WHOLE ORCHARD RECYCLING

GUIDE FOR CALIFORNIA ALMOND GROWERS

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Almond Board of California

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

INTRODUCTION TO WHOLE ORCHARD RECYCLING

At the end of an orchard's productive life, almond growers must decide what to do with their older trees before either replanting immediately or waiting a year.

Removing old orchards and preparing to plant new trees is an intense job with important decisions required at every turn, including whether to fumigate, what varieties and rootstocks to plant, what irrigation system to install and what practices will be the best for soil health and long-term orchard productivity. For some growers, immediately replanting may not be the best option – taking a year off to reestablish the next orchard may be a wise decision.

Whole Orchard Recycling (WOR) provides a solution that not only addresses the question of how to dispose of old trees but also provides a sustainable alternative to co-generation burning that can be integrated into standard orchard replanting practices, potentially improving soil health and increasing yields in the next orchard.

WOR involves grinding whole trees into wood chips, spreading the chips evenly on the soil surface, then incorporating them into the soil before replanting. Research by the University of California Cooperative Extension (UCCE), initially funded and supported by the Almond Board of California (ABC) and later by the California Department of Food and Agriculture, has identified significant advantages of WOR, such as increased soil organic matter, improved water holding capacity and increased cumulative yields in one location.

WOR is an innovative and sustainable growing practice that contributes to the success of the subsequent orchard by not only using everything grown in the previous orchard (achieving zero waste) but also providing value back to the grower by delivering nutrients and improving soil quality. WOR supports two of the industry's Almond Orchard 2025 Goals: achieving zero waste by putting everything grown to optimal use, and potentially increasing water use efficiency.

AN ALTERNATIVE TO BURNING AND COGENERATION PROCESSING

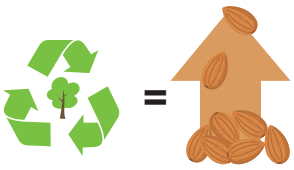
Of the 1.2 million acres of bearing almonds in California, roughly 88,000 are nearing the end of their expected lifespan and soon will be removed. Until recently, a large portion of orchard biomass was either burned in the field or used to generate power at cogeneration plants across the state. In the San Joaquin Valley, agricultural burning is no longer permitted, with some limited exemptions, and most cogeneration plants are no longer accepting orchard biomass. Almond growers who wish to remove unproductive orchards need an alternative method of orchard removal that is sustainable.

Until recently, a large portion of orchard biomass was burned in the field. Air quality regulations have decreased the number of burning day permits. *Photo courtesy of Brent Holtz*

BENEFITS OF WHOLE ORCHARD RECYCLING

Researchers implemented trial plots where WOR was compared to burning in 2009 at the UC Kearney Research and Extension Center in Parlier. Prior to replanting, plots were set up comparing either grinding up old trees and incorporating them into the soil (WOR plots) to burning trees and tilling their ashes into the soil (burn plots). The plots where WOR occurred showed significant positive results when compared to the burn treatment plots over time.

A decade worth of research on WOR points to increased yields, carbon storage, irrigation efficiency, and improved soil health.[1] Results from this experiment were published in 2020 through the journal PLOS ONE.[2] In the first six harvests, researchers observed a 19% cumulative yield increase, or 2,000 kernel pounds per acre, when WOR plots were compared to burn plots under normal irrigation. The researchers also noted benefits to the tree's nutrition with WOR, and that nine years after WOR occurred, 3 tons of carbon were captured and sequestered per acre.



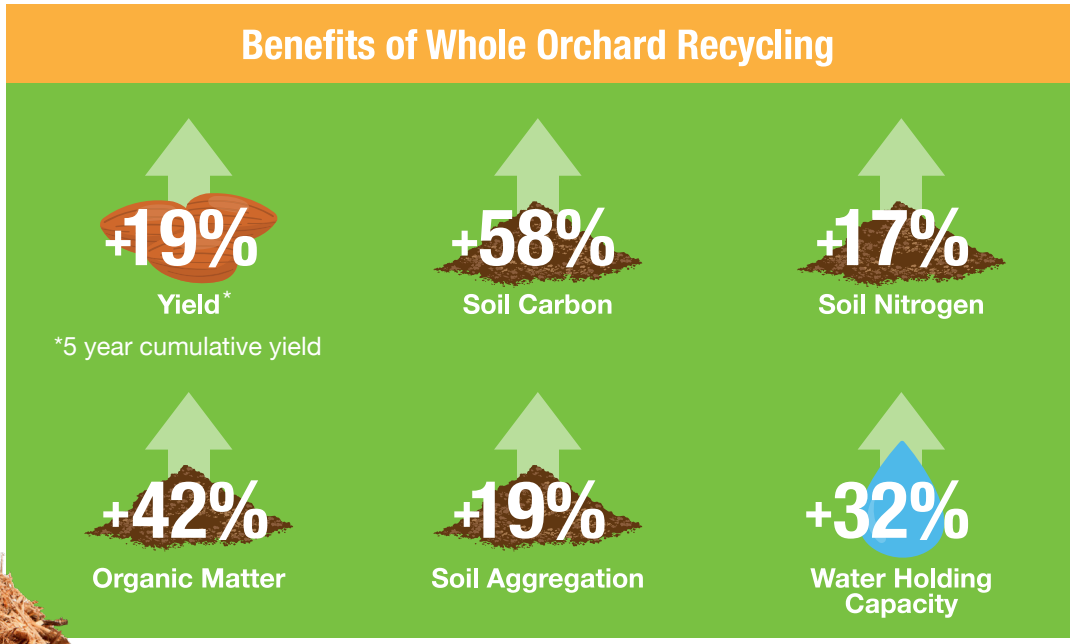
Putting the woody biomass into the ground helps to extend the carbon that has been sequestered in the growing trees for a longer period of time. The Almond Board of California hopes this ecosystem service may be rewarded in developing carbon markets.

In addition, the UC researchers compared the impact of deficit irrigation (80% ET) between the WOR and burn treatments in one season, and found that the WOR treatment plots still yielded more than the burn treatment plots. The midday stem water potential – a direct measurement of water tension within the tree – was on average 13% lower in the deficit-irrigated WOR treatment trees compared to the midday stem water potential of the deficit-irrigated burn treatment trees, indicating less tree stress in the plots where WOR occurred.

Trees seem to experience less stress in soils that have significantly higher levels of soil organic matter – WOR is a practice that significantly increases soil organic matter. Increased organic matter enhances water holding capacity, which increases moisture availability for tree roots in the upper layers of the soil. Trees planted in WOR blocks appear to be more buffered from water stress.

"Our soils in the San Joaquin Valley typically only average one percent organic material or less. Whole Orchard Recycling is a once-in-25-year opportunity to add organic material to your soil."
— Brent Holtz

The gains realized in the WOR study are considered positive indicators of improved soil health. Healthy soils help cycle and store nutrients, provide stability and support for plant roots, filter and buffer potential pollutants and regulate water infiltration and storage.



In the UC's first orchard grinding trial, where the previous orchard was stone fruit, 30 tons per acre of woody biomass was incorporated into Hanford Sandy Loam. Almond trees were replanted in the same tree sites and obtained the adjacent benefits.

STEPS TO IMPLEMENT WHOLE ORCHARD RECYCLING: From End of Productive Orchard Life to Replant

STEP 1

Excavating: Remove as much of the tree as possible, including roots and crown.

STEP 2

Grinding: Trees are carried to a stationary horizontal grinder with a front-in loader and ground into wood chips using screens that are either two inches (recommended) or four inches to limit the chip size.

Note: There is some evidence that pathogens, such as *Ganoderma*, a wood decay pathogen, or *Armillaria*, the oak root rot pathogen, do not survive well after being chipped into smaller sizes.

STEP 3

Spreading: Wood chips are loaded into modified compost spreaders and spread on the orchard floor.

STEP 4

Ripping: A deep rip (5-6 feet deep) is performed to break up soil compaction layers, hard pans or to pull up large roots.

STEP 5

Incorporating: Stubble disks, plowing or roto-tilling is needed to smooth out ruts created by the ripper and to incorporate wood chips into the soil.

STEP 6

Fumigating: The wood chips are generally incorporated in the top 6 inches of soil and the fumigant is injected at depths between 18 and 24 inches.

Determine Your Timing

After fumigation, the orchard floor is typically prepared for replanting by disking, leveling and berm building, while a new irrigation system is installed. It is strongly suggested that growers take a year off between taking out an orchard and replanting – trying to accomplish all the required steps in a few short months is very difficult and stressful. Fortunately, with potted trees, growers have more flexibility and can replant in the late summer or fall, if desired.

STEP 7

Replanting: Disking, leveling, building berms, installing irrigation systems and planting are the same as in conventional orchards.

STEP 1: Excavating
Old almond trees are removed and prepared to be sent through the grinder.

STEP 2: Grinding
Full almond trees are ground up with a horizontal grinder.

STEP 3: Spreading
Front loader dumps wood chips into a spreader.

STEP 3: Spreading
Wood chips are spread evenly.

STEP 4: Ripping
Deep rip to break up the soil and optimize WOR conditions.

STEP 5: Incorporating
Work the wood chips into the soil.

STEP 6: Fumigating (if needed)
Inject fumigant about 18-24 inches into the soil.

STEP 7: Replanting
Growers are encouraged to take a year off between removal and replanting.

All photos on this page are courtesy of Brent Holtz

ORCHARD MANAGEMENT: NITROGEN RECOMMENDATIONS

In WOR test sites, research has shown the need for supplemental nitrogen fertilization in the first year after planting. Current UC recommendations for the first growing season are to apply 25-35 lbs. of nitrogen per acre for ideal growth rates for young trees. However, when WOR is performed, 40-60 tons per acre of wood chips that contain 20-30 tons per acre of organic carbon are incorporated into the soil. Based on recent research, growers are encouraged to increase their nitrogen applications after WOR in only the first year of their replanted orchard. In the second and following years, nitrogen applications should return to standard nitrogen recommendations.

Rate: Research is ongoing but at this time 5-8 oz. nitrogen per tree after WOR is recommended in the first year. Recommended rates vary depending on the fertilizer application method. Nutrient uptake of fertilizers applied via a double-line drip system is less efficient than granular fertilzers ringed around individual trees in the first year, when trees and roots are small. A recent study found no additional growth benefit with applications exceeding 9 oz. nitrogen per tree in the first year after WOR.[3] The recommendation to apply 5-8 ounces of nitrogen is more than the 3 ounces of nitrogen per tree that is recommended for first-leaf, conventionally planted trees.[4] Trunk growth data indicates that trees planted after WOR reach the same size as conventionally planted trees by the end of the second season. Second-year trees replanted after WOR can be fertilized with the standard 4 oz. of nitrogen per tree – no more than 6 oz. is suggested.

Timing: Nitrogen applications at planting and immediately following, in small frequent doses, have achieved the most growth after WOR. Newly recycled and replanted orchards have a high soil carbon (C) to nitrogen ratio, which immobilizes available nitrogen from trees. As a result, one quarter oz. nitrogen, in the form of triple 15, applied at planting time and every two weeks with each irrigation, resulted in significantly larger tree circumference following WOR when compared to conventionally planted trees.[5] No more than 1 oz. nitrogen per tree should be applied in any single application during the first season.

TABLE 1

Nitrogen fertility recommendations for the first two seasons after conventional planting and WOR replanting.

	First Leaf	Second Leaf
	Ounces of Nitrogen per Tree	
Conventional Planting	3	4
WOR Replant	5-8	4-6

A first leaf almond tree growing in a control row without wood chips. *Photo courtesy of Brent Holtz*

A first leaf almond tree growing in a recycled row with wood chips on the soil surface. *Photo courtesy of Brent Holtz*

PREPARING FOR YOUR FIRST HARVEST

Wood chips don't have to be completely incorporated or decomposed in the first year – growers have three years before the first harvest of their second-generation orchard. A rototiller with a roller has been used successfully to further incorporate wood chips and smooth the orchard floor after replanting. Nut harvest samples collected from bank out wagons found very few wood chips when growers used a Northwest Tiller to incorporate wood chips and smooth the orchard floor before their first harvest.

OFFSET COSTS OF WOR

Growers may have access to incentive funding programs to help offset the cost of WOR. With recognition of the wide-ranging environmental benefits associated with WOR, such as improved soil structure, increased water use efficiency and carbon sequestration, federal, state and regional agencies have created grant funding for growers to implement this practice.

There are also efforts underway to develop private ecosystem service markets for carbon sequestration or water conservation practices, as food companies realize they cannot meet their goal without the help of growers.

Available Incentives: Almonds.com/Grants

FUTURE RESEARCH

In addition to the WOR trial site established in 2009 at the Kearney Research and Extension Center, WOR trials were established in private orchards in Kern, San Joaquin and Fresno counties in 2016, 2017 and 2018. These trials are testing the effects of WOR in different soils and studying the impacts to soil health, greenhouse gas emissions and tree growth in orchards where WOR is used versus exporting whole biomass from the field.

Continued research also seeks to better understand nitrogen use efficiency, while also monitoring nitrous oxide and carbon dioxide emissions, soil carbon and nitrogen dynamics, and soil health indicators in the years following WOR.

More information about continued research and the benefits of WOR is available from UC Davis at **OrchardRecycling.UCDavis.edu.**

ADDITIONAL RESOURCES

Visit **Almonds.com/IndustryNews** to stay up-to-date on ABC-funded research and continued research findings related to WOR.

Visit **Almonds.com/Grants** for an overview of available incentives to assist growers with Whole Orchard Recycling.

Visit **orchardrecycling.sf.ucdavis.edu/** for additional tools and resources, frequently asked questions, a cost-benefit guide and more when using WOR.

Increasing numbers of orchard removal companies in California are offering WOR services. Visit **orchardrecycling.sf.ucdavis.edu/california-orchard-recycling-resources** for a list of service providers.

References

[1] Holtz, B., Browne, G. T., Doll, D., Culumber, C. M., Yaghmour, M. A., Jahanzad, E., Lampinen, B. and Gaudin, A. 2018. Whole almond orchard recycling and the effect on second generation tree growth, yield, light interception, and soil fertility. Acta Hortic. 1219, 265-272
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[2] Jahanzad, E., Holtz, B. A., Zuber, C. A., Doll, D., Brewer, K. M., Hogan, S., and Gaudin, A. 2020. Orchard recycling improves climate change adaptation and mitigation potential of almond production systems. PLOS ONE 15 (3), e0229588

[3] Holtz, B. and Culumber, C. M. 2019. “2019 Nitrogen Considerations”. West Coast Nut, February, 2019, 14-18.

[4] Brown, P. H., Saa, S., Muhammad, S., and Khalsa, S. D. 2020. Nitrogen Best Management Practices. Almond Board of California

[5] Holtz, B., Culumber, C. M., Zuber, C., Browne, G. T., 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, 2020, 20-26.

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