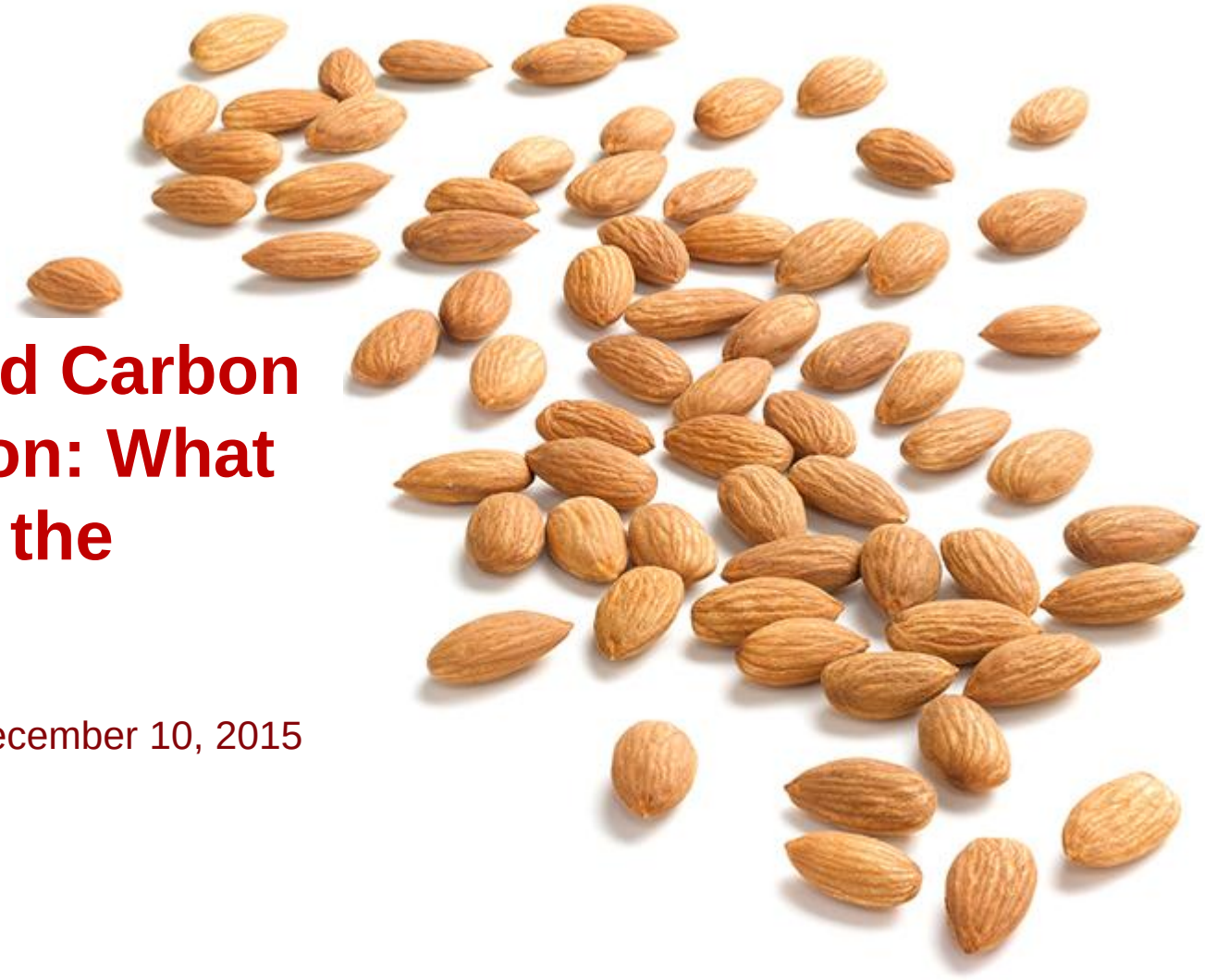

Almonds and Carbon Sequestration: What it Means for the Future

December 10, 2015

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The Almond Conference

Gabriele Ludwig, Almond Board

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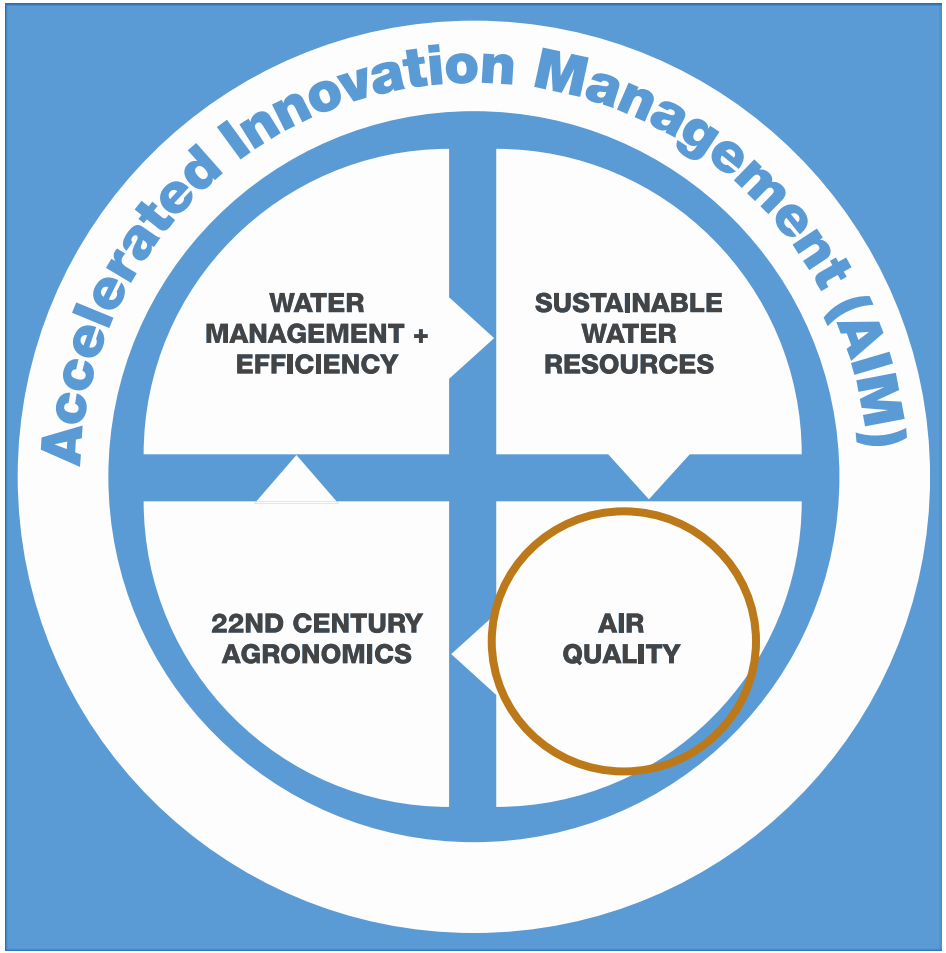
Accelerated Innovation Management (AIM)
WATER MANAGEMENT + EFFICIENCY
SUSTAINABLE WATER RESOURCES
22ND CENTURY AGRONOMICS
AIR QUALITY

Speakers

Gabriele Ludwig, Almond Board (Moderator)

Alissa Kendall, UC Davis

Sara Kroopf, Environmental Defense Fund

Alissa Kendall,
University of California, Davis

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Almonds and Carbon Sequestration: What It Means for the Future

Alissa Kendall, UC Davis (amkendall@ucdavis.edu)

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A Life Cycle Assessment (LCA) Perspective

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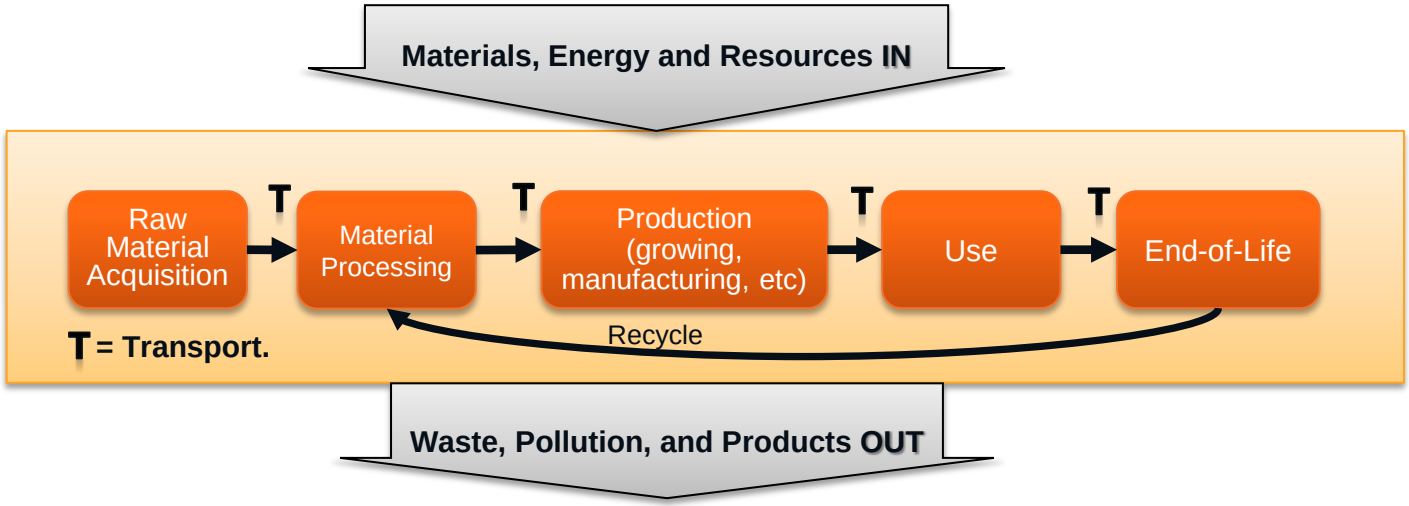
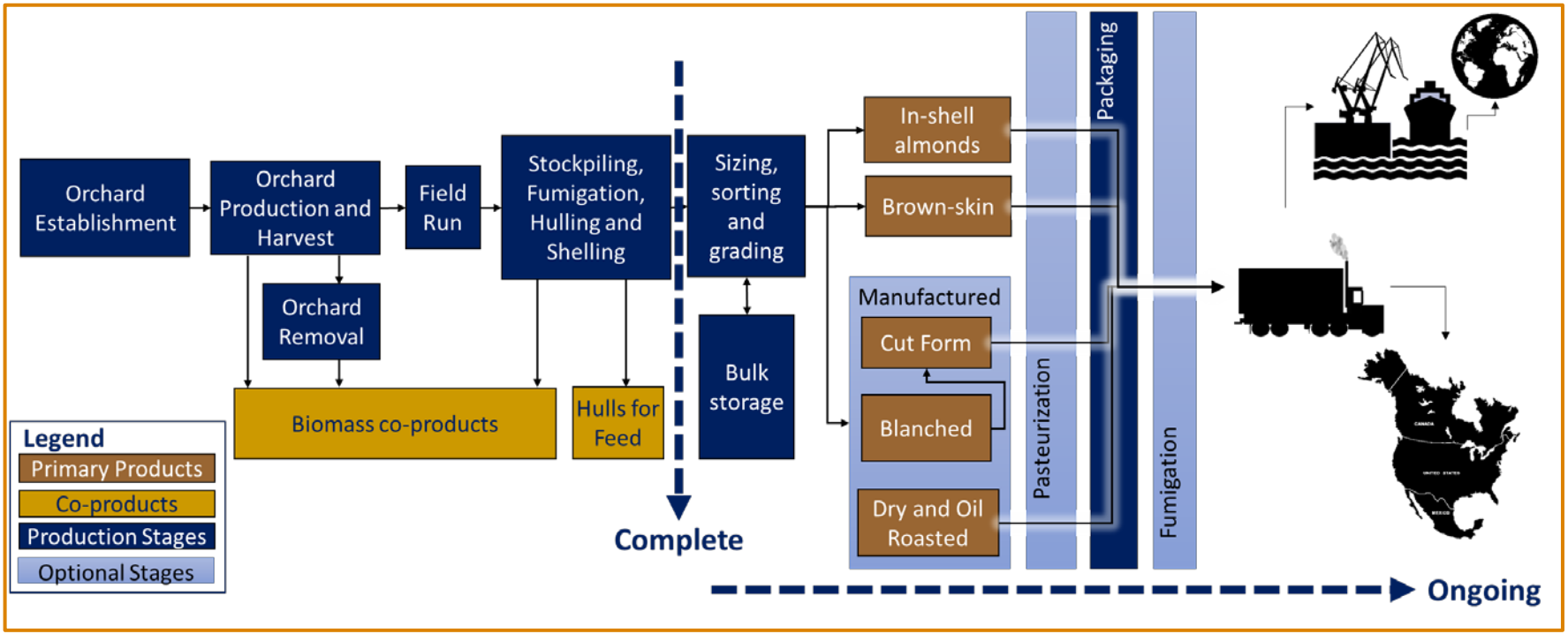
Life Cycle Assessment (LCA)

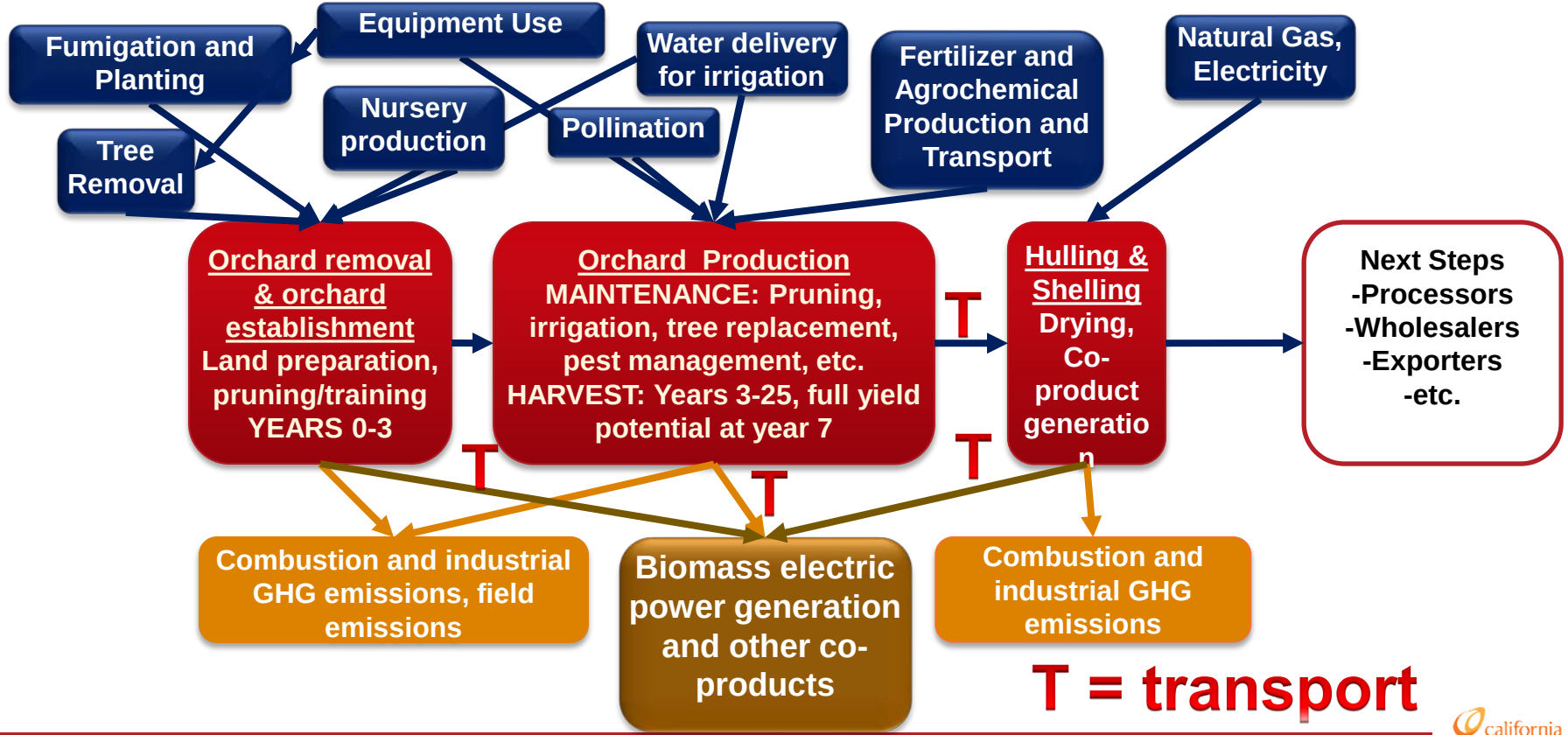
- A method for characterizing, quantifying, and interpreting environmental flows for a product or service from a “cradle-to-grave” perspective. The goal is to understand system-wide effects.
- In our study we examine energy, greenhouse gas emissions, criteria pollutants, and direct water use.



Scope of our LCA study: Nursery (“Cradle”) to First Port of Entry

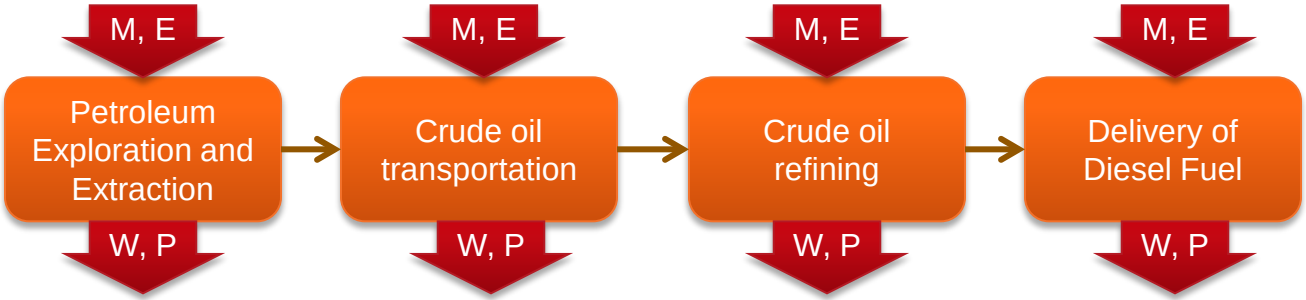


Scope of Completed Analysis: Processes included



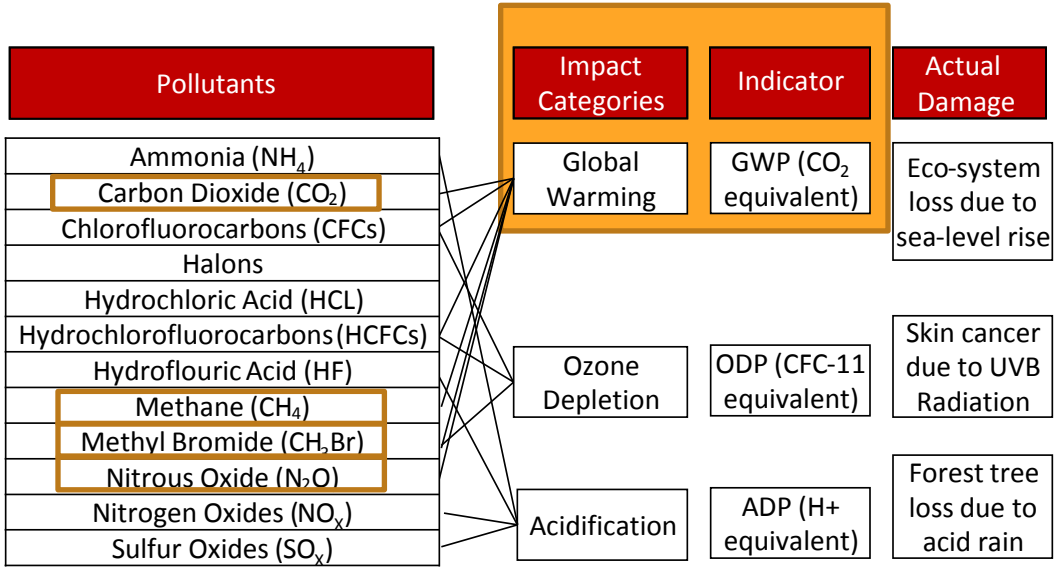
The Life Cycles of Inputs are Modeled too

- Life cycle inventory datasets are required for each material or process included in the LCA
- The inventory datasets reflect the life cycle of each component material or process, for example:
  - Assuming diesel fuel is part of the life cycle, the diesel LCI dataset would reflect the following
  - This means we always examine energy starting at the original resource…we track all the energy it takes to make the energy we consume

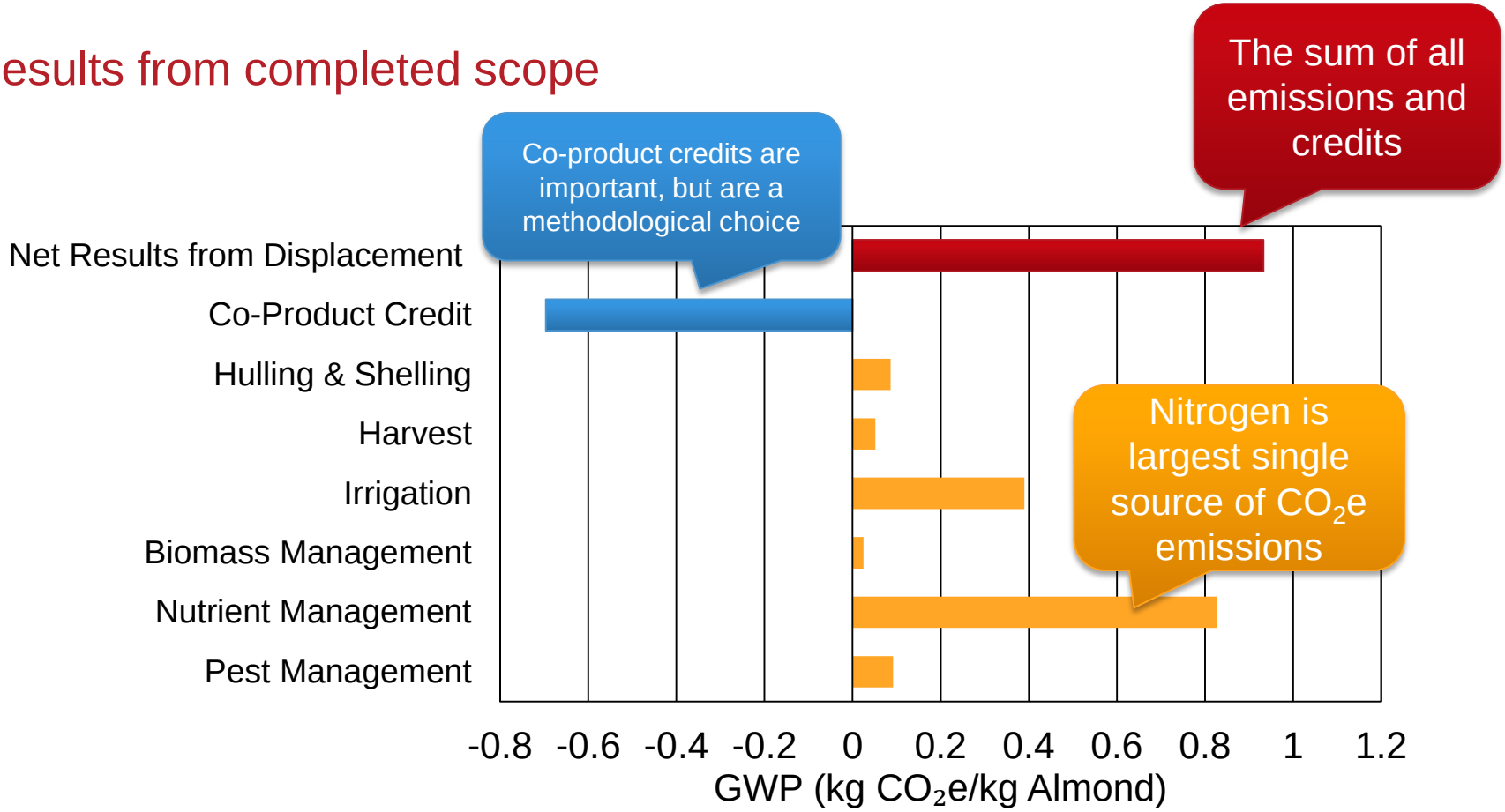


LCA, Life cycle greenhouse gas (GHG) assessment, or Carbon Footprint?

- A traditional LCA considers a whole range of environmental impact categories.
- *A carbon footprint*, only considers the GHGs
- Carbon Footprints and LCA use the same indicator – **CO_2-equivalent (CO_2e)** emissions – to condense all GHG emissions or credits into a single indicator



Results from completed scope

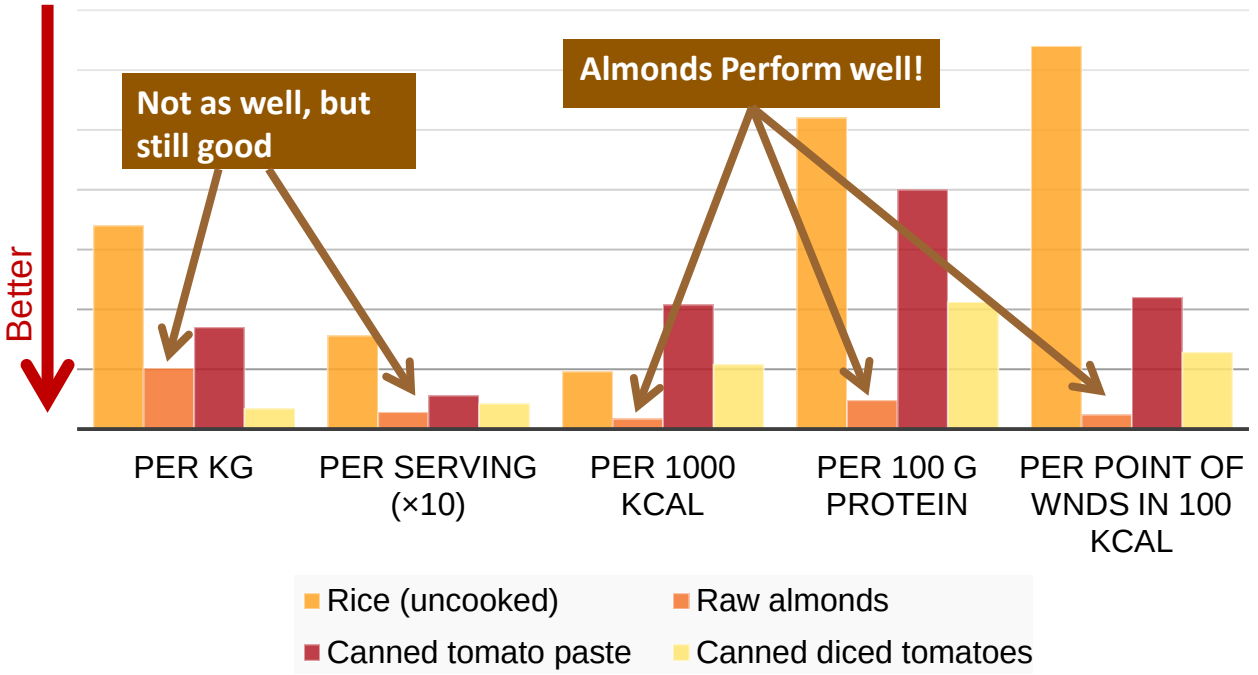


How do almonds compare to other foods?
GWP_{100} for four evaluated food products from California (uncooked)

Almonds

Rice

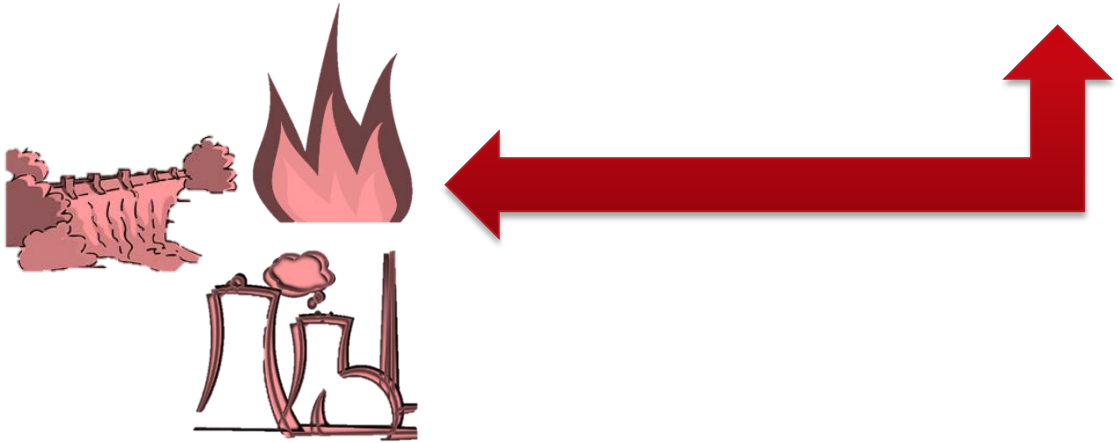
Processed tomatoes



WNDS = weighted nutrient density score

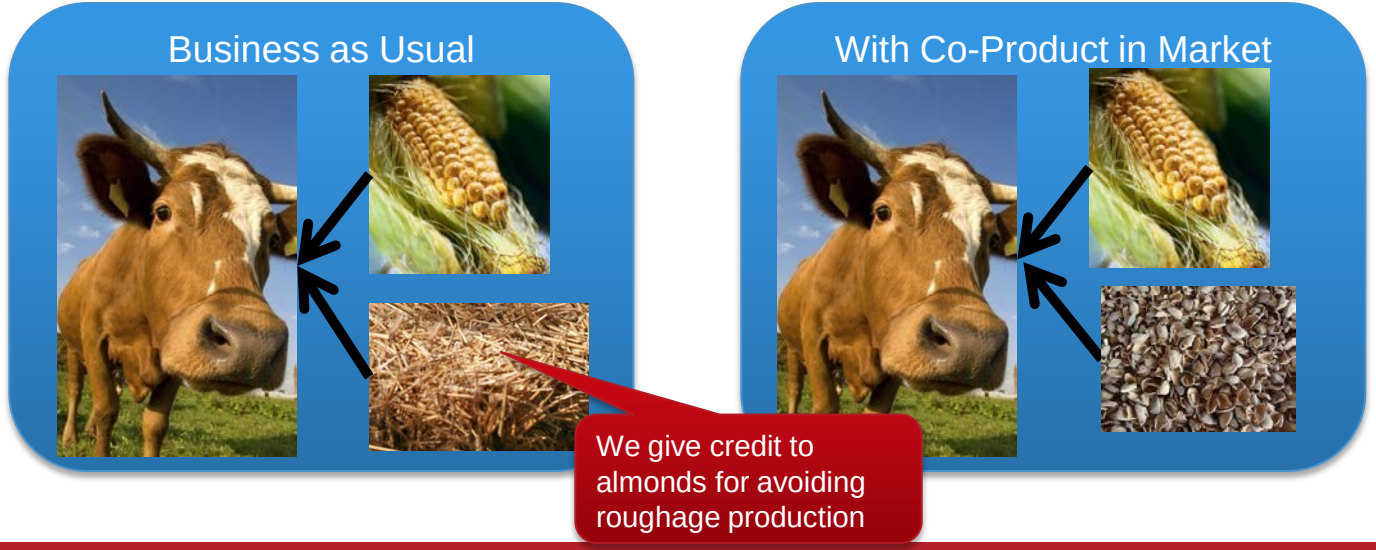
Co-Products: Biomass power from orchard waste ‘displaces’ the average kWh of grid electricity used in California

- Average California Electricity modeled as displaced by biopower electricity

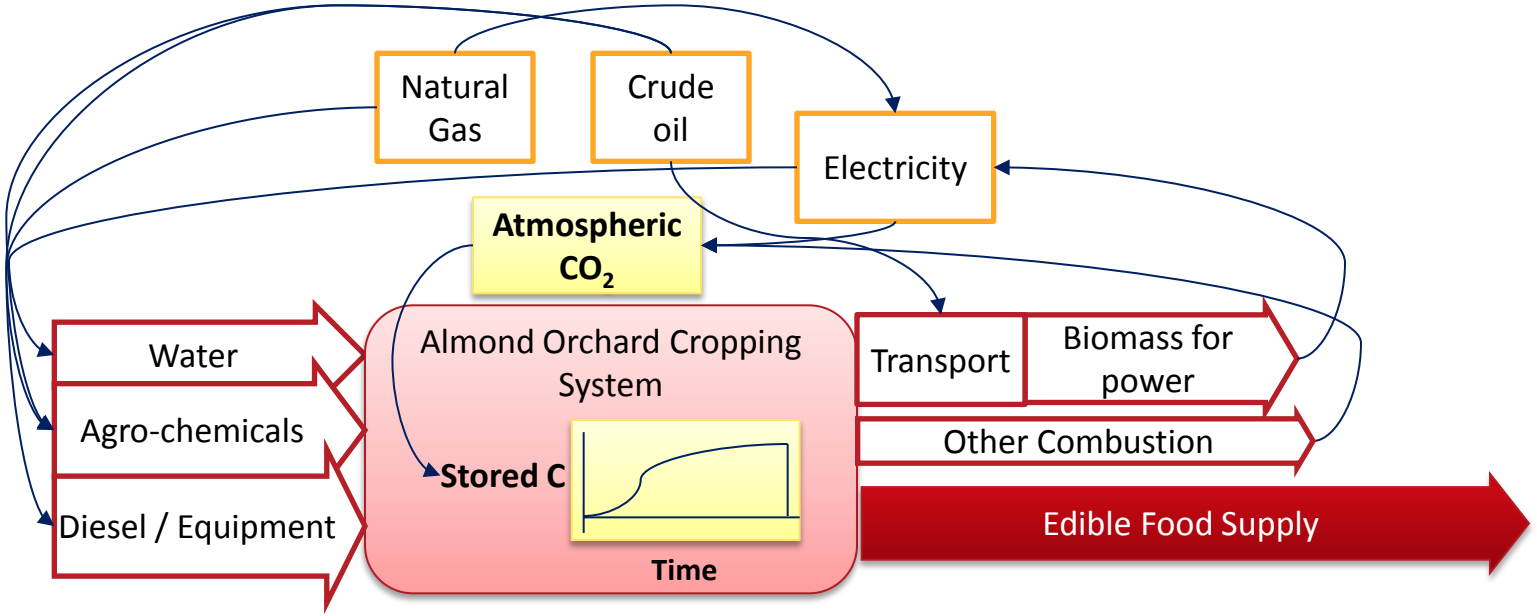


Co-Products: Almond hulls “displace” dairy ration components in California

- Since co-products have some value to them and displace some other product in the market, some “credit” to the primary product (almonds) should be assigned



Orchards fix CO_2 from the atmosphere in biomass and soils during their lifetime. But where was this in the results?



Global Warming Potentials

- Nearly all methods use the Intergovernmental Panel on Climate Change's (IPCC's) 100-year GWPs (GWP_{100}) to turn non-CO_2 gases into CO_2-equivalent (**CO_2e**)
- Sum CO_2e emissions over the entire life cycle of the product or system
- Ignore emissions after AT (almost always 100-years)

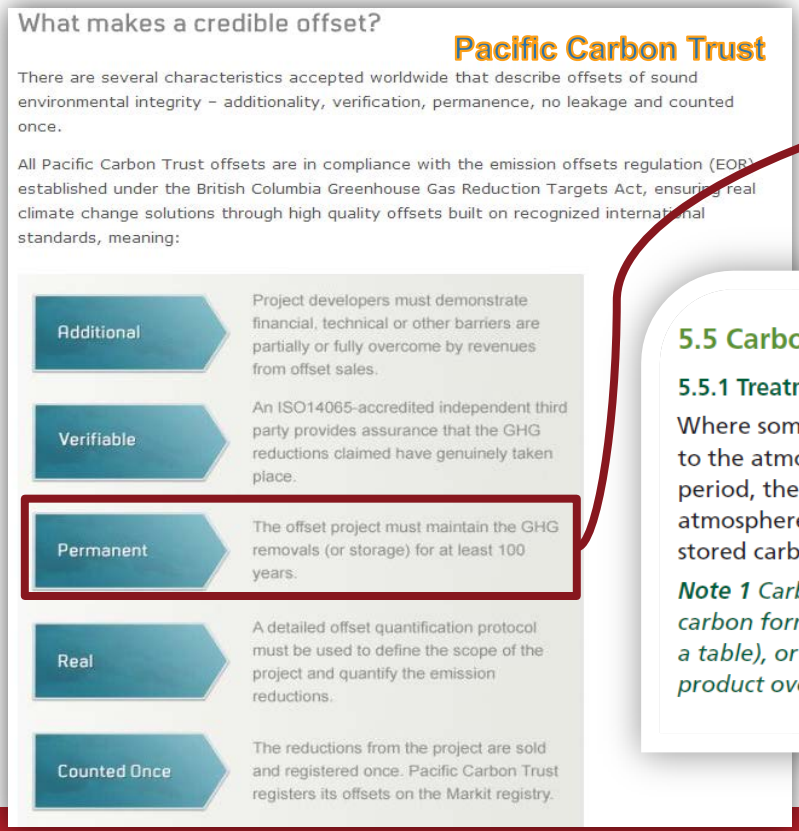
CO_2 x 1 = CO_2e
N_2O x 265 = CO_2e
CH_4 x 28 = CO_2e

Total heat trapped over a time period by a GHG "i"

$$GWP = \frac{\int_0^{AT} RF_i\,dt}{\int_0^{AT} RF_{CO_2}\,dt}$$

Total heat trapped over the same time period by CO_2

What are the rules for carbon storage in most sanctioned methods?



What makes a credible offset?

Pacific Carbon Trust

There are several characteristics accepted worldwide that describe offsets of sound environmental integrity – additionality, verification, permanence, no leakage and counted once.

All Pacific Carbon Trust offsets are in compliance with the emission offsets regulation (EOR) established under the British Columbia Greenhouse Gas Reduction Targets Act, ensuring real climate change solutions through high quality offsets built on recognized international standards, meaning:

Additional	Project developers must demonstrate financial, technical or other barriers are partially or fully overcome by revenues from offset sales.
Verifiable	An ISO14065-accredited independent third party provides assurance that the GHG reductions claimed have genuinely taken place.
Permanent	The offset project must maintain the GHG removals (or storage) for at least 100 years.
Real	A detailed offset quantification protocol must be used to define the scope of the project and quantify the emission reductions.
Counted Once	The reductions from the project are sold and registered once. Pacific Carbon Trust registers its offsets on the Markit registry.

PAS 2050:2011

5.5 Carbon storage in products

5.5.1 Treatment of stored carbon

Where some or all removed carbon will not be emitted to the atmosphere within the 100-year assessment period, the portion of carbon not emitted to the atmosphere during that period shall be treated as stored carbon.

Note 1 *Carbon storage might arise where biogenic carbon forms part or all of a product (e.g. wood fibre in a table), or where atmospheric carbon is taken up by a product over its life cycle (e.g. cement).*

- For carbon to be considered 'stored' or 'sequestered' it has to be removed from the atmosphere for **a minimum of 100 years**
- The PAS2050 standard, along with most other carbon accounting protocols use this rule
  - Though PAS2050 does acknowledge that carbon storage less than 100 years *could* be accounted for.

Alternative metrics/approaches for CO_2e factors that account for timing

- Time-adjusted warming potentials (TAWPs)
  - Yields units CO_2e equivalent 'today' for various analytical time horizons and GHGs
    - Kendall (2012) *International Journal of LCA*
- Time correction factors (TCFs) for amortized CO_2 emissions
  - Useful for emissions intensity estimates (e.g. gCO_2e/MJ, gCO_2e/mi, etc.)
    - Kendall et al. (2009), and Kendall and Price (2012) *Environmental Science & Technology*
- Note: There are other proposed metrics, many of which rely on similar underlying principles

Time Adjusted Warming Potential (TAWP)

Typical Carbon Accounting Methods

Does not allow for temporary Storage to be valued

$$GWP = \frac{\int_0^{AT} RF_i dt}{\int_0^{AT} RF_{CO_2} dt} = \frac{CRF_i}{CRF_{CO_2}}$$

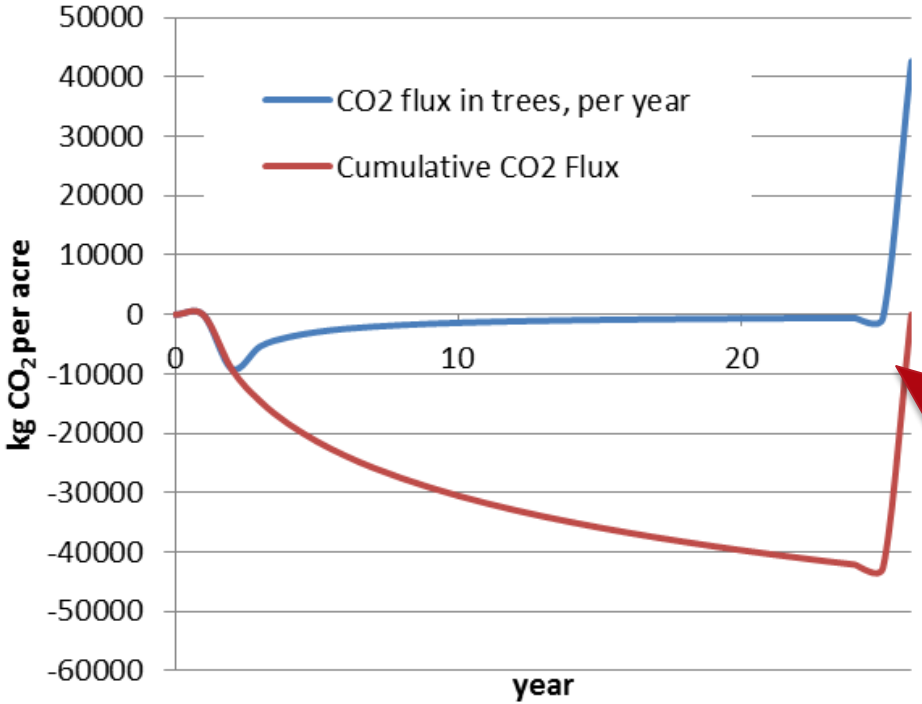
GHG flux occurring **y** years in the future

$$TAWP = \frac{\int_0^{AT-y} RF_i(t) dt}{\int_0^{AT} RF_{CO_2}(t) dt}$$

Alternative methods that can value temporary carbon storage

 Source: Kendall (2012)

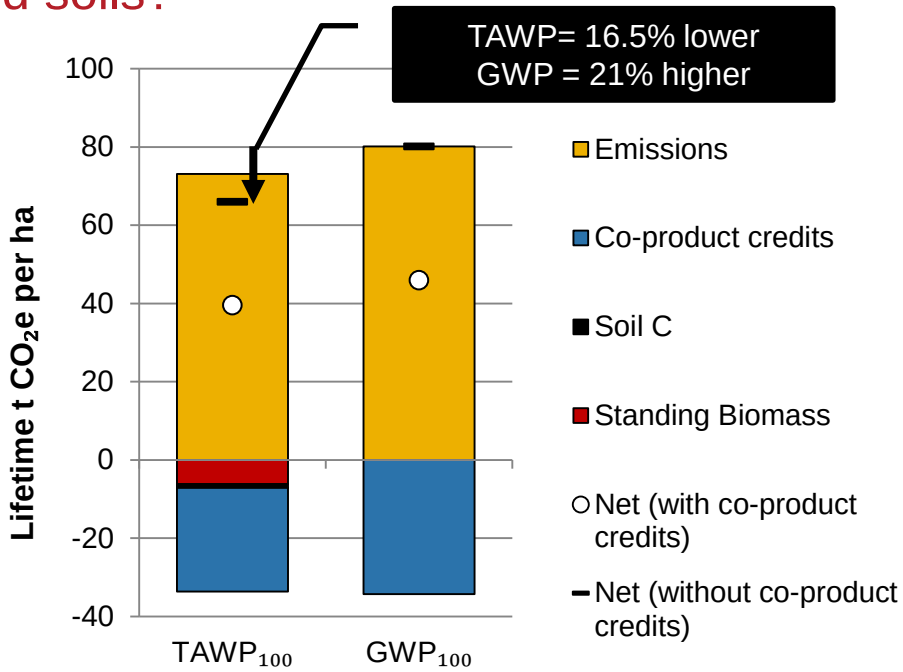
Carbon dioxide fixed/stored in above-ground orchard biomass



Carbon in trees is lost at the end of the orchard lifespan when removed trees are used in biomass power plants.

Though carbon is also stored in below ground biomass (not burned for power), no sequestration is included because of high uncertainty in values.

What happens when we account for temporary carbon storage in orchard trees and soils?



(1) If orchard lifetime was longer, storage credit would be bigger
(2) If carbon in removed trees was preserved, storage credit would be bigger, but co-product credit would be smaller

*Note, this reflects study up to hulling and shelling, but not processing and distribution

Conclusions

- Almonds perform well in terms of GWP compared to other foods *if* we compare them based on nutrient density or other metrics that better represent their value (i.e. not mass)
- LCA shows that fertilizer is an important source of emissions, along with irrigation. And co-products are important to account for because they may provide large credits when they are valued
- *If* we account for temporary carbon storage, the CO_2e emissions from almond orchards are reduce by about one fifth (~20%). If we can account for soil carbon changes this could be higher
  - *Current* standards for carbon accounting do not permit this

Sara Kroopf, Environmental Defense Fund

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Generating Carbon Credits from Nitrogen Fertilizer Optimization

December 10, 2015

Almond Board of California

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california almonds
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Optimizing Nitrogen Fertilizer Management in California Crops

Over the next three years, EDF will pilot a large-scale nitrogen management project with **annual and perennial crops** to demonstrate how soil health management systems and nitrogen management can be **integrated into carbon markets**.

What is the Environmental Defense Fund's history of working on credits from agriculture?

What is the Rice Protocol and why does it matter to almonds?

- Rice production emits methane, a potent greenhouse gas.
- In 2007, EDF began work with UC Davis and the California Rice Commission to identify practices that would reduce methane production from rice.
- With the support of a USDA-NRCS Conservation Innovation Grant, EDF and project partners developed a method for quantifying reductions in emissions from implementing any these practices on their fields.
- Growers interested in participating collected information to establish a baseline and then adopted any of the three approved practices.
- In June 2015, after a thorough three-year process, the California Air Resources Board approved their Rice Cultivation Compliance Offset Protocol, opening the door for all rice growers to generate revenue from creating credits.

Is there interest in credits from working lands?

- Through a pilot project, the first carbon credits from **reducing nitrogen fertilizer** use have already been generated by a farm in Michigan.
- More than **11 million metric tons of carbon credits** from forest owners have been approved for sale in California's cap-and-trade program.
- In 2014, Chevrolet purchased **40,000 tons** from ranchers in the Prairie Pothole region.
- Already 21 rice farmers on more than 22,000 acres (**almost 1% of all rice grown in the U.S.**) are participating in carbon offset projects.
- Market analysts predict that by 2030, the carbon market will be short between **30 to 350 million metric tons**.

What is a nitrogen fertilizer efficiency credit?

- A nitrogen fertilizer efficiency credit is a marketable commodity that represents the quantity of emissions reduced by changing nitrogen application practices.

- By applying nitrogen fertilizer more optimally, growers will reduce the amount of nitrous oxide emissions generated from their orchards.

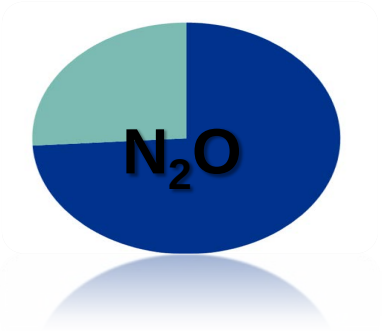
What is a protocol?

- There is a method or a ‘protocol’ based on studies of nitrogen applications that describes how to quantify the amount of nitrous oxide emissions reduced from a baseline.

- As part of our grants, we will adapt this ‘protocol’ to allow almond growers to quantify their emissions reductions on a yearly basis and qualify to generate nitrogen fertilizer efficiency credits.

Optimizing Nitrogen Fertilizer Management in California Crops

- According to EPA, **approximately 75%** of all U.S. nitrous oxide emissions is generated by agriculture.



- EDF is partnering with growers and the Almond Board of California to **identify** and **incentivize** activities that reduce nitrous oxide emissions and nitrate leaching.

Optimizing Nitrogen Fertilizer Management in California Crops

- In California, EDF and ABC will develop a ‘maximum mitigation potential’ map that geographically displays the best practices for different areas of California.

- We intend to pilot with 5-10 almond growers who are actively managing nitrogen applications and collecting information on irrigation management in areas with the greatest potential for mitigation.

- Recognizing the overlap in required data, project partners are involving the Irrigation Lands Regulatory Program water coalitions already collecting and aggregating data on nitrogen applications through Nutrient Management Plans (NMP).

Why generate credits?

- Growers are under increasing pressure to **minimize nitrogen losses** to air and water.
- **Optimizing nitrogen applications** can reduce nitrate leaching and nitrous oxide emissions.
- Companies are interested in **paying growers** for reducing nitrous oxide emissions.
- Reducing nitrogen losses will help reduce operational costs and maximize the nitrogen reaching the plant to ensure that growers **maintain or increase yields**.
- Credits are an **economic reward** for farmers who are implementing nitrogen management practices.

What are the benefits from creating nitrogen fertilizer efficiency credits?

Growers
• Earn revenue for optimizing nitrogen applications
• Maintain or increase yields
• Prove contribution to reducing nitrogen losses and avoid regulation

What are the approved practices to generate nitrogen fertilizer efficiency credits?

As part of our Specialty Crop Block Grant, we are finalizing the list of approved practices that reduce nitrous oxide emissions. While the best practices for any given orchard in any given year may vary, the practices will be based on the concept of Right Timing, Right Placement, Right Form, and Right Rate of nitrogen.

- Growers may choose to implement **one or more** of the approved practices, depending on specific farm conditions.
- Implementation of any practice is the decision of the grower.
- Growers may change which practices they implement each year.

What kind of data is needed to create credits?

Soil type
Field location (to collect location-specific weather data)
Lbs N per acre (includes synthetic and organic N)
Type of nitrogen stabilizer used (nitrification inhibitor, etc.)
Fertilizer application method (fertigation, etc.)
Irrigation events (places that supplement rain- date and amount of irrigation)
Yield (projection and actual)
Dates of applications of N and stabilizers
Harvesting dates per field
Tillage type and date

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