit 9** shows the evolution of Canopy's harvester product line.)

Project Selection and Execution

In Canopy's early years, project selection was informal and intuitive. Rodriguez and Chen would meet over coffee at the Healdsburg facility, review technical possibilities and customer feedback, and decide what to build next. With a single product family—the SV-100 guidance system and its successors—this approach worked well. The team was small, priorities were obvious, and Rodriguez and Chen understood the technology and the market intimately.

The impetus to formalize came when Canopy entered the harvester business in 2016-2017. Harvesters were dramatically more complex than guidance systems, requiring expertise across mechanical systems, power electronics, computer vision, and control software. Hillview Partners, the lead VC investor, wanted visibility into development commitments and resource allocation. Multiple product families meant coordination challenges that informal conversations couldn't address. Chen took the lead in developing a structured process, drawing on practices he had observed at Tesla.

The result was a three-stage process introduced in 2018. In the first stage, opportunity identification, the R&D team conducted quarterly sessions with sales, marketing, manufacturing, and field service to gather input on customer needs, competitive threats, technical possibilities, and operational improvements. Chen also led technology roadmap sessions where engineers presented emerging capabilities that might enable future products. In the second stage, proposal development, any idea that found a sponsor—whether from engineering, sales, manufacturing, or field service—was developed into a formal proposal documenting scope, timeline, resource requirements, technical risks, and projected financial returns. The bar for advancing to formal proposal was deliberately low—Chen believed that filtering ideas too early risked missing breakthrough opportunities. Each proposal included a standardized NPV analysis using assumptions vetted by Liu's finance team. In the third stage, project selection, the head of engineering selected which projects to fund, balancing projected returns against available resources and strategic priorities. When David Ashworth left for John Deere in late July 2025, Okafor was promoted to succeed him with full authority over resource allocation. (**Exhibit 10** shows the NPV worksheet template used to evaluate project proposals.) Okafor appreciated the process Chen had built:

> *We hear from everyone—sales, manufacturing, the field service technicians who see what breaks, the engineers who know what's technically possible. If someone in this company believes in an idea enough to develop a proposal, we owe it to them to evaluate it seriously. The final decision on which projects to pursue rests with engineering leadership, which is appropriate since our competitive advantage rests on technical excellence.*

The 2018 formalization of project selection was accompanied by a parallel effort in project execution. Chen established a stage-gate process modeled on best practices he had seen at Tesla: defined phases separated by review gates, cross-functional teams including manufacturing and service representatives, and formal documentation of requirements, designs, and test results. In the two years after implementation, average project lead times improved by 30%. Management was convinced the process was working.

But delays began creeping back after 2021. Projects that had been scoped for twelve months stretched to eighteen. Ship dates slipped by quarters rather than weeks. Engineers blamed interruptions; project leaders blamed resource constraints; manufacturing blamed changing specifications. One marketing team member offered his assessment: "The process works when we follow it. The problem is that engineers keep getting pulled onto other things—customer emergencies, manufacturing problems, requests from sales. And somehow we end up with more projects than we have people to staff them."

Maya Okafor inherited this situation when she was appointed VP of R&D in September 2025. She had spent six years at Canopy, rising through the Perception and AI group to lead several successful projects, but her new role put her at the center of competing demands she had previously observed only from a distance. The board meeting was two weeks away. Liu wanted a finalized development plan. Rodriguez wanted breakthrough innovation. The investors wanted clarity on path to returns. And her engineers wanted relief from what they described as unsustainable workloads.

Recent Market Developments

In its early years, Canopy Systems had successfully established itself as the technology leader in premium vineyard automation. The company's emphasis on quality metrics—particularly the whole-berry integrity standard Rodriguez had pioneered—resonated with Napa and Sonoma producers who measured success in dollars per ton, not tons per hour. Strong margins from harvester sales drove financial performance near the top of the agricultural equipment industry. Through 2021, Canopy commanded price premiums of 15-25% over European competitors while delivering technology those competitors lacked.

The competitive landscape had shifted considerably by 2025. European manufacturers who had initially dismissed Canopy's quality-focused positioning had invested heavily in catching up. Pellenc's latest Optimum harvesters incorporated Selectiv' Process onboard sorting that the company claimed achieved

99.0% whole-berry integrity—within measurement error of Canopy's 99.2%. Braud had introduced optical sorting options across its premium line. These companies brought advantages Canopy couldn't match: global manufacturing scale, decades of service network development, and financing capabilities that made $450,000 equipment purchases easier for customers to justify. The quality gap that had justified Canopy's premium pricing was closing. (**Exhibit 11** shows the convergence in whole-berry integrity scores between 2019 and 2025.)

Closer to home, a new category of competitors had emerged from the Bay Area technology ecosystem. Agtonomy, Monarch Tractor, Verdant Robotics, and other startups had raised hundreds of millions of dollars to automate vineyard operations. None had entered the harvesting market yet—their focus remained on cultivation, navigation, and pest management—but the talent, capital, and ambition were present. A strategic acquisition or partnership could bring any of them into direct competition with Canopy's core business. Alternatively, Pellenc or Braud might acquire one, gaining autonomous capabilities that would take years to develop internally.

The most significant competitive threat, however, remained largely unspoken in Canopy's strategic discussions. John Deere had not yet focused on premium vineyard applications—the volumes were too small to interest a company with 60% of the North American tractor market—but that could change. If Deere decided that autonomous harvesting represented a strategic growth opportunity, or if a major wine producer requested it, Canopy could find itself competing against a company with research budgets larger than Canopy's entire revenue.

The cumulative effect of these pressures was visible in Canopy's financial trajectory. While revenue had grown steadily, reaching $105 million in 2024, margins had compressed as premium pricing became harder to sustain. The tension between investors pressing for liquidity and Rodriguez's insistence on long-term technology bets formed the backdrop to every resource allocation decision Maya Okafor now faced.

The Crisis

For years, Canopy Systems had successfully fended off pressure on margins by positioning itself at the premium end of the vineyard automation market while steadily improving its cost structure through manufacturing automation, global component sourcing, and operational improvements. The company had maintained its price premiums by renewing its product offering frequently—the short development cycle that Chen had engineered was widely regarded as a source of competitive advantage. Canopy aimed to introduce significant upgrades across at least a third of its harvester configurations each year, staying ahead of competitors who required longer development timelines. Overall, Chen was proud of the technology organization he had built. When portfolio responsibility passed to Maya in the fall of 2025, she inherited a formidable legacy.

However, Pellenc's latest harvesters now claimed whole-berry integrity scores within a percentage point of Canopy's best machines. The trends had decreased Canopy's margins in recent years (**Exhibit 12** shows the company's financial performance). By November, Liu was projecting the first unprofitable quarter since 2013, when the company had finally turned the corner from its startup losses. The poor performance was attributed to missed revenue targets, higher-than-expected warranty costs, and increased operating expenses across nearly every department. What's more, the Harvest platform—the company's flagship product line—appeared to be the chief culprit in this decline.

Since her promotion in September, Maya had heard plenty of explanations for the company's troubles—and plenty of blame-shifting. Gérard Moreau, the director of manufacturing, had made his views clear:

> *We have already realized most of the cost reductions available from automation and global sourcing. Any further attempts at reducing costs will compromise quality or reliability—and we can't afford warranty claims in this market. I know we're still above competitor cost levels, but that's because we lack the unit volumes to amortize fixed costs. We're building thirty-two harvester configurations on what's supposed to be a production line. Fewer than a third of the software parameters optimized for VSP Cabernet work with the head-trained Zinfandel configurations, even though they share the same chassis. The proliferation of model variants has added substantially to manufacturing complexity and driven up our per-unit costs.*

Elizabeth Hartley, the director of marketing, saw it differently:

> *Delays in the development and introduction of new features have made it impossible to sustain premium prices. The OptiSort 4.0 upgrade was supposed to ship in Q2—it's still not out. Meanwhile, Pellenc is claiming performance parity in every trade publication. We've had to increase advertising and promotional spending just to maintain market share, and the added expenses have blown through my budget for the year. Customers used to seek us out; now we're fighting for every sale.*

Maya found herself defending her department:

> *We have thirty engineers working on seven active development projects, while also supporting manufacturing's requests for design changes on existing products. With limited resources and this many projects in the pipeline, schedule pressure is inevitable. R&D is inherently uncertain—we can't always predict when we'll hit a technical roadblock. What we won't do is release a product before it meets our standards. That would compromise our reputation. And despite everything, we've been shipping regular product upgrades—more than any of our competitors.*

Rodriguez had made clear that she expected more than explanations. In their last one-on-one, she had been direct:

> *Canopy has always depended on its engineering team to maintain our competitive edge. We spend eight percent of revenue on R&D—more than twice the industry average. But we seem to be getting fewer and fewer wins that actually move the needle. If we're going to compete against Pellenc and Braud—let alone survive if Deere decides to enter our market—we have to fix this problem. The board needs to see a development plan that addresses this. And soon.*

Maya's Dilemma

Okafor stared at the list of proposed projects that had emerged from the recent round of proposal development (see **Exhibit 13**). She had spent the afternoon canvassing opinions from her R&D team as to the direction they should take. Engineers were never short of opinions, and her staff had not let her down. She recalled her conversation with Venkatesh Subramanian, a senior engineer in the Perception and AI group:

> *Maya, we have to act now if we're going to survive long-term. HarvestAI isn't just another product—it's a category-defining technology. Fully autonomous harvesting with hand-pick gentleness. No operator, no labor crisis, twenty-four-hour operation. The vision systems are nearly there; we've been doing the foundational work for three years. Give me a dedicated team and I'm confident we can demonstrate a working prototype within eighteen months. Yes, the timeline to commercial deployment is longer, but whoever cracks this owns the future of premium viticulture.*

Okafor looked at her R&D staff list (see **Exhibits 7a-b**) and wondered if her team had the required expertise and resources available to take on such a project. She cast a glance at the projected return on the HarvestAI proposal. The NPV per engineering month was barely a tenth of some other projects. How could she justify a long-shot capability investment at the expense of projects that would be more immediately lucrative? Chen had made clear he supported the HarvestAI vision—it was, after all, his long-range strategic priority—but the resource allocation decision was Maya's to make. She remembered Hartley's comments at the recent meeting:

> *Whole-berry integrity is a wonderful metric, but it's invisible to customers. When a vineyard manager is standing in front of two harvesters at a dealer, they can't see quality scores—they see features, they see price, they see what their neighbors bought. The dealers prefer products with visible differentiation. Our premium positioning only works if customers can articulate why they're paying more.*

The sales team had strongly pushed a proposal from Kevin Tran, one of the regional sales managers. Tran had proposed cost-reducing the existing H-100 harvester to quickly introduce a "Central Valley Express" line for the volume market—both in California and globally. Tran believed that a competitively priced line would sell based on the Canopy brand alone. The greater size of the volume segment and hence the larger expected sales volume would more than compensate for the lower margins. The NPV looked attractive.

But her afternoon walkabout in engineering had produced a lukewarm response to Tran's proposal. One R&D staffer had complained:

> *Cost-reducing the H-100 is a wasted effort. It's like trying to trim a Tesla down to make a golf cart. The architecture wasn't designed for low cost—it was designed for performance. The only way we'll develop a genuinely competitive volume product is to design it from scratch, using commodity components and simplified sorting. That takes longer and requires significantly more resources than the proposal assumes.*

Hartley had raised a different concern: whether a "budget Canopy" product line might confuse customers in Napa and Sonoma about what the company stood for. Despite the engineer's comments, the sales-backed proposal appeared very attractive based on the financial projections. The R&D team's counter-proposal—a clean-sheet design—had a far lower return because of the additional resources required. Furthermore, where would the resources come from for an entirely new platform? She wondered if she should consider canceling any of the seven ongoing projects (see **Exhibit 14**) to free up capacity. Before taking medical leave, Michael Santos—her most talented harvester systems architect—had been blunt about the situation:

> *Maya, management has to understand what it's actually like to do these projects. As the lead architect on OptiSort 4.0 and the Monarch platform integration, I was also assigned to two other projects. Plus I was spending at least ten percent of my time on manufacturing change requests for products already in production. And every August through October, I'm basically on call—when a harvester goes down during crush at Silver Oak or Caymus, I drop everything and drive up there. So I became the bottleneck. I know on a few occasions people worked around me, and as a result we missed integration issues that cost us months of delay. But I can't blame them—I would have done the same thing.*

Scanning the list of ongoing projects, Okafor paused at the Zinfandel harvesting head—sixty person-months for a mechanical redesign targeting old-vine, head-trained vineyards. It was the second-largest commitment on the list, trailing only the Monarch platform integration. Hartley had mentioned at the last marketing review that old-vine Zinfandel acreage had been essentially flat for a decade, with younger growers increasingly favoring Cabernet and Pinot Noir.[23] "It's a heritage segment," Hartley had said. "Loyal customers, but not exactly a growth story." She had paused. "That said, our sales team in Lodi would tell you those growers have been waiting three years for a proper harvesting head. We keep shipping them the H-100Z and telling them the mechanical redesign is coming. At some point, 'next year' stops being credible." The project had strong internal champions, and Maya could see why. She moved on down the list.

What should she do before the board meeting? She had been in the job less than three months. Everyone in the room would be watching intently to see how she handled the situation.

Exhibit 1 The Mecca-Nized Grape Harvester

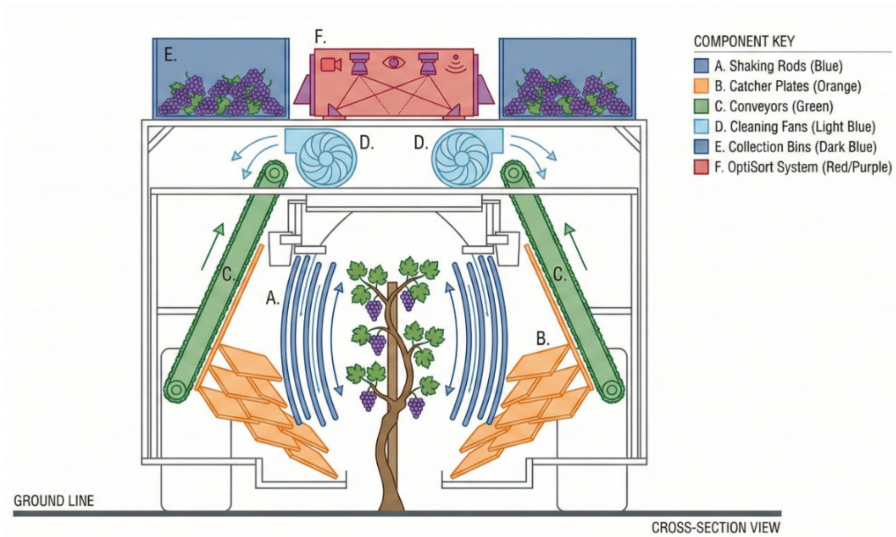
Notes:
Leonard Mecca's preserved 1978 unit at Florida Flywheelers. Additional photos available in Farm Collector article, https://www.farmcollector.com/equipment/mecca-nized-grape-harvester/

Source: https://www.flickr.com/photos/73683441@N07/25266619993

Exhibit 2 Modern Mechanical Grape Technology

Panel A: Rear view of a self-propelled grape harvester

Panel B: Cross-section schematic showing internal components



Note: A mechanical harvester straddles a vineyard row, with vines passing through the central picking zone. Collection bins and conveyors are visible on either side.

Source: Pellenc America, Inc. (Panel A) and case writer illustration (Panel B).

Exhibit 3 Cost Structure of a Mechanical Grape Harvester (2024)

Manufacturing Cost Structure	% of Total
Raw Materials	52%
Direct Labor	18%
Indirect Labor	8%
General Overhead & Depreciation	12%
Logistics & Inventory	6%
Development Allocation	4%
Total	**100%**

Module & Assembly Costs	% of Total
Chassis and frame	18%
Drivetrain and hydraulics	15%
Shaking mechanism	12%
Catching plates and conveyors	10%
Sorting subsystem (fans, screens)	8%
Operator cab and controls	10%
Navigation/autonomy systems	12%
Final assembly and test	15%
Total	**100%**

Source: Cost structure reflects mid-volume production (~180 units/year). Larger manufacturers with higher volumes achieve 10-15% lower per-unit costs through scale economies in raw materials and overhead allocation. Cost breakdowns correspond to plausible estimate based on agricultural equipment industry norms; specific manufacturer cost structures are proprietary.

Notes:

- Shaking mechanism and catching plates represent highest engineering complexity per dollar of cost.
- Sorting subsystem costs vary dramatically with sophistication: basic fan/screen systems at 8% vs. integrated optical sorting at 23-28% of total cost.
- Autonomy systems (navigation, sensors, software) are fastest-growing cost category as industry shifts toward driver-optional operation.
- OptiSort optical sorting adds 15-20% to base harvester cost.
- Full autonomy package adds 25-30% to base harvester cost.

Exhibit 4 California Wine Grape Economics by Market Segment (2024)

Metric	Napa Valley	Sonoma County	Central Valley	California Total
Production Volume				
Bearing acreage (2024)	45,000	61,000	420,000	615,000
% of California wine grapes	4%	6%	68%	100%
Avg. yield (tons/acre)	3.2	4.1	9.5	7.8
Pricing				
Avg. price per ton—red varieties	$8,200	$3,100	$340	—
Avg. price per ton—white varieties	$3,400	$1,900	$290	—
Avg. price per ton—all varieties	$6,100	$2,600	$320	$890
Price premium vs. Central Valley	19×	8×	1×	—
Harvesting Economics				
Hand harvesting cost ($/ton)	$320-400	$250-350	$180-250	—
Mechanical harvesting cost ($/ton)	$35-55	$30-50	$25-40	—
% mechanically harvested (2024)	<10%	35-40%	85%+	~70%
Labor Availability				
Unfilled harvest positions (2024)	1,200+	800+	2,500+	8,000+
Median farmworker age	43	41	38	40
% farmworkers over 55	18%	15%	14%	16%
Median home price (2024)	$1.5M	$980K	$420K	—
% workers commuting >30 miles	68%	52%	28%	—

Sources: *USDA National Agricultural Statistics Service; California Employment Development Department; Napa Valley Vintners; Sonoma County Winegrowers; UC Davis Cost Studies. Labor availability data from county Farm Bureau surveys, 2024.*

Notes:

- Napa and Sonoma produce 8-10% of California wine volume but generate approximately 35-40% of revenue
- Hand harvesting persists in premium regions despite 8-10× cost premium due to quality perception and terrain constraints
- Labor shortage is most acute in high-cost housing markets where workers cannot afford to live near vineyards
- Central Valley's high mechanization rate reflects flat terrain, lower-value fruit, and production-oriented economics

Exhibit 5 Canopy Systems Product Mix and Revenue by Platform (2024)

Platform	Description	Price Range	Units Sold	Revenue ($M)	% of Revenue	Gross Margin
Harvest Platform	Self-propelled mechanical harvesters with OptiSort onboard sorting	$320K-$475K	124	$47.25	45%	35%
Drive Platform	GPS-guided autonomous tractors (driver-assist to fully driverless)	$85K-$180K	205	$31.5	30%	32%
Tend Platform	Autonomous weeding, mowing, and cultivation equipment	$45K-$95K	255	$15.75	15%	30%
Sense Platform	NDVI mapping, yield estimation, vineyard management software	$8K-$25K (annual)	615 subscriptions	$10.5	10%	68%
Total				**$105.0**	**100%**	**36.5%**

Source: *Company records.*

Exhibit 6 Canopy Systems Organization Structure (December 2025)

Function	Head	Staff	Location	Key Responsibilities
Executive	Elena Rodriguez (CEO)	5	Healdsburg	Corporate strategy, investor relations, key account relationships
Technology Strategy	Marcus Chen (CTO)	—	Healdsburg	Long-range technology vision, technical architecture, advanced research direction
R&D	Maya Okafor (VP)	30	Healdsburg	Project portfolio, resource allocation, engineering team management, product delivery
Finance & Operations	James Liu (CFO)	36	Healdsburg	Finance, HR, facilities, administration
Manufacturing	Gérard Moreau (Director)	86	Healdsburg	Production, assembly, quality control, process engineering
Sales	Regional Managers	12	Field/Healdsburg	Direct sales, dealer relationships, customer demonstrations
Marketing	Elizabeth Hartley (Director)	8	Healdsburg	Market analysis, product positioning, demand generation
Field Service	Service Manager	10	Field/Napa	Installation, maintenance, harvest-season support
Total		**187**		

Source: *Company HR records, December 2025.*

Notes:

- All functions except field sales and service are co-located at Healdsburg headquarters
- Maya Okafor reports to Elena Rodriguez; the 30-person engineering organization reports to her. She succeeded David Ashworth, who left for John Deere in July 2025.
- Manufacturing operates two production lines; one supervisor per 12-15 production workers
- Field service team expands to 15+ during harvest season (August-October) with contract technicians

Exhibit 7a R&D Engineering Staff by Group

Engineering Group	Engineers	Group Lead	Key Expertise	Current Focus Areas
Mechanical Systems	10	Thomas Eriksen	Harvesting mechanisms, sorting systems, chassis design, structural engineering	OptiSort 4.0 upgrade; Zinfandel harvesting head; hillside capability
Electrical Systems	5	Noam Ohayon	Power electronics, motor controllers, battery integration, electrical architecture	Monarch platform integration; power management optimization
Perception and AI	5	Venkatesh Subramanian	Computer vision, ML models, object detection, sensor fusion	Night harvesting vision; yield prediction; HarvestAI research
Autonomy and Control	4	Carlos Mendez	GPS/RTK positioning, path planning, vehicle control software, safety systems	Remote supervision system; Cal/OSHA compliance
Software Platform	3	Amy Zhao	Sense platform, data systems, fleet management, cloud infrastructure	Yield prediction integration; data pipeline improvements
Test and Validation	3	Chad Taber	Field testing, system integration, regulatory compliance, quality assurance	OptiSort verification; whole-berry integrity testing
Total	**30**			

Note: Marcus Chen remains closely involved in Perception and AI technical direction as part of his strategic CTO role, although day-to-day group leadership transferred to Subramanian in 2023.

Source: *Company HR records, December 2025.*

Exhibit 7b Key Personnel Note

Name	Group	Status	Significance
Michael Santos	Mechanical Systems	Medical leave (burnout)	Senior Architect; lead on H-150 platform, OptiSort 4.0, and multiple derivatives; departure created bottleneck
Venkatesh Subramanian	Perception and AI	Active	Group lead; 7 years computer vision experience; previously Waymo; would lead HarvestAI technical development
Thomas Eriksen	Mechanical Systems	Active	Group lead; 15 years agricultural equipment experience; joined from John Deere combine division in 2019
Marcus Chen	Tech Strategy	Active (as CTO)	Co-founder; transitioned from engineering leadership in 2023 to focus on long-range technology strategy; primary advocate for HarvestAI investment

Source: *Company HR records, December 2025.*

Exhibit 7c R&D Capability Assessment by Area

Capability Area	Primary Group	Supporting Groups	Depth Assessment
Harvester mechanical design	Mechanical (10)	—	Strong; core competency
Optical sorting systems	Mechanical (4) + Perception (2)	Test (1)	Strong; OptiSort leadership
Autonomous navigation	Autonomy (4)	Perception (2)	Adequate; depends on partnerships
Computer vision/ML	Perception (5)	Software (1)	Developing; key gap for HarvestAI
Electric/hybrid powertrains	Electrical (5)	Mechanical (2)	Adequate; leverages Monarch partnership
Software/data systems	Software (3)	Perception (2)	Adequate; not a differentiator

Source: *Company HR records, December 2025.*

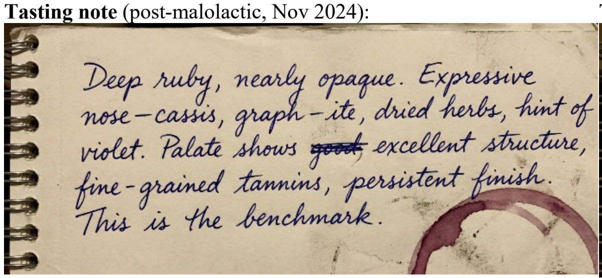
Exhibit 8 Winemaker Quality Assessment—OptiSort Demonstration Trial

HAND-HARVESTED
(Control)

Sept 18, 2024 • 5:45-9:30 AM
14-person crew

Receiving: Clusters intact, minimal leaf. 2-3% green berries, 1-2% raisined. Stem inclusion negligible.
Sorting: Light pass. Removed ~4% by weight.
Fermentation: Clean start, steady progression. No off-aromas.

Tasting note (post-malolactic, Nov 2024):



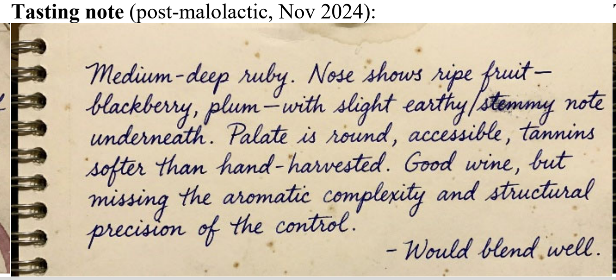
Deep ruby, nearly opaque. Expressive nose—cassis, graph-ite, dried herbs, hint of violet. Palate shows ~~good~~ excellent structure, fine-grained tannins, persistent finish. This is the benchmark.

PELLENC OPTIMUM 640
(Conventional Mechanical)

Sept 18, 2024 • 10:15 PM-1:30 AM
Night operation

Receiving: Mostly destemmed berries. MOG 2.8%. Juice in bins indicates berry damage. Fruit at 58°F.
Sorting: Moderate pass. Removed ~8% by weight—damaged berries, stem fragments.
Fermentation: Faster start. Some VA detected day 3—managed. More solids at pressing.

Tasting note (post-malolactic, Nov 2024):



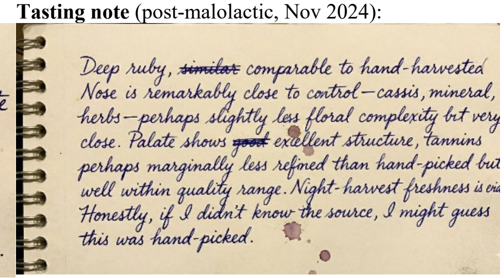
Medium-deep ruby. Nose shows ripe fruit—blackberry, plum—with slight earthy/~~stemmy~~ note underneath. Palate is round, accessible, tannins softer than hand-harvested. Good wine, but missing the aromatic complexity and structural precision of the control.
– Would blend well.

CANOPY H-100S
(with OptiSort)

Sept 18, 2024 • 11:45 PM-3:00 AM
Night operation

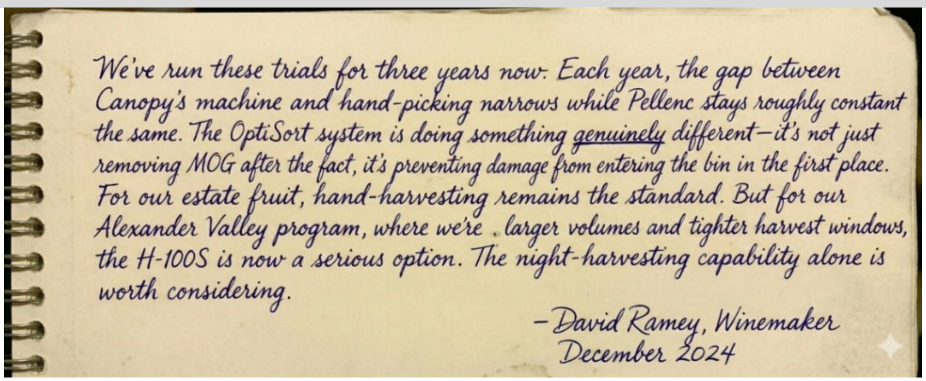
Receiving: Berries almost entirely whole—like hand-picked. MOG 1.1%. Minimal juice in bins. Fruit at 58°F.
Sorting: Very light pass. Removed ~3%—for ripeness uniformity, not damage.
Fermentation: Clean, controlled start. No off-aromas. Pressing straightforward.

Tasting note (post-malolactic, Nov 2024):



Deep ruby, ~~similar~~ comparable to hand-harvested Nose is remarkably close to control—cassis, mineral, herbs—perhaps slightly less floral complexity but very close. Palate shows ~~good~~ excellent structure, tannins perhaps marginally less refined than hand-picked but well within quality range. Night-harvest freshness is evi
Honestly, if I didn't know the source, I might guess this was hand-picked.

WINEMAKER SUMMARY



We've run these trials for three years now. Each year, the gap between Canopy's machine and hand-picking narrows while Pellenc stays roughly constant the same. The OptiSort system is doing something genuinely different—it's not just removing MOG after the fact, it's preventing damage from entering the bin in the first place. For our estate fruit, hand-harvesting remains the standard. But for our Alexander Valley program, where we're larger volumes and tighter harvest windows, the H-100S is now a serious option. The night-harvesting capability alone is worth considering.

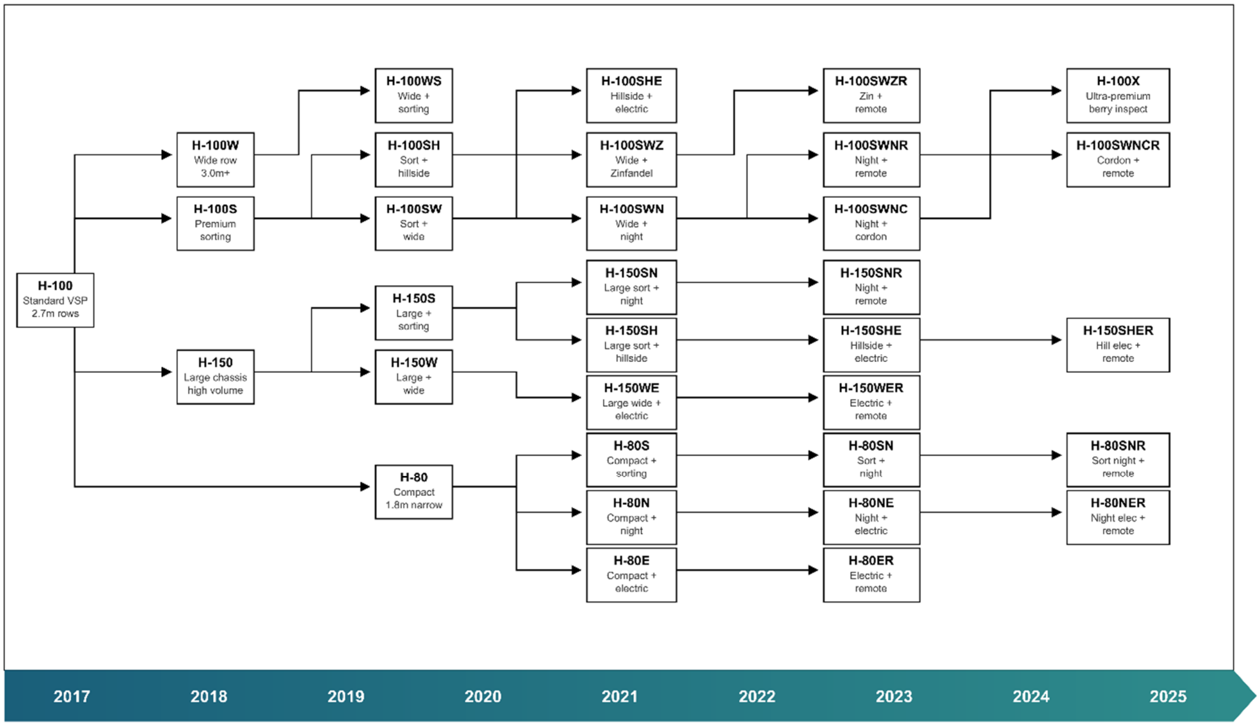
–David Ramey, Winemaker
December 2024

Note: This assessment was prepared for Canopy Systems' customer demonstration program. Silver Oak purchased two H-100S units in January 2025. Hand-harvested fruit was assessed as intact clusters prior to winery destemming.

Source: Silver Oak Cellars | Alexander Valley | 2024 Harvest | Cabernet Sauvignon Block 7A Comparison Trial.

Exhibit 9a Canopy Systems Harvester Product Line Evolution (2017-2025)

Suffix Key: **S** = Premium Sorting **W** = Wide Row (3.0m+) **H** = Hillside (15%+ slope) **Z** = Head-trained (Zinfandel) **E** = Electric Drive **N** = Night Harvest **R** = Remote Supv.



Note: Canopy Systems maintained 32 active harvester configurations in 2025. Each configuration requires distinct software parameters, testing protocols, manufacturing documentation, and spare parts inventory.

Exhibit 9b Harvest Platform Sales by Configuration (2024)

Configuration	Chassis	Sorting Level	Autonomy	Units	Avg. Price	Notes
H-100 Standard	Medium	OptiSort 3.0	Driver-assist	40	$320K	VSP-trained vineyards
H-100S Premium	Medium	OptiSort 3.0+	Driver-assist	18	$425K	Enhanced optical inspection
H-100E Electric	Medium	OptiSort 3.0	Driver-assist	12	$410K	Monarch platform integration
H-100R Remote	Medium	OptiSort 3.0	Remote-supervised	9	$445K	Cal/OSHA compliant autonomous
H-100N Night	Medium	OptiSort 3.0	Driver-assist	7	$365K	Thermal vision package
H-100H Hillside	Medium	OptiSort 3.0	Driver-assist	6	$440K	15% slope tolerance
H-100Z Zinfandel	Medium	OptiSort 3.0	Driver-assist	10	$350K	Software optimization for head-trained vines; uses standard harvesting head
H-150 Large	Large	OptiSort 3.0	Driver-assist	15	$395K	High-volume operations
H-150S Large Premium	Large	OptiSort 3.0+	Driver-assist	4	$475K	Ultra-premium estates
H-150H Large Hillside	Large	OptiSort 3.0	Driver-assist	3	$465K	Mountain vineyards
Total Harvest				**124**	**$381K avg.**	

Note: Table displays only the 10 configurations with non-negligible sales volume in 2024. The remaining 22 configurations generated no sales in 2024 but continued to impose full manufacturing and support overhead. Engineering resources required for maintaining dormant configurations—responding to spare parts requests, updating documentation for regulatory changes, supporting occasional field service calls—are not formally tracked.

Source: *Company sales records, fiscal year 2024.*

Exhibit 10 NPV calculation worksheet

Year	0	1	2	3	4	5
Development Investment						
Engineering						
Software development						
Mechanical engineering						
Testing & validation						
Total Engineering						
Manufacturing Setup						
Line configuration						
Supplier qualification						
Total Manufacturing Setup						
Marketing & launch costs						
Total Development Investment						
Discount rate						
PV of Development Investment						
Projected unit volume						
Unit price						
Projected revenues						
EBITDA margin						
Projected EBITDA						
Discount rate						
PV of EBITDA						
Cumulative PV of EBITDA						
Total Development Investment (PV)						
Total Project Returns (PV)						
Project NPV						

Source: Canopy Systems

Exhibit 11 Whole-berry Integrity Performance

Manufacturer	Model	2019 Score	2025 Score
Canopy Systems	H-100S	97.0%	99.2%
Pellenc	OPTIMUM 640	91.5%	97.5%*
Braud	9090X Optimal	92.8%	97.1%
OXBO	CVS 3000	89.2%	96.1%
Grégoire	G8.270	90.4%	97.3%

Source: Canopy Systems test vineyard data; manufacturer specifications. Whole-berry integrity defined as percentage of harvested fruit with unruptured skins, measured by optical inspection of 1,000-berry samples at three harvest speeds.

Note: Pellenc claims 99.0%+ with Selectiv' Process on latest equipment; 97.5% reflects independent field testing of units currently deployed. Canopy's lead narrowed from 4.2-7.8 percentage points in 2019 to 1.7-3.1 percentage points in 2025.

Exhibit 12 Canopy Systems financial performance (2018-2025)

Year	Revenue ($M)	Gross Margin	Operating Margin	Net Margin
2018	$26.0	44.8%	14.5%	10.8%
2019	$42.0	43.5%	13.8%	10.1%
2020	$58.0	42.1%	12.8%	9.2%
2021	$72.0	41.3%	11.4%	8.1%
2022	$84.0	39.8%	9.7%	6.8%
2023	$94.0	38.2%	7.9%	5.3%
2024	$105.0	36.5%	5.6%	3.4%
2025 (Q1)	$26.0	35.8%	4.2%	2.5%
2025 (Q2)	$26.9	35.1%	3.1%	1.6%
2025 (Q3)	$27.9	34.2%	1.8%	0.4%
2025 (Q4, projected)	*$27.0*	*33.5%*	*(1.2%)*	*(2.8%)*

Source: Company financial records. Q4 2025 figures are management projections as of November 2025.

Notes:
- Revenue growth driven primarily by unit volume increases; average selling prices declined approximately 3% annually from 2022-2025
- Gross margin compression reflects competitive pricing pressure and increased warranty costs
- Operating margin decline reflects higher R&D spending (increased from 7.2% of revenue in 2020 to 8.1% in 2025) and increased marketing expenses
- Q4 2025 would represent the first unprofitable quarter since 2013.

Exhibit 13 Proposed Development Projects

#	Project Description	Person-Months	Duration	NPV ($M)	Comments
a	HarvestAI: Fully autonomous grape harvesting system with computer vision cluster detection, soft robotics manipulation, and real-time sorting—no operator required	220	36 months	$9.0	Extensive technology development; high uncertainty
b	Central Valley Express (de-featured): Cost-reduced version of H-100 for volume market	45	10 months	$10.5	Proposal from sales; leverages existing design
c	Central Valley Express (clean-sheet): Purpose-built high-volume harvester	110	18 months	$8.0	Engineering counter-proposal
d	Harvest Universal: Modular architecture with common chassis and interchangeable modules	170	24 months	$21.0	Would reduce manufacturing complexity
e	Agtonomy TeleFarmer Integration: Partnership for remote supervision platform	30	8 months	$12.0	Low internal resource requirement

Source: R&D project proposals, December 2025.

Note: NPV calculations assume 12% discount rate and 5-year revenue horizon.

Exhibit 14 Ongoing Development Projects

#	Project Description	Person-Months Remaining	Ship Date	NPV ($M)	Comments
1	OptiSort 4.0 individual berry inspection upgrade	40	Sep ’26	$16.0	Core technology enhancement; Behind schedule (originally Q2 2025)
2	Electric drive integration (next-generation Monarch platform)	72	Dec ’26	$7.0	Dependent on Monarch updates
3	Hillside capability upgrade	20	Apr ’26	$5.5	Customer-requested feature; extends slope tolerance from 15% to 20%
4	Remote supervision system (Cal/OSHA compliance)	54	Nov ’26	$8.0	Regulatory requirement
5	Night harvesting package (thermal vision + lighting)	28	Aug ’26	$5.8	High customer interest
6	Zinfandel-specific harvesting head (old-vine, head-trained)	60	Apr ’27	$12.0	Mechanical redesign; current H-100Z is software-only optimization on standard hardware
7	Sense platform yield prediction integration	55	Dec ’26	$10.5	Cross-platform initiative; data/analytics feature

Source: R&D project tracking system, December 2025

Note: Canopy Systems has 30 engineers in the R&D organization, representing approximately 360 person-months of annual capacity.

GLOSSARY OF TECHNICAL TERMS

VINEYARD & VITICULTURE

Bearing acreage
Vineyard land planted with mature vines that are producing harvestable fruit, as opposed to newly planted vines not yet in production.

Bilateral cordon
A vine training system where two permanent horizontal arms extend in opposite directions from the trunk along a support wire.

California Sprawl
A canopy management system where shoots are allowed to cascade downward naturally rather than being trained upward, common in warm California regions.

Canopy
The above-ground portion of the vine including leaves, shoots, and fruit clusters. Canopy density and architecture affect fruit quality and harvesting difficulty.

Cover crops
Plants grown between vineyard rows to prevent erosion, improve soil health, manage water, and provide habitat for beneficial insects.

Fruiting zone
The vertical band along the vine where grape clusters hang, typically 2-4 feet above ground. Mechanical harvesters target this zone.

Head-trained vines
Free-standing vines grown as bushes without trellis support, a traditional method predating modern mechanization. Common for old-vine Zinfandel.

Old-vine
Vines typically 35+ years old, valued for producing lower yields of more concentrated, complex fruit. No legal definition exists.

Row spacing
The distance between vineyard rows, ranging from 6 feet (older plantings) to 12 feet (modern mechanical-access configurations).

Trellis/trellising system
The framework of posts and wires supporting grapevines, determining vine shape, sun exposure, and compatibility with mechanical equipment.

Vertical Shoot Positioning (VSP)
A widely used trellis system where shoots are trained upward between parallel catch wires, creating a neat "hedgerow" canopy ideal for mechanical harvesting.

Grape Varieties

Cabernet Sauvignon

The dominant red grape of Napa Valley, producing full-bodied wines. Typically grown on VSP trellises.

Chardonnay

The most planted white grape in California, producing wines ranging from crisp and unoaked to rich and buttery.

Pinot Noir

A thin-skinned red grape requiring cool climates, dominant in Sonoma's Russian River Valley and Carneros.

Zinfandel

A red grape with California heritage, often grown as head-trained old vines in Lodi and Dry Creek Valley.

Wine Production

Crush

The harvest season (August-October in California) when grapes are picked and processed. Also refers to the initial processing of grapes at the winery.

Destemming

Removing grape berries from their stems before fermentation. Mechanical harvesters perform this in the field; hand-harvested fruit requires winery destemming.

Fermentation

The conversion of grape sugars to alcohol by yeast. Primary fermentation produces wine; secondary (malolactic) fermentation softens acidity.

Malolactic fermentation

A secondary fermentation converting sharp malic acid to softer lactic acid, typically desired in red wines and some Chardonnays.

Oxidation

Chemical degradation from oxygen exposure. Broken grape skins accelerate oxidation, which is why whole-berry integrity matters for quality.

Tannins

Compounds from grape skins, seeds, and stems that create astringency and structure in red wine. Harsh tannins can result from rough handling.

VA (volatile acidity)

Acetic acid and related compounds that produce vinegar-like aromas. Elevated VA indicates bacterial spoilage, often from damaged fruit.

Whole-berry integrity

The percentage of harvested grapes with unruptured skins. A quality metric introduced by Canopy Systems; higher integrity reduces oxidation and harsh tannin extraction.

HARVESTING EQUIPMENT

Gondola

A large open-top trailer towed behind a harvester or tractor to receive harvested grapes for transport to the winery.

MOG (Material Other than Grapes)

Leaves, stems, insects, and debris that enter the harvest stream. Modern sorting systems aim to reduce MOG to below 3%.

Throughput

The rate at which a harvester processes vineyard acreage, typically measured in acres per hour. Higher throughput often trades off against gentler handling.

TECHNOLOGY

Computer vision

AI systems that interpret visual data from cameras to identify objects—in viticulture, detecting grape clusters within canopy for autonomous harvesting.

GPS / RTK positioning

Global Positioning System enhanced with Real-Time Kinematic corrections, achieving centimeter-level accuracy for autonomous navigation in vineyard rows.

NDVI (Normalized Difference Vegetation Index)

A measure of plant health derived from aerial or satellite imagery, used to map vineyard vigor and predict yields.

Soft robotics

Robotic systems using flexible, compliant materials rather than rigid components, potentially enabling gentle manipulation of delicate grape clusters.

REGULATORY

Cal/OSHA

California's Division of Occupational Safety and Health, which regulates workplace safety including requirements for autonomous agricultural equipment.

H-2A visa

A U.S. temporary agricultural worker program allowing employers to bring foreign nationals for seasonal farm work when domestic workers are unavailable

Endnotes

[1] Smithsonian National Museum of American History, "Innovations in the Vineyard," https://americanhistory.si.edu/explore/exhibitions/food/online/wine-table/innovations-vineyard
[2] The Wine Society, "The Challenges of Wine Harvesting," https://www.thewinesociety.com/discover/explore/the-road-less-travelled/man-vs-machine-the-challenges-of-harvesting/
[3] Smithsonian, ibid.
[4] Plausible estimate based on manufacturer list prices and Wine Spectator, "Rise of the Machines," September 19, 2012, https://www.winespectator.com/articles/rise-of-the-machines-47334
[5] Shaking frequencies typically range between 400 and 450 beats per minute; optimal frequencies vary by grape variety and trellis system.
[6] Shaking mechanism and catching plates account for approximately 35% of manufacturing costs; frame, drivetrain, and mobility systems another 30%; sorting subsystem and controls the remaining 35%. Cost breakdown is a plausible estimate based on agricultural equipment industry norms; specific manufacturer cost structures are proprietary.
[7] Common canopy management systems include Vertical Shoot Positioning (VSP), where shoots are trained upward between catch wires, and California Sprawl, where shoots cascade downward. Each requires different harvester configurations.
[8] Napa Valley Vintners, https://napavintners.com/napa-valley/napa-valley-appellation/
[9] George Taber, Time Magazine, "Judgment of Paris," June 7, 1976, https://time.com/archive/6880821/modern-living-judgment-of-paris/
[10] Wine Business Monthly, plausible estimate based on industry sources.
[11] UC Davis Cost Studies, https://coststudies.ucdavis.edu
[12] Napa County Farm Bureau, plausible estimate based on industry reports.
[13] California Employment Development Department; Napa Valley Register, housing data.
[14] Pellenc North America, https://www.pellenc.com/agriculture/en/
[15] UC Davis Department of Viticulture & Enology.
[16] California Code of Regulations, Title 8, Section 3441(b), https://www.dir.ca.gov/title8/3441.html; Cal/OSHA memorandum, August 2024; Cal/OSHA Standards Board advisory committee approved November 21, 2024. See Ag Alert, "Farm Groups Seek New Autonomous Tractor Regulation," November 5, 2025, https://www.agalert.com/california-ag-news/archives/november-5-2025/farm-groups-seek-new-autonomous-tractor-regulation
[17] Sensors journal, "Occluded Grape Cluster Detection and Vine Canopy Visualisation," 2021, https://www.mdpi.com/1424-8220/21/6/2182
[18] The WSU gripper achieved an 87.5% success rate with only 4.55% damage, at a production cost of approximately $30 per unit. See WSU News, "New robotic gripper for automated apple picking developed," June 2024, https://news.wsu.edu/news/2024/06/12/new-robotic-gripper-for-automated-apple-picking-developed/
[19] Stanford Technology Ventures Program, Elena Rodriguez's speaking engagement.
[20] Unit count reflects Harvest and Drive platform equipment assembled at Healdsburg. Tend platform cultivation equipment is largely assembled by partner firms, with Canopy providing control systems and integration; Sense platform consists entirely of software and sensors requiring no factory production.
[21] Whole-berry integrity comparisons between mechanical and hand-harvesting require careful interpretation. Mechanical harvesters detach individual berries from their stems in the field—essentially performing destemming during harvest. Hand-harvested fruit arrives at the winery as intact clusters and must pass through a mechanical destemmer before fermentation, a process that inevitably ruptures some skins. A fair comparison of berry condition at fermentation start would measure hand-harvested fruit after winery destemming, at which point the quality gap narrows. However, Canopy and its competitors report whole-berry integrity at the point of harvest, which is standard industry practice for comparing harvester performance.
[22] SITEVI (Salon International des Techniques vitivinicoles) is held biennially in Montpellier, France. The SITEVI Innovation Awards recognize the most innovative equipment presented by exhibitors; a jury of industry experts selects Gold, Silver, and Bronze Medal winners. See https://www.sitevi.com.
[23] Old-vine, head-trained Zinfandel represents approximately 3% of California premium wine grape acreage, concentrated in Lodi and Dry Creek Valley. Head-trained vines are free-standing bushes with no trellis wires—a traditional method that predates modern vineyard mechanization. The irregular canopy geometry makes these vines particularly challenging for mechanical harvesters designed around trellised systems.