



## California Bioresources Economy Summit

### Session 4: Learning from Biomass Supply Chains

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# Scope of the California Almond Industry

1.07 million bearing acres spanning 500 miles (804 km), farmgate value \$5.6 B

6,800 growers, 101 handler/processors

2018 crop forecast at 2.45 billion pounds, up 7.9%

97,000 jobs in the Central Valley; 104,000 statewide

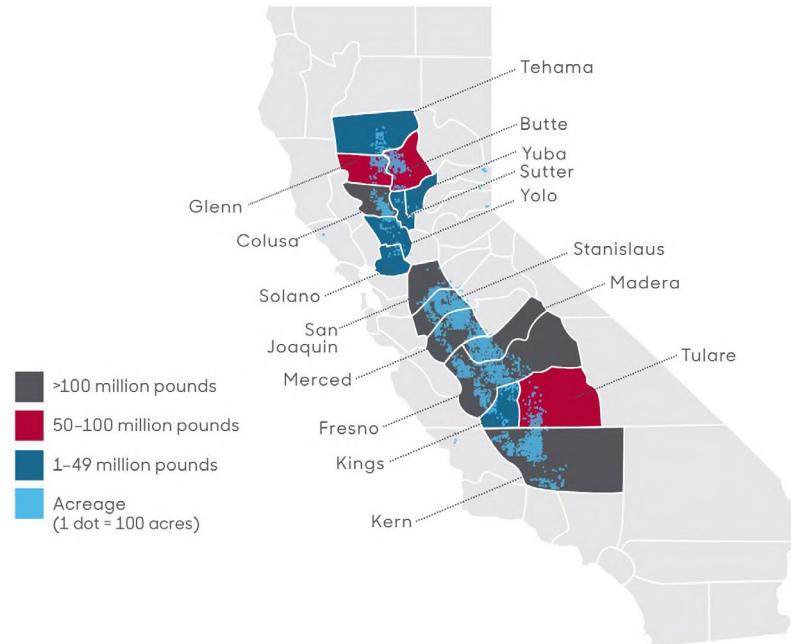
\$11 billion contribution to state GDP

## Production

- 100% of U.S. production
- 68% export; 32% domestic
- 80% of worldwide production

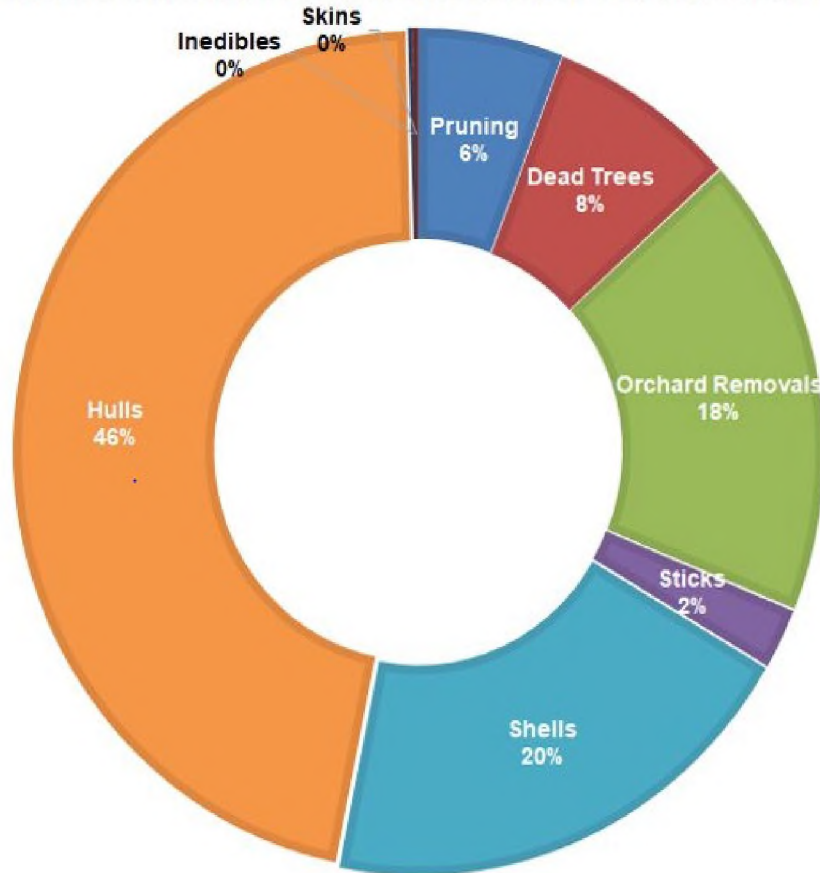
## Exports by value

- Top California agricultural export
- Top U.S. specialty crop export



Sources:  
USDA National Agricultural Statistics Service, Pacific Region (NASS/PR)  
U.S. Department of Commerce, Foreign Trade Statistics  
Economic Impacts of the California Almond Industry, UC Ag Issues Center, 2014

## 2018 CALIFORNIA ALMOND BIOMASS ESTIMATION (3.4 MIL. MT, DM)





REDUCE THE AMOUNT OF  
WATER USED TO GROW A  
POUND OF ALMONDS BY 20%



REDUCE DUST DURING ALMOND  
HARVEST BY 50%



INCREASE ADOPTION OF  
ENVIRONMENTALLY FRIENDLY  
PEST MANAGEMENT TOOLS BY  
25%



ACHIEVE ZERO WASTE  
IN OUR ORCHARDS BY PUTTING  
EVERYTHING WE GROW TO  
OPTIMAL USE



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# Current Options Versus Future Solutions for Almond Biomass

## Current Options

- Dairy Feed Supplement (6 to 12% substitution rate)

- Co-gen plant
- Orchard recycling
- Open burning
- Pile up
- Dairy ranch bedding
- Wood chip mulching
- Give away

2018 Almond Biomass Estimation (MT DM)



## Future Solutions

- Increased substitution rate
- Expanded market for dairy feed
- Feed for poultry industry
- High protein feed conversion by insects and yeasts
- Food grade applications
- Soil solarization
- Orchard recycling
- Torrefied materials for plastic applications, energy briquette
- Thermochemical conversion for energy, biochar, and activated carbon
- Absorbents and soil amendment
- Controlled burning

# Almond Biomass – LOTS of work needed to minimize waste and add value !!

19 projects funded to date:  
Hulls (8), shells (4), woody (2)  
General (5)...more to come!

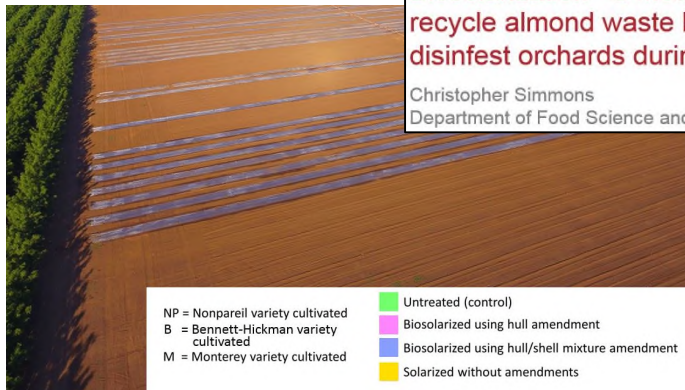
## BLOG

Blog » About the Almond Board » Article

### Whole Orchard Recycling Could Benefit Soil Quality and Provide Additional Carbon Sequestration

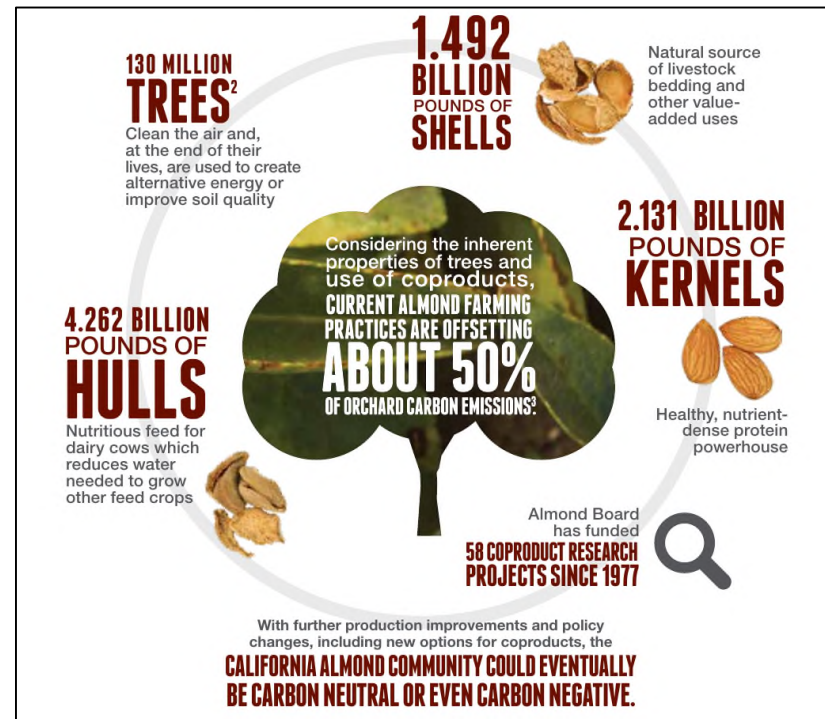
**Biosolarization - a method to recycle almond waste biomass and disinfest orchards during replant**

Christopher Simmons  
Department of Food Science and Technology, UC Davis

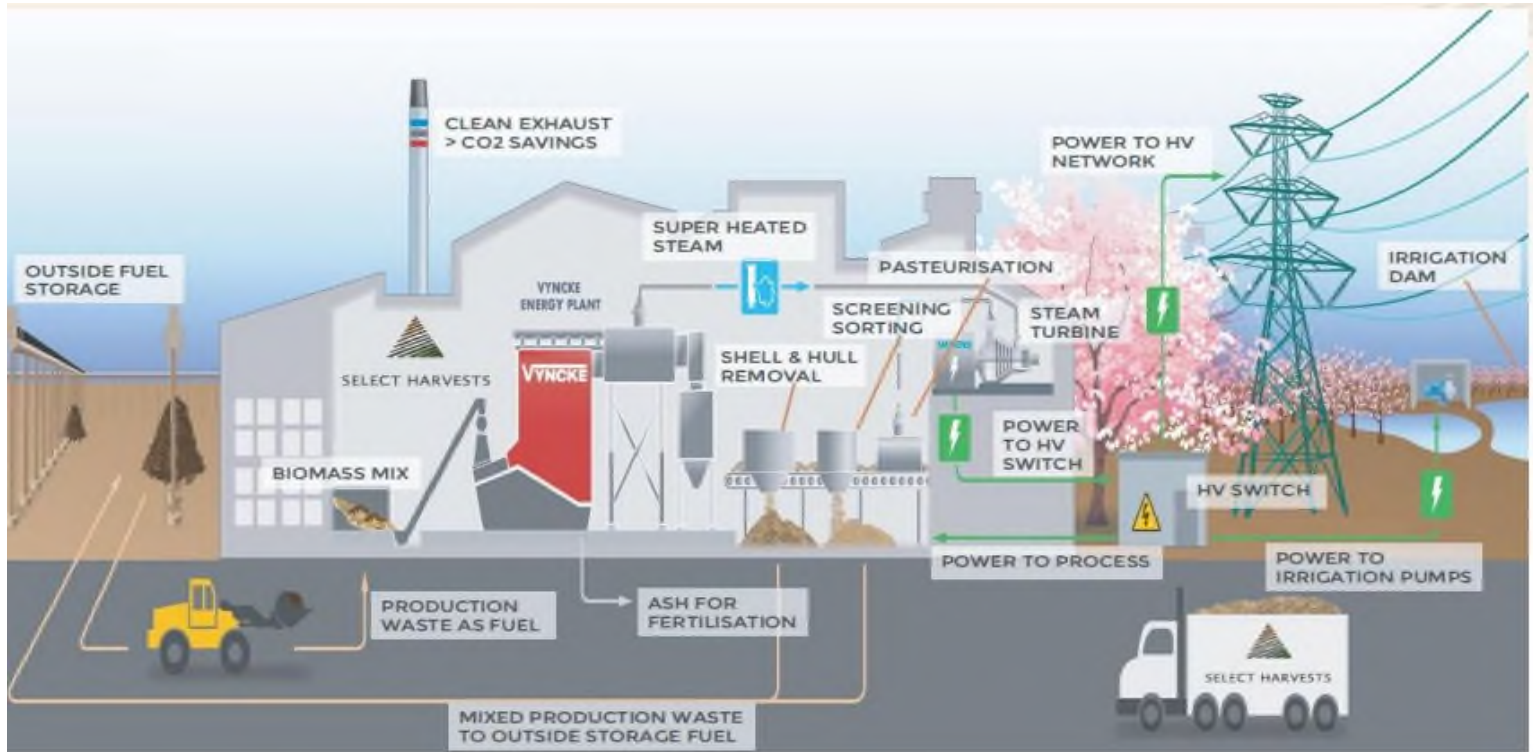


NP = Nonpareil variety cultivated  
B = Bennett-Hickman variety cultivated  
M = Monterey variety cultivated

Untreated (control)  
Biosolarized using hull amendment  
Biosolarized using hull/shell mixture amendment  
Solarized without amendments



# Australian Almond Industry also addressing biomass holistically





# CASE STUDY : From Almond Shells to Plastic Products – challenges to scale up research!!



Shells from Huller/Sheller

Grind or No Grind

Torrefaction

No commercial operations to torrefy agriculture waste in California. Only testing facilities offer torrefaction services.

Fine Grinding

Need to grind to fine particles (<100 microns) for better bonding with plastics, some facilities offer grinding services

Plastic Compounding

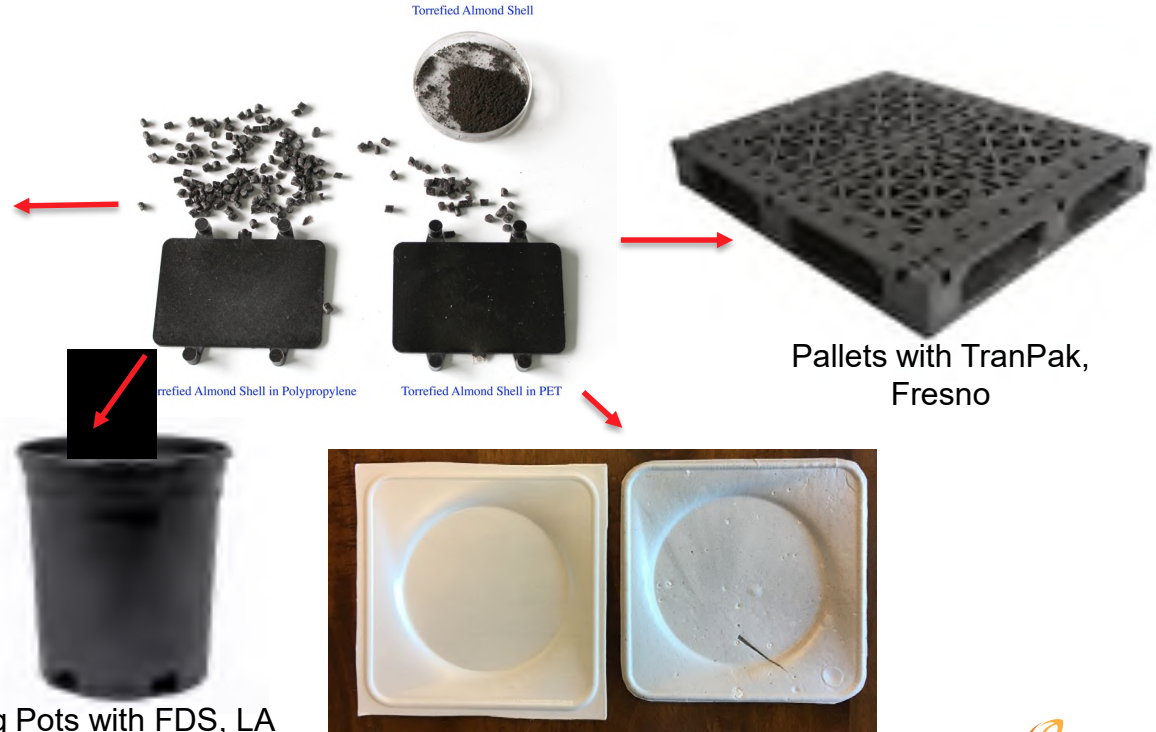
Hard to mix torrefied shell powder with plastics in a single step to make final products, need to make composite pellets first. Decking lumber may be made from unground torrefied shells directly as its line has good mix with fine woody particles

Pallet or Slipsheet or Decking Companies

Torrefied shells have potentials for many non-food contact plastic products

# Potential Applications of Torrefied Shells Being Explored

- Torrefied shells may be used as plastic filler and enhancer, black carbon replacer for recycled plastics



# Torrefaction Process Parameters for Modeling

<b>Temperature</b>	(°C)	<b>250</b>
<b>Duration</b>	(min)	<b>30</b>
<b>Torrefaction yield of solid</b>	(%)	<b>50%</b>
<b>Torrefaction yield of vapor</b>	(%)	<b>50%</b>
Energy density before	(MJ/kg)	19
Energy density after	(MJ/kg)	25
Nitrogen purge before reaction	(min)	20
Average density of shells, at 20 °C, 1 atm	(kg/m <sup>3</sup> )	0.20
Density of milled shells/hulls, at 20 °C, 1 atm	(kg/m <sup>3</sup> )	0.43

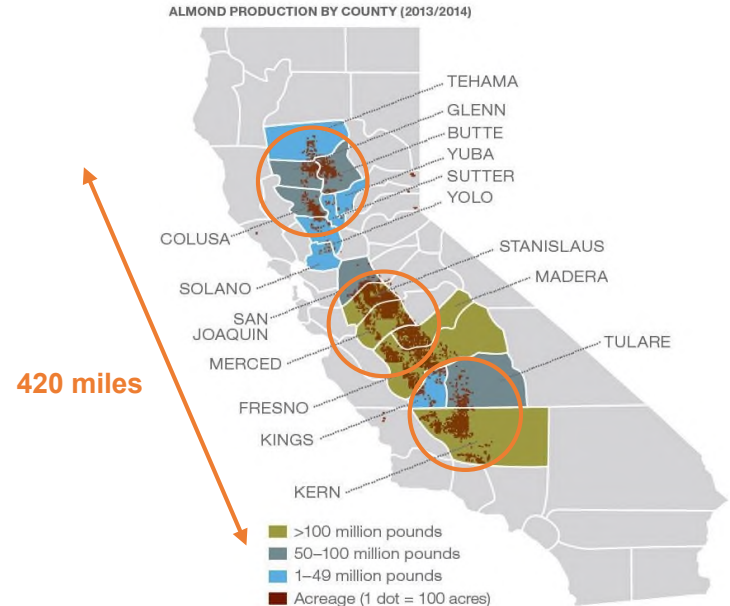
- Torrefaction of biomass involves heating between 200 ~ 300 °C for 1 hour or less. This removes most moisture and volatile components to produce a fuel comparable to low-rank coal.
- Biomass after torrefaction can be used as a filler in polymer composites
- According to USDA report, the filler concentrations were 5, 10, and 20% (w/w). The filler sizes were 163, 854, and 1545  $\mu\text{m}$ .



# Technoeconomic Modelling Options: Satellite Processing Centers

- In total **3 satellite centers** (northern, central valley, southern) could process the whole industry's 520,000 metric ton almond shells. The annual production is projected to increase.
- Feedstock is assumed to be delivered to the satellite storage near the plant, each storage/plant represents a **70-mile** feedstock collection radius. Assuming 100% of the feedstock within that radius was available to the plant. The satellite plant size in present design is: 200,000 dry metric ton/year, (606 metric ton/day). With 12-months operation per year (24 hour/day).

Category	Unit	Whole industry	Satellite process center
Yearly	(MT/yr)	520,000	200,000
Yearly	(lb/yr)	1,146,392,000	440,920,000
Daily	(MT/day)	5,778	606
Daily	(lb/day)	12,737,689	1,336,121
Hourly	(MT/h)	722	25
Hourly	(lb/h)	1,592,211	55,671
Farm land coverage	(acre)	1,330,000	200,000



## A NEW GREAT OPPORTUNITY! Trex is Interested in Using Almond Shells and Torrefied Shells in Their Decking and Fence Product Lines

- Trex is the world #1 decking brand and the inventor of alternative composite decking
- Using 50% woody materials and 50% plastics in their composite products
- Tested almond tree wood in their Oregon plant
- ABC staff convinced them to try almond shells for woody materials and torrefied shells to replace a portion of plastic
- They engaged with USDA Albany team for an agreement to generate 1200lbs of torrefied almond shells to run trials in their products ...
- GOV'T SHUTDOWN has slowed down progress.....



## In Summary:

- CA almond industry is committed to finding higher value uses for almond biomass, for both economic and environmental reasons
- ABC is exploring a range of scalable technologies and interested to find more applied research partners. Technoeconomic analysis will be conducted to determine upscaling versus downscaling options
- CA agriculture and the almond industry specifically needs straight forward techniques to help determine which technologies will meet air quality requirements, especially for the San Joaquin Valley
- The carbon market is one example of how farmers can be economically rewarded for ecosystem services. ARB should carefully assess how such market mechanisms could help encourage the use of bio-based products that improve air quality in central California