

Creating and Maintaining Biodiversity in Organic Perennial Systems

NRCS Science & Technology Training Library Webinar

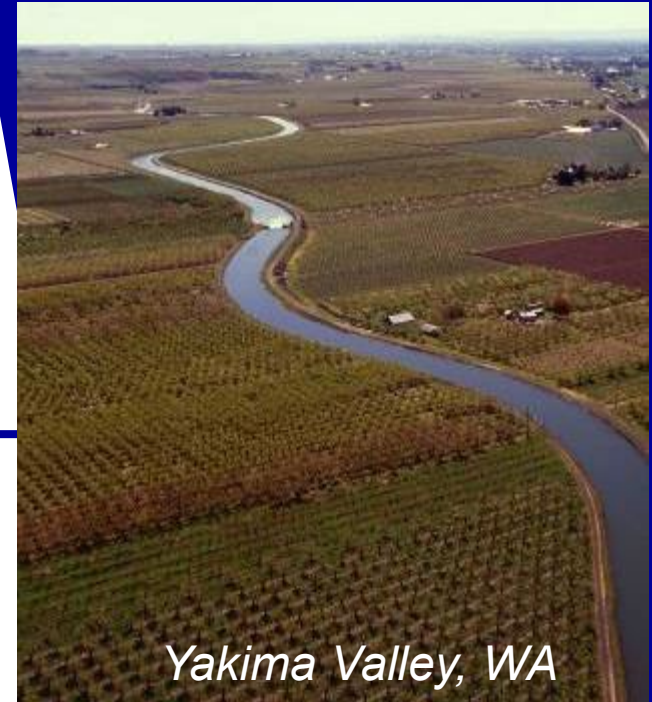
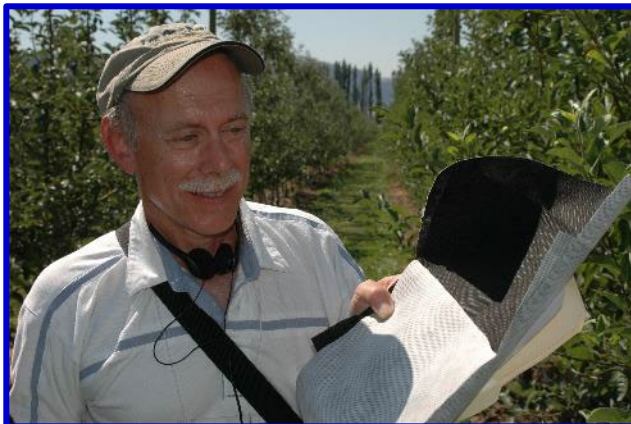
June 7, 2022

Presented in partnership with Oregon Tilth

Adding Biodiversity in Perennial Crops

David Granatstein

*WSU TFREC (retired)
Wenatchee, WA USA*

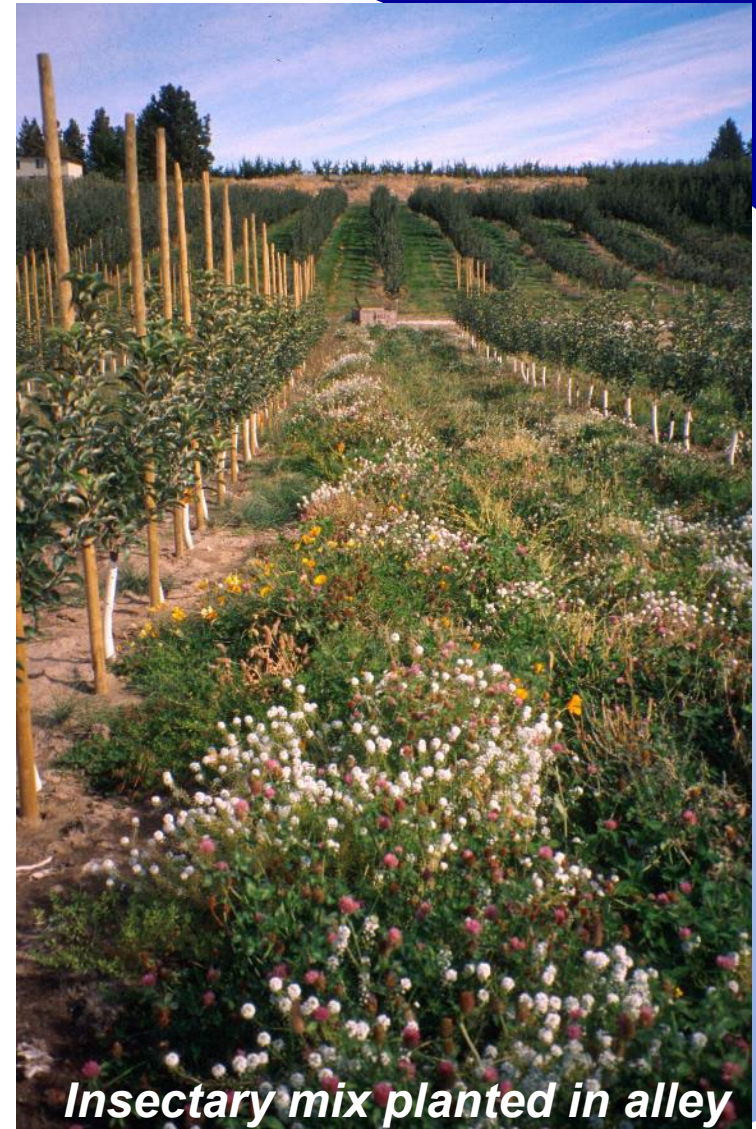


Yakima Valley, WA

NRCS Organic Webinar
June 7, 2022

Purpose of webinar:

Help answer the question “How do organic perennial crop producers introduce biodiversity, in lieu of crop rotation, in a practical manner?”



Insectary mix planted in alley

NOP Crop Rotation

Four functions

- Maintain/improve soil quality, organic matter
- Manage crop nutrients and soil fertility
- Prevent crop pests, weeds, diseases
- Provide erosion control

Perennial systems employ...such as **alley cropping**, **intercropping**, **hedgerows** to introduce biodiversity in lieu of crop rotation

NOP Natural Resource, Biodiversity Conservation

- Harder to define, no set benchmarks
- Site specific – starting point, improvement
- Trying new practices; they don't always work
- Use existing orchard features – trellis ends; pond borders; hedgerow for buffer zone

Biodiversity and Perennials

Potential benefits known for years

- pest, disease suppression; nutrient cycling; C sequester; weather/climate resilience

Few examples of widespread application

- shade grown coffee, cocoa
- Leucaena / maize alley crop (N fix, fodder, wood, grain)

Temperate zones – lack of research, need productive germplasm to make options economically competitive with annual crops

Existing high-value tree crops

- risk avoidance
- incompatible with fruit quality, machinery, pesticide use



Shade-grown coffee
(*Science Photo Library*)

Walnut-wheat alley crop
near Montpellier, France
(*Lovell et al., 2018*)



Redesign for Biodiversity: Strip Intercrop - Iowa

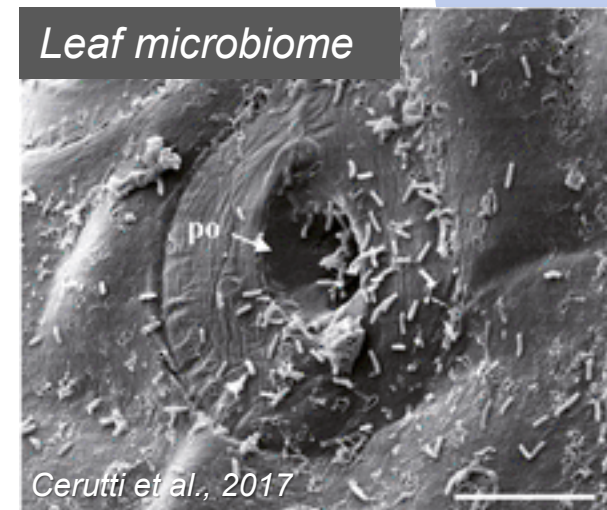


Barley, soybean and corn in a 15 ft strip intercrop system, NE Iowa

Different Kinds of Biodiversity

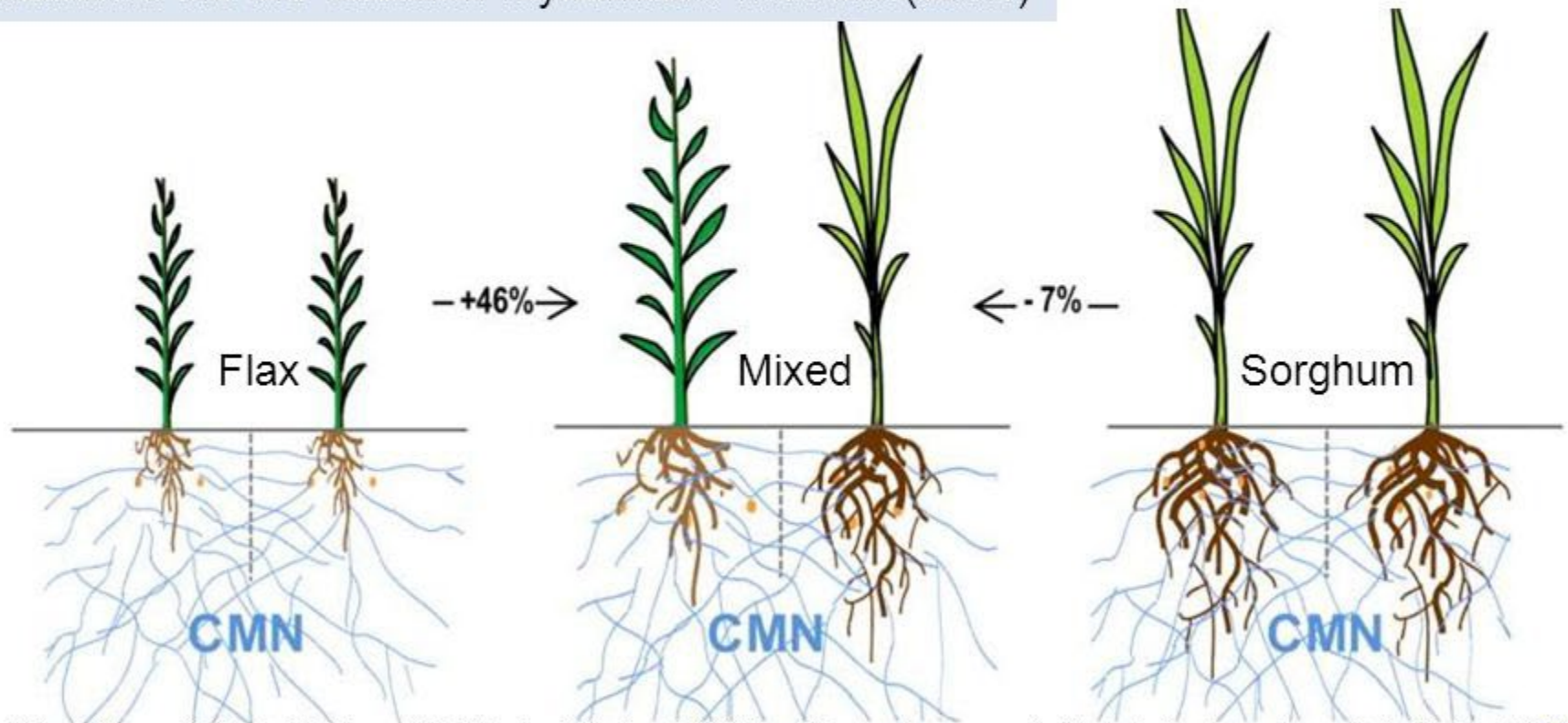
Below ground – roots, microbes, mycorrhizae, nematodes, insects, allelopathy ...

Above ground – plant genetics, plant architecture, semiochemicals, pollen, nectar, phenology stage, habitat, microclimate ...



A common mycorrhizal network can facilitate resource sharing

Intercropping with sorghum drastically enhanced flax's growth (+46% increase). Nutrient uptake was facilitated via the common mycorrhizal network (CMN)



Walder, F., Niemann, H., Natarajan, M., Lehmann, M.F., Boller, T. and Wiemken, A. (2012). Mycorrhizal networks: common goods of plants shared under unequal terms of trade. *Plant Physiol.* 159: 789-797.

Almonds, CA



Getty Images

1 species, clonal germplasm

Range of possibilities

Multi-variety, multi-species, multi-story



23 yr old food forest, NZ

Almonds, CA



- Grass alley
- Mixed species alley
- Plants in tree row – in-season, off-season
- Row end plantings – shrubs, overstory
- Border planting – shrubs
- Hedgerow



Almonds, CA



- Grass alley
- Mixed species alley
- Plants in tree row – in-season, off-season
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- Interplant – alternate row, in row; varieties, similar crops
- Alley crop – tree + annual
- Multi-story – overstory, short trees, shrubs, ground cover
- “Food forest”



Fruit and Nut Orchards

Key goal for production: **Uniformity**

- Light, nutrients, water
- Microclimate
- Genetics
- Crop protection
- Harvest

Inherent conflict with biodiversity and constraints to change

Can enhanced biodiversity “pay” for itself?

Tree Fruit Orchards

Standard Practice

- clonal trees –dwarf rootstock, scion
- bare tree row
- perennial grass alley
- frequent mow in place

In WA, standard practice for all orchards; organic expected to do more



Trellis end plantings



Tree Fruit Orchards

Change Alley Vegetation

- legumes for N
- can supply much of orchard N need
- timing important
- potential for pests, diseases



Legume 'mow and blow' system in apples 16

Tree Fruit Orchards

Biocontrol

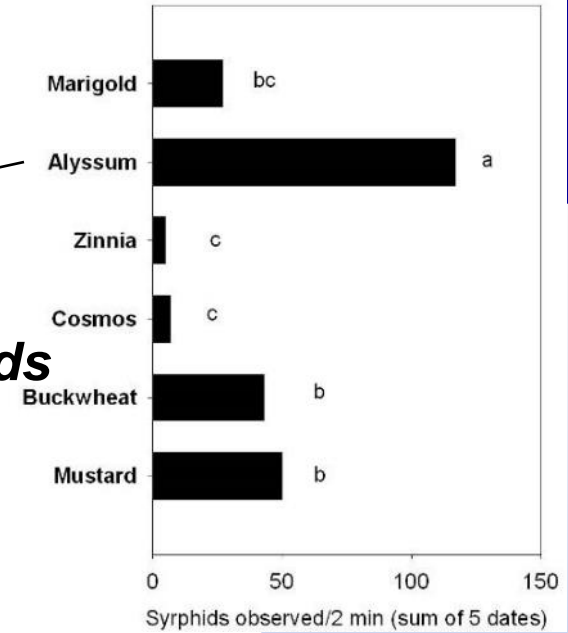
- Citrus red mite (China) – conserve weed *Ageratum conyzoides* which attracts predatory mite (*Amblyseius newsami*) that control citrus red mite; used on over 135,000 ha of citrus (*Liang and Huang, 1994*)
- Aphids (Germany) - flowering strips (diverse species) in orchard alleys effective management for aphid control (*Föll et al., 2015*), used on hundreds of hectares.
- Woolly apple aphid (WA) – screened flowering plants for most attractive to syrphids; sweet alyssum was best (*Gontijo et al., 2013*)

Syrphids to Control Woolly Apple Aphid



(Courtesy: E. Beers)

Attractiveness to Syrphids



Trefoil Insectary Mix



Tree Fruit Orchards

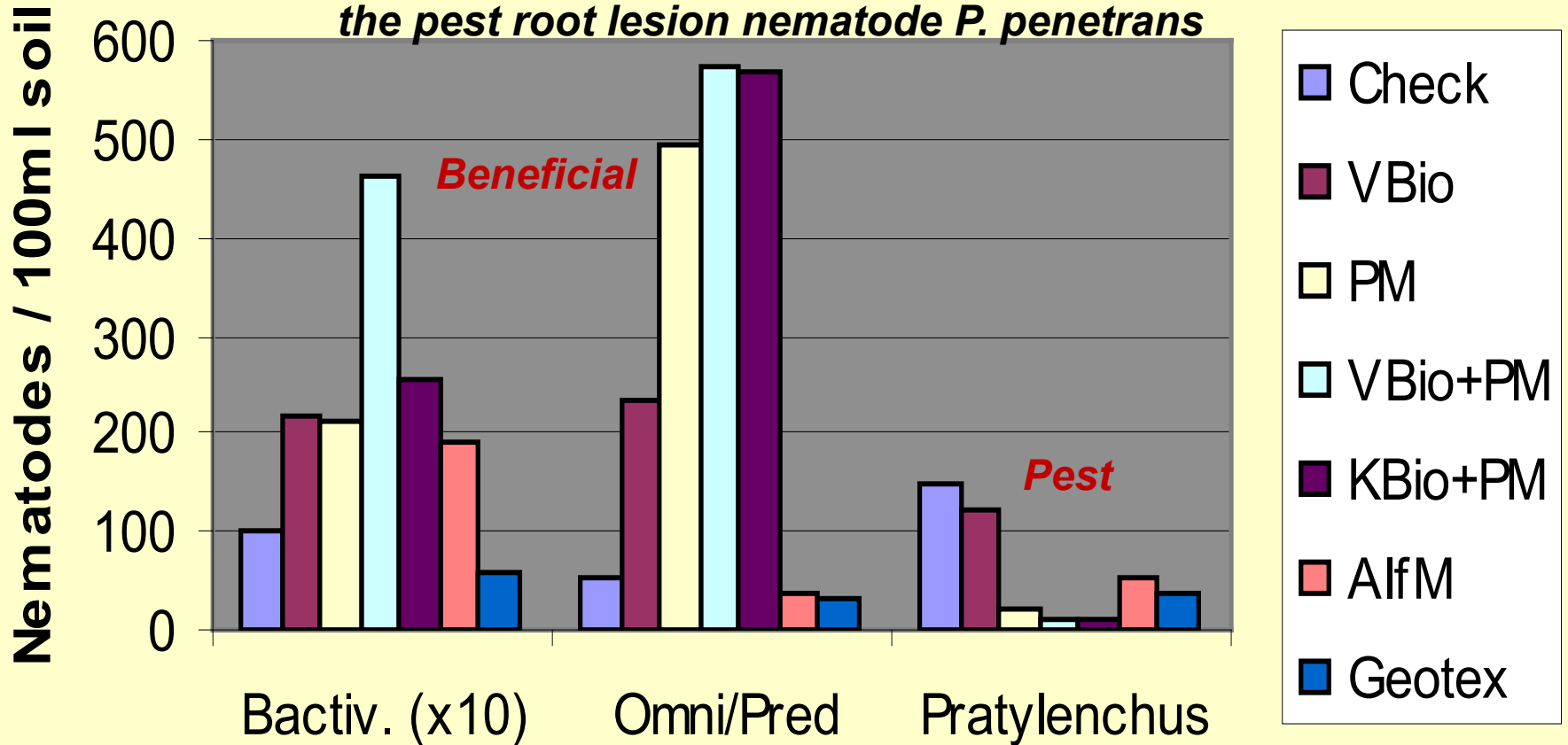
Mow 'n Blow Mulch

- tall fescue + clover in alley
- side delivery mower
- excellent weed control
- moisture conservation
- enhanced soil health
- increased young tree growth



Effect of Mulches on Nematodes in Orchard Soil - Summerland, BC

Increases in 'beneficial' nematodes suppressed the pest root lesion nematode P. penetrans



Tree Fruit Orchards

Plants in Tree Row

- annuals vs perennials
- in-season vs dormant season
- ground cover, N fixation, extended bloom, food crops, rodent repellent
- young vs old trees
- let “weeds” fill in, mow



Fall-panted mustard



Mowing “weeds” in-row

Tree Fruit Orchards

'Living' mulches



Sweet woodruff



Thyme

Testing species for weed suppression, rodent repellency, competition with trees – Wenatchee, WA; more info at

<https://tfrec.cahnrs.wsu.edu/organicag/tree-fruit/orchard-floor-management/>

Tree Fruit Orchards

'Living' mulch

- recent EU research project DOMINO
- tested 40 wild and cultivated species as living mulch in tree row

<http://www.domino-coreorganic.eu/>

Youtube webinar on their findings

<https://www.youtube.com/playlist?list=PLijBgairkUaA0PEFvoBgfU4UkGZbRe21>



Annual medic

Tree Fruit Orchards

Hedgerows

- extensive research in Europe
- many examples of pest suppression
- habitat for beneficial insects, birds
- Hedgerow Resource Guide, Calif., 2018

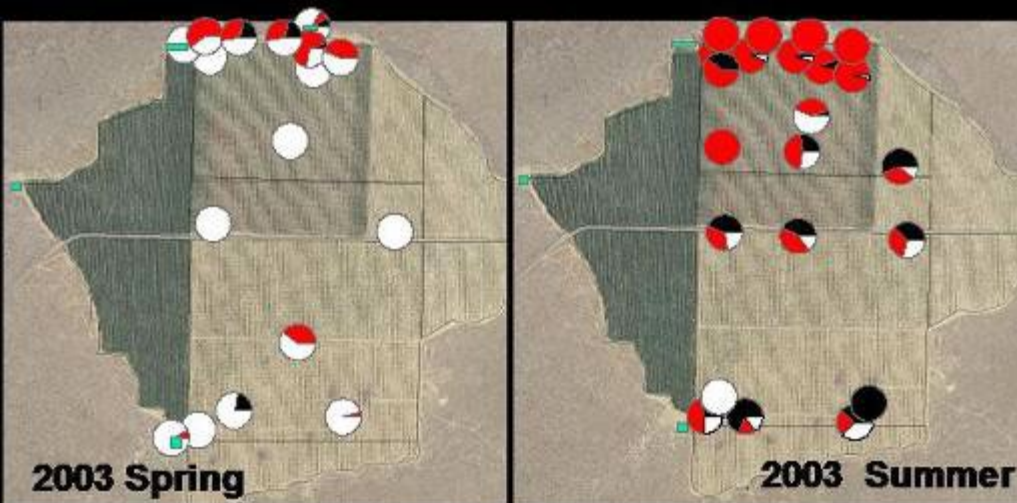
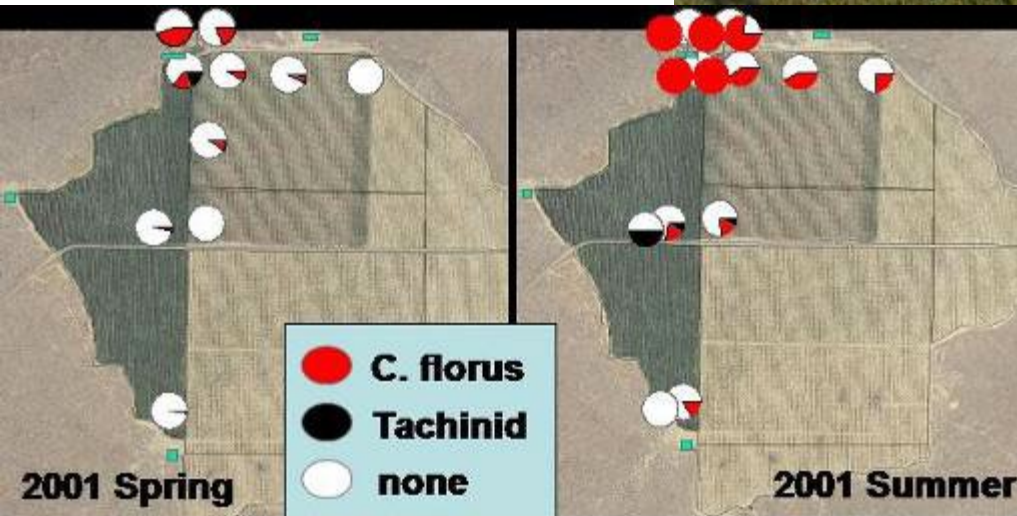
https://www.rcdmonterey.org/images/docs/publications/CAF_F_Hedgerow_Manual_2018.pdf



<https://kentorchards.org.uk/advice/hedgerows/>

Tree Fruit Orchards

Redesign with 'Rose Garden' Border Planting



Rose gardens planted in 2000; leafroller parasitism increases thru the summer and has increased from 2001-2005

Interplanting Cultivars and Species

- Apples and peaches, WV; 2 apple, 2 peach in row; less apple injury due to San Jose scale and stink bug (*Brown et al., 2010*)
- Mixed scab susceptible and resistant apple cultivars in orchard to reduce scab; disease incidence reduced 7-21%, disease severity reduced 35% (*Didelot et al., 2007*)
- Multi-functional Woody Polyculture:
e.g. walnut-apple-currant-maize; chestnut-hazelnut-black currant-elderberry (*Lovell et al., 2018*)
- 'Food forests'

Multifunctional Woody Polyculture

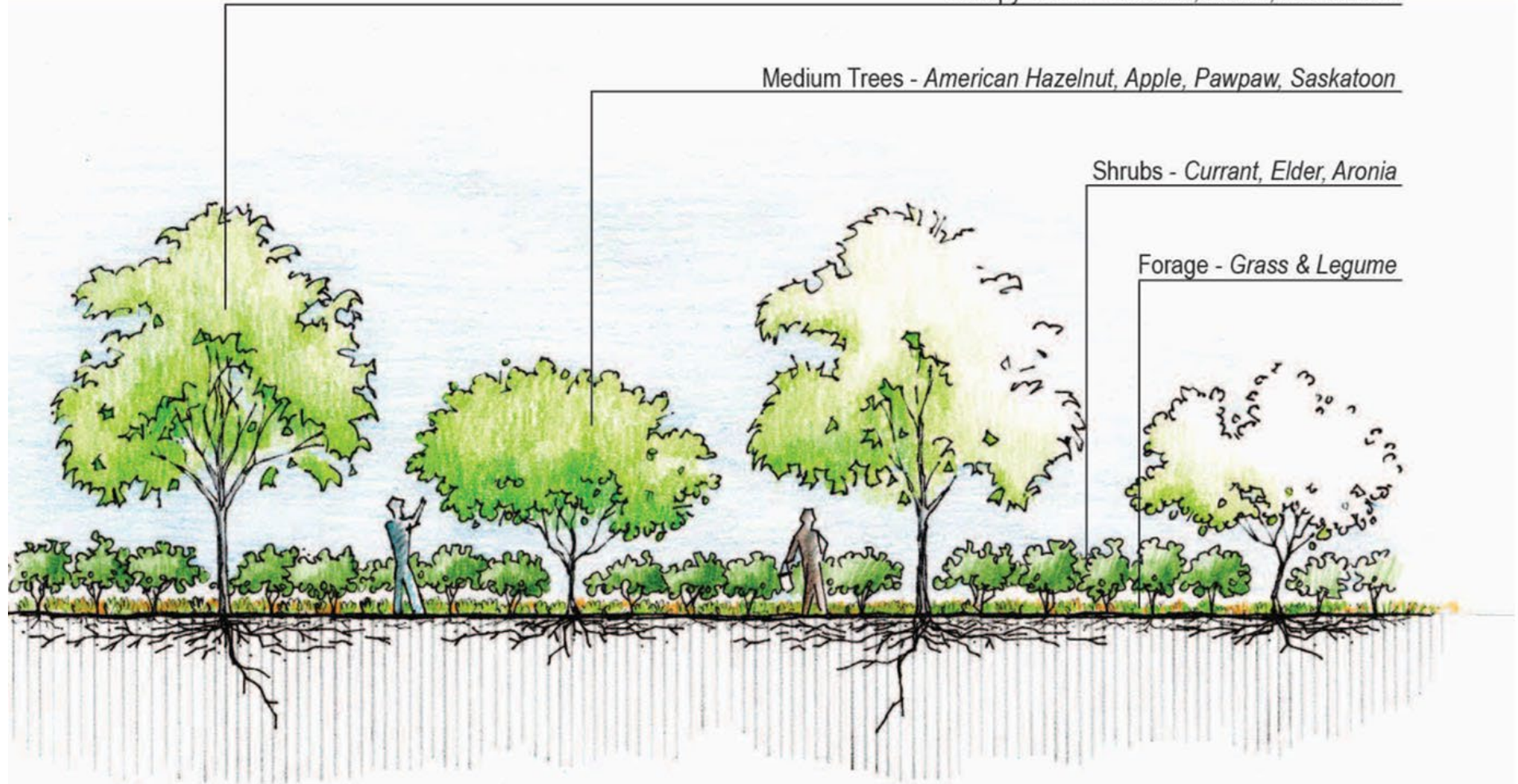
research, Univ. Illinois (Lovell et al., 2018)

Canopy Trees - Chestnut, Pecan, Persimmon

Medium Trees - American Hazelnut, Apple, Pawpaw, Saskatoon

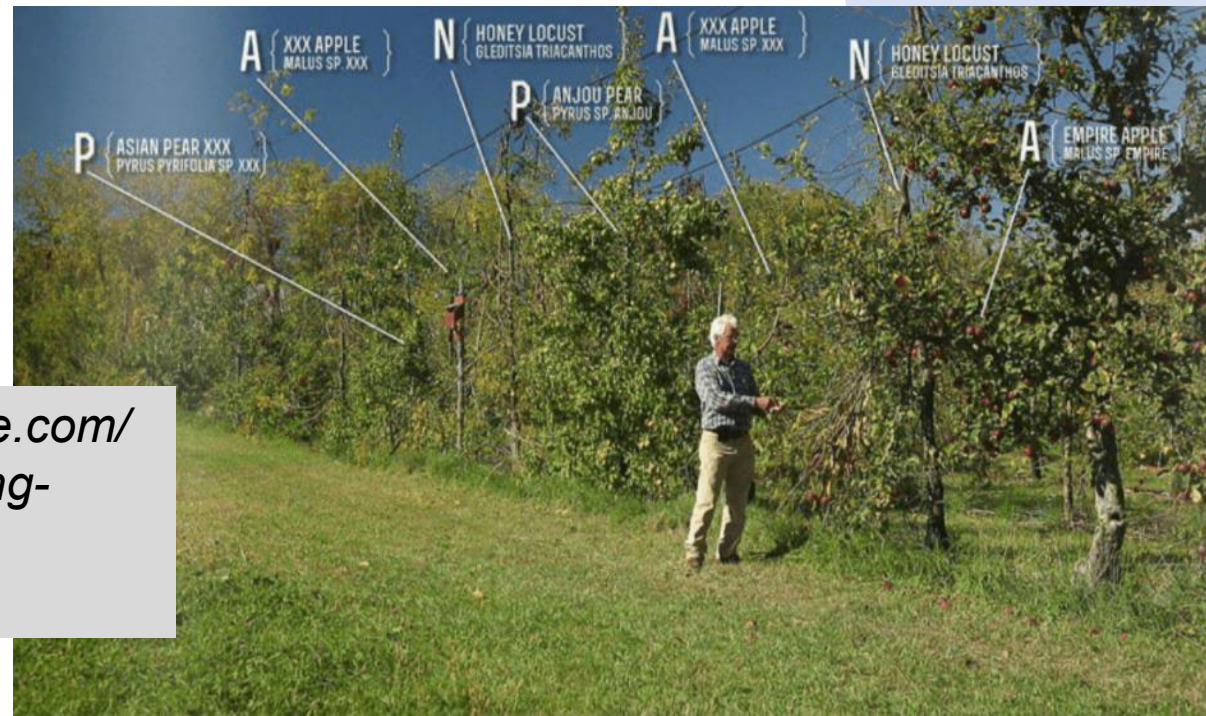
Shrubs - Currant, Elder, Aronia

Forage - Grass & Legume



Permaculture Orchard

- 4-acre orchard, southern Quebec
- TRIOS system – pear/plum; apple; honey locust
- tree never adjacent to same species
- everything in row ready to harvest in 10-day window
- Membership U-pick harvest



[http://permacultureapprentice.com/
here-is-how-you-make-a-living-
from-a-4-acre-permaculture-
orchard/](http://permacultureapprentice.com/here-is-how-you-make-a-living-from-a-4-acre-permaculture-orchard/)

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Note: I am retired!!



Orchard floor management website:

<https://tfrec.cahnrs.wsu.edu/organicag/tree-fruit/orchard-floor-management/>

USDA National Resource Conservation Service Live Webinar : Creating and Maintaining Biodiversity in Organic Perennial Systems

June 7, 2022

Mae Culumber PhD
UC Cooperative Extension
Nut Crops Advisor
Fresno County



University of California

Agriculture and Natural Resources

Cooperative Extension

- California's agricultural sector—the nation's largest—generates more than \$50 billion dollars in annual revenue and employs more than 420,000 people (PPIC, 2022)
- 2,186,551 organic acres in 2020
- Sales of organic products \$11.9 billion in 2020



Megadroughts and precipitation whiplash common in agricultural regions of California



Madera Ca, May 2021 Getty Images



Floods in California in 2017. Credit Flickr

Extreme climate and intensive Ag management degrades soil quality

- Compaction
- Surface sealing
- Erosion and runoff
- Reduced fertility
- Salinity buildup
- Stunted crops and reduced yield





Guidance Natural Resources and Biodiversity Conservation

Links Update: August 31, 2018

Organic system plan (OSP) must comprehensively support natural resources and biodiversity conservation

Example activities: establishing a diversity of crops and inputs, using no-till or conservation tillage

How can perennial crop producers increase biodiversity in a practical manner?



1 species, clonal germplasm

(Tomas Ovalle / For The Times)

How can perennial crop producers increase biodiversity in a practical manner?



1 species, clonal germplasm

- **Grass or mixed species alley**
- Plants in tree row – in-season, off-season
- Row end plantings – shrubs, overstory
- Border planting – shrubs
- Hedgerows

Grass or mixed species cover crops improve soil conditions



- protect soil from surface crusting
- Improve soil structure
- water holding capacity
- infiltration and permeability through the rootzone
- Enhanced carbon levels and soil microorganism function

Cover crops for bee forage?

- Flowering covers can provide habitat and nutrition before and during almond bloom
- Most species tested arrive at peak bloom after almond bloom
- No evidence of reduced bee visitation to almond trees
(Creze et al. 2019)



Brassicas can be an important source of pollen and nectar for bees.

Annual reseeding legume species

- **Clovers:**

- **Subterranean**
- **Persian**
- **Rose**
- **Crimson clover**

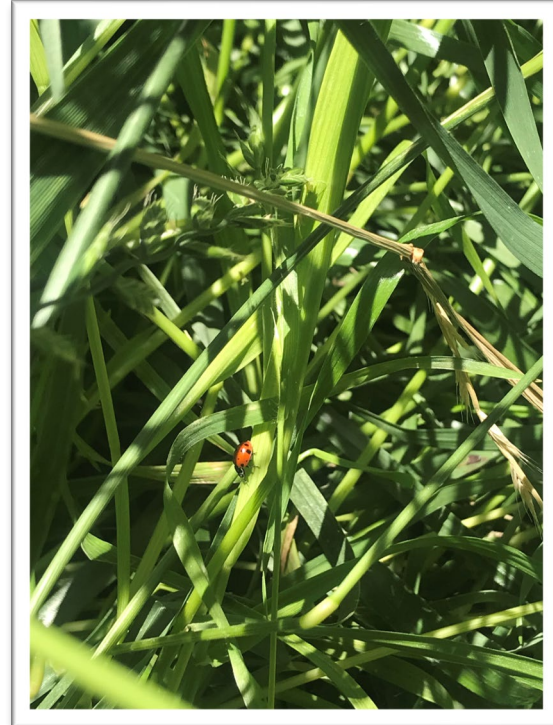


Bur medic

Annual reseeding grass species



20 lbs. per acre rate in mature pistachio



'Blando' Soft brome
Bromus hordeaceus L. *ssp.*
hordeaceus

Concerns about increased water use

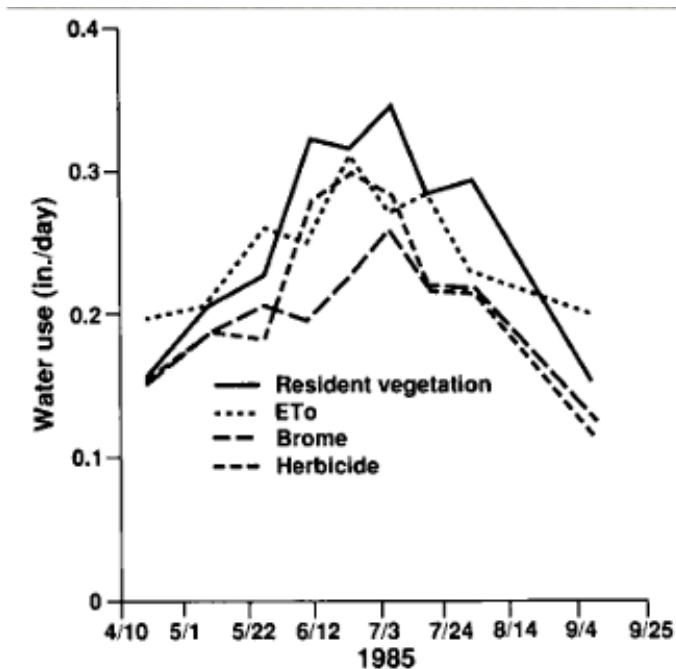
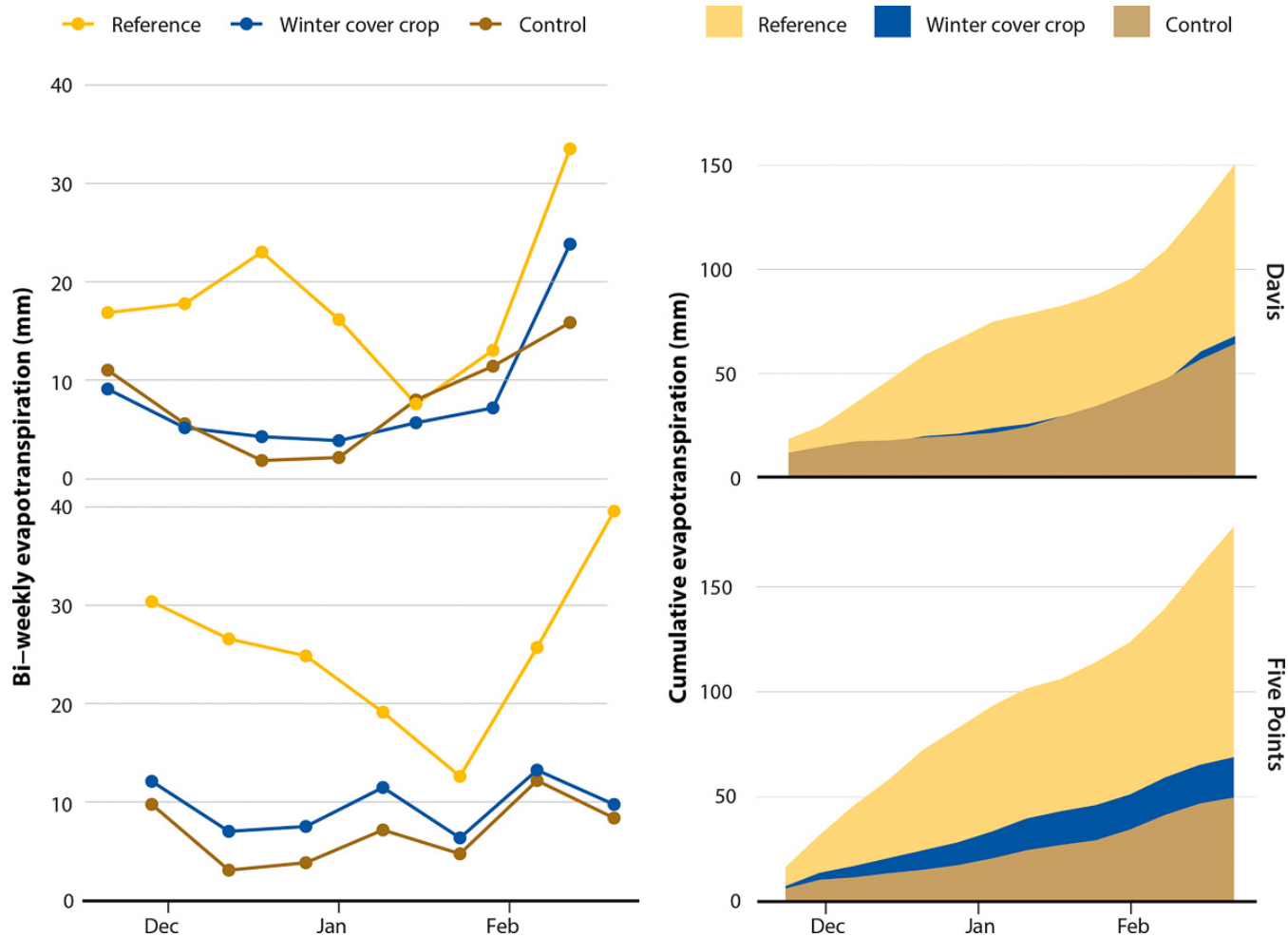


Fig. 1. Daily water use in four treatments in 1985 season, orchard B. Chemical mowing dates were 4/16, 6/18, 7/19, 8/14; mechanical mowing, 3/5, 4/24, 5/30, 6/13, 7/18, 8/6, 8/28.

- Resident vegetation or clover used 20-30% more water per season
- **Winter** annual Brome grass cover same water use as herbicide and mowing treatments
- Brome mulch left on the soil surface after mowing reduced surface evaporation

Pritchard et al. 1989



Another CA study found winter cover crops (annual grasses, annual legumes, and mixes) have similar water use as clean cultivated soil (DeVincentis et al. 2022)



University of California
Agriculture and Natural Resources

***Investigating the Effects of Winter Cover
Cropping on ET, WP and Soil-water Functions
of Micro-irrigated Pistachio in the S.J.V.***

Project Leader: Daniele Zaccaria, Ph.D. - Associate Professor and Agricultural Water Management Specialist for UC Cooperative Extension, L.A.W.R. Department – UC Davis

Project Co-PI: Catherine Mae Culumber, Ph.D. – Nut Crops Farm Advisor UC Cooperative Extension Fresno County, Fresno, CA 93710

Benefits may outweigh costs



Bright vegetation residues of terminated Blando Brome cover crop may re-distribute part of incoming radiation, increase light interception by trees, transpiration, and net CO_2 assimilation relative to clean-cultivated ground

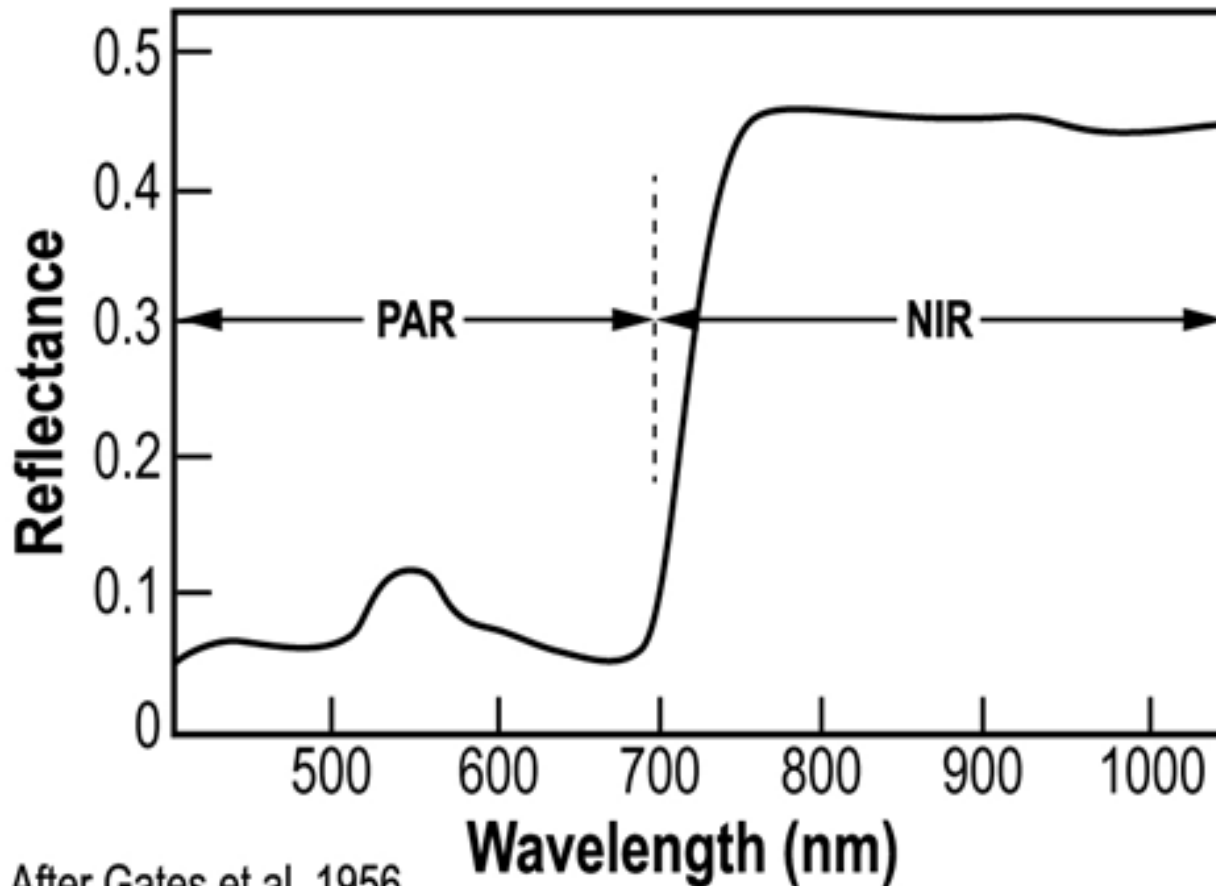
Oxygen availability increase in the soil for root activity, and uptake of water & nutrients

Investigate cover crop influence on evapotranspiration (ET) and water use efficiency (WUE) in pistachio

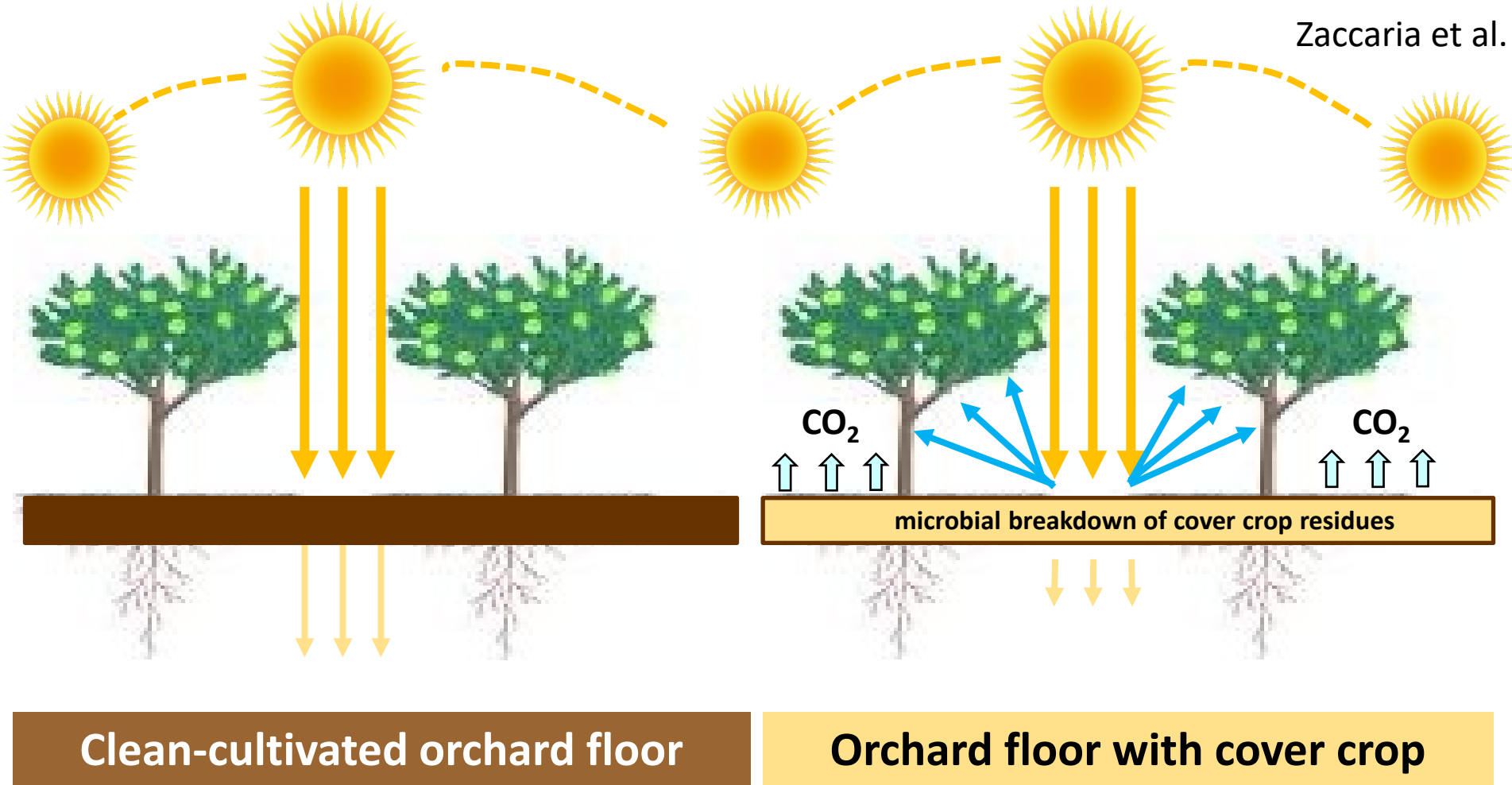
Instrument and monitor cover cropped and clean-cultivated orchard floor in pistachio orchards with same row orientation and similar canopy conditions (tree age and spacing)



Radiation sensors and infrared thermometers (IRT) above and below the tree canopies monitor incoming and reflected radiation and measure the actual partition between the photosynthetically active radiation (PAR) and near-infrared radiation (NIR)



- PAR is the spectral range (wave band) of solar radiation from 400 to 700 nm that photosynthetic organisms are able to absorb for photosynthesis .
- Near-infrared radiation (NIR) is mostly reflected or transmitted



Study orchard	Orchard floor management	Incoming short-wave radiation	Outgoing short-wave radiation	Incoming long-wave radiation	Outgoing long-wave radiation	Net radiation	Albedo
Coalinga	Cover crop	60,953	9,620	105,231	137,640	18,924	0.16
Hanford	Clean-cultivated	54,682	7,187	111,838	142,289	17,044	0.13

Planting equipment



No-till drill



Soil preparation and seeding cover crops

- Seeding in the fall $\frac{1}{4}$ " to $\frac{1}{2}$ " deep by the end of October or early November before rain begins
- no-till seeder is best option
- If soil surface is hard, prepare the top 1" of the seed bed using a disc plow, or a rototiller to loosen the soil surface



Photo: Mohammad Yaghmour

Two passes to seed the cover crop



Photos: Mohammad Yaghmour

Seeding as close as possible to trees' trunks



Photos: Mohammad Yaghmour

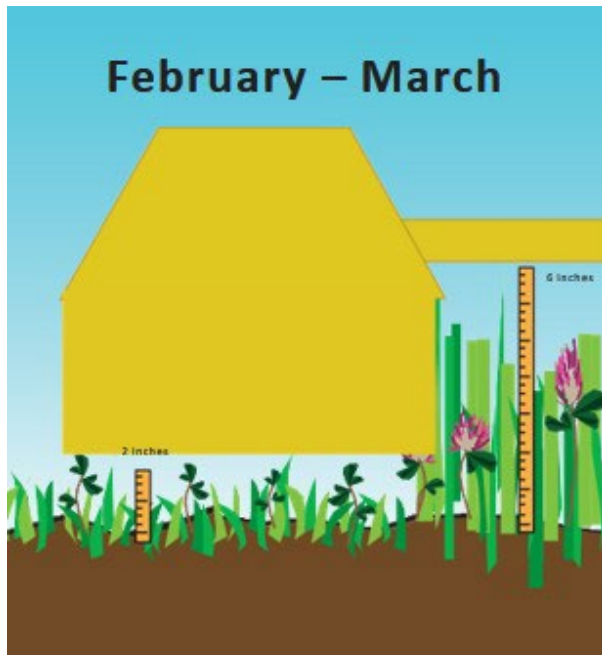
Cover crop emerges in the wetting zones or evenly after sufficient rainfall



Photos: Mohammad Yaghmour

Managing reseeding annuals

Mow ~1-2” in late February/early March



- Reduces winter weed competition for clovers
- Reduces risk of frost injury to trees
- Do not leave a smothering mulch on top

To ensure seed production and natural reseeding the for the next fall

**Growth and flowering stage -
Allow plants to mature, may
look overgrown**

**Mow when seed matures or
hardens to remove dead cover
crop; clippings decompose on
soil surface**



Green manure cover crop management – Removal

- Remove at early flowering for maximum N content
- Allow removal of excessive soil moisture without depleting stored reserves



Almond Harvest

Conditioner
equipment
removes leaves
and any residues
left from the cover
crop that did not
decompose by
harvest time



Photos: Mohammad Yaghmour

Conclusions

- Perennial organics small but significant value to CA agriculture
- Climate extremes degrade soil and water resources
- Annual reseeding or green manure cover crops benefit pollinators, soil, water, and air and may improve crop production efficiency
- Over all water use may not increase in all circumstances, particularly with annual seeded covers
- Even stand establishment may require more water than provided by rainfall

Thank you!!!

Questions?

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