UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

II. Academic Program Review Dossier Cover Page | 2024 Cycle

Name, Lived Name:	**Brent A. Holtz, Ph.D.**
Preferred Pronoun:	he/him
Academic Title:	• Full Title Cooperative Extension Advisor
County/Program:	• UC ANR in San Joaquin County
Review Type:	• Merit
Current Rank/Step:	• Full Title Cooperative Extension Advisor VIII
Requested Rank/Step:	• Full Title Cooperative Extension Advisor IX
Review Time Period:	• October 1, 2020 to September 30, 2023
Thematic Areas:	• Administration and Sustainable Agriculture

IV. Program Summary Narrative

I am a Full Title Cooperative Extension Advisor VIII seeking a merit to step IX. As County Director (CD), I am responsible for the overall operation of the University of California Cooperative Extension (UCCE) in San Joaquin County (SJC), supervising 5 advisors and 15 staff. I provide academic and programmatic guidance to advisors and staff, ensuring that their programs and professional development are in alignment with ANR's Strategic Vision and Public Value Statements. I work with advisors to ensure that outcomes and impacts are measured and communicated. I give special attention to new advisors in need of mentoring and program development. I ensure that our programs are compliant with UC and SJC policies while maintaining a positive and supportive attitude towards my staff. As CD, it is my responsibility to establish and maintain a good working relationship with SJC Government.

As an orchard systems advisor, I conduct an extension education and research program with an emphasis on sustainable agriculture in SJC and throughout the San Joaquin Valley (SJV). My program includes research and the dissemination of educational information to deciduous tree fruit growers, pest control advisors, processors, farm managers, and related clientele. My major responsibility is a research and extension program on almond (occasionally pistachio and stone fruit), the largest commodity in SJC with 115,000 acres and 1,000 growers and pest control advisors (PCAs).

Theme: Administration and Leadership

For the review period, 2021-2023, I negotiated three budget cycles for UCCE in SJC totaling $2,962,342 with successive inflationary increases. This county funding supports four full-time county employees, nine county vehicles, and office and laboratory space in our SJC Ag Center. I also facilitate the funding agreement between SJC and UC which has provided $130,000 annually to support our Environmental Horticulture and Master Gardener programs and Community Educator (CES), with her salary and program expenses ($3.2 million since 2007). Funding from SJC's Public Works Division is obtained from a tax on landfill usage for education and outreach, that we provide, on how to divert organic waste from landfill.

During the review period, Dr. Justin Tanner joined our staff as our Viticulture Advisor. I have given him special attention and mentoring as he developed his needs assessment, position description, and program. During Covid-19, I made sure UCCE in SJC followed both county and UC policies as our staff safely transitioned to an online platform and back. When our Nutrition Advisor retired, I became the PI for both CalFresh Healthy Living (6 staff) and our Expanded Food Nutrition Education Program (EFNEP, 3 staff). During the review period, we also lost our 4-H advisor and CES, giving me more responsibilities even though we hired a regional supervisor. I also oversaw our Master Food Preserver Program that is without a CES or supervisor. The multitude of administrative matters that require my attention as CD seem endless and dilute my ability to carry out my academic program. But these drawbacks are outweighed by the academic freedom and opportunities UC ANR has given me to develop my own research and extension program, and to work with such an excellent group of academics and staff who are fulfilling our land grant mission: helping our clientele with their problems and becoming their friends in the process. I have worked hard to foster a supportive and inclusive environment where diverse views and backgrounds are embraced. We celebrate staff birthdays once a month with festive potlucks, often with diverse ethnic cuisines, that allows for cultural exchanges that build morale and friendships. I feel fortunate and privileged to administer UCCE in SJC. My biggest administrative concern: we need more advisors to meet clientele needs.

Theme: Whole Orchard Recycling (WOR)

For this review I will focus on my orchard recycling project since it has had the greatest impacts. Over 35 years ago, my family started wood chipping annual prunings in our almond orchard because of our close proximity to urban development—ag burning was not allowed within the city limit. Almost 30 years ago, as an assistant farm advisor with a personal interest in wood chipping, I initiated studies that ultimately showed that the shredding of prunings is a viable alternative to burning that returned valuable organic matter and carbon to soils. In my first decade as a farm advisor, I provided leadership and guidance to the almond industry as it transitioned from open field burning of prunings to shredding, giving growers a viable and sustainable alternative that enhanced soil and air quality.

But when an orchard reaches the end of its productive life, could the bulk and mass of a whole orchard be shredded and returned to the soil, could growers cultivate that ground, would the next generation trees be able to grow, would there be disease, and what would whole orchard recycling (WOR) do to soil carbon, organic matter, or the carbon to nitrogen ratio? My past two decades of research have been devoted to understanding these questions. I started with a small-scale barrel trial in 2000 on my family farm, because I couldn't find a grower willing to experiment with putting all that biomass back into the soil. In 2008, I recycled my first orchard at the Kearney REC using the Iron wolf, a 100,000-pound 1,000-horsepower machine designed to crush rock.

Before air quality restrictions, orchard removal meant pushing trees into large piles and burning them. On burn days, the SJV would fill with unhealthy smoke and greenhouse gases contributing to global warming. When air quality regulations were first implemented in 2002, under the Clean Air Act, removed orchards were ground up and the woody debris was hauled to a co-generation plant to generate electricity. However, since 2015, many biomass co-generation facilities have closed throughout CA because utility companies are mandated to obtain cleaner sources of energy (solar and wind). Burning wood chips is like burning coal in terms of air quality. Thus, tree fruit growers who wished to remove dead trees and unproductive old orchards, needed an alternative method of orchard removal. I am the principal investigator of the first WOR projects that compared the grinding and incorporation of 60 tons per acre of whole trees into the soil with burning the trees and spreading the ash. Second generation almond trees were planted in both treatments and I evaluated tree growth, disease, soil fertility, yield, and the nitrogen to carbon ratio. Over a decade of observations showed trees growing in the recycled orchard had greater yields, significantly more soil nutrients, soil organic matter, total carbon, and increased water holding capacity! Now there are ten WOR research sites from Arbuckle to Bakersfield.

I made an extraordinary effort to extend the results of these projects, with numerous presentations and publications, to meet the urgent need of CA's tree fruit industries to find a sustainable alternative to biomass co-generation. During the review period, I organized 7 extension-meetings, gave 26 presentations, wrote 4 peer-reviewed publications and 27 popular press articles on WOR. Information from my research and extension program was referred to by ten authors in popular press articles, blogs, and podcasts. In 2021, the Almond Board of California (ABC) produced a video 'Resilience: the whole orchard recycling origin story', outlining how I conceived the concept and initiated the first studies. The video won a gold medal at the national Golden Ag Relations Council Awards in 2022, under 'digital and social media' promoting excellence in agriculture. ABC features the video on their website and UCANR featured it on the Green Blog, and it has over 2,000 views on YouTube. My research and extension program provided our tree fruit industries with an alternative to co-generation and open field burning that has increased soil health and fertility.

WOR, by replacing open field or co-generation burning, has significantly reduced air pollution and increased soil carbon and organic matter. Since 2018, when the San Joaquin Valley Air Pollution Control District (SJVUAPCD) began funding WOR at $600-900 per acre: 3,019 growers (projects) received $137 million in funding and 162,775 acres have been recycled (2023 report). As a result, 4.5 million tons of agricultural biomass were diverted from burning, resulting in the reduction of 8,791 tons of nitrogen oxides (NOx), 16,212 tons of particulate matter (PM), and 13,702 tons of volatile organic carbons (VOC). Open field burning in the SJV has dropped from an average of one million tons annually to only 125,000 tons in 2022. From 9/2021 to 2/2023 SJVUAPCD also provided the orchard removal industry $30 million to purchase additional recycling equipment to meet increased demand.

On July 19, 2022, Governor Newsom signed AB 2101 (Flora) CA Carbon Sequestration and Climate Resiliency Project Registry: Whole Orchard Recycling Projects. This bill was specifically designed to make funding available for WOR projects. The SJVUAPCD received an additional $178 million to fund future recycling efforts in the SJV. In addition, the CA Department of Food and Agriculture's (CDFA Report) Healthy Soils Program and the Natural Resources Conservation Service's (NRCS) Environmental Quality Incentives Program (EQIP) both received funding for orchard recycling projects. This is important for growers in the Sacramento Valley and along the coast who are outside of the SJVUAPCD. WOR quickly became the most requested orchard practice for all three funding agencies.

The Blue Diamond Growers Cooperative, and their 3,000 members, received a $40 million Climate Smart USDA grant in 2023 to implement practices that increase carbon sequestration. WOR is a major component of the grant, I helped write the proposal, and I'm now training their trainers on how to successfully implement WOR without negatively affecting the soil carbon to nitrogen balance in the next generation almond orchard.

As the popularity of orchard recycling increased, so did funding and research opportunities. After receiving minimal funding from 2000 to 2015, I brought in direct funding for my research and extension program totaling $477,873 and assembled a team of researchers that were awarded over $2 million during the review period to study carbon sequestration, soil nutrient cycling, and greenhouse gas emissions from recycled almond orchards. We developed a website to extend information.

One of our peer-reviewed publications (example 1) showed that WOR could substantially reduce nitrogen leaching into groundwater. This will have important implications on low-income rural communities throughout the SJV that are primarily drinking groundwater, often contaminated with high levels of nitrate. To highlight the environmental importance of these findings, a CSA News article was written by Kristen Coyne (example 2), that featured me on the front cover standing on a mountain of wood chips. CSA News has a circulation of 8,000 scientists nationally and worldwide, giving me both national and international recognition. Colleagues congratulated me from as far away as Switzerland and South America. The article was also featured in World Environment Day 2023, bringing together 150 countries to participate in United Nations International Day, celebrating environmental action and the power of governments, businesses, and individuals to create a more sustainable world.

Theme: Extending knowledge throughout the San Joaquin Valley (SJV)

I have authored Pacific Nut Producer's (PNP) magazine article 'Almond Tasks' for 15 years (example 3). This represents my most significant extension activity, reaching 11,000 growers and PCAs monthly. "Almond Tasks" has allowed me to extend my research and education program

statewide to growers farming CA's largest commodity in terms of acreage, annual value, and grower numbers. I discuss many topics related to almond production: IPM practices, crop evaporative needs, nutritional requirements, disease control, replant disease options, fungicide and insecticide efficacy and rotation practices, and of course WOR. The PNP has allowed me to use high quality digital photos to identify disease symptoms, pests, or to illustrate practices, and it represents my primary affirmative action effort—reaching a diverse audience.

Professional competence and activity

I was invited to give many presentations during the review period. Most of my presentations were given to almond growers in the SJV, focused on sustainable farming practices such as WOR or integrated pest management (IPM). During the review period I gave 42 presentations: 26 were related to my research and extension program on WOR, while 10 were related to almond production or IPM practices. Seven presentations were administrative and related to my role as CD, advocating for UCCE in SJC. I am considered the orchard recycling expert in CA, and my international reputation continues to grow. I often receive phone calls, emails, and visits from Australian almond growers who receive the PNP magazine and read my articles.

On February 25, 2021 I gave virtual testimony to the CA Air Resources Board (CARB) and 450 attendees on the benefits of WOR as a sustainable alternative to open-field burning. This was a public meeting to consider the SJV 2020 agricultural burning assessment, and the postponement of prohibition on open burning for certain crops and materials under Senate Bill 705. Michael Benjamin, Division Chief of the Air Quality Planning and Science Division of CARB, complimented me afterwards by saying that my presentation and research were influencing state policy. At the meetings conclusion, CARB voted to implement the ban on all open field burning in the SJV beginning January 1st, 2025!

Economist Joel Ferguson discusses 'How much will air quality improve thanks to the SJV Agricultural Burning Ban?' in Agriculture and Resource Economics Update 26(4):9-11. Improved air quality in the SJV will directly benefit its 4 million residents, many who live in impoverished diverse rural communities that were traditionally impacted by agricultural burning. An estimate published in the American Economic Review suggests that exposing a million Medicare beneficiaries to the pollution generated by one agricultural fire would be expected to increase emergency room spending on respiratory ailments by $100,000. The adoption of WOR will improve human health and reduce Medicare spending.

In 2018, I was the keynote speaker at the 18th Australian Almond Conference. Initially, I didn't think the Australians would be interested in WOR since their bush burns regularly and they don't have air quality or burning restrictions. But their soils are sandy, much sandier than ours, and they are interested in any practice that can build soil organic matter, nutrient fertility, and increase water holding capacity. Knowledge of WOR created a sensation in Oz, and during this review period, eight large growers recycled their orchards 'Down Under'! But before recycling, skeptical Australians had to first visit my trials in CA before they could be convinced that second generation trees could grow in soils amended with 60 tons per acre of wood chips. A contingent of Almond Board of Australia (ABA) members attended my WOR field day on May 18th, 2023, in the SJV, a week after hearing me give another keynote presentation on WOR at the 8th International Symposium on Almond and Pistachio, hosted by the International Society of Horticultural Science at UC Davis. As a consequence, I have been invited back to Australia in 2024, by the ABA, to give five presentations on WOR in five days (January 15th-19th) from Adelaide to Griffith, along an 800-mile stretch of the Murray River, where most almonds are grown in South Australia.

I was also invited to give the keynote address to the Hawaii Macadamia Nut Growers Association, at their 53rd annual meeting, Hilo, Hawaii, on July 10, 2021. The association wanted to hear about WOR and whether the practice could prove beneficial to their volcanic soils, typically low in soil organic matter. I was fascinated with their 100 plus year-old island industry, and we had in depth discussions on the potential benefits of WOR. Two macadamia growers started recycling trees from orchards that were being thinned days after my presentation. Several growers invited me to visit their farms, and it was an amazing experience to see Macadamia trees growing on beautiful island hillsides that ran into the sea. I want to be a Macadamia Nut Farm Advisor on the Big Island in my next career.

Improving, developing, and maintaining a high level of professional competence is an integral part of my research and extension program. During the review period, I published 8 peer-reviewed articles, 29 technical reports, 13 abstracts, and 47 popular press articles. During the review period I attended 52 professional development training and educational programs. I am active in three professional societies and I maintain a CA Qualified Applicator Certificate License.

University Service

For the review period, I served on the UC IPM Program Advisory Committee, sharing new or developing pest management issues, providing guidance to the UC IPM program on planning and priorities through responsible pest management. I also served as peer reviewer of the disease section of the UC Pest Management Guidelines for Almond and Pistachio. I participated in six advisor search committees, chairing the Orchard Systems Advisor search in Sutter/Yuba Counties. Each search involved multiple conference calls, e-mails, and in-person interviews. Serving on a search committee represents a tremendous time commitment, but the selection of new academics is one the most important activities we can engage in to ensure the future success of ANR. I also chaired four SJC office assistant search committees. I chaired two Ad Hoc Review Committees during the review period. I have spent considerable time mentoring new advisors, helping Yaghmour, Culumber, Gordon, Milliron, Nouri, Zuber, and Reyes establish WOR trials in their respective counties. I also mentored three masters and three PhD students, allowing them to use my research plots for their thesis projects. I provide our SJC Master Gardeners with in-service training in pomology, plant pathology, and entomology, and I help them answer questions from the public.

Public Service

I am a member of the SJC Agricultural Advisory Board, which advises the Board of Supervisors (BOS) on agriculture issues. Related to this role I chair the SJC Agricultural Advisory Board Grievance Committee, tasked with mitigating grower disputes. I am also a member of the SJC Farm Bureau Board of Directors, that represents SJC's farm centers and their constituents, typically advocating for agriculture; The SJC 4-H Club Foundation, that distributes 4-H scholarships. As CD I attend SJC's Department Head meetings every other month. I'm a member of the SJC Agricultural Drought Task Force, which advises the BOS on the effects of a drought on agriculture and precautions that can be taken to conserve water. I am a regular presenter at 'Ag Venture-Select San Joaquin', an event funded by a specialty crop grant administered by SJC's Agricultural Commissioner, Farm Bureau, and the Stockton, Lodi, Manteca and Tracy Unified School Districts. Four events are held annually and over 3,000 third graders participate in each event, learning about agriculture in SJC. I was appointed to the CA Clean Biomass Collaborative by CARB, with a mission of finding alternatives to agricultural burning.

Affirmative action activities contributing to diversity, equity, and inclusion (DEI)

I am committed to the University's policy of nondiscrimination, equal opportunity, and outreach and diversity. I encourage the participation of underserved clientele, often giving them preferential treatment. I have used the agricultural commissioner's census data on pesticide permit holders as a first step in identifying clientele, and I have space on my meeting sign-up sheets to collect the ethnicity and gender of participants should they self-identify. I am in parity with regard to my programming and contacts, and believe I am demonstrating all reasonable efforts to encourage participation of under-represented clientele. I encourage all prospective clientele to sign up for our online Field Notes newsletter and the PNP magazine (both free). As CD, I provide suggestions to other academics, helping them make programmatic decisions in order to remain in parity, encouraging the participation of disadvantaged clientele.

The PNP is my affirmative action driver, reaching diverse clientele every month. Often a grower will show their field managers or farm workers, who are typically Hispanic, a copy of my PNP article, with nice pictures that illustrate disease symptoms or cultural control strategies for pests or diseases. I frequently receive calls to discuss these articles, and I'm often asked to explain in more detail the pictures, illustrations, or concepts I introduced. Sometimes these conversations are in Spanish and I use my office manager or field technician, who are both fluent, to help me with these conversations.

Every year growers call me out to their orchards where I find young trees dying from being planted improperly. Most of the time it is because the trees were planted too deep and over irrigated, often infected with *Phytophthora*, a plant pathogenic soilborne fungus. For most of my career I have tried to communicate proper tree planting techniques, and I realized that my growers were getting the message, but that their farm labor crews planting the trees, who typically only speak Spanish, were not. In early 2023, I asked ABC if they would fund a video that would demonstrate proper tree planting in English and Spanish, and they agreed. The English version is almost complete, and the Spanish will be translated in early 2024. I'm hoping that growers will have their labor crews watch the video before tree planting, and that more trees will be planted correctly. I believe the Spanish video will be my most successful outreach to a group that has been difficult to reach.

Closing summary

I have developed an exceptional program in administration, extending knowledge and information, applied research and creative activity, professional competence, university and public service, and affirmative action. I have become a respected leader in pomology and WOR throughout the SJV of CA, nationally, and internationally. My program has resulted in significant benefits to Californians and our environment by influencing the State, CARB, CDFA, SJVUAPCD, and NRCS to provide our growers with incentives to implement WOR, drastically reducing open field burning, bringing prestige to myself and UC ANR. The adoption of WOR has improved soil quality and health by increasing soil organic matter, fertility, and the water holding capacity of our soils. WOR has improved air quality by diverting woody biomass from being burned while increasing our soil's resilience to climate change by sequestering carbon and reducing greenhouse gases. WOR has reduced nitrogen leaching into our groundwater while making the growing of California's largest commodity more sustainable. WOR has improved the air and groundwater quality for diverse rural communities living in the SJV.

I would like to thank UC ANR for giving me the academic freedom to pursue a 30-year dream that I was able to watch grow into an industry wide practice with so many positive benefits to agriculture, our environment, and society. I am living my dream!

V. Supporting Documentation

A. Project(s) Summary: October 1, 2020-September 30, 2023

Primary Projects:

1. **Holtz, B. A.** (Principal Investigator), Culumber, M., Browne, G., Gao, S., Poret-Peterson, A., Gaudin, A., Westphal, A., Yaghmour, M., Gordon, P., Niederholzer, F., and Marvinney, E. 2019-2021. Almond Orchard Recycling. The Almond Board of California **($264,717)**. I was the recipient of these funds which were used for lab analysis, Kearney REC fees, and a field technician. Study is focused on the WOR trials I established at the Kearney REC: block 31 in 2008, block 74 in 2015, and block 92 in 2018.

2. **Holtz, B.A.** (Principal Investigator), 2021-2023. Efficacy trials of registered and developmental fungicides for the control of brown rot, shot-hole, and scab on almond. Syngenta, Nichino America Inc., and Corteva Agriscience **($55,250)**.

3. Culumber, M., **Holtz, B. A.** (Co-Principal Investigator), Gao, S., Brown, G., Gaudin, A., and Marvinney, E. 2018-2020. Influence of whole orchard recycling on greenhouse gas emissions and soil health in a newly established almond orchard. Collaborative funding from the California Department of Food and Agriculture (CDFA) with the California Air Resources Board (CARB) through the Healthy Soils Program (HSP) Demonstration Projects, with third year funding from the Almond Board of California **($417,950)**. Funding will be used primarily for greenhouse gas analysis in the Gao laboratory. I helped Dr. Culumber write the proposal and I established the research plots with the grower cooperator. We development of a website to be housed at UC SAREP.

4. Culumber, M., **Holtz, B. A.** (Co-Principal Investigator), Gao, S., Poret-Peterson, A., Browne, G., Gaudin, A., Zuber, C., Niederholzer, F., Yaghmour, M., and Gordon, P. 2023-2026. Optimizing nitrogen and water use efficiency in replanted orchards after whole orchard recycling. The Almond Board of California **($355,105)**, Holtz portion is $157,906.

5. Poret-Peterson, A., Culumber, M., **Holtz, B. A.** (Co-Principal Investigator), Gao, S. Browne, G. and Zuber, C. 2019-2022. Optimizing fertilization and irrigation recommendations in a newly planted almond orchard after recycling. California Department of Food and Agriculture (CDFA) 2019 Specialty Crop Block Grant Program (SCBGP) award **($439,570)**. The Holtz portion is $64,198. I established the research site in 2018 at the Kearney REC (block 92), helped with proposal development, and continue to supervise the research block and data collection.

6. Culumber, M., **Holtz, B. A.** (Co-Principal Investigator), Gao, S., Poret-Peterson, A., Brown, G., Zuber, C., Yaghmour, M., Niederholzer, F., and Gordon, P. 2020-2023. Regional orchard soil health and greenhouse gas emissions after whole orchard recycling. California Department of Food and Agriculture (CDFA) 2020 Specialty Crop Block Grant Program (SCBGP) award **($450,000)**. I established regional whole orchard recycling sites with grower cooperators from Arbuckle to Bakersfield before the proposal was written.

7. Hale, L., Gaudin, A., Marshall, K., Yaghmour, M., Culumber, M., Poret-Peterson, A., Kaiser, D., and **Holtz, B.A.** (Co-Principal Investigator). 2023-2025. Linking soil carbon building practices to almond nutritional quality. California Department of Food and

Agriculture (CDFA) Specialty Crop Block Grant Program (SCBGP) award **($460,939)**. I established the research site at Kearney REC (block 92) and supervise the block.

8. Poret-Peterson, A., Robles, D., Forbes, H., Culumber, M., **Holtz, B.A.** (Co-Principal Investigator), Gao, S., and Steenwerth, K. 2023-2024. Microbial nitrogen use efficiencies and their molecular controls in carbon sequestering soils, Environmental Molecular Sciences Laboratory (EMSL), Pacific Northwest National Laboratory, U.S. Gov (project # 60373, **$100,000**). I established the research site at the Kearney REC (blocks 31, 74, 92) and supervise the blocks.

9. Suduan Gao, Aileen Hendratna, Touyee Thao, Mae Culumber, Amisha PoretPeterson, Cameron Zuber, and **Brent Holtz**. 2021-2023. Influence of woodchip size and nitrogen fertilization on carbon dioxide and nitrous oxide emissions, USDAARS award **($300,000)**. I established the research site at the Kearney (block 92) and supervise the block.

For the current review period, 2021-2023, I brought in direct funding for my research and extension program totaling: **$477,873.** The team of researchers that I assembled to study whole orchard recycling was able to secure **$2,168,459** in funding during the review period as noted above.

Secondary Projects:

10. Browne, G., Ott, N., Khan, A., Poret-Peterson, A., Forbes, H., Sanchez, K., Gillis, M., Hodson, A., Yaghmour, M., **Holtz, B.**, Gordon, P., Niederholzer, F., Brar, G., Culumber, M., and Trouillas, F. 2021-2023. Improving non-fumigant-based approaches for management of almond replant problem. Almond Board of California (cooperator, helped establish trials and collect data, no direct funding).

11. Adaskaveg, J., Thompson, D., Forster, H., Haack, S., Cary, D., Duncan, R., **Holtz, B.**, Yaghmour, M., and Wade. L. 2021-2023. Biology and management of almond brown rot, jacket rot, shot hole, rust and hull rot. Almond Board of California (cooperator, helped establish trials, no direct funding).

12. Adaskaveg, J., Haack, S., Forster, H., Duncan, R., **Holtz, B.,** Doll, D., and Wade, L. 2021-2023. Biology and management of bacterial spot of almond in California. Almond Board of California (cooperator, helped establish trials, no direct funding).

13. Trouillas, F., Holland, L., Nouri, M., **Holtz, B.**, Niederholzer, F., Haviland, D., Yaghmour, M. 2021-2023. Trunk and scaffold canker diseases of Almond in California (cooperator, helped establish trials and collect data, no direct funding).

14. Trouillas, F., Maguvu, T., Frias, R., Hernandez-Rosas, A., **Holtz, B.**, Culumber, M., Niederholzer, F., Duncan, R., Yaghmour, M., Gordon, P., Rolshausen, P., Adaskaveg. 2021-2023. Improve the detection and risk prediction of *Pseudomonas syringae* causing bacterial blast and bacterial canker of almond in California. Almond Board of California (cooperator, helped establish trials, no direct funding).

15. Yaghmour, M., Michailides, T., **Holtz, B.**, Culumber, M., and Trouillas, F. 2021-2023. Investigation of *Aspergillus niger* causing hull rot, and conditions conducive to disease development in Kern County, Almond Board of California (cooperator, helped establish trials, no direct funding).

16. Lampinen, B., Upadhyaya, S., Udompetaikul, V., Slaughter, D., Shackel, K., Porris Gomes, I., Stewart, W., Metcalf, S., Browne, G., Doll, D., Duncan, R., Fichtner, E., Fulton, A., **Holtz, B**., Lightle, D., Niederholzer, F., Sanden, B. 2020-2021. Development and testing of a mobile platform for measuring canopy light interception, Almond Board of California (cooperator, helped establish trials, no direct funding).

17. Khalsa, S. D. S., Brown, P., Lepsch, H., Duncan, R., Rivers, D., **Holtz, B.,** and McGarvey, J. 2021-2023. Effect of partial fertilizer substitution with organic amendments on nutrient cycling, Almond Board of California (cooperator, helped establish trials, no direct funding).

18. Brown, P., Khalsa, S. D. S., Haviland, D.R., **Holtz, B.**, and Camargo, R. 2021-2023. Evaluation of potential pest pressure reduction for early off-ground harvest. Almond Board of California (cooperator, helped establish trials, no direct funding).

19. Zwieniecki, M. Delegado, P., Bailey, B., Culumber, M., **Holtz, B.**, McElrone, A., Bambach, N., Suvocarev, K., Wilson, H., Marino, G. 2021-2023. Cross-project approach to accelerate multidisciplinary research on the interaction of nonstructural carbohydrates (NSC) with biotic and abiotic stresses management practices in assessing NSC's dynamics impact on yield. Almond Board of California (cooperator, helped establish trials, no direct funding).

Administrative Budgets for UCCE in San Joaquin County:

Fiscal Year:

2009-2010	$332,784
2010-2011	$274,782
2011-2012	$256,266
2012-2013	$263,452
2013-2014	$266,964
2014-2015	$350,496
2015-2016	$355,247
2016-2017	$371,754
2017-2018	$390,728
2018-2019	$381,404
2019-2020	$817,579*
2020-2021	$846,913
2021-2022	$1,068,058
2022-2023	$921,860
2023-2024	$972,424
	$7,870,711

During the review period I negotiated 3 budgets (2021-2023) totaling **$2,962,342**.
As CD in SJC I have negotiated 15 fiscal budgets totaling $7,870,711.
* The significant budget increase is primarily due to salary and benefit adjustments, and a recalculation of San Joaquin County's Countywide cost allocation plan.

B. Professional Competence and Professional Activity

Professional Development and Training, listed chronologically: Oct 1, 2020 - Sept 30, 2023

1. 2020 Virtual Tree and Vine Expo, Malcolm Media Ag Expo, agespo.biz/ 2020-tree- vine-expo-schedule/, November 10, 2020.

2. 2021 ANR Academic Advancement, guidelines for preparing the thematic program review dossier for academics (e-book), December 4th, 2020.

3. The Almond Conference, The Almond Board of California, Virtual Conference, Sacramento, December 8th-10th, 2020.

4. 2020 UC Almond Workgroup Zoom Meeting, December 16th, 2020.

5. San Joaquin Valley Almond Day, a virtual event by zoom, January 14, 2021, http://ucanr.edu/2021sjvalmondday

6. California Plant and Soil Conference, CA Chapter of the American Society of Agronomy, Fresno, virtual conference, February 1-3, 2021, http://calasa.ucdavis.edu/

7. Public meeting to consider the San Joaquin Valley 2020 agricultural burning assessment, and the postponement of prohibition on open burning for certain crops and materials under Senate Bill 705 (Florez, 2003). California Air Resources Board (CARB), virtual meeting, February 25, 2021.

8. Pomology Educational Continuing Conference (PECC), Virtual, March 24th, 2021.

9. UC ANR pesticide policy update trainings, on-line, April 14th, 2021.

10. The nitty gritty of California Soils, sponsored by the California Farm Demonstration Network (CFDN), California Association of Resource Conservation Districts, https://carcd.org/rcds/conservation-resources/cfdn-soilseries-2021/, April 21, 2021.

11. Diversity consciousness: leading for greater equity and inclusion excellence, UCANR County Director Quarterly Training, Spring 2021, May 26, 2021.

12. Nickels Soil Laboratory Annual Field Day, Arbuckle, June 1, 2021.

13. Plant Pathology workgroup meeting, UC Virtual Pomology Specialist, June 10, 2021.

14. Hawaii Macadamia Nut Association, 53rd annual meeting, Nani Mau Gardens, Hilo, Hawaii, July 10, 2021.

15. County Directors Quarterly Training, virtual, September 15th, 2021.

16. Almond soil health, regenerative agriculture meeting, UC Davis, October 13th, 2021.

17. The four essential roles of Leadership, Franklin Covey, Co. the ultimate competitive advantage, training for San Joaquin County Department Heads, November 4, 2021.

18. UC pest management program team meeting, virtual, November 5th, 2021.

19. Tree and Vine Expo, Malcolm Media Ag Expo, Stanislaus County Fairgrounds, Turlock, November 9, 2021.

20. Grape, Nut and Tree Fruit Expo, Malcolm Media Ag Expo, The Big Fresno Fairgrounds, Fresno, November 12, 2021.

21. 2021 California Bioresources Alliance Symposium Program, Pathways for integrating our bioresources management, 16th annual symposium focusing on the use of bio resources in CA, and the best strategies for organic residues in CA. Sponsored by CA EPA, virtual event, November 19th, 2021.

22. UC Almond Workgroup Meeting, virtual, December 7, 2021.

23. 2022 ANR Academic Advancement, guidelines for preparing the thematic program review dossier for academics (e-book), January 13th and 18th, 2022.

24. 2022 UC ANR Ad Hoc Review Committee virtual training, Academic Assembly Council Personnel Committee, January 18th, 2022.

25. SJC Master Gardener monthly training meeting, Stockton, January 19, 2022.

26. Northern San Joaquin Valley Almond Day, Modesto Centre Plaza, February 8, 2022.

27. Black history month: critical race theory, February 9th, voting rights in history, February 23rd, affirmative action training, 2022.

28. Pomology Educational Continuing Conference (PECC), Davis, March 23-24, 2022.

29. Mealybug and virus outreach meeting, Lodi Woodbridge Winegrape Association, Stockton, April 7th, 2022.

30. UC ANR pesticide policy update trainings, on-line, May 3rd, 2022.

31. California Department of Food and Agriculture (CDFA) / Fertilizer Research and Extension Program (FREP) Tour, KREC, Parlier, October 25, 2022.

32. Orchard and Vineyard Field Day, UC ANR-Kearney Research and Extension Center, Parlier, November 16, 2022.

33. Mid-Winter Institute, California Community Colleges with Agricultural and Natural

Resources, Central Mother Lode Regional Consortium, SJC Ag Center, Stockton, December 2, 2022.

34. UC almond workgroup meeting, UC Davis, December 9, 2022.

35. 2023 North San Joaquin Valley Almond Day, Modesto Center Plaza, January 12, 2023.

36. 2023 UC ANR Ad Hoc Review Committee virtual training, Academic Assembly Council Personnel Committee, January 27th, 2023.

37. Association of Applied Insect Ecologists (AAIE) Nut Crop Round Table Agenda, Lodi, February 7, 2023.

38. UC Virtual Pomology Coffee Shop Talk, February 9, 2023.

39. Integrated Pest Management + Navel Orangeworm Summit, Almond Board of California, Modesto Junior College West Campus, February 21, 2023.

40. 51st Quad County Walnut Institute, SJC Ag Center, Stockton, February 28th, 2023.

41. Pomology Educational Continuing Conference (PECC), Davis, March 27-28, 2022.

42. Integrated Pest Management Breakfast, Modesto, March 15th, 2023.

43. Crop manage workshop and in-field training: using a pressure chamber for irrigation scheduling in trees and vines, UC ANR-Kearney REC, Parlier, April 19, 2023.

44. UC ANR Statewide Conference, Fresno, April 24-25, 2023.

45. VIII International Symposium on Almonds and Pistachios, International Society Horticultural Science (ISHS), Davis CA, May 7-11th, 2023.

46. Almond Replant Field Day, UC ANR-Kearney Research and Extension Center, Parlier, May 17th, 2023.

47. Soil health and sustainability field day: whole almond orchard recycling, 3978 Orchard Road, Gustine, May 18th, 2023.

48. Train the Trainer zoom workshop, Blue Diamond Growers leadership team, to help growers implement whole orchard recycling, funded by a USDA Climate Smart grant, May 22nd and 29th, 2023.

49. Asian American Pacific Islander (AAPI) Heritage Month, listened to a presentation from Hardeep Singh about the Punjabi region of Indian and their culture, May 30, 2023.

50. UC ANR pesticide policy update trainings, on-line, June 6th, 2023.

51. AlmondCo Australia Ltd, visiting California to learn about our almond industry, San Joaquin County Ag Center, Stockton, August 17, 2023.

52. Almond Rootstock Field Day, hosted by R. Duncan, Kearney REC, September 27, 2023.

Disciplinary Society or Professional Association

I maintain professional society memberships and participate with the:
American Phytopathological Society (APS)
American Society for Horticultural Science (ASHS)
International Society of Horticultural Science (ISHS)

I keep a Qualified Applicator Certificate (QAC) License with the CA Department of Pesticide Regulation by attending 20 hours of required training every two years.

Evidence of Professional Competence

Selected presentations that illustrate my Professional Competence: Oct 1, 2020 - Sept 30, 2023

1. "Whole orchard recycling," 2020 Virtual Tree and Vine Expo, Malcolm Media Ag Exp, agespo.biz/2020-tree-vine-expo-schedule/, November 10, 2020 (1,100 Attendees).

2. "Early nitrogen fertilization is important on first-year second generation almond trees following whole orchard recycling," California Plant and Soil Conference, CA Chapter of the American Society of Agronomy, virtual event, February 2, 2021 (205 attendees), http://calasa.ucdavis.edu/

3. "Whole orchard recycling in the San Joaquin Valley of California, and how small growers can survive without open field burning." Public meeting to consider the San Joaquin Valley 2020 agricultural burning assessment, and the postponement of prohibition on open burning for certain crops and materials under Senate Bill 705 (Florez, 2003). California Air Resources Board (CARB), virtual presentation, February 25, 2021 (450 attendees). Michael Benjamin, Division Chief, Air Quality Planning and Science Division, California Air Resources Board, said that my presentation and research program were influencing state policy!

4. "Whole orchard recycling and its effect on second generation tree growth, yield, and replant disease." The nitty gritty of California Soils, sponsored by the California Farm Demonstration Network (CFDN), California Association of Resource Conservation Districts, https://carcd.org/rcds/conservation-resources/cfdn-soilseries-2021/, virtual presentation, April 21, 2021 (90 attendees).

5. "Whole orchard recycling in the San Joaquin Valley of California and its potential for Macadamia Nuts." Keynote speaker for the Hawaii Macadamia Nut Association, 53rd annual meeting, Nani Mau Gardens, Hilo, Hawaii, July 10, 2021 (86 attendees).

6. "Whole orchard recycling to reduce organic residue while building soil organic matter, carbon, and fertility," 2021 California Bioresources Alliance Symposium Program, Pathways for integrating our bioresources management, 16th annual symposium focusing on the use of bio resources in CA, and the best strategies for organic residues in CA. Sponsored by CA EPA, virtual event, November 19th, 2021 (64 attendees).

7. "Whole almond orchard recycling and the effect on second generation tree growth, yield, and soil fertility," VIII International Symposium on Almonds and Pistachios, International

Society Horticultural Science (ISHS), keynote for tree nutrition and fertilization section, Davis CA, May 10, 2023 (170 attendees).

C. University Service
Items under review Oct 1, 2020-Sept 30, 2023

1. Staff Research Associate Search Committee, for orchard recycling projects in Fresno County, involving zoom interviews, November 9-12, 2020, Diana Camarena hired.

2. 2021-2023 UC Almond Workgroup activities, virtual and in-person.

3. 2021-2023 County Directors and Executive Working Group conference calls, typically the first Friday of the month, with two face-to-face meetings per year, typically in May and November.

4. UC IPM Program Advisory Committee Meeting 2021-2023.

5. Small Farms Farm Advisor Search Committee for San Joaquin, Stanislaus, and Merced Counties, ex-officio member, multiple conference calls, e-mails, in person meetings, and interviews in 2021, Dr. Anthony Fulford hired.

6. SJC Master Gardener monthly meeting and training, Stockton, January 19, 2022.

7. 2022 and 2023 chaired Ad Hoc Review Committees.

8. San Joaquin County Master Gardener training, Plant Pathology, SJC Ag Center, Stockton, April 12th and May 18th, 2022.

9. Office Assistant (OWII) search committee, SJC position working for UCCE, including position, re-evaluation, recruitment and interviews conducted in April and May, 2022, Joeviena Sans hired.

10. Viticulture Advisor San Joaquin County Search Committee, committee member and CD, multiple zoom committee calls, e-mails, and virtual interviews in 2022, Dr. Justin Tanner was hired in second round.

11. Hosted Professor Botir Dosov, Fulbright Visiting Scholar from Uzbekistan, CEO Executive Secretary, Central Asian and the Caucasus Association of Agricultural Research Institutions (CACAARI), with Jim Hill, Deans office UC Davis, and Mick Canevari, Advisor Emeritus, for agricultural tour in SJC, September 14, 2022.

12. Sustainable Orchard Systems Advisor Sutter Yuba Counties, I chaired the search committee, multiple zoom committee calls, e-mails, and virtual interviews in 2022, Clarissa Reyes was hired.

13. Office Assistant (OWII) search committee, SJC position working for UCCE, including position, re-evaluation, recruitment and interviews conducted in November, 2022, Saiha Sans hired.

14. Soils and Irrigation Advisor Search Committee for Stanislaus, San Joaquin, and Merced Counties ex-officio member, multiple zoom committee calls, e-mails, and virtual interviews and in person meeting in 2022, Dr. Abdelmoneim Z. Mohamed hired.

15. Agronomy and Weed Science Advisor Search Committee for Merced, Stanislaus, and San Joaquin Counties ex-officio member, multiple zoom committee calls, e-mails, and virtual interviews and in person meeting in 2022, Giuliano Carneiro Galdi hired.

16. Community Health and Nutrition Advisor San Joaquin, Stanislaus, and Merced Counties, ex-officio member of the search committee, multiple conference calls, e-mails, and zoom interviews, 2023 (1st round failed).

17. Office Assistant (OWII) search committee, SJC position working for UCCE, including position, re-evaluation, recruitment and interviews, June 13, 2023, Genara Salinas hired.

18. Administrative Assistant (AAI) or Office Manager (UC) search committee, SJC position working for UCCE, including position, re-evaluation, recruitment and interviews conducted in September / October 2023, Nicole Alferez hired.

D. Public Service
Items under review Oct 1, 2020-Sept 30, 2023

1. 2021-2023 San Joaquin County Department Heads Meetings, County Administration, typically meets every other month.

2. 2021-2023 San Joaquin County Agricultural Advisory Board Meetings, Robert J. Cabral Ag Center, Stockton, typically meets the first Monday of the month.

3. 2021-2023 San Joaquin Farm Bureau Federation, Board of Directors Meeting, Stockton, typically meeting the second Wednesday of every month.

4. 2021-2022 San Joaquin County Drought Advisory Task Force, SJC Ag Center, Stockton, typically meets monthly when the BOS declares a draught.

5. Budget negotiations for UC Cooperative Extension's 2021-2022 budget, Monica Nino, San Joaquin County's Chief Administrative Officer, April 9th, 2021.

6. 2021-2023 San Joaquin Farm Bureau Federation, Board of Directors Meeting, Stockton, typically meeting the second Wednesday of every month.

7. California Clean Biomass Collaborative, virtual meeting, with a goal of reducing agricultural burning in the San Joaquin Valley, September 8th, November 22nd, 2021.

8. California Clean Biomass Collaborative, virtual meeting, with a goal of reducing agricultural burning in the San Joaquin Valley, January 11th, March 16th, 2022.

9. Lodi Ag Venture Agricultural Presenter, 'Select San Joaquin' sponsored by SJC Board of

Supervisors and SJC Agricultural Commissioner, March 3, 2022.

10. Budget negotiations for UC Cooperative Extension's 2022-2023 budget, Jay Wilverding, SJC's Chief Administrative Officer (CAO) and Suzie Saiers, April 6th, 2022.

11. Manteca Ag Venture Agricultural Presenter, 'Select San Joaquin' sponsored by SJC Board of Supervisors and SJC Agricultural Commissioner, October 19, 2023.

12. Budget negotiations for UC Cooperative Extension's 2023-2024 budget, Jay Wilverding, SJC's Chief Administrative Officer (CAO) and Suzie Saiers, April 5th, 2023.

E. Extension Activities

Listed chronologically: Oct 1, 2020 - Sept 30, 2023

a. Meetings Organized

1. Northern San Joaquin Valley Almond Day, a virtual event by zoom, January 14, 2021 (200 attendees), http://ucanr.edu/2021sjvalmondday

2. Northern San Joaquin Valley Almond Day, Modesto Centre Plaza, 1150 9th Street, February 8, 2022 (200 attendees).

3. Delta Rootstock Tour and Discussion, Contra Costa and San Joaquin Counties, February 11, 2022 (10 attendees).

4. Orchard and Vineyard Field Day, UC ANR-Kearney Research and Extension Center, Parlier, November 16, 2022 (30 attendees).

5. Northern San Joaquin Valley Almond Day, Modesto Centre Plaza, 1150 9th Street, January 12, 2023 (300 attendees).

6. Crop manage workshop and in-field training: using a pressure chamber for irrigation scheduling in trees and vines, UC ANR-Kearney Research and Extension Center, Parlier, April 19th, 2023 (30 attendees).

7. Almond Replant Field Day, UC ANR-Kearney Research and Extension Center, Parlier, May 17th, 2023 (55 attendees).

8. Soil health and sustainability field day whole almond orchard recycling, 3978 Orchard Road, Gustine, May 18th, 2023 (81 attendees).

9. Management of X-Disease in stone fruit, San Joaquin County Ag Center (I was the building host), Stockton, July 27, 2023 (20 attendees).

10. Field Visit: Nematode Management in Walnut, Dr. Westphal, Escalon, CA August 17, 2023 (55 attendees).

b. Educational Presentations

1. "Early nitrogen fertilization is important on first-year second generation almond trees following whole orchard recycling," Almond Board of California video filming with Fowler Brothers Orchard Removal, Escalon, October 21, 2020 (8 attendees).

2. "Nitrogen considerations in replanted orchards following whole orchard recycling," San Joaquin Valley Almond Day, a virtual event by zoom, January 14, 2021 (200 attendees), http://ucanr.edu/2021sjvalmondday

3. "Early nitrogen fertilization is important on first-year second generation almond trees following whole orchard recycling," a virtual presentation recorded by Amy Siliznoff and Mark Hutson, Madera and Fresno Counties Resource Conservation Districts, May 21, 2021 (2 attendees).

4. "Whole orchard recycling (WOR): fertilization recommendations for first and second year second generation almond trees." Nickels Soil Laboratory Annual Field Day, Arbuckle, June 1, 2021 (88 attendees).

5. "Senator Laird has lobbied for a $31 million increase in UC ANR's budget to support the hire of over 100 farm advisors to boost our agricultural footprint." San Joaquin County Agricultural Advisory Board Meeting, Stockton, August 2, 2021 (20 attendees).

6. "$31 million was approved in the state budget to boost UC ANR's shrinking footprint-- the Viticulture Advisor position serving San Joaquin County is still our top priority." San Joaquin Farm Bureau Board of Directors Mtg, Stockton, September 8, 2021 (55 attendees).

7. "UC ANR approved a Northern San Joaquin Valley Viticulture Advisor position to be headquartered in San Joaquin County, covering southern Sacramento and Stanislaus Counties." San Joaquin County Agricultural Advisory Board Meeting, November 1, 2021 (16 attendees).

8. "Bloom diseases of almond and control strategies reduce fungicide resistance," Tree and Vine Expo, Malcolm Media Ag Expo, Stanislaus County Fairgrounds, Turlock, November 9, 2021 (454 attendees).

9. "UC ANR approved a Northern San Joaquin Valley Viticulture Advisor position to be headquartered in San Joaquin County, covering southern Sacramento and Stanislaus Counties." San Joaquin Farm Bureau Board of Directors Mtg, Stockton, November 10th, 2021 (50 attendees).

10. "Nitrogen recommendations in almond following whole orchard recycling," Grape, Nut and Tree Fruit Expo, Malcolm Media Ag Expo, The Big Fresno Fairgrounds, Fresno, November 12, 2021 (55 attendees).

11. "Whole orchard recycling to reduce organic residue while building soil organic matter, carbon, and fertility," 2021 California Bioresources Alliance Symposium Program, Pathways for integrating our bioresources management, 16th annual symposium focusing on the use of bio resources in CA, and the best strategies for organic residues in CA.

Sponsored by CA EPA, virtual event, November 19th, 2021 (64 attendees).

12. "Nitrogen recommendations in almond following whole orchard recycling," UC Almond Workgroup Meeting, virtual, December 7, 2021 (35 attendees).

13. "Growing almonds in the San Joaquin Valley of California," Stockton Ag Venture Agricultural Presenter, 'Select San Joaquin' sponsored by SJC Board of Supervisors and SJC Agricultural Commissioner, January 19, 2022 (450 3rd grade students).

14. "The benefits of whole orchard recycling on second generation almond trees, and how a wood chip mulch could benefit plants in the urban landscape," SJC Master Gardener monthly meeting, Stockton, January 19, 2022 (50 attendees).

15. "Nitrogen recommendations in almond following whole orchard recycling," Northern San Joaquin Valley Almond Day, Modesto Centre Plaza, February 8, 2022 (200 attendees).

16. "Growing almonds in the San Joaquin Valley of California," Lodi Ag Venture Agricultural Presenter, 'Select San Joaquin' sponsored by SJC Board of Supervisors and SJC Agricultural Commissioner, March 3, 2022 (450 3rd grade students).

17. "Fruit tree diseases in the home garden," San Joaquin County Master Gardener training, Plant Pathology, SJC Ag Center, Stockton, April 12, 2022 (45 attendees).

18. "Growing and grafting Mexican avocado varieties in the Northern San Joaquin Valley of California," Master Gardener meeting, Stockton, May 18, 2022 (60 attendees).

19. "UC ANR approves 60 new positions statewide with Senator Laird funding," San Joaquin County Agricultural Advisory Board Meeting, Stockton, June 6, 2022 (15 attendees).

20. "Nitrogen efficiency in young almond orchards after whole orchard recycling," California Department of Food and Agriculture (CDFA)/ Fertilizer Research and Extension Program (FREP) Tour, KREC, Parlier, October 25, 2022 (40 attendees).

21. "Nitrogen and other nutrients management for non-bearing and bearing almond trees with and without whole orchard recycling," Orchard and Vineyard Field Day, UC ANR-Kearney Research and Extension Center, Parlier, November 16, 2022 (30 attendees).

22. "Integrating whole orchard recycling with fumigation and anerobic soil disinfestation to mitigate replant pathogens," Orchard and Vineyard Field Day, UC ANR-Kearney Research and Extension Center, Parlier, November 16, 2022 (30 attendees).

23. "Whole orchard recycling is sustainable agricultural practice being incorporated in the San Joaquin Valley of California," Mid-Winter Institute, California Community Colleges with Agricultural and Natural Resources, Central Mother Lode Regional Consortium, SJC Ag Center, Stockton, December 2, 2022 (50 attendees).

24. "Incompatibility between the Independence scion and the Krymsk rootstock and their influence on bacterial canker disease," UC almond workgroup meeting, UC Davis, December 9, 2022 (30 attendees).

25. "Dr. Justin Tanner has started as our new regional viticulture advisor serving southern Sacramento, San Joaquin, and Stanislaus Counties," San Joaquin Farm Bureau Board of Directors Meeting, Stockton, January 11, 2023 (40 attendees).

26. "Controlling fungal and bacterial bloom diseases of almond," 2023 North San Joaquin Valley Almond Day, Modesto Center Plaza, January 12, 2023 (300 attendees).

27. "Krymsk rootstock incompatibility with the Independence almond scion and enhanced susceptibility to bacterial canker," Association of Applied Insect Ecologists (AAIE) Nut Crop Round Table Agenda, Lodi, February 7, 2023 (55 attendees).

28. "Growing and grafting Mexican avocado varieties in the Northern San Joaquin Valley of California," UC Virtual Pomology Coffee Shop Talk, February 9, 2023 (7 attendees).

29. "Hull Rot, back to basics: deficit irrigation and nitrogen management," Integrated Pest Management + Navel Orangeworm Summit, Almond Board of California, Modesto Junior College West Campus, February 21, 2023 (125 attendees).

30. "Dr. Justin Tanner has started as our new regional viticulture advisor serving southern Sacramento, San Joaquin, and Stanislaus Counties," San Joaquin County Agricultural Advisory Board Meeting, Stockton, March 6, 2023 (15 attendees).

31. "The basics of whole orchard recycling," Almond Replant Field Day, UC ANR-Kearney Research and Extension Center, Parlier, May 17th, 2023, (55 attendees).

32. "Nitrogen management in newly planted almond orchards," Almond Replant Field Day, UC ANR-Kearney Research and Extension Center, Parlier, May 17th, 2023, (55 attendees).

33. "Orchard recycling and the effect on tree growth, yield, and fertility," Soil health and sustainability field day: whole almond orchard recycling, 3978 Orchard Road, Gustine, May 18th, 2023 (81 attendees).

34. "Nitrogen management in newly planted almond orchards," Train the Trainer zoom workshop, Blue Diamond Growers leadership team, to help growers implement whole orchard recycling, funded by a USDA Climate Smart grant, May 22, 2023 (21 attendees).

35. "Almond nutrient management after whole orchard recycling," Train the Trainer zoom workshop, Blue Diamond Growers leadership team, implementing whole orchard recycling, funded by a USDA Climate Smart grant, June 29, 2023 (16 attendees).

36. "Woodchip size and distribution after whole orchard recycling," Train the Trainer zoom workshop, Blue Diamond Growers leadership team, implementing whole orchard recycling, funded by a USDA Climate Smart grant, June 29, 2023 (16 attendees).

37. "Whole Orchard recycling and the effect on second generation tree growth, yield, and carbon sequestration," AlmondCo Australia Ltd, visiting California to learn about our almond industry, San Joaquin County Ag Center, Stockton, August 17, 2023 (5 attendees).

F. Publications (Bibliography for Brent A. Holtz)

Items are listed chronologically and identified by E-book categories

E-book categories	Period under review	Prior to review	Career Total
A. Popular press, newsletters	47	351	398
B. Peer-review in scholarly journals	6	42	48
C. Peer-review other, IPM or ANR	2	40	42
D. Technical reports	29	251	280
E. Abstracts, posters	13	46	59
Totals for all categories (A-E)	97	730	827

Peer Reviewed: Oct 1, 2020 - Sept 30, 2023

1. **(B)** Poret-Peterson, Amisha T., Jahanzad, Emad, Gaudin, Amelie C.M., Culumber, C. Mae, Gao, Suduan, **Holtz, Brent A**. 2021. Whole orchard recycling as a practice to build soil organic carbon in the San Joaquin Valley, California, USA. In Food and Agriculture Organization of the United Nations (FAO) and Intergovernmental Technical Panel on Soils (ITPS) (Eds.) Recarbonizing global soils: A technical manual of best management practices, Volume 4. Cropland, Grassland, Integrated systems and farming approaches – Case-studies. Food and Agriculture Organization of the United Nations, Rome, Italy, pages 515-546, ISBN:978-92-5-134897-0, https://doi.org/10.4060/cb6598en

2. **(B)** Smith, Evie E., Brown, Patrick H., Andrews, Ellie M., Shackel, Kenneth A., **Holtz, Brent A.**, Rivers, Daniel J., Haviland, David R., S. Khalsa, Sat Darshan. 2021. Early almond harvest as a strategy for sustainable irrigation, pest and disease management. Scientia Horticulturae Volume 293 5 February 2022, 110651, ELSEVIER, https://doi.org/10.1016/j.scienta.2021.110651

3. **(B)** Khalsa, S.D.S., Rivers, D.J., **Holtz, B.A.**, Brown, P.H. 2022. Effects of organic matter amendments on soil nutrient availability and tree nutrient status in California almond, Proc. IX International Symposium on Mineral Nutrition of Fruit Crops. ISHS 2022, Eds.: A. Dag et al., DOI 10.17660, Acta Horticulturae 1333.7: 51-57.

4. **(B)** Jahanzad, E., Brewer, K.M., Poret-Peterson, A.T., Culumber, C.M., **Holtz, B.A**., Gaudin, A.C.M. 2022. Effects of Whole Orchard Recycling on Nitrate Leaching Potential in Almond Production Systems. Journal of Environmental Quality, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, https://doi.org/10.1002/jeq2.20385

5. **(C)** Haviland DR, Symmes EJ, Adaskaveg JE, Duncan RA, Roncoroni JA, Gubler WD, Hanson B, Hembree KJ, **Holtz BA**, Stapleton JJ, Tollerup KE, Trouillas FP, Zalom FG. 2022 (most recent revision). UC IPM Pest Management Guidelines: Almond. UC ANR Publication 3431. Oakland, CA, http://ipm.ucanr.edu/PMG/pmgchanges.html

6. **(C)** Coyne, K.2023. Thinking big about recycling: for the growing practice of orchard recycling, the story just keeps getting better. CSA News published by Wiley Periodicals inc. on behalf of American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, ISSN 1529-9163, eISSN 2325-3584, 27 February 2023, https://doi.org/10.1002/csan.20966

7. **(B)** Mohamed T. Nouri, Sampson Li, Renaud Travadon, **Brent A. Holtz**, and Florent P. Trouillas. 2023. First Report of *Cytospora azerbaijanica* Causing Cytospora Canker and Shoot Dieback on Peach (Prunus persica) in California, U.S.A., Plant Disease, First Look, May 2023, American Phytopathological Society, ISSN: 0191-2917, e-ISSN: 1943-7692, https://apsjournals.apsnet.org/toc/pdis/0/ja

8. **(B)** Phoebe E. Gordon, Natalia J. Ott, Raman K. Brar, and **Brent A. Holtz**, and Greg T. Browne. 2023. Phosphorus fertilization can improve young almond tree growth in multiple replant settings. HortTechnology (accepted for publication 09-28-2023).

The publications below will be published after September 30th, 2023, and are not under review, but considerable time was spent developing them during the review period, and since I'm hopeful this will be my last merit attempt, I have included them to demonstrate continued scholarship, teamwork, and mentorship.

(B) Suduan Gao, Aileen Hendratna, Touyee Thao, Mae Culumber, Amisha PoretPeterson, Cameron Zuber, and **Brent Holtz**. 2024. Influence of woodchip size and nitrogen fertilization on carbon dioxide and nitrous oxide emissions. Soil Science Society of America Journal (submitted 9-25-2023).

(B) Maguvu, T., Frias, R., Hernandez-Rosas, A., **Holtz, B.**, Culumber, M., Niederholzer, F., Duncan, R., Yaghmour, M., Gordon, P., Rolshausen, P., Adaskaveg, J., Trouillas, F. 2024. Comprehensive phylogenomic and comparative genomic analysis of *Pseudomonas syringae* associated with almonds in California. Acta Horticulturae (accepted 10-23-2023).

(B) Holtz, B., Culumber, M., Zuber, C., Browne, G., Doll, D., Jahanzad, E., Yaghmour, M., Niederholzer, F., Gordon, P., Poret-Peterson, A., Gao, S., Gaudin, A. 2023. Whole almond orchard recycling and the effect on second generation tree growth, yield, and soil fertility. Acta Horticulturae (submitted 10-26-2023).

(B) Thao, T., Culumber, C.M., Poret-Peterson, A.T., Zuber, C.A., **Holtz, B.A.**, Gao, S. 2024. Evaluating the seasonal effects of whole orchard recycling on water movement and nitrogen retention for a newly established almond orchard: simulation using HYDRUS-1D. Soil Science Society of America Journal (submitted 11-16-2023).

(B) Maguvu, T., Frias, R., Hernandez-Rosas, A.I., **Holtz, B.**, Niederholzer, F.A., Duncan, R.A., Yaghmour, M.A., Culumber, C.M., Gordon, P.E., Rolshausen, P.E., Adaskaveg, J.E., Trouillas, F.P. 2024. Phylogenomic and comparative genomics of *Pseudomonas syringae* associated with almond (*Prunus dulcis*) in California. PLOS ONE (submitted 11-23-2023).

(B) Culumber, M., Gao, S., Poret-Peterson, A., **Holtz, B**. 2024. Influence of Whole Orchard Recycling on Greenhouse Gas Emissions and Soil Health in a Newly Established Almond Orchard. Agriculture, Ecosystems & Environment Journal (in-preparation).

(B) Hana You, Paul Martinez, Mae Culumber, **Brent Holtz**, and Astrid Volder. 2024 Wood chip incorporation increases root length density of almond trees. Agriculture, Ecosystem and Environment Journal (in-preparation, PhD dissertation).

(B) Holtz, Brent A., Browne, Greg T., Doll, David., Culumber, C. Mae, Zuber, Cameron A., Jahanzad, Emad, Poret-Peterson, Amisha T., Gao, Suduan, Gaudin, and Amelie C.M. 2024. Whole orchard recycling is a sustainable alternative to burning that increases soil carbon, organic matter, tree growth and orchard productivity. California Agriculture (in-preparation).

(B) Cameron Zuber, Mae Culumber, **Brent Holtz**, David Doll, Amisha Poret-Peterson, David Robles, Taniya RoyChowdhury, Suduan Gao, Diana Camarena-Onofre, and Safeeq Khan. 2024. Response of selected soil physical and hydrological properties to soil applied and incorporated wood biomass in almond orchards. Vadose Zone Journal (in-preparation, PhD dissertation).

(B) Cameron Zuber, Mae Culumber, **Brent Holtz**, Phoebe Gordon, Franz Niederholzer, and Safeeq Khan. 2024. Evaluation of saturated hydraulic conductivity estimations from pedotransfer functions and in-situ measurements of soil properties for incorporated wood biomass in almond orchards. Soil and Water Research (in-preparation, PhD dissertation).

(B) Cameron Zuber, Mae Culumber, **Brent Holtz**, Amisha Poret-Peterson, David Robles, Taniya RoyChowdhury, Suduan Gao, Diana Camarena-Onofre, Ramandeep Kaur Brar, Benjamin Halleck, and Safeeq Khan. 2024. Comparison of crop water use efficiency of conventional almond management versus implementing whole orchard recycling. Agricultural Water Management (in-preparation, PhD dissertation).

(B) Cameron Zuber, Mae Culumber, **Brent Holtz**, Suduan Gao, Aileen Hendratna, Lauren Hale, and Safeeq Khan. 2024. Influence of whole orchard recycling on micrometeorology and evapotranspiration in almond production systems. Soil Use and Management (in-preparation, PhD dissertation).

(B) Huang, J., Maung, Z.T.Z., **Holtz, B.**, Gaudin, A., and Westphal, A. 2024 Influence of almond production practices on soil suppressiveness against plant-parasitic nematodes. MDPI Microorganisms (ISSN 2076-2607) (in-preparation, PhD dissertation).

(B) David Robles, Holly Forbes, Suduan Gao, Mae Culumber, **Brent Holtz**, Kerri Steenwerth, and Amisha Poret-Peterson. 2024. Soil microbiome shifts associated with organic amendment by whole orchard recycling. Frontiers in Microbiology (in-preparation, PhD dissertation).

Non-Peer Reviewed Publications Oct 1, 2017 - Sept 30, 2020:

9. **(A) Holtz, B.A.**, 2020. Pacific Nut Producer's October Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 26, number 10, pages 16-23, Alternaria Leaf Spot, band canker diagnosis, post-harvest irrigation and crop evapotranspiration (ET), replant disease, fumigation and anaerobic soil disinfestation, water penetration, www.pacific nutproducer.com.

10. **(A) Holtz, B.A.**, 2020. Pacific Nut Producer's November Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 26, number 11, pages 16-22, zinc deficiency symptoms and treatment, iron induced chlorosis, crop evapotranspiration (ET), UC IPM website, soil fumigation, gopher control, www.pacific nutproducer.com.

11. **(A) Holtz, B.A.**, Holtz, B., Culumber, M., Zuber, C., Browne, G., Yaghmour, M., Gao, S., Poret-Peterson, A., and Gordon, P. 2020. Early nitrogen fertilization is important on first-year second generation almond trees following whole orchard recycling. West Coast Nut, November Issue, pages 20-26: http://www.wcngg.com/2020/11/23/whole-orchard-recycling-in-almond/

12. **(A) Holtz, B.A.**, 2020. Second generation almond tree nitrogen needs following whole orchard recycling. San Joaquin County Field Notes, a quarterly publication of University of California Cooperative Extension, November, http://cesanjoaquin.ucdavis.edu.

13. **(A) Holtz, B.A.**, and Canevari, M. 2020. Pacific Nut Producer's December Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 26, number 12, pages 22-32, dormant weed control while preventing weed resistance, potassium nutrition, mummy removal, www.pacific nutproducer.com.

14. **(D) Holtz, B.**, Culumber, M., Browne, G., Gao, S., Poret-Petersen, A., Zuber, C., Gaudin, A., Jahanzad, E., Yaghmour, M., Niederholzer, F., and Gordon, P. 2020. Almond Orchard Recycling. Almond Board of California Research Update, page 17.

15. **(D)** Khalsa, S. D. S., Brown, P., Lepsch, H., Duncan, R., Rivers, D., **Holtz, B.,** and McGarvey, J. 2020. Effect of partial fertilizer substitution with organic matter amendments on nutrient cycling. Almond Board of California Research Update, page 18.

16. **(D)** Lampinen, B., Upadhyaya, S., Shackel, K., Pourreza, A., Bailey, B., Gradziel, T., Metcalf, S., Browne, G., Culumber, M., Doll, D., Duncan, R., Fichtner, E., Fulton, A., Gordon, P., **Holtz, B**., Lightle, D., Milliron, L., Niederholzer, F., Sanden, B. 2020. Development and testing of a mobile platform for measuring canopy light interception. Almond Board of California, Research Update, page 25.

17. **(D)** Brown, P., Khalsa, S. D. S., Smith, E., Shackel, K., and **Holtz, B.** 2020. Evaluation of potential pest pressure reduction for early off-ground harvest. Almond Board of California Research Update, page 51.

18. **(D)** Browne, G., Ott, N., Khan, A., Poret-Peterson, A., Sanchez, K., Gillis, M., Adaskaveg, J., Forster, H., Hodson, A., Yaghmour, M., **Holtz, B.**, Gordon, P., Culumber, M., Niederholzer, F., and Trouillas, F. 2020. Non-fumigant approaches and diagnostics for orchard replacement and soilborne disease management. Almond Board of California, Research Update, page 10.

19. **(D)** Adaskaveg, J., Thompson, D., Forster, H., Cary, D., Duncan, R., **Holtz, B.**, Yaghmour, M., and Wade. L. 2020. Biology and management of almond brown rot, jacket rot, shot hole, rust and hull rot. Almond Board of California, Research Update, page 54.

20. **(D)** Adaskaveg, J., Forster, H., Duncan, R., **Holtz, B.**, and Wade, L. 2020. Biology and management of bacterial spot of almond in California. Almond Board of California, Research Update, page 55.

21. **(D)** Trouillas, F., Holland, L., Nouri, M., **Holtz, B.**, Niederholzer, F., Haviland, D., Yaghmour, M. 2020. Management of trunk and scaffold canker diseases of Almond in California, Almond Board of California Research Update, page 57.

22. **(D)** Yaghmour, M., Michailides, T., **Holtz, B.**, Culumber, M., and Trouillas, F. 2020. Investigation of *Aspergillus niger* causing hull rot, and conditions conducive to disease development in Kern County. Research Update Almond Board of California, page 60.

23. **(D)** Culumber, M., Gao, S., **Holtz, B.,** Browne, G., Gaudin, A., Marvinney, E., Poret-Petersen, A., Jahanzad, E., Zuber, C., Toledo, L., Rivers, D. 2020. Influence of whole orchard recycling on greenhouse gas emissions and soil health in a newly established almond orchard. Almond Board of California Research Update, page 70.

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26. **(E) Holtz, B.,** Culumber, M., Zuber, C., Browne, G., Gao, S, and Poret-Peterson, A. 2021. Early nitrogen fertilization is important on first-year second generation almond trees following whole orchard recycling. California Plant and Soil Conference, American Society of Agronomy, California Chapter, Plant and Soil Conference, February 1-3, http://calasa.ucdavis.edu/Conference_Proceedings/

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33. **(A) Holtz, B.A.**, 2021. Pacific Nut Producer's August Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 27, number 8, pages 10-14, over irrigation and Verticillium Wilt, crop evapotranspiration (ET), spidermite, Navel Orangeworm and ant management, boron deficiency, nut drying, www.pacific nutproducer.com.

34. **(A) Holtz, B.A.**, 2021. Nitrogen fertility in common beans following whole orchard recycling. San Joaquin County Field Notes, a quarterly publication of University of California Cooperative Extension, August, http://cesanjoaquin.ucdavis.edu.

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36. **(A) Holtz, B.A.**, 2021. Pacific Nut Producer's October Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 27, number 10, pages 8-13, Band Canker diagnosis and management, post-harvest irrigation and crop evapotranspiration (ET), replant disease, fumigation and anaerobic soil disinfestation, water penetration, www.pacific nutproducer.com.

37. **(A) Holtz, B.A.**, 2021. Pacific Nut Producer's November Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 27, number 11, pages 14-22, potassium and zinc deficiency symptoms and treatment, iron induced chlorosis, crop evapotranspiration (ET), soil fumigation, gopher control, www.pacific nutproducer.com.

38. **(A) Holtz, B.A.**, and Canevari, M. 2021. Pacific Nut Producer's December Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 27, number 12, pages 10-18, pre-emergent weed control while preventing weed resistance, new herbicides, potassium nutrition, mummy removal, www.pacific nutproducer.com.

39. **(D)** Almond Board of California and **Holtz, B**. 2021 Whole Orchard Recycling Can Increase Yields Over Time. https://www.almonds.com/almond-industry/industry-news/whole-orchard-recycling-can-increase-yields-over-time

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42. **(D)** Brown, P., Khalsa, S. D. S., Smith, E., Shackel, K., and **Holtz, B.** 2021. Evaluation of potential pest pressure reduction for early off-ground harvest. Almond Board of California Research Update, page 40.

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44. **(D)** Adaskaveg, J., Thompson, D., Forster, H., Cary, D., Duncan, R., **Holtz, B.**, and Yaghmour, M. 2021. Biology and management of almond brown rot, jacket rot, shot hole, rust and hull rot. Almond Board of California, Research Update, page 42.

45. **(D)** Yaghmour, M., Michailides, T., **Holtz, B.**, Culumber, M., and Trouillas, F. 2021. Investigation of *Aspergillus niger* causing hull rot, and conditions conducive to disease development in Kern County. Research Update Almond Board of California, page 45.

46. **(D)** Lampinen, B., Upadhyaya, S., Shackel, K., Pourreza, A., Bailey, B., Gradziel, T., Metcalf, S., Browne, G., Culumber, M., Duncan, R., Fichtner, E., Fulton, A., Gordon, P., **Holtz, B**., Milliron, L., Niederholzer, F. 2021. Development and testing of a mobile platform for measuring canopy light interception. Almond Board of California, Research Update, page 54.

47. **(D)** Culumber, M., Gao, S., Poret-Petersen, A., **Holtz, B.** 2021. Influence of whole orchard recycling on greenhouse gas emissions and soil health in a newly established almond orchard. Almond Board of California Research Update, page 57.

48. **(D)** Culumber, M., Gao, S., Poret-Peterson, A., **Holtz, B.** 2021. Influence of whole orchard recycling on GHG emissions and soil health in a newly established almond orchard. Final report to CDFA Healthy Soils Program, Sacramento, CA. Grant Agreement No. 17-0614-000-HS. 30 p.

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58. **(A) Holtz, B.A.**, 2022. Crop evapotranspiration, nitrogen best management practices, nitrogen after whole orchard recycling, hull rot management, In Your Orchard, Time to Consider, Blue Diamond Growers, Almond Facts, pages 48-52, May-June, www.AlmondFacts.com, www.BlueDiamond.com.

59. **(A) Holtz, B.A.**, 2022. Pacific Nut Producer's July Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 28, number 7, pages 10-16, crop evapotranspiration (ET), deficit irrigation can reduce hull rot, Navel Orange worm, ant and mite management, leaf analysis and nutrient management, www.pacific nutproducer.com.

60. **(A) Holtz, B.A.**, 2022. Pacific Nut Producer's August Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 28, number 8, pages 12-16, Phytophthora root rot and sucker damage, crop evapotranspiration (ET), spidermite, Navel Orangeworm and ant management, boron deficiency, nut drying, www.pacific nutproducer.com.

61. **(A) Holtz, B.A.**, 2022. Pacific Nut Producer's September Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 28, number 9, pages 12-17, Almond Leaf Scorch and salt burn, post-harvest irrigation, crop evapotranspiration (ET), Navel Orange and worm safely stockpiling nuts, pruning, www.pacific nutproducer.com.

62. **(A) Holtz, B.A.**, 2022. Pacific Nut Producer's October Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 28, number 10, pages 14-18, Alternaria Leaf Spot, post-harvest irrigation and crop evapotranspiration (ET), replant disease, fumigation, water penetration, www.pacific nutproducer.com.

63. **(A) Holtz, B.A.**, 2022. Pacific Nut Producer's November Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 28, number 11, pages 16-22, zinc deficiency symptoms and treatment, iron induced chlorosis, crop evapotranspiration (ET), replant disease and soil fumigation, gopher control, www.pacific nutproducer.com.

64. **(A) Holtz, B.A.**, and Canevari, M. 2022. Pacific Nut Producer's December Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 28, number 12, pages 14-24, pre-emergent weed control while preventing weed resistance, new herbicides, potassium nutrition, mummy removal, www.pacific nutproducer.com.

65. **(D)** Culumber, M., Gao, S., Poret-Petersen, A., **Holtz, B.** 2022. Influence of whole orchard recycling on greenhouse gas emissions and soil health in a newly established almond orchard. Almond Board of California Research Update, page 13.

66. **(D) Holtz, B.**, Culumber, M., Browne, G., Gao, S., Poret-Petersen, A., Robles, D., Zuber, C., Gaudin, A., Jahanzad, E., Yaghmour, M., Niederholzer, F., and Gordon, P. 2022. Almond Orchard Recycling. Almond Board of California Research Update, page 17.

67. **(D)** Browne, G., Ott, N., Khan, A., Gordon, P., **Holtz, B.**, Poret-Peterson, A. 2022. Improving non-fumigant-based approaches for management of almond replant problem. Almond Board of California, Research Update, page 30.

68. **(D)** Yaghmour, M., Michailides, T., **Holtz, B.**, Culumber, M., and Trouillas, F. 2022. Investigation of *Aspergillus niger* causing hull rot, and conditions conducive to disease development in Kern County. Research Update Almond Board of California, page 33.

69. **(D)** Trouillas, F., Maguvu, T., Frias, R., Hernandez-Rosas, A., **Holtz, B.**, Culumber, M., Niederholzer, F., Duncan, R., Yaghmour, M., Gordon, P., Rolshausen, P., Adaskaveg. 2022. Improve the detection and risk prediction of *Pseudomonas syringae* causing bacterial blast and bacterial canker of almond in California. Research Update Almond Board of California, page 35.

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72. **(D)** Lampinen, B., Upadhyaya, S., Shackel, K., Pourreza, A., Bailey, B., Gradziel, T., Metcalf, S., Browne, G., Culumber, M., Duncan, R., Fichtner, E., Fulton, A., Gordon, P., **Holtz, B**., Milliron, L., Niederholzer, F. 2022. Utilizing canopy light interception-yield potential data to improve management of almond. Almond Board of California, Research Update, page 47.

73. **(D)** Zwieniecki, M. Delegado, P., Bailey, B., Culumber, M., **Holtz, B.**, McElrone, A., Bambach, N., Suvocarev, K., Wilson, H., Marino, G. 2022. Cross-project approach to accelerate multidisciplinary research on the interaction of nonstructural carbohydrates (NSC) with biotic and abiotic stresses management practices in assessing NSC's dynamics impact on yield. Almond Board of California, Research Update, page 61.

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75. **(A) Holtz, B.A.**, 2023. Pacific Nut Producer's January Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 29, number 1, pages 12-20, plant trees high, first season dormant short, intermediate, long, and minimal pruning, fungal cankers, honey bee best management practices, weeds, www.pacific nutproducer.com.

76. **(A) Holtz, B.A.**, 2023. Pacific Nut Producer's February Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 29, number 2, pages 18-26, Phytopthora root and crown rot, bee management, bloom disease control (brown rot, shot hole, scab, Alternaria) and fungicide efficacy, bacterial spot control, www.pacific nutproducer.com.

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81. **(A) Holtz, B.A.**, 2023. Pacific Nut Producer's June Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 29, number 6, pages 12-20, crop evapotranspiration (ET), sprayer calibration, IPM mite management, deficit irrigation and hull rot, Navel Orangeworm, and ground squirrel management, www.pacific nutproducer.com.

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85. **(A) Holtz, B.A.**, 2023. Pacific Nut Producer's September Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 29, number 9, pages 8-12, Pacific flatheaded borer damage and sunburn, post-harvest irrigation, crop evapotranspiration (ET), NOW, safely stockpiling nuts, pruning, www.pacific nutproducer.com.

86. **(E)** Robles, D., Zuber, C., **Holtz, B.**, Gao, S., Culumber, M., Steenwerth, K., and Poret-Peterson, A. 2023. Responses of soil microbes to whole orchard recycling: microbial community composition and nitrogen cycling. Third Global Soil Biodiversity Conference, Dublin, Ireland, March 13-15, 2023.

87. **(E)** M. A. Yaghmour, M.A, Michailides, T. J., **Holtz, B.A.**, and Trouillas, F.P. 2023 Effect of Almond fruit developmental stages and leaf nitrogen content on Hull Rot caused by *Aspergillus niger*. ISHS abstract, https://www.ishs.org/symposium/581

88. **(E)** Maguvu, T., Frias, R., Hernandez-Rosa, A., **Holtz, B.**, Culumber, M., Niederholzer, F., Duncan, R., Yaghmour, M., Gordon, P., Rolshausen, P., Adaskaveg, J., Trouillias, F. 2023. Comprehensive Phylogenomic and Comparative Genomic Analysis of *Pseudomonas syringae* associated with almonds In California. ISHS abstract. https://www.ishs.org/symposium/581

89. **(E) Holtz, B.**, Culumber, M., Zuber, C., Browne, G., Doll, D., Jahanzad, E., Yaghmour, M., Niederholzer, F., Gordon, P., Poret-Peterson, A., Gao, S., Gaudin, A. 2023. Whole almond orchard recycling and the effect on second generation tree growth, yield, and soil fertility, VIII International Symposium on Almonds and Pistahios, pp 65-66, ISHS, https://www.ishs.org/symposium/581

90. **(E)** Culumber, M., **Holtz, B.**, Zuber, C., Yaghmour, M., Niederholzer, F., Poret-Peterson, A., Gao, S. 2023. Influence of Whole Orchard Recycling on soil nutrient cycling dynamics and productivity in replanted almond orchards. VIII International Symposium on Almonds and Pistahios, pp 66-67, ISHS, https://www.ishs.org/symposium/581

91. **(E)** You, H., Culumber, M., Samaddar, S., Scow, K., Laca, E., Volder, A. 2023. Does incorporating wood chips affect the microbiome of soil and almond root rhizosphere equally? VIII International Symposium on Almonds and Pistahios, pgs 67-68, ISHS, https://www.ishs.org/symposium/581

92. **E)** Maguvu, T., Frias, R., Hernandez-Rosa, A., **Holtz, B.**, Culumber, M., Niederholzer, F., Duncan, R., Yaghmour, M., Gordon, P., Rolshausen, P., Adaskaveg, J., Trouillias, F. 2023. Comprehensive phylogenomic and comparative genomic analysis of *Pseudomonas syringae* associated with almond in California" Florent, American Phytopathological Society, Pacific Division Meeting, Tucson, AZ, www.apsnet.org

93. **(E)** Robles, D., **Holtz, B.**, Gao, S., Culumber, M., Steenwerth, K., and Poret-Peterson, A. 2023. Organic matter accumulation in biomass-amended agricultural soils. Enhancing a Molecular Understanding of Soil Biogeochemistry from Local to Continental Scales, The Ecological Society of America, www.esa.org.

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Subject: FW: HortTechnology 05143RRR accepted for publication in HortTechnology
Date: Thursday, September 28, 2023 at 2:44:47 PM Pacific Daylight Time
From: Browne, Gregory - REE-ARS
To: Phoebe E Gordon, Brent Allen Holtz, Jaime Ott, Ramandeep Brar

Here you go. Accepted, though "due numerous deviations from "ASHS/HortTechnology format", much editing will be required"

Greg

From: horttech@msubmit.net <horttech@msubmit.net>
Sent: Thursday, September 28, 2023 2:27 PM
To: Browne, Gregory - REE-ARS <gregory.browne@usda.gov>
Cc: gtbrowne@ucdavis.edu
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28 Sep 2023

Dear Dr. Browne:

The review of your revised manuscript "Phosphorus fertilization can improve young almond tree growth in multiple replant settings" has been completed. I am pleased to inform you that this manuscript has been accepted for publication in HortTechnology.

When your paper nears publication, you will be sent page proofs in PDF format via email attachment. The purpose of the proofs is to allow authors to check for possible errors. Please look for an email message from "ashrproofs.djs@sheridan.com" with your manuscript number and eProof in the subject line.

Please check the page proofs CAREFULLY. Due to numerous deviations from ASHS/HortTechnology format, much editing will be required.

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Sincerely,

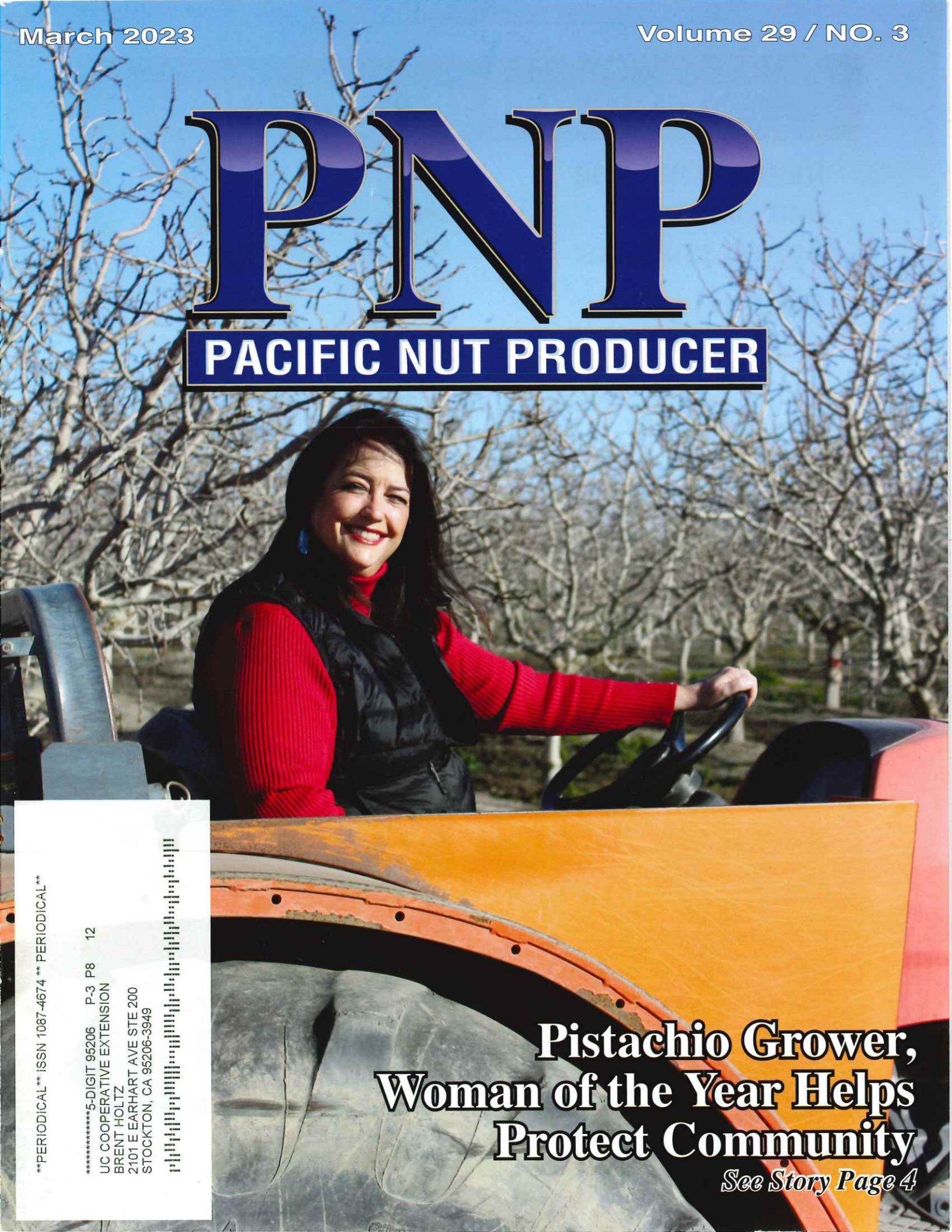
Neal De Vos

Neal E. De Vos, PhD
Editor-in-Chief

March 2023 Volume 29 / NO. 3

PNP

PACIFIC NUT PRODUCER



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UC COOPERATIVE EXTENSION
BRENT HOLTZ
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Pistachio Grower, Woman of the Year Helps Protect Community

See Story Page 4

About the Cover: Fifth generation Central Valley diversified farmer Lorna Roush adds pistachios to her family portfolio of almonds and wine grapes.. *See story page 4.*

Photo by Matthew Malcolm.

PNP

March 2023

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PACIFIC NUT PRODUCER

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Almond Tasks

By Brent Holtz, Ph.D.

As I write this article, our almond trees are just starting to bloom, and it looks like the next few days will be rain free but cold. Hopefully we will have some good pollination days and weather ahead. In 2020 I observed a number of almond orchards where fruit buds never pushed and appeared to die while the trees were dormant, other buds pushed but blossoms and growing shoot tips soon blighted with bacterial blast like symptoms (**see Picture 1**), followed by blighted leaves (**see Picture 2**), with a couple of trees in sandy soils showing full bacterial canker symptoms (**see Picture 3**), that I worried would not survive. The Independence variety appears susceptible. Bacterial canker, blossom, and bud blast are all caused by the plant pathogenic bacteria Pseudomondas syringae pv. syringae that is usually found living on the surface of healthy plants. Pseudomondas syringae lives most of the time as an 'omnipresent epiphyte,' always present on the surface of plants, living happily, just waiting for certain environmental conditions (cold and wet) that allow it to enter the plant, multiply, and build to high enough populations within the tree to trigger a disease (bacterial blast or canker).

Relatively little is known about blossom bacterial blast, but we do know that cold wet weather can be an important predisposing factor that can worsen the disease. Like last year, we received a Section 18 Emergency Exemption for Kasumin 2L (the antibiotic Kasugamycin) to be used on almond trees to control bacterial blast from February through petal fall. Kasumin 2L should be sprayed before a frost event, if possible, to enhance efficacy. The registration allows up to two applications under anticipated cold or freezing conditions on almond at a use rate of 64 fluid ounces per acre.

Frost can occur in late March and

Picture 1: Blossom and shoot tip blast of almond

Picture 2: Leaf blast symptoms on almond

Picture 3: Almond tree infected with bacterial canker

d Tasks For March

even early April, so keep vegetation mowed and avoid working the soil from bloom through the end of March. The UC Almond Production Manual has a chart that displays temperatures at which cold induced damage can occur for different varieties. It can freeze through early April, despite global warming, so be prepared. As almond flowers bloom small nuts begin to form that are more susceptible to frost damage. The amount of damage is dependent on the lowest temperatures received and the duration of the freeze. In the small nut stage, Nonpareil can have 25 % loss with 29 ˚F for 30 minutes, 50 % loss with 28 ˚F for 30 minutes, and 100 % loss with 27 ˚F or less for 30 minutes. In 2009 a March 10th frost caught many growers by surprise. Orchards that had water running or had been recently irrigated appeared to have less frost damage than others nearby that were not irrigated. A one-degree variation in temperature can mean the difference between slight damage and a major loss. Freezing

Brent Holtz PhD., is a Farm Advisor and County Director of UC Cooperative Extension, San Joaquin County.

temperatures followed by warm weather can cause more damage than a frost followed by cold weather as trees can acclimate to the cold. See

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Orchard Tasks

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Chapter 23 in our Almond Production Manual, available in our county offices and at http://anrcatalog.ucdavis.edu.

Even though we need the water, problems can occur if it rains immediately after bloom. Almond trees are susceptible to foliar fungal diseases if conditions are wet and warm a few weeks after bloom. The decision of when to spray and what fungicides to use can be difficult. Diseases like Scab and Anthracnose are often controlled with fungicide sprays 2 – 5 weeks after petal fall. If your orchard has a history of these diseases, they can be quite difficult to control. Disease causing fungi are usually present in almond orchards before bloom in various inoculum levels depending on the previous year's disease severity and environmental conditions. Generally, a good disease control program is based upon a wise choice of fungicides and good timing and coverage. Growers should assess the diseases present in their orchards and select materials carefully to avoid the development of resistance. Not all fungicides are equally effective on all diseases. It is a good idea to use more than one kind of fungicide for a broader spectrum of activity. Please read the almond section of the "Fungicide efficacy and timing for deciduous tree fruit and nut crops and grapevines" that can be found at http://www.ipm.ucdavis.edu.

Scab (Cladosporium carpophilum or Fusicladium carpophilum) was effectively controlled with the strobilurin fungicides (Abound, Gem, Pristine) for years, but resistance to these fungicides is developing and we now recommend using other mode of action fungicides. Dr. Adaskaveg has developed a three-spray strategy for scab control that includes a delayed dormant application of copper or chlorothalonil and oil, a two-week after petal fall spray that includes chlorothalonil (Echo, Bravo, Equus), and a 5-week after petal fall spray that includes Captan (FRAC M4), Ziram (FRAC M3), or pre-mixtures of DMI (FRAC 3), SDHI (FRAC 7), or QoI (FRAC 11) fungicides. I annually performed a scab trial where fungicides other than strobilurins are studied for their efficacy against scab. Microthiol Disperse (micronized wettable sulfur), at 20 pounds per acre, has consistently been one of the best organic products studied—I would recommend using it in a rotation program or for Scab and Rust control.

A pressure chamber is especially useful in early spring to determine tree water status and when irrigation should begin. Dr. Bruce Lampinen, UC Davis, has written a nice article 'Using Midday Stem Water Potential to Refine Irrigation Scheduling in Almond' found at the Fruit and Nut Research and Information Center http://fruitsandnuts. ucdavis.edu/. Crop evapotranspiration (ETc) is the sum of transpiration from leaves and evaporation from soil and is referred to as the crop water requirement, or orchard water requirement. In Dr. David Goldhamer's irrigation scheduling chapter, in our Almond Production Manual, ETc from March 16–31 is 1.8 inches (18.4 gallons/tree/day). The amount of water stored in the soil depends on rainfall intensity, duration, and soil water holding capacity, but generally it is between 50 – 70 % of total winter rainfall. There is obviously much more stored water in our soil this year that should be accounted for. I suspect that many growers will need to perform their first irrigation of the season a month or more earlier this spring because it has been so dry.

Peach Twig Borer (PTB) pheromone traps should be placed in orchards, one per 20 acres by March 20 in the southern San Joaquin Valley (SJV) and by April 1st in the Sacramento and northern SJV. Hang traps 6 to 7 feet high in the northern quadrant of the tree, 1 to 3 feet from the outer canopy. Monitor twice a week; replace pheromone caps at the interval recommended by the manufacturer and trap bottoms after 100 moths have been counted and removed. If shoot strike monitoring indicates treatment is necessary, use trap catches and degree days to time a

May spray. Optimum timing for first generation larvae (the May spray) is between 400 and 500 degree-days after the first male is trapped in April when using spinosad (Entrust, Success), spinetoram (Delegate), or the organophosphates. When using insect growth regulators (IGRs) like Intrepid, make the application at 300-400 degree-days. Accumulate degree-days for peach twig borer using a lower threshold of 50 °F and an upper threshold of 88 °F. See calculating degree days at http://www.ipm.ucdavis.edu looking under almond and then peach twig borer.

Weeds have a tremendous capacity to spread within your orchard. The first line of defense is identifying the weeds you need to control and selecting the best herbicides or cultural practices to control those weeds. If you use the same herbicide(s) each year, some tolerant weed species may dominate the orchard floor. Weed control issues and management tools are a constantly moving target. Weed species shift as orchards age, new species appear, and herbicide resistant species have in some case become more prevalent. Herbicide options can vary significantly among crops and from year-to-year as new herbicides are registered or old materials lose registration. Fortunately, Dr. Brad Hanson, UC Extension Weed Specialist at UC Davis, has created an excellent online resource for identifying and controlling weeds that is available at the University of California Weed Research and Information Center website. This site will help growers and PCAs make informed weed control decisions. The UC IPM website has charts that show which weeds are controlled by what herbicides, and an excellent weed photo gallery that includes many weed species commonly found in California for easy identification and reference. The Pacific Northwest Weed Management Handbook is now available online at: http://pnwpest.org/pnw/weeds. The handbook lists all the registered herbicides that can be used in orchards along with recommended rates and application tips. There is a table that rates the efficacy of different herbicides against specific weed species.

Gophers are actively burrowing and feeding. Make sure the mounds are active by leveling them and revisiting to see if mounds are repaired. Poison bait and trapping can be used successfully for smaller populations. For severe infestations, the burrow builder can help manage populations that are high throughout the orchard. Ground squirrels usually start emerging in late February or early March. When one notices a few adult squirrels actively emerging

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Orchard Tasks

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and feeding, pellets and/or gas cartridges can be used for fumigating the burrows. Remember to follow the label directions carefully. Baits will not be effective until squirrels stop feeding on green vegetation and start feeding on weed seeds in a few months, especially when vegetation starts drying in late spring. For more information on ground squirrel management, visit this website: http://groups.ucanr.org/gsbmp.

Good Luck and Stay Warm!!

Gophers are actively burrowing and feeding. Determine whether their mounds are active, level and revisit them to see if mounds are repaired.

Hazelnut Tasks

By Marcelo L Moretti

Consider Adding a Spring Preemergence Herbicide: Over the last few years,

Figure 1. May 2022. The weedy plot in this experimental site did not receive a fall preemergence herbicide application; spring post-emergence treatments did not control the large weeds.

we have noticed an increase in annual bluegrass, and Italian ryegrass in fields treated the previous fall with preemergence herbicides. These are not isolated cases suggestive of a missed application, poor coverage, or other management error. Some have questioned whether fall-applied preemergence herbicides would be necessary or whether weed control should focus on early spring.

We spent three years evaluating the performance of fall-applied herbicides and the benefit of adding a spring-applied preemergence herbicide application. We focused on orchards infested at various densities with annual bluegrass and Italian ryegrass. Regardless of the research site, fall-applied preemergence herbicides improved weed control compared to postemergence-only or spring-applied preemergence herbicides only. Most fall-applied preemergence herbicides provided complete weed control for the first three to four months. As a result, we were dealing with fewer and smaller weeds when spring began. Conversely, weeds grew vigorously when only a foliar-active (post-emergence) herbicide was used, making control in the spring very difficult (**Figure 1**). Fall-applied preemergence herbicides are very effective in hazelnut orchards.

A well-chosen spring preemergence herbicide application

MARCH 2023

CROP SCIENCE, SOIL SCIENCE, AGRONOMY

csa news

Thinking Big About Recycling

For the Growing Practice of Orchard Recycling, the Story Just Keeps Getting Better

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Science

Cover: California almond growers, who replace their orchards once every few decades, used to have two options for disposing of aging trees: After uprooting them, they could either burn them on site, or grind them and sell the biomass to cogeneration plants. As new environmental policies take hold in the state, those options are being phased out. Filling the gap is the more environmentally friendly practice of whole-orchard recycling, which though costlier in the short term, offers considerable long-term agronomic benefits. Scientists hope their deepening understanding of these advantages will convince more farmers to make the switch. See story on p. 12. Cover photo shows Brent Holtz, a farm adviser with the University of California's Agriculture and Natural Resources division, standing atop a pile of wood chips ground up from almond trees. The chips will be incorporated into the soil before a new orchard is planted. Photo courtesy of Brent Holtz.

News & Perspectives

Career & Education

Thinking Big About Recycling

For the Growing Practice of Orchard Recycling, the Story Just Keeps Getting Better

By Kristen Coyne

California almond growers, who replace their orchards once every few decades, used to have two options for disposing of aging trees: After uprooting them, they could either burn them on site, or grind them and sell the biomass to cogeneration plants. As new environmental policies take hold in the state, those options are being phased out. Filling the gap is the more environmentally friendly practice of whole-orchard recycling, which though costlier in the short term, offers considerable long-term agronomic benefits. Scientists hope their deepening understanding of these advantages will convince more farmers to make the switch.

Researcher Emad Jahanzad takes soil samples at a recycled almond orchard at the University of California's Agriculture and Natural Resources division. Photo courtesy of Emad Jahanzad.

We all know recycling is a good thing, and most of us try to do our part. This time of year, with Global Recycling Day (18 March) and Earth Day (22 April) upon us, we may be especially careful to toss used cans, papers, and bottles in the proper bins. But in California, the birthplace of many a green innovation, almond growers are taking the practice to an entirely different level: Recycling entire orchards.

Almond trees don't produce forever. After 20 to 25 years, as yields drop off, growers in the state's 7,600 almond farms know it's time for a reboot. In the past, this typically meant one of two things: burning the trees and then spreading the ash back on the land; or grinding them and selling the chips to cogeneration plants.

While many of the state's 1.6 million acres of almonds are still managed that way, an alternative has gained traction over the past decade: Grind up aging trees on site and then incorporate the chips right back into the soil. Studies have shown that whole-orchard recycling (WOR) provides enough long-term benefits for the soil and trees to make the once-in-a-generation investment well worth it.

"There's no practice that puts that much organic matter into the soil at any one time," says Josette Lewis, chief scientific officer for the Almond Board of California (ABC). "No amount of composting does that in such a short period of time. It really has, as we've seen through the research, this really dramatic impact on soil quality."

The more they study WOR, scientists say, the more pros for soil and trees they are discovering. But in addition to this enticing carrot, a powerful stick is prodding farmers toward recycling: state regulations aimed at improving air quality and promoting renewable energy. These powerful factors are driving a veritable WOR revolution: According to ABC estimates, almost half of the orchards removed in the past two years have been recycled. But, as we'll explore in this story, many other factors are contributing to this shift, as well, including market pressures for sustainable farming, vocal industry support, financial incentives, compelling research, and the persistence of the inspired innovator who got the WOR ball rolling.

Opposite page: Brent Holtz, a farm adviser with the University of California's Agriculture and Natural Resources division, has been a pioneer in whole-orchard recycling research. Here he stands atop a pile of wood chips ground up from almond trees. The chips will be incorporated into the soil before a new orchard is planted. Photo courtesy of Brent Holtz.

A Small Idea Gets Bigger … and Bigger

In the late 1940s, a nurseryman named Leonard James acquired 70 acres in California's Stanislaus

DOI: 10.1002/csan.20966

Whole Orchard Recycling

Photo by Emad Jahanzad.

Uproot

Uprooted trees await the grinder in an orchard that is being recycled.

Photo by the Almond Board of California.

Grind

Trees from an outgoing orchard are fed to a grinder. The chips will be incorporated into the soil before the next generation of trees is planted.

Photo by the Almond Board of California.

Spread

Chips from recycled trees are spread on the soil surface.

County and began farming almonds. Over the years, the nearby city of Modesto sprawled ever closer to his orchards, eventually enveloping them. At the same time, concerns over air pollution grew in that booming part of the northern San Joaquin Valley, situated within 100 miles of San Francisco, Sacramento, San Jose, and Fresno. By the late 1990s, it became clear that the days of burning old trees to make way for new were numbered.

So, James's family bought a small woodchipper and began chipping rather than burning prunings and then spread the mulch below their trees. Brent Holtz, James's grandson and a doctoral student in plant pathology at the University of California–Berkeley, observed how well the trees thrived and soil texture improved.

By the turn of the century, Holtz, by then a farm adviser with the University of California's Agriculture and Natural Resources division (UCANR), decided to go a step further. If recycled branches could benefit the trees, what about recycling an entire orchard? To test this idea, he ran his own experiment at the farm, planting 10 young trees in barrels filled with soil amended with the quantity of woodchips that, he estimated, would be generated by grinding a whole orchard and spreading it out on the land. As the saplings grew, he compared them to a second set of trees planted in unamended soils.

Over the years, he observed that the trees with woodchips not only stayed healthy, but also grew and produced more than the control trees. Underground, water infiltration, soil organic matter (SOM), and soil organic carbon all improved—encouraging news given the drought-prone climate and area soils naturally low in carbon and SOM. Holtz was eager to ramp up to a large-scale orchard trial.

In 2008, an experimental orchard finally became available at UCANR's Kearney Agricultural Research and Extension Center. But there was a big problem: Where would Holtz get a machine powerful enough to grind up all those existing trees? As luck would have it, a massive rock crusher was spotted doing work near the Kearney Center one day, and Holtz pounced. If it could grind up rocks and roads, he figured, it could grind up whole trees. He arranged to rent the "Iron Wolf" the following day (paying the $4,000 fee out of his own pocket), designed a replicated experiment that night, and unleashed the 100,000-pound monster the next morning.

"I can't say I woke up one day and wanted to do a whole-orchard recycling trial," recalls Holtz, now UCANR's county director in San Joaquin County. "But I saw the benefit of chipping up prunings, and then the goals and the dreams just kept getting bigger and bigger."

The Iron Wolf sucked in whole trees through its 6-inch titanium teeth and spat them back out in pieces, creating mountains of mulch. (The rock crusher turned out to be a bit overkill: Today excavators, working with horizontal grinders and front-end loaders, recycle orchards much faster.) About 30 tons of chips per acre were incorporated into the soil, and then new almond trees were planted exactly where their predecessors had stood. Holtz began gathering data.

In 2015, Holtz met Amélie Gaudin, an associate professor in the Department of Plant Sciences at the University of California–Davis, who signed on to the project, found funding, and brought in a postdoc, Emad Jahanzad. The researchers compiled data and compared the trees' performance over a decade to nearby treatment plots where trees had been pushed and burned.

In results published in 2020, the team reported that WOR resulted in a slew of benefits. The soil in the recycled orchard had better SOM, soil carbon, water retention, and soil aggregation. The trees displayed less water stress and—of key importance to growers—better yields. "Over a 10-year period, there's almost 2,000 kernel pounds more in the grind treatment than the burn," Holtz says. "At $2 or $3 a pound, that started to be an incentive alone for growers."

But was it incentive enough for growers to overlook the $1,000-per-acre cost—much pricier than conventional orchard replacement? Not really. Although growers first heard about WOR's agronomic benefits when Holtz wrote about it in *Pacific Nut Producer* in 2015, few farmers were willing to try. However, other forces were conspiring to steer producers toward the practice until it seemed just a matter of time before all of the state's 140 million trees—80% of world production—would end up right back in the ground they came from, by way of a grinder's jaw.

Environmental Pressures and Industry Support

As a new way to replace orchards gained a foothold, the two existing methods seemed destined for extinction.

Almond orchard panorama. Photo by Flickr.com/Marc.

In efforts to control pollution, California's local air districts were issuing fewer burn permits to farmers. The San Joaquin Valley Air Pollution Control District, grappling with some of the nation's worst air quality, is slated to phase out ag burning completely in 2025. And the state's decision to move toward 100% carbon-free electricity by 2045 sounded the death knell for cogeneration plants, which stopped buying woodchips from farmers.

It was about that time that a very important player entered the picture, Holtz notes: the state's Almond Board.

"That's when the Almond Board and industry really got interested because the industry needed an alternative," Holtz says. "They couldn't burn in the field, and they couldn't burn in the cogeneration plant."

A key tipping point, it seems, had been reached. The Almond Board of California began funding WOR research and spreading the word about its benefits. The practice became a linchpin of its sustainability plan, which includes a goal to achieve zero waste by 2025. Lewis says that between solving the woodchip problem, more water retention, and other agronomic perks, WOR is the industry's future.

"There aren't that many practices that have such multiplier effects in terms of benefits sets," she says.

One huge such effect is carbon sequestration. The practice, according to the Almond Board, could sequester an estimated 2.4 tons of carbon per acre. In addition to being a potential source of farmer income through the carbon market, WOR tells a compelling stewardship narrative that increasingly resonates with food producers and consumers. With the right product, sustainability sells.

"There are companies that are trying to incentivize and encourage growers to use whole-orchard recycling—food companies or almond processor companies that sell into the marketplace—in part because of that powerful storytelling," Lewis explains.

Consumers are more likely to respond to a narrative about the delicious drupes than one about anonymous legumes. "It's not like corn or soybeans, which are often fed to animals or highly processed into a food product," Lewis points out. "An almond is something that people really recognize directly."

While heart-warming tales about almonds may not motivate growers to switch to WOR, another time-honored strategy is proving effective: money. Several agencies are helping with costs for producers, including the San Joaquin Valley Air District, the California Department of Food and Agriculture's (CDFA) Healthy Soils Program, and USDA-NRCS. While many farmers remain reticent, others are converting. In the San Joaquin Valley alone, more than 500 growers have recycled 26,000-plus acres, according to the Almond Board. Businesses have sprouted up to respond to growers' demand for large-scale grinding. Walnuts and other orchard crops have begun adopting the practice, and last year, a trial launched in Australia, the world's second largest almond producer.

Gaudin credits Holtz for much of this success, thanks to his passion, teamwork skills, and connection with growers. "Brent has been a true visionary for researching and developing WOR practices at scale," she says, recalling the team's struggle to find funding early in the project. "He was 10 years ahead of his time, and it took a lot of perseverance and courage to move forward."

For many farmers, the clock is ticking: Those slated to replant their orchards soon may not get another chance to try WOR since turnover happens only once a generation. "If you get the opportunity to time it just

right, you'll reap those benefits for many years to come," Lewis says.

Still, there's one big problem with dumping tons of carbon into the soil at one fell swoop: Nitrogen immobilization. The most recent publication coming out of the WOR research team tackles it head on.

Managing Nitrogen in Recycled Orchards

A healthy soil is a well-balanced soil. You want enough carbon and nitrogen to make both crops and soil microbes happy. Typically, that means a C to N ratio of no more than 20:1 to 24:1, explains Jahanzad, who went on to be a senior environmental scientist with CDFA. But WOR throws that balance way out of whack.

"When you return 40, 50, 60, 70 tons of carbon per acre to the soil, it's a lot of carbon," Jahanzad says. "When you add that much carbon to the soil, there is a risk to immobilize nitrogen temporarily."

As Jahanzad explains, the sudden carbon deluge—the C:N ratio catapults to 140:1—is a windfall for soil microbes, whose populations surge. The ensuing microbial multitudes quickly deplete the initial N influx, leaving little for the N-hungry almond saplings. Unaddressed, the imbalance can lead to stunted trees.

That would appear a significant strike against WOR. However, ongoing research led by Holtz and UCANR colleague Mae Culumber shows those deficits last just one year and can be managed. Although the researchers initially recommended that growers increase nitrogen fertilization from 3 oz per tree to 5 that first year, they now believe early fertilization and better root zone placement may mitigate the need for additional nitrogen, Holtz says. By Year 2, the cycle appears to catch up with itself with enough microbes dying to release sufficient N back to the soil to replenish N supplies for saplings.

"A major part of biologically active nitrogen comes from the microbial biomass," explains Jahanzad, a co-author on these findings. "When they start decomposing organic matter in the soil, they release that nitrogen available to the plants." The research, which informed new guidelines for WOR-practicing growers, are slated to be published later this year.

And what about nitrogen and water quality? The researchers tackled that, too.

Over the decades, due in part to inefficient fertilization and irrigation, nitrates have leached into California's groundwater, raising health concerns. The WOR researchers reasoned that recycling would mitigate leaching.

"Since nitrate is mobile in the soil, wherever water goes, it takes nitrates with it," Jahanzad explains. "If the water can be retained in the root zone, that means that nitrate can be retained the root zone too, meaning that it's not going to be lost through leaching."

The team designed a column study to test their ideas. They compared soil gathered from a 10-year-old orchard managed by burning to a WOR orchard of the same vintage. They did the same with a pair of one-year-old recycled orchards.

To distinguish the fate of N applied in fertilizer from that of N already in the soil, they isotopically labeled it. After spreading the fertilizer and irrigating, they measured parameters related to nitrogen release, including microbial biomass, nitrogen, total nitrogen, and nitrate in the leachate.

In the one-year-old orchards, they found little difference in the leaching while, as expected, microbes immobilized part of the N from the fertilizer. But samples from the 10-year-old WOC-managed orchard told a different story: As the

Growing almonds in California's Central Valley, in Stanislaus County, California. Photo by Flickr.com/Eric Sonstroem.

team recently reported in the *Journal of Environmental Quality* (https://doi.org/10.1002/jeq2.20385), leaching was 52% lower in the recycled treatment than in the burn-managed orchard, and immobilization was no longer an issue.

"That's an enormous difference," Lewis says. That retention power is especially important given state mandates that farmers report nitrogen application and uptake and that they lower nitrogen use. "To help meet another regulatory requirement here in the state," Lewis adds, "that will be of significant value."

The Long-Term Dividends of Recycling

Holtz is still working to demonstrate WOR's value. He continues to monitor the trees in his at-home barrel trial and reports that SOM and soil carbon remain significantly greater 20 years later.

The escalating effects of climate change will only multiply WOR's benefits. Water retention will be even more valuable as temperatures rise and droughts worsen: Jahanzad says farmers who practice WOR tell him they need to irrigate much less.

Holtz is excited about the team's latest trial at the Kearney Center where they are fertilizing trees with three different N rates: the recommended rate, 20% less than that rate, and 40% less. "We have two preliminary harvests, and right now we haven't seen any difference between our low treatment, our medium, and high treatment," Holtz reports. "So, we hope to show that with whole-orchard recycling we can use less nitrogen in the long term."

Holtz is also experimenting with adding even *more* chips on WOR orchards. "I think our soils can handle more organic matter than we're giving it once every 30 years in this process," he says. "I'm hoping that this annual application of woodchips will be like growing a cover crop, helping with infiltration and fertility." He's also looking forward to *re*-recycling the orchard the team recycled at Kearney back in 2008, which would be the first time an orchard has been recycled twice.

That's the kind of bold, creative, and positive thinking agronomy needs these days, Gaudin says. "Disruptive and innovative ideas like this have to be celebrated," she says, "and Brent's efforts with this practice in particular will have a lasting impact on California agriculture and our ability to meet our sustainability and resilience goals."

DIG DEEPER

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TECHNICAL REPORT

Groundwater Quality

Effects of whole-orchard recycling on nitrate leaching potential in almond production systems

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Abstract

Inefficient nitrogen (N) fertilization and irrigation have led to unhealthy nitrate levels in groundwater bodies of agricultural areas in California. Simultaneously, high commodity prices and drought have encouraged perennial crop growers to turnover less-productive orchards, providing opportunities to recycle tree biomass in situ and to use high-carbon (C) residues to conserve soil and water resources. Although climate change adaptation and mitigation benefits of high-C soil amendments have been shown, uncertainties remain regarding the benefits and trade-offs of this practice for N cycling and retention. We used established almond [*Prunus dulcis* (Mill.) D. A. Webb] orchard trials on Hanford fine sandy loam with short-term and long-term biomass recycling legacies to better understand the changes in N dynamics and retention capacity associated with this practice. In a soil column experiment, labeled N fertilizer was added and traced into various N pools, including microbial biomass and inorganic fractions in soil and leachate. Shifts in microbial communities were characterized using the abundance of key N cycling functional genes regulating nitrification and denitrification processes. Our findings showed that, in the short term, biomass recycling led to N immobilization within the orchard biomass incorporation depth zone (0–15 cm) without impacts on N leaching potential. However, this practice drastically reduced nitrate leaching potential by 52%, 10 yr after biomass incorporation without an increase in N immobilization. Although the timing of these potential benefits as a function of microbial population and C and N biogeochemical cycles still needs to be clarified, our results highlight the potential of this practice to meaningfully mitigate nitrate discharges into groundwater while conserving soil resources.

Abbreviations: GNI, gross nitrogen immobilization; GNM, gross nitrogen mineralization; MBN, microbial biomass nitrogen; NRI, net rate of immobilization; SOC, soil organic carbon; UC, University of California.

1 | INTRODUCTION

Nitrate is one of the most widespread contaminants of groundwater within agricultural regions and therefore represents a threat to the quality and safety of drinking water (Bastani & Harter, 2019; van Grinsven et al., 2015). Intensive input-based agriculture and long-term use of synthetic N fertilizers and manures are the dominant non-point sources of N-based pollutants, primarily through nitrate leaching (Burow et al., 2008; Harter et al., 2017; Kourakos et al., 2012). This is exemplified in California, where inefficient irrigation and nutrient management practices of irrigated specialty crop production systems have turned one of the most productive agricultural regions in the world into a hotspot for nitrate contamination and poor water quality (Harter et al., 2021; Lockhart et al., 2013). This contamination is especially pervasive in rural disadvantaged communities that rely solely on groundwater wells as potable drinking sources (Brown et al., 2013). Restoring water quality is therefore urgent, and concerted efforts must be prioritized to reach the large reduction in nitrate discharge needed to maintain environmental integrity and ensure safe drinking water availability in an uncertain future.

Improving N management practices in perennial cropping systems has the potential to reduce nitrate leaching on a large scale because these systems are prominent and rapidly expanding across California's fragile watershed (CDFA, 2018; Khalsa & Brown, 2017; Zhang & Hiscock, 2016). In almond [*Prunus dulcis* (Mill.) D. A. Webb] production systems, high commodity prices and increasingly scarce irrigation water have promoted turnover of less-productive orchards to new plantings and growing interest in using in situ biomass recycling as a climate adaptation and mitigation tool (Holtz et al., 2018; Jahanzad et al., 2020; Kendall et al., 2015). Whole-orchard recycling refers to the grinding and soil incorporation of whole-orchard biomass before replanting an orchard. It allows the addition of large quantities of C-rich woodchips to soils and has been shown to significantly increase soil C stocks and soil's capacity to cycle nutrients and conserve water (Jahanzad et al., 2020; Kendall et al., 2015). Incorporation of high C/N residues also provides opportunities to retain N through recoupling of C and N biogeochemical cycles and improvements in soil health. Although larger soil microbial communities may retain N in organic forms, improvements in soil physical characteristics and water retention capacity may further reduce losses associated with percolation and runoffs. The impacts of high-C biomass on nitrate leaching have been mostly studied in the context of woodchips bioreactors to limit surface drainage in annual cropping systems (Christianson et al., 2012; Schipper et al., 2010; Warneke et al., 2011) but are seldom documented when large amounts are incorporated in situ into agricultural soils upon replanting of orchards.

Core Ideas

- Biomass recycling can mitigate nitrate discharges while conserving soil resources.
- Biomass recycling immobilized fertilizer N without reducing leaching in the short term.
- Biomass recycling reduced nitrate leaching potential by 52% in the long term.

Although soil health benefits associated with biomass recycling are documented in almond systems (Holtz et al., 2016; Jahanzad et al., 2020), the short-term and longer-term impacts on nitrate leaching potential remain unclear. Studies point to reduced nitrate leaching with organic amendments through (a) short-term inhibition of organic N mineralization (Knowles et al., 2011) or N immobilization (Malcolm et al., 2019); (b) enhanced N retention due to improvements in soil physical and hydraulic properties, such as increased water holding capacity associated with within-aggregate soil pores (Insam & Merschak, 1997; Xu et al., 2016; Yoo et al., 2014); and (c) denitrification (Jang et al., 2019). Despite potential growth stunting with N immobilization during the first year after biomass incorporation, long-term gains in soil health observed with whole-orchard recycling highlight the potential of this practice to reduce nitrate discharges to groundwater and make significant improvements to the sustainability of perennial cropping systems.

Understanding the mechanisms affecting N retention and cycling dynamics upon biomass recycling is critical to harness the full potential of this practice to mitigate N losses to groundwater and develop efficient N fertilization strategies that minimize potential trade-offs associated with the application of high-C orchard biomass. The objective of this study was to evaluate how soil N dynamics and retention were affected by biomass incorporation and its impacts on the fate of N fertilizer in the short term (1 yr) and longer term (10 yr). We hypothesized that large inputs of orchard biomass will mitigate fertilizer N leaching potential by rapidly increasing N cycling and net N immobilization through shifts in C pools and bacterial communities. Improved soil hydraulic characteristics associated with the addition of orchard biomass will drive changes in leaching potential on the longer term.

2 | MATERIALS AND METHODS

2.1 | Site description and experimental design

Soil was collected in 2018 from two California almond orchard systems with short-term (1 yr) and long-term (10 yr)

tree biomass management legacies before replant in Lincoln (short term; 36°38′37.0″ N, 119°30′37.7″ W) and Kearney (long term; 36°35′59.4″ N, 119°30′11.7″ W). Field sites are located nearby each other in a Mediterranean climate, with precipitation levels below evapotranspiration requirements during most of the growing season. At both sites, long-term (68 yr) annual rainfall and temperature averages are 285 mm and 17 °C, respectively. Soil at both locations is Hanford fine sandy loam (Supplemental Table S1). At the long-term experiment (Kearney), soil treatments were established in 2008 following termination and shredding of a 20-yr-old peach (*Prunus persica* var. Fay Elberta) orchard in a complete randomized design with seven replications. At the main plot level, two biomass management treatments were established: a whole-orchard recycling treatment (+biomass), where the woody biomass was incorporated within the top 15 cm of soil in the tree row prior to planting by using land clearing equipment (Ironwolf 700B Slasher), which produced variable sizes of woody biomass ranging from ∼5 to 30 cm and a control treatment (−biomass), where trees were uprooted, burnt, and ashes reincorporated to the surface soil. Details of the trial design, establishment, and management can be found in Jahanzad et al. (2020). At the short-term experiment (Lincoln), soil treatments were established in 2017 after termination of a 20-yr-old Westerner plum (*Prunus salicina* Lind) orchard in a complete randomized design with four replications. Plots (60 m by 33.5 m) were randomly established across the orchard upon replanting of almonds with either woody biomass incorporated within top 0–15 cm of soil (+biomass) or exported (−biomass).

2.2 | Sampling and soil column experiment

Undisturbed soil cores were taken in July 2018 for each site and biomass treatment (+/− biomass) from the berms between trees to a depth of 0–30 cm using a soil core sampler with plastic storage liners (AMS Inc.). Four soil samples per treatment were taken from three randomly chosen replicates at each experiment (n = 24 soil cores from each experiment). Four additional soil cores were sampled at the same locations for analysis of soil chemical properties, split into two soil depths (0–15 and 15–30 cm), composited for each depth zone, and dried in a forced-air oven at 50 °C prior to analysis.

Undisturbed soil cores in the plastic cylinder liners were directly set up as soil columns inside opaque polyvinyl chloride tubes to prevent soil disturbance from repacking and to maintain soil structural and hydrological properties associated with biomass inputs. Columns were secured in an upright position using retort stands and rings and saturated with deionized water (Mailapalli & Thompson, 2012). Excess water was allowed to drain prior to installing the soil columns on the retort stands to homogenize soil moisture at field capacity. Small holes were made in the bottom cap, which was filled with gravel, to allow percolation of the leachate without losing soil from the column. Leachate collection units (250-ml plastic container) were attached to the lower caps.

Isotopically labeled ammonium sulfate fertilizer [$(^{15}NH_4)_2SO_4$ 10% ^{15}N] was dissolved with deionized water, and 10 μg N per gram of soil was applied to the columns using burettes installed on top of the columns to allow a gradual matrix flow (Regehr et al., 2015). This ammonium-based fertilizer was chosen because it is one of the most common forms of inorganic N fertilizers applied to almond orchards and provides sufficient N and readily available sulfur to support plant growth. After 24 h (t = 0), half of the soil columns were extracted and processed upon removal to allow for initial and complete immobilization of ^{15}N (Hood et al., 2003). The remaining soil columns were extracted and processed after 96 h (t = 1), allowing sufficient time for N transformations to occur but before re-mineralization begins (Regehr et al., 2015). Soil columns were sliced using a hack saw to separate the 0-to-15-cm and 15-to-30-cm soil layers, and subsamples were taken from each soil depth for analysis.

2.3 | Microbial biomass N and isotope signature

Microbial biomass N (MBN) was measured on 6 g of moist soil using the chloroform fumigation extraction method (Horwath & Paul, 1994). Dissolved N in extracts was measured using the alkaline persulfate oxidation method (Cabrera & Beare, 1993). Microbial biomass N was calculated by dividing the difference in N content between the fumigated and unfumigated samples using a 0.68 correction factor to account for incomplete N extraction (Horwath & Paul, 1994). The second set of soil samples was extracted with 0.25 M K_2SO_4, and liquid samples were then oven dried (50 °C), ground to a fine powder using a ball mill grinder, and encapsulated to tin capsules for ^{15}N isotope analysis. A Vario EL Cube (Elementar Analysensysteme GmbH) (Coyle et al., 2009; Stark & Hart, 1996) linked with a PDZ Europa 20-20 isotope ratio mass spectrometer (Sercon Ltd.) was used at the University of California (UC) Davis Stable Isotope Facility for ^{15}N isotope analysis.

Isotope composition of microbial biomass ($\delta^{15}N_{MB}$) was calculated using mass balance (Coyle et al., 2009) as

$$\delta^{15}N_{MB} = \frac{([\delta^{15}N_F \times N_F]) - ([\delta^{15}N_{NF} \times N_{NF}])}{MBN}$$

where F and NF are fumigated and nonfumigated samples, respectively.

2.4 | N immobilization and mineralization rates

The ^{15}N isotope pool dilution technique was used to quantify gross N immobilization (GNI) and gross N mineralization (GNM) rates (Davidson et al., 1991). Briefly, N from 20 g of moist soil was extracted with 100 ml of 2 M KCl. Extracts were immediately frozen and analyzed at the UC Davis Stable Isotope Facility for ammonium content (Hannon & Bohlke, 2008). Gross N mineralization and immobilization rates were calculated as follows (Regehr et al., 2015):

$$m = \frac{[NH_4^+]_0 - [NH_4^+]_t}{\Delta t} \times \frac{\ln(APE_0/APE_t)}{\ln [NH_4^+]_0/[NH_4^+]_t}$$

$$i = \frac{[NH_4^+]_0 - [NH_4^+]_t}{\Delta t} \times \frac{\ln([NH_4^+]_0 APE_0)/\ln([NH_4^+]_t APE_t)}{\ln [NH_4^+]_0/[NH_4^+]_t}$$

where m is the gross N mineralization rate (μg N g^{-1} soil d^{-1}); i is the gross N immobilization rate (μg N g^{-1} soil d^{-1}); NH_4^+ is the total soil ammonium content (μg N g^{-1} soil); Δt is the related time interval (days); APE is the atom percent ^{15}N excess of NH_4^+; and 0 ($t = 0$) and t ($t = 1$) indicate the two sampling time points. The net rate of immobilization (NRI) was calculated by subtracting the GNM from the GNI (Regehr et al., 2015).

2.5 | Nitrate leaching

Collected leachate samples from the soil columns were filtered with 0.2-μm filters upon collection and stored frozen. Samples were then analyzed for ^{15}N nitrate using bacterial denitrification assay with a ThermoFinnigan GasBench + PreCon trace gas concentration system interfaced to a ThermoScientific Delta V Plus isotope–ratio mass spectrometer (Rock & Ellert, 2007) at the UC Davis Stable Isotope Facility.

2.6 | Abundance of N cycling functional genes

Abundance of a subset of microbial genes involved in N-cycling processes was measured by real-time polymerase chain reaction on DNA extracted from 0.25 g of soil subsamples using the FastDNA Spin Kit for Soil (MP Biomedicals). Nitrogen cycling functional genes involved in nitrification (bacterial *amoA*, *amoA*-1F, and *amoA*-2R) (Rotthauwe et al., 1997) and denitrification, including the copper-dependent nitrite reductase (*nirK*, F1aCu, and R3Cu) (Throbäck et al., 2004) and cytochrome cd_1-containing nitrite reductase (*nirS*, cd3aF, and R3cd) (Throbäck et al., 2004), were quantified by quantitative polymerase chain reaction using 10-μl reactions and the Stratagene Brilliant III Ultra-Fast SYBR Green QPCR Master Mix (Agilent) as described in Schmidt et al. (2020) at the USDA-ARS Crops Pathology and Genetics Research Center, Davis, CA.

2.7 | Soil chemical analysis

Dry soil samples were analyzed at the UC Division of Agriculture and Natural Resources Analytical Laboratory. The pH was determined using a saturated paste method (U.S. Salinity Laboratory Staff, 1954). Electrical conductivity was measured according to the method described by Rhoades (1982). Sodium, calcium, and magnesium were measured using inductively coupled plasma emission spectroscopy (Meyer & Keliher, 1992), which followed a nitric acid/hydrogen peroxide microwave digestion method (Sah & Miller, 1992). Cation exchange capacity was determined based on the method described by Rible and Quick (1960). Total N was measured by combustion method (ECS 4010, Costech Analytical Technologies Inc.). Soil organic matter was measured using the loss-on-ignition method (Nelson & Sommers, 1996).

2.8 | Statistical analysis

Data were analyzed using the PROC Mixed procedure with Kenward–Roger degrees of freedom approximation in SAS (SAS Institute, 2009). Soil treatments (+/− biomass) and soil depth and their interactions were considered as fixed effects, and blocks and the interaction of blocks with fixed effects were considered as random effects. Data from the long-term and short-term sites were analyzed as separate experiments due to differences in management practices and the variable timeframes of the experimental setups at the two distinct locations. The assumptions of ANOVA were tested, and transformations were applied where necessary to achieve normality and heterogeneity of residuals (i.e., *nirS*). When ANOVA showed significant fixed effects or interactions ($P < .05$), comparisons of means were made using the adjusted Tukey's range test.

3 | RESULTS

3.1 | Nitrate leaching

Addition of woody biomass did not significantly mitigate leaching potential of fertilizer N in the short term (1 yr after addition) despite trends toward lower nitrate leaching losses

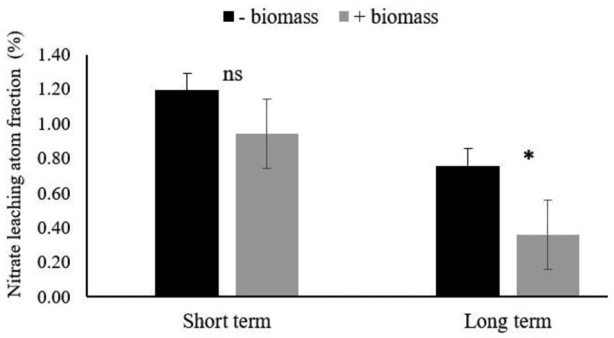

FIGURE 1 Amount of $^{15}NO_3^-$ recovered in leachate samples as affected by biomass incorporation at the long-term (10 yr, Kearney) and short-term (1 yr, Lincoln) experiments. ns, no significant difference. *Significant difference at $P \leq .05$

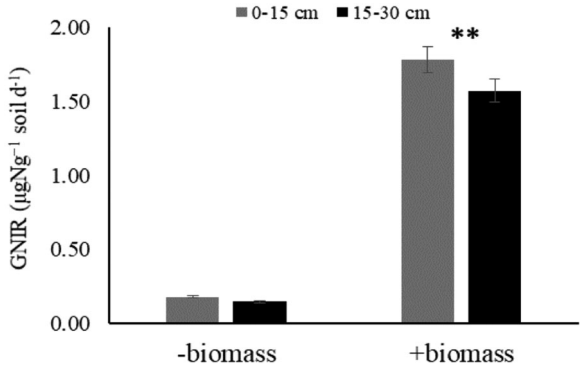

FIGURE 2 Impacts of biomass incorporation on gross N immobilization rate (GNIR) at different soil depths in the short-term experiment. **Significant difference at $P \leq .01$

in the +biomass treatment (1.19 vs. 0.94, atom % ^{15}N for –biomass vs. +biomass treatments) (Figure 1). Ten years after recycling, nitrate leaching from fertilizer N was significantly reduced by 52% compared with the −biomass treatment.

3.2 | GNM

We found no significant effects of biomass addition on GNM rates either in the short term or long term, with trends toward lower mineralization 10 yr after biomass incorporation. We observed higher GNM rates at lower soil layers (15–30 cm) compared with the topsoil (1.64 vs. 1.02 μg N g^{-1} soil d^{-1}) for both biomass treatments at the short-term experiment (Table 1).

3.3 | MBN and isotope signature

More N was incorporated into MBN in the 0-to-15-cm soil layer compared with the 15-to-30-cm layer across both biomass treatments in the short-term experiment (+23% in the 0-to-15-cm layer). Addition of woody biomass (+biomass) increased MBN by 95% compared with the −biomass control in the short term across all soil depths (Table 1). Similarly, ^{15}N recovery of N fertilizer into microbial biomass ($\delta^{15}N_{MB}$) was 94% higher in the +biomass treatment than in the −biomass 1 yr after incorporation, especially in the topsoil layer (Table 1). No significant differences were found 10 yr after incorporation in terms of MBN and $\delta^{15}N_{MB}$, despite slight increases in the 0-to-15-cm soil layer with biomass addition (Table 1).

3.4 | N immobilization rates

Soils in the recycled orchards demonstrated higher GNI rates in the short-term experiment, with a 10-fold increase compared with the −biomass treatment across soil depths (1.67 vs. 0.16 μg N g^{-1} soil d^{-1}) (Table 1). There was a significant interaction of soil depth × biomass treatment with higher GNI rate observed in the 0-to-15-cm soil layer of +biomass soil compared with the lower soil depth (1.78 vs. 1.57 μg N g^{-1} soil d^{-1}, respectively) (Figure 2). We also observed higher NRI with biomass incorporation in the short term (0.65 vs. −1.72 μg N g^{-1} soil d^{-1}, respectively), especially in the topsoil layer. Although biomass addition did not significantly affect GNI in the long-term experiment, increases in NRI were observed with biomass addition across soil depths (Table 1).

3.5 | Bacterial functional N cycling genes

Biomass inputs and soil depth significantly affected the abundance of bacterial nitrification gene *amoA*, which is the most abundant gene involved in N cycling. The relative abundance of bacterial *amoA* genes was ninefold higher in the 15-to-30-cm soil layer compared with the 0-to-15-cm layer (Table 2), with the highest abundance of bacterial *amoA* observed in the lower soil layer of the −biomass treatment (Figure 3). Albeit nonsignificant, the abundance of bacterial *amoA* tended to be greater in the +biomass treatment compared with the −biomass treatment across depth zones. Biomass incorporation led to less *nirK*, and the topsoil layer was richer in *nirK* functional genes (Table 2). No significant effect of soil depth or biomass treatments was observed on *nirS* abundance (Table 2).

Soils from the long-term experiment showed 10-fold greater abundance of *amoA* in the 15-to-30-cm soil layer compared with the 0-to-15-cm layer across biomass treatments (1,025 vs. 87 copies ng^{-1} DNA, respectively) (Table 2). Soils from the long-term experiment exhibited a 71% increase in abundance of nitrate reductase *nirK* with biomass incorporation (Table 2). Also, greater abundance of *nirK* was observed in the lower soil layer (15–30 cm) compared with the topsoil

TABLE 1 Impact of biomass inputs on microbial biomass N (MBN), isotopic signature of the microbial biomass ($\delta^{15}N_{MB}$), gross N immobilization (GNI) rate, gross N mineralization (GNM) rate, and net rate of immobilization (NRI) at two soil depths

Experiment	Treatment	MBN	$\delta^{15}N_{MB}$	GNM	GNI	NRI
		μg N g^{-1} soil d^{-1}	‰	μg N g^{-1} soil d^{-1}		
Short term	−biomass	11.962	6.264	1.188	0.164	−1.725
	+biomass	23.412	12.165	1.015	1.674	0.658
	0–15 cm	19.573	11.962	1.026	0.979	−0.280
	15–30 cm	15.800	6.467	1.644	0.859	−0.785
Effects				*p* value		
	biomass	.013	.059	.391	.005	.012
	depth	.022	.044	.027	.557	.052
	biomass × depth	.269	.308	.894	.033[a]	.561
		μg N g^{-1} soil d^{-1}	‰	μg N g^{-1} soil d^{-1}		
Long term	−biomass	13.477	6.446	4.061	0.557	−3.904
	+biomass	13.944	7.676	2.665	0.832	−1.835
	0–15 cm	14.806	7.431	2.977	0.563	−2.665
	15–30 cm	12.615	6.691	3.755	0.426	−3.074
Effects				*p* value		
	biomass	.867	.241	.062	.681	.041
	depth	.388	.337	.653	.471	.586
	biomass × depth	.398	.629	.306	.593	.320

[a]Refer to Figure 2 for this significant interaction effect with depth.

TABLE 2 Impact of biomass inputs on abundance of bacterial *amoA*, *nirK*, and *nirS* at two soil depths

Experiment	Treatment	*amoA*	*nirK*	*nirS*
		copies ng^{-1} DNA		
Short term	−biomass	279	40,525	1,003
	+biomass	773	26,125	1,295
	0–15 cm	147	37,311	992
	15–30 cm	905	29,339	1,306
		p value		
Effects	biomass	.071	.022	.499
	depth	<.0001	.034	.384
	biomass × depth	.008[a]	.220	.841
		copies ng^{-1} DNA		
Long term	−biomass	545	4,572	2,427
	+biomass	567	7,969	1,986
	0–15 cm	87	4,413	529
	15–30 cm	1,025	8,129	3,885
		p value		
Effects	biomass	.941	.038	.400
	depth	<.0001	.023	<.0001
	biomass × depth	.843	.201	.130

[a]Refer to Figure 3 for this significant interaction effect.

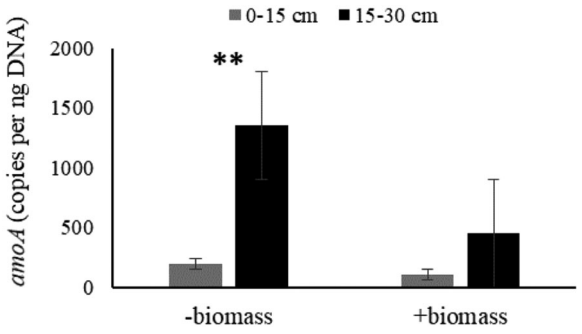

FIGURE 3 Impacts of biomass incorporation on abundance of bacterial *amoA* at different soil depths in the short-term experiment. **Significant difference at $P \leq .01$

(8,129 vs. 4,413 copies ng^{-1} DNA, respectively) (Table 2). A significantly greater concentration of the nitrate reductase gene *nirS* was also detected in the lower soil depth compared with topsoil layer (3,885 vs. 529 copies ng^{-1} DNA, respectively) without significant impacts of biomass addition (Table 2).

4 | DISCUSSION

The goal of this study was to assess the N retention potential and leaching dynamics of applied labeled ammonium fertilizer in soils with recent orchard biomass incorporation (short term) and whether the legacy effects of this biomass incorporation alter N dynamics in the long-term. We found that in situ biomass recycling prior to tree replanting significantly increased N fertilizer immobilization shortly after incorporation into the soil, especially within the topsoil (0–15 cm). In the longer term, we observed a 52% reduction in the leaching potential of N fertilizer without increased immobilization of recently applied N fertilizer. Although there may be short-term trade-offs associated with soil incorporation of woody biomass, the long-term environmental benefits are significant. Long-term gains associated with this practice can have potential positive impacts on water quality, agricultural communities and growers trying to comply with increasing water quality regulations in California.

4.1 | Whole-orchard recycling increases N immobilization without reducing fertilizer N leaching in the short term

It has previously been demonstrated that the addition of organic amendments with high C/N ratios generally increases soil N immobilization, which may result in reduced availability of recently applied N fertilizers within recycled orchard soils (Culumber et al., 2018). Our findings confirm these results, with higher gross and net N immobilization rates in an orchard recently amended with large amount of biomass. Net N mineralization rates have been shown to decrease with increasing immobilization rates associated with increased amounts of added C (Bengtsson et al., 2003; Binh & Shima, 2018), and the ammonium utilization pathway gradually switches over time from net nitrification to immobilization as the C/N ratio of amendment increases (Feng & Zhu, 2017). We did not detect differences in mineralization dynamics with biomass addition in the short-term experiment, indicating potential substantial immobilization within the microbial biomass with limited turnover soon after incorporation. This is corroborated by our results of increased immobilization within the microbial biomass, which acted as a significant and immediate sink for recently added N, as shown by elevated isotope signature from fertilizer in microbial biomass ($\delta^{15}N_{MB}$). Detection of greater values of $\delta^{15}N$ in the MBN pool with biomass addition might indicate greater competition for N in the recycled orchard soil in the short term, with the high N demand required for the decomposition and assimilation of high C/N ratio (~160) orchard biomass.

As such, microbial utilization of orchard biomass, or any other low-N substrates, is often accompanied by the immobilization of inorganic N from the soil and heightened competition for N, leading to increased microbial investment in N acquisition strategies (Avnimelech, 1999; Malik et al., 2020). This is particularly supported by the significantly uniquely higher MBN and $\delta^{15}N_{MB}$ values observed in the topsoil within the orchard biomass incorporation zone. This is likely attributed to an increase in microbial biomass C, associated with the substantial input of orchard biomass, and the stoichiometric necessity of assimilating additional N to balance the C/N ratio requirements of biomolecule synthesis. This is supported by a well-documented positive correlation between soil microbial biomass C and MBN across studies (Geisseler et al., 2010; Jahanzad et al., 2020). Thus, the increase in sustained soil microbial growth of the +biomass treatment and immobilization potential is likely associated with the additional energy and nutrients of incorporated orchard biomass within the topsoil (Bonanomi et al., 2011; Throckmorton et al., 2012).

Despite the significant short-term immobilization potential of N within the microbial biomass (Table 1), recently recycled orchards may be prone to losses of applied N through leaching, as represented by similar $\delta^{15}N$ nitrate values in the leachate of +biomass and −biomass treatments. This may be due to a lack of adequate decomposition time for the newly incorporated orchard biomass, as indicated by similar soil organic C (SOC) and soil organic matter values across the soil profile, which may limit N sorption sites and soil water holding capacity, both important drivers of N retention. Higher activity and abundance of bacterial *amoA* in the lower soil layer (15–30 cm) compared with the topsoil could also be

a driver of rapid N transformation into mobile nitrate, balancing out potential gain in N retention via immobilization at the soil surface. Other studies have linked high rates of nitrate leaching to the abundance and activity of bacterial *amoA* in saturated soils (Di & Cameron, 2012; Di et al., 2010; Galloway et al., 2003; Isobe et al., 2018). However, a lack of significant difference in gross mineralization and significant increases in MBN with biomass addition indicate that this heightened *amoA* abundance might be more related to the increased short-term microbial assimilation of recently deposited NH_4–N fertilizer under woody biomass incorporation. Additions of orchard biomass, when combined with the application of $(NH_4)_2SO_4$ fertilizer, also resulted in a short-term decrease of nitrite reducing functional gene (*nirK*) abundance, perhaps indicating shifts in loss pathways toward leaching.

4.2 | Biomass recycling reduces nitrate leaching potential in the long term

Although recently recycled orchards may still be prone to higher nitrate leaching potentials due to recent soil disturbance for land preparation, we observed significantly lower nitrate leaching 10 yr after orchard biomass additions. Notably, there were no long-term significant differences in GNI with biomass recycling, and lower mineralization rates contributed to a significantly lower negative net N immobilization (NRI) value in the +biomass treatment. Interestingly, soils exhibited a marked increase in abundance of nitrite reductase *nirK* with biomass incorporation, which may indicate a reduction in nitrate leaching potential.

The decrease in nitrate leaching for recycled orchard soils may also be explained by higher water retention with SOC-dependent improvements in soil physical and hydraulic properties. An increase of 30% in field water holding capacity has been reported for biomass-amended soils at this site (Jahanzad et al., 2020). Biomass additions also increased the formation and stability of large macroaggregates (>2 mm diameter) while occluding a larger quantity of intra-aggregate SOC (Jahanzad et al., 2020). Previous studies have linked soil C amendments with improved water retention and lower nitrate leaching potentials, attributing the observed benefits to factors such as increased soil aggregate formation and stabilization (Colombani et al., 2020; Liu et al., 2017; Lu et al., 2020). Subsequently, improved soil structure increases the diversity of soil pore-size distribution and decreases the prevalence of preferential hydraulic flow channels, which could result in lower nitrate leaching potential.

Depending on C/N ratio of soil amendments and inherent soil characteristics, literature varies in terms of functional gene abundance and bacterial community responses. Although several studies highlight a significant response of functional gene abundance to the soil amendments such as compost and biochar (Li et al., 2019; Lu et al., 2020; Wu et al., 2016), other studies report a neutral or negative correlation response between organic soil amendments and the presence of functional N cycling genes (Ouyang et al., 2018; Wessén et al., 2010; Yu et al., 2019). Several influential factors, such as climatic conditions, soil type, soil physicochemical properties, and residue quality, likely regulate responses of N cycling genes to soil amendments (Gonzalez Perez et al., 2014; Lin et al., 2018; Pereira e Silva et al., 2011). Due to the high C/N ratio of the orchard biomass incorporated, results are likely to shift across locations and recycling methodologies (i.e., particle size) in these irrigated landscapes. As such, further elucidating variation in N pools and associated shifts in microbial functions with biomass addition across a co-management gradient and various woodchip sizes will be critical to tailor this practice to the various environments, increase benefits, and lower potential production tradeoffs.

5 | CONCLUSION

We present here the first exploration of shifts in N dynamics and leaching potential with whole-orchard recycling practice in the California Central Valley on the short term (1 yr) and longer term (10 yr). Our results, coupled with previous reports of benefits for tree productivity and soil health (Jahanzad et al, 2020), highlight the potential of whole-orchard recycling to harness soil ecosystems for sustainable perennial crop production systems and conservation of groundwater quality. Stacking practices such as implementing legume cover crops to add labile C and N before replanting and establishing zone-specific management strategies to prime mineralization in the tree row while catching leachable N in the alleyways would likely help offset short-term tradeoffs. Proactive adaptation of N management practices, such as early fertilization and rootzone placement of N fertilizer, might also mitigate the potential need for higher fertilizer application rates than the standard recommendation for first-year trees. Biomass recycling can therefore be considered as a promising long-term, climate-smart agriculture practice that offers broad ecosystems services for adaptation to future climate variation while mitigating nitrate discharges to groundwater bodies during the orchard productive phase.

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AUTHOR CONTRIBUTIONS

Emad Jahanzad: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing. Kelsey M. Brewer: Conceptualization; Methodology; Validation; Writing – review & editing. Amisha T. Poret-Peterson: Resources; Validation; Writing – review & editing. Catherine M. Culumber: Resources; Validation; Writing – review & editing. Brent A. Holtz: Resources; Validation; Writing – review & editing. Amélie C. M. Gaudin: Conceptualization; Funding acquisition; Investigation; Project administration; Resources; Supervision; Validation; Writing – review & editing.

CONFLICT OF INTEREST

There are no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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G. Summary of Publication Examples

Publication example 1 (#4 in the bibliography under review)

Jahanzad, E., Brewer, K.M., Poret-Peterson, A.T., Culumber, C.M., **Holtz, B.A**., Gaudin, A.C.M. 2022. Effects of Whole Orchard Recycling on Nitrate Leaching Potential in Almond Production Systems. Journal of Environmental Quality, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, https://doi.org/10.1002/jeq2.20385

This peer reviewed publication showed that WOR could substantially reduce nitrogen leaching into ground water. This could have important implications for low-income rural communities throughout the SJV that are primarily reliant on ground water for drinking, often contaminated with high levels of nitrate. A CDFA Specialty Block Grant, written by Dr. Amelie Gaudin, at UC Davis, and her post-doc Emad Jahanzad did the laboratory analysis. I helped with soil sampling and manuscript review, experiment block 31 at the Kearney REC.

Publication 2 (# 6 in the bibliography under review)

Coyne, K. 2023. Thinking big about recycling: for the growing practice of orchard recycling, the story just keeps getting better. CSA News published by Wiley Periodicals Inc. on behalf of the American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America, ISSN 1529-9163, eISSN 2325-3584, 27 February 2023, https://doi.org/10.1002/csan.20966

To highlight the environmental importance of publication #1 above, this CSA News article was written by Kristen Coyne, a writer for the Crop Science Society of America, the Soil Science Society of America, and the American Society of Agronomy (CSA), that highlighted my initial studies on WOR. The article was published jointly by the three societies, and it features me on the front cover standing on a mountain of wood chips. CSA News has a circulation of 8,000 scientists nationally and worldwide, giving me both national and international professional recognition. I was interviewed for this article and reviewed it for accuracy.

Publication 3 (# 78 in the bibliography under review)

Holtz, B.A., 2023. Pacific Nut Producer's March Orchard Tasks: Almonds. Pacific Nut Producer (ISSN 1087-4674) Volume 29, number 3, pages 14-18, bacterial blast and canker, frost protection, midday stem water potential to refine irrigation, scab and anthracnose, ground squirrels, UC IPM website, https://pacificnutproducer.com/

I author the “almond tasks” section of the Pacific Nut Producer (PNP) magazine published by Malcolm Media. The PNP represents my most significant extension and affirmative action activity, reaching 11,000 growers monthly. The PNP has allowed me to extend my research and extension program to growers statewide, nationally, and internationally. This particular article focuses on identifying almond diseases, illustrating how I can use high quality digital photos to identify plant disease symptoms in mass media. This publication continued to be my main avenue of extending information during the COVID-19 pandemic.

Goals and Objectives for the Coming Year:
For the Period October 1, 2023 - September 30, 2024

Due by August 17, 2023 for review with Lynn Schmitt-McQuitty on August 22, 2023. I will be attempting a merit in the 2023-24 cycle to Full Title Advisor IX, uploading program review by **December 8, 2023**.

Include goals and objectives you intend to accomplish in the coming year, anticipated collaborators, and anticipated outcomes and impacts. It is recommended that you organize your objectives according to the themes you are going to use in your program review dossier. Remember to include objectives addressing the advancement criteria for your title series. Academic HR recommends that academics and supervisors have a conversation about goals and objectives in the fall; there is not firm deadline set by ANR.

Name:	Brent A. Holtz
Academic Title:	Full Cooperative Extension Advisor
County/Program:	San Joaquin County
Current Rank/Step:	Full Title Advisor VIII

Part 1. Goals and Objectives for the Coming Year

Specific Goals	Anticipated Collaborators	Anticipated Outcomes and Impacts
Theme 1 (Goal): [Administration of UCANR in San Joaquin County]		
Objective: to secure continued funding for UCCE in San Joaquin County (SJC)	SJC Administrator and analysts, UC colleagues and clientele, SJC's Public Works Division that supports our Master Gardener program	Securing a budget for 2024-2025 that continues to support our 4-county staff, 9 county vehicles, and our space in the SJC Agricultural Center that includes supplies, printers, and various office equipment. Program support for our over 200 master gardeners and 10 master food preservers.
Objective: to provide academic and programmatic guidance to UC advisors and staff in SJC.	UC ANR leadership and SJC staff,	To provide mentorship and guidance to our staff through individual consultations, staff conferences, ANR leadership emails, DEI activities, covid safety, UC and County compliance.
Objective: to develop a succession plan	UC ANR leadership and SJC staff, Dr. Michelle Leinfelder-Miles served as CD while I was on sabbatical, acting CD	My three-year CD appointment ends June 30th, 2024, after 15 years as CD, I don't intend to renew. I would like to concentrate on completing publications before retirement. Michelle or multi-county CD.

Objective: develop advisor positions for San Joaquin County	UC ANR leadership and SJC staff, program and workgroup team leaders, specialists, professors	We are currently without a 4-H Advisor, a position we have shared with Stanislaus County. Compounding this vacancy our Orchard Systems Advisor resigned in 2023. We desperately need both positions in San Joaquin County. I hope to write position descriptions for the next call.
Theme 2 (Goal): [Sustainability and Viability of Agriculture]		
Objective: Whole Orchard Recycling (WOR), Principal Investigator, writing *California Agriculture* article, extending knowledge	UC and USDA colleagues, clientele, CDFA, San Joaquin Air Pollution Control District, and the Almond Board of California	Increased knowledge and acceptance of WOR, extension of nitrogen and water use efficiencies, less nitrogen leaching into ground water—positive impacts on low income rural communities. Increased yields, soil organic matter, carbon sequestration, while reducing climate change and the amount of biomass burned. Resulting in improved air quality, increased state and federal funding, increased funding for growers. State and international impacts will be addressed in merit. Complete adoption of WOR in the San Joaquin Valley by January 1st, 2025.
Objective: Extending knowledge throughout the San Joaquin Valley (SJV), the state, nationally, and internationally	Pacific Nut Producer (PNP) Magazine where I write the Almond Task article with a circulation of 11,000 monthly. Other mass media activities: emails, websites, blogs	Increased knowledge of many topics: WOR, IPM practices, irrigation needs, nutritional requirements, disease and pest control. Increased sustainability of almond production.
Objective:		
General/Other		
Objective: Mentoring new colleagues, serving on search and adhoc review committees.	UC ANR leadership and new colleagues	Successful candidate searches and improved moral and retention within ANR
Objective: Engaging with agencies and departments that work with UCCE	SJC Ag Advisory Board, Farm Bureau, Ag Drought Task Force, Ag Venture	Increased science awareness in Agriculture will result in better decisions and opportunities

Part 2. Anticipated Barriers or Obstacles in Accomplishing Your Goals and Objectives

Self-discipline, prioritizing activities, and time management are my biggest obstacles. Improving my work efficiency is important. I need to work more efficiently and productively to accomplish what I use to in the same amount of time. Staying up late at night to finish writing assignments or PNP articles doesn't work for me anymore—I have been writing in the morning when my mind is the sharpest, and doing emails, farm calls, and other activities in the afternoon. This is working for me in 2023, I just wish I had learned to set more time aside for writing years ago. I am setting short term weekly writing goals for completing my *California Agriculture* article in 2023.

Part 3. Support from Supervisor(s)
Briefly describe any support you would find helpful from your supervisor(s).

I would appreciate support in trying to convince UC ANR to completely fund our 4-H CES positions. Finding additional financial support for their positions has been difficult and time consuming, and I believe demoralizing for our CES specialists. San Joaquin and Stanislaus Counties will be without a 4-H Advisor in 2023, helping to prioritize our counties need within the larger 4-H statewide program would be helpful and appreciated (I hope to discuss this topic with Lynn during our zoom meeting).

Describe any transportation/mileage concerns that need to be addressed for you and your Advisors in FY 23-24.

I do not have mileage concerns, unlimited county mileage

Please outline your actions for addressing the comments from your 2022-2023 review:

Interim director for county CE:
1) While the AE provides limited space to report impacts, when time to write a PR, it will be essential Holtz demonstrate how his efforts help clientele realize measurable changes. Holtz cites anticipated changes in knowledge which should be strengthened by adding measurements i.e. the number of growers adopting the practice, the amount of recycled material, acres, reduction in landfill loads. Inserting impacts and research findings from his publications into his PR narrative is another way to report impacts with little effort on his part as the data is already available.
2) Holtz's goals could be strengthened by enhancing his anticipated outcomes by outlining how creative activity will follow the extension continuum of using research to inform practice. This can be demonstrated by expanding what deliverables, products or actions will be taken after studies are complete i.e. popular press articles, scholarly publications, extension courses created, professional society presentations. These goals will intentionally demonstrate how your work will purposefully impact clientele and set milestones for you to achieve.
3) Holtz has plans to complete a California Agriculture article, and has identified time management as an obstacle to accomplish this goal. I might suggest Holtz block out writing dates or weeks to accomplish this with the intent of not taking any meetings and not answering calls or emails during these times. This strategy may allow for focused and dedicated writing time to complete this goal.

Outcomes and Impacts
As mentioned previously, I will attempt a merit to Full Title IX in the 2023-24 cycle, where I will articulate outcomes and impacts that show I have been on a three decade trajectory to develop, study, and implement whole orchard recycling (WOR) as an alternative to open field and co-generation burning. My research and education program has demonstrated that WOR has improved air quality, increased yields, increased carbon sequestration, increased soil organic matter, increased the water holding capacity of soils, and reduced nitrogen leaching into our groundwater (see peer reviewed bibliography on the ANR portal). I have gained national and international recognition, and I have brought prestige to the University of California. The following impacts and outcomes were observed since my last review, and I will develop them further for my merit to Full Title IX:

The Almond Board of California produced a film 'Resilience: the whole orchard recycling origin story' available on YouTube, outlining how I conceived the concept of orchard recycling and initiated studies. I spent five days filming this video with Lux Production Company in 2021—and the final version turned out to be only five minutes long. I'm not sure if that is a compliment to them or an indicator that I'm not good with a camera. But the video won a gold medal at the national Golden ARC (Ag Relations Council) Awards in 2022, under 'digital and social media' promoting excellence in agricultural and public relations (almost 2,000 views on YouTube).

Whole orchard recycling, instead of burning orchard biomass in the field or at co-generation facility, has significantly reduced air pollution and increased soil carbon and organic matter. Since 2018, when the San Joaquin Valley Air Pollution Control District (SJVAPCD 2023 report at www.valleyair.org) began funding orchard recycling at $600-900 per acre: 3,019 orchards (grower projects) on 162,775 acres have been recycled! As a result, 4.5 million-tons of agricultural biomass was not burned but recycled, resulting in the reduction of 8,791 tons of nitrogen oxides (NOx), 16,212 tons of particulate matter (PM), and 13,702 tons of volatile organic carbons (VOC). From 9/2021 to 2/2023 SJVAPCD funded $137 million on whole orchard recycling projects with growers and $30 million to purchase horizontal grinders to expand the orchard removal industry.

In July 19, 2022, Governor Newsom signed AB 2101 (Flora) California Carbon Sequestration and Climate Resiliency Project Registry: Whole Orchard Recycling Projects. This bill was specifically designed to make funding available for whole orchard recycling projects. The SJVAPCD received an additional $178 million to fund recycling efforts in the San Joaquin Valley. In addition, the California Department of Food and Agriculture's Healthy Soils Program and Natural Resources Conservation Service Environmental Quality Incentives Program (EQIP) both received funding for orchard recycling projects. This is important for growers in the Sacramento Valley and along the coast who are outside of the SJVAPCD.

The Blue Diamond Almond Growers Cooperative received a $40 million Climate Smart USDA grant in 2023 to implement practices that increase carbon sequestration. Whole orchard recycling is a major component of the grant, and I helped with the concept proposal, and I'm now training their trainers on how to successfully implement WOR without negatively affecting the soil carbon to nitrogen balance in the next generation orchard.

On February 25, 2021 I gave virtual testimony to the California Air Resources Board (CARB) and 450 attendees on WOR as an alternative to open field burning. This was a public meeting to consider the San Joaquin Valley 2020 agricultural burning assessment, and the postponement of prohibition on open burning for certain crops and materials under Senate Bill 705 (Florez 2003). Michael Benjamin, Division Chief of the Air Quality Planning and Science Division of CARB, complemented me by saying that my presentation and research were influencing state policy! After the meeting CARB voted to implement the ban on all open field burning in the San Joaquin Valley beginning January 1, 2025. Whole orchard recycling has become the tree fruit industry standard for biomass removal!

I was the keynote speaker at the 18th Australian Almond Conference, held in Melbourne in November 2018. Initially, I didn't think the Australians would be interested in orchard recycling since their bush burns regularly and they don't have air quality restrictions. But their soils are very sandy, much sandier than ours, and they are very interested in any practice that can build soil organic matter, nutrient fertility, and increase water holding capacity. Knowledge of WOR created a sensation in Oz, and 8 large growers have since recycled their almond orchards 'Down Under' since my presentation. Several of these growers visited me and my trial sites in California before recycling their own orchards, and several members of the Australian Almond Board attended my whole orchard recycling field day on May 18, 2023, a week after hearing me give another keynote presentation on WOR on May 10th, at the 8th International Symposium on Almond and Pistachio, part of the International Society of Horticultural Science, hosted by UC Davis. As a consequence, I have been invited back to Australia in January 2024, by the Australian Almond Board, to give five presentations in five days (January 15-19) from Adelaide to Griffith along the almond growing regions of the Murray River in South Australia.

I was invited to give the keynote address to the Hawaii Macadamia Nut Growers Association, at their 53rd annual meeting, Nani Mau Gardens, Hilo, Hawaii, on July 10, 2021. I didn't know anything about growing Macadamia Nuts then, but the association wanted to hear about orchard recycling and wondered if such a practice could prove beneficial to the volcanic soils of Hawaii, that are typically low in soil organic matter. I was fascinated with their industry and they enjoyed hearing about my research and extension efforts. Two of their growers started recycling trees from orchards that were being thinned soon after my visit. Several growers invited me to visit their farms, and it amazing to see Macadamia trees growing on beautiful hillsides that ran to the sea.

The peer reviewed publication below showed that whole orchard recycling could substantially reduce nitrogen leaching into ground water. This could have important implications for low-income rural communities throughout the San Joaquin Valley that are primarily reliant on ground water for drinking, often contaminated with high levels of nitrate. The research was performed in experimental plots that I established in 2008 at the Kearney Research and Extension Center, in Parlier.

Jahanzad, E., Brewer, K.M., Poret-Peterson, A.T., Culumber, C.M., **Holtz, B.A**., Gaudin, A.C.M. 2022. Effects of Whole Orchard Recycling on Nitrate Leaching Potential in Almond Production Systems. Journal of Environmental Quality, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, https://doi.org/10.1002/jeq2.20385

To highlight these findings an article was written by Kristen Coyne, after interviewing me and other authors, and published by CSA News listed below. This newsletter, published in coordination with three academic societies, gave me both national and international professional recognition.
Coyne, K. 2023. Thinking big about recycling: for the growing practice of orchard recycling, the story just keeps getting better. CSA News published by Wiley Periodicals Inc. on behalf of the American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America, ISSN 1529-9163, eISSN 2325-3584, 27 February 2023, https://doi.org/10.1002/csan.20966

The article above was also published in World Environment Day 2023, bringing together 150 countries to participate in this United Nations International Day, celebrating environmental action and the power of governments, businesses, and individuals to create a more sustainable world. https://acsess.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)9999-0007.world-environment-day-2023

I will discuss my current publications, presentations, funding, extension activities, university and public service, and my affirmative action program in my merit attempt in December.

Ad Hoc Committee (if appropriate):

Program Review Committee (if appropriate):

AVP (if appropriate):

The 2023-2024 goals outlined by Advisor/County Director Holtz are reasonable and commensurate with rank and step. Barring no unforeseen circumstances, and being mindful to address comments from the previous review period, I have reason to believe that Advisor/County Director Holtz will successfully achieve the outlined goals and be in a positive position for future advancement.

Meeting Notes:

Frequency of office staff meetings

- Method of staff meeting (in-person/virtual)
- Who attends staff meeting
- How information is shared with those not in attendance