

Plant Ecology in Organic Olive Orchards

Ellie Andrews

UC Davis Olive Center Organic Management Course

July 21 & 22, 2023



Background

- Ellie Andrews
 - UCCE Specialty Crops Advisor, Sonoma, Marin, Napa Counties
 - PhD Horticulture & Agronomy, UC Davis
 - Masters in Plant Health Management, Ohio State University
 - Bachelors in Field Ecology, Ohio University



Background

- Ellie Andrews
 - UCCE Specialty Crops Advisor, Sonoma, Marin, Napa Counties
 - PhD Horticulture & Agronomy, UC Davis
 - Masters in Plant Health Management, Ohio State University
 - Bachelors in Field Ecology, Ohio University

- Thank you!
 - Joe Connell: lots of photos & content
 - McEvoy Ranch: photos & anecdotes
 - UC Davis Olive Center



Ecological Principles



Zuazo et al. 2020

Ecosystem: all organisms & the abiotic pools with which they interact

Biodiversity: variety of organisms' forms & functions

Ecological Principles



Zuazo et al. 2020

Processes: transfer of energy & materials thru organisms & their environment

- Pools: quantities
- Fluxes: flows

Example of Pools & Fluxes



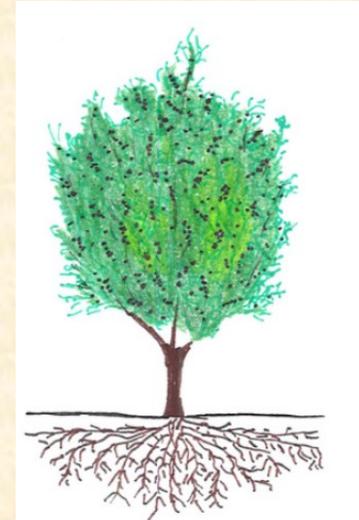
Cover crop
biomass
nitrogen
pool

Transfer



Soil nitrogen pool

Transfer



Tree
nitrogen
pool

Mowing & throwing helps
transfer nitrogen to soil N
pool over tree roots,
microbes decompose
biomass

Ecological Principles



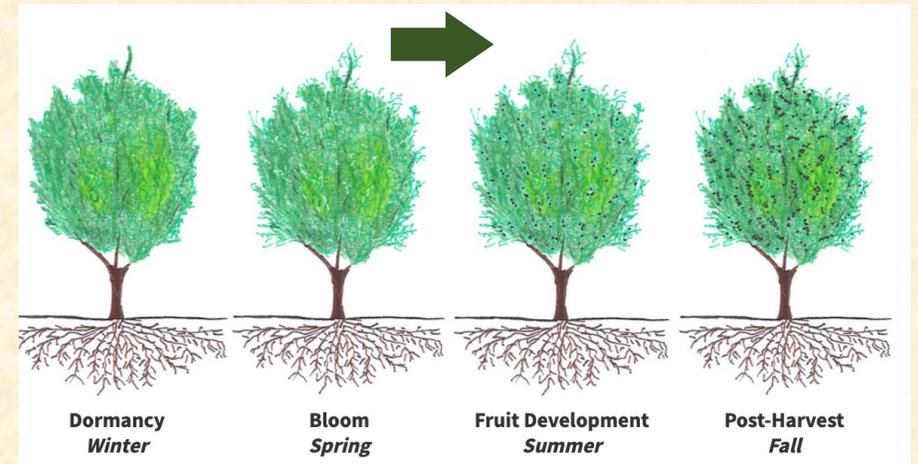
Across different spatial scales

Ecological Principles

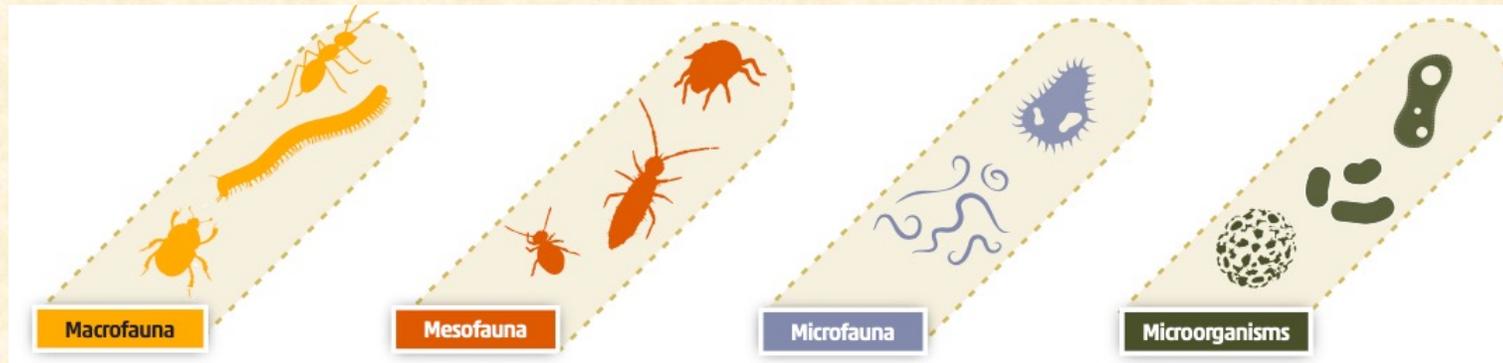


Across different spatial scales

Across different temporal scales



Ecological Principles



FAO 2020

Trophic chains: who eats whom,
energy transfer thru food webs

Ecological Principles

Niches: physical space & associated resources used by plant



Zuazo et al. 2020

Ecological Principles

Niches: physical space & associated resources used by plant



Zuazo et al. 2020

Niche differentiation: opportunities to use different space or resources

Ecological Principles

Ecosystem services: the benefits that people derive from ecosystems



Gold Ridge Organic Farms, photo from California Olive Oil Council

Ecological Principles

Ecosystem services: the benefits that people derive from ecosystems

Multifunctionality: ability of an ecosystem to provide multiple functions and services

- pollinator habitat
- soil water retention
- nitrogen cycling
- windbreaks
- etc.



Gold Ridge Organic Farms, photo from California Olive Oil Council

Ecological Principles

Disturbances

- Ongoing inputs & losses
- Most ecosystems experience this
- No single stable “equilibrium”
- Internal & external factors
- Human activities have a big impact
- Past events matter



Tillage. Photo credit: Oliviada Olive Oil

How can plant ecology benefit olive orchards?



Photo credit: Il Circolo Olive Oil

Resiliency: setting up a system that can better handle stress

How can plant ecology benefit olive orchards?



Photo credit: Il Circolo Olive Oil

Resiliency: setting up a system that can better handle stress

How can different plant species enhance my...?

- Integrated Pest Management Plan
- Water conservation
- Nutrient management
- Soil functioning
- Climate adaptation strategies
- Crop system stability

How can plant ecology benefit olive orchards?



Photo credit: Il Circolo Olive Oil

Resiliency: setting up a system that can better handle stress

Which plants could help...?

- Reduce costly inputs
- Increase profitability
- Create more income stability

Ecological Principles in Ag



Photo credit: Il Circolo Olive Oil

Planned biodiversity: strategic plant choices for different orchard niches (alley, edges, hedgerows, etc.)

Timing: when do you want ecosystem services to be available? (pollinators, nutrient cycling, etc.)

Ecological Principles in Ag



Composting operation.
Photos from Joe Connell.

Ecological intensification:
using natural processes to replace inputs
while increasing food production in an area



Mulch shredder for olive prunings. McEvoy Ranch.

Common Themes

Biodiversity

- multifunctionality
- promote beneficial insects
- nutrient cycling from mowed biomass, legume nitrogen fixation



Cover crop mix in orchard.
Photo by Vivian Wauters.

Living Roots in the Soil

- reduce erosion risk
- allow better equipment access
- promote water infiltration
- carbon exudates from plant roots

Common Themes

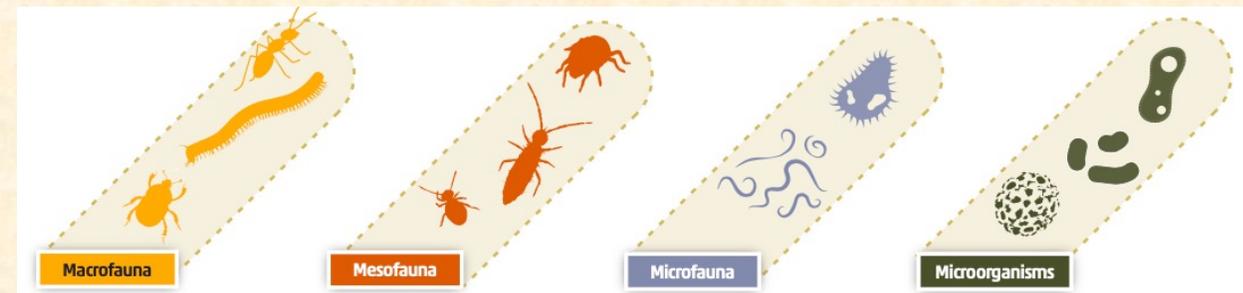


Organic Matter Amendments

- promote root growth
- promote soil biology
- increase soil organic matter

Minimizing Soil Disturbance

- maintain ecological communities
- reduce risk of erosion
- maintain soil organic matter



Plant Ecology

How can we harness the relationships between plants & their environment in organic olive orchards?



Plant Ecology

How can we harness the relationships between plants & their environment in organic olive orchards?



- cover crops / resident vegetation
- intercrops
- hedgerows
- organic weed management

Alley Niche – Soil Conservation



Cover crops

compete with weeds,
help cycle nutrients,
build soil organic matter



Intercrops

secondary crop,
forage for animals



Resident vegetation

(as long as it's not
weedy/invasive)

Cover Crops

- A non-cash crop grown in addition to the primary crop



Cover crop mix in orchard. Photo by Vivian Wauters.

Cover Crops

- Can provide multiple ecosystem services
 - increase soil organic matter
 - biological nitrogen fixation by legumes
 - increase water infiltration, reduce runoff
 - can compete with weeds
 - promotes pollinator insects
 - can increase crop yield (depends on many factors)



Cover crop mix in orchard. Photo by Vivian Wauters.

Cover Crops

- Seed in fall, terminate in early spring
 - terminating via mow or till: mowing takes less energy & has more advantages than tilling
- To improve establishment & competition with weeds, consider
 - timing of seeding & termination
 - cover crop type: site context, vigor



Cover crop mix in orchard. Photo by Vivian Wauters.

Cover Crops

- Costs: seed, soil preparation, planting costs vary widely
 - see SARE resource [Cover Crop Economics](#)
 - ANR Cost Study for winter cover crops in [annuals](#)



Cover crop mix in orchard. Photo by Vivian Wauters.

Cover Crops



UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources



SAREP

California Cover Crops Resources



Cover Crops for California Farms

Learn more about incorporating cover crops into your farming operations using the resources on this website.

 <p>How to Manage Cover Crops</p>	 <p>Cover Crop Selection</p>	 <p>Resources</p>
---	--	---

Cover Crops



Cover Crop Selection



UC SAREP
Cover Crop
Database



Cover Crops Database



Click on a cover crop name to learn more about that crop.

Crop	Growing Period	Type	Annual or Perennial	Drought Tolerance	Shade Tolerance	Salinity Tolerance
Annual Fescue	Cool Season	Grass	Annual	High	Low	Low
Annual Ryegrass	Cool Season	Grass	Annual	High	Intolerant	High
Barley	Cool Season	Grass	Annual	Moderate	Intolerant	High
Barrel Medic	Cool Season	Legume	Annual			Moderate
Bell Bean	Cool Season	Legume	Annual	Intolerant		Low
Berseem Clover	Cool Season	Legume	Annual	Low	Intolerant	Moderate
Birdsfoot	Warm Season	Legume	Perennial	Moderate	Intolerant	Moderate

Cover Crops



Cover Crop Selection



Common California Cover Crops



Top Regional Cover Crops

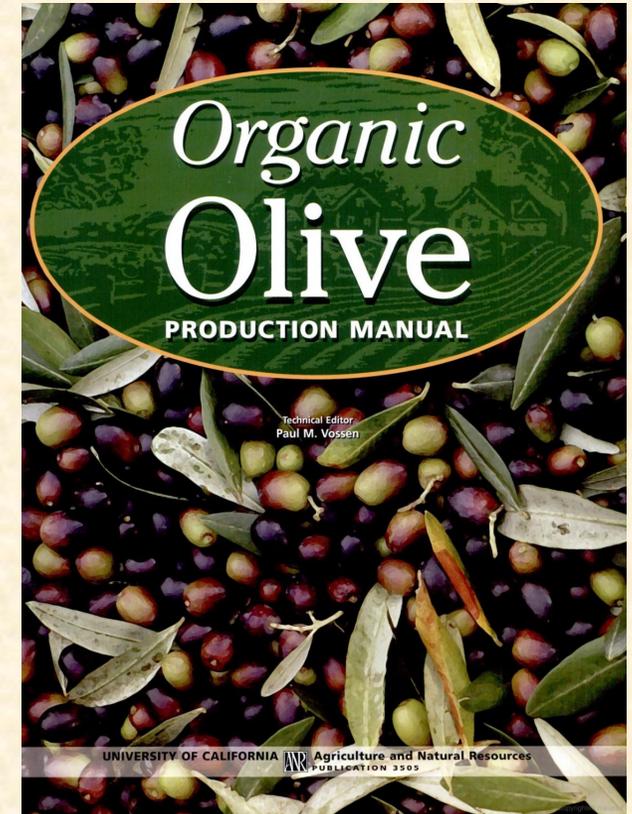
Cover crop recommendations for the Central Valley and coastal regions of California categorized by use.



Bioregion	N Source	Soil Builder	Erosion Fighter	Subsoil Loosener	Weed Fighter	Pest Fighter
Coastal California	<ul style="list-style-type: none"> • berseem clover • subterranean clover • Lana woollypod vetch • medic 	<ul style="list-style-type: none"> • annual ryegrass • rye • sorghum-sudangrass hybrid • Lana woollypod vetch 	<ul style="list-style-type: none"> • white clover • cowpeas • rye • annual ryegrass 	<ul style="list-style-type: none"> • sorghum-sudangrass hybrid • sweetclover 	<ul style="list-style-type: none"> • rye • annual ryegrass • berseem clover • white clover 	<ul style="list-style-type: none"> • sorghum-sudangrass hybrid • crimson clover • rye
California Central Valley	<ul style="list-style-type: none"> • Austrian winter peas • Lana woollypod vetch • subterranean clover • medic 	<ul style="list-style-type: none"> • medic • subterranean clover 	<ul style="list-style-type: none"> • white clover • barley • rye • annual ryegrass 	<ul style="list-style-type: none"> • sorghum-sudangrass hybrid • sweetclover 	<ul style="list-style-type: none"> • annual ryegrass • white clover • rye • Lana woollypod vetch 	<ul style="list-style-type: none"> • sorghum-sudangrass hybrid • crimson clover • rye

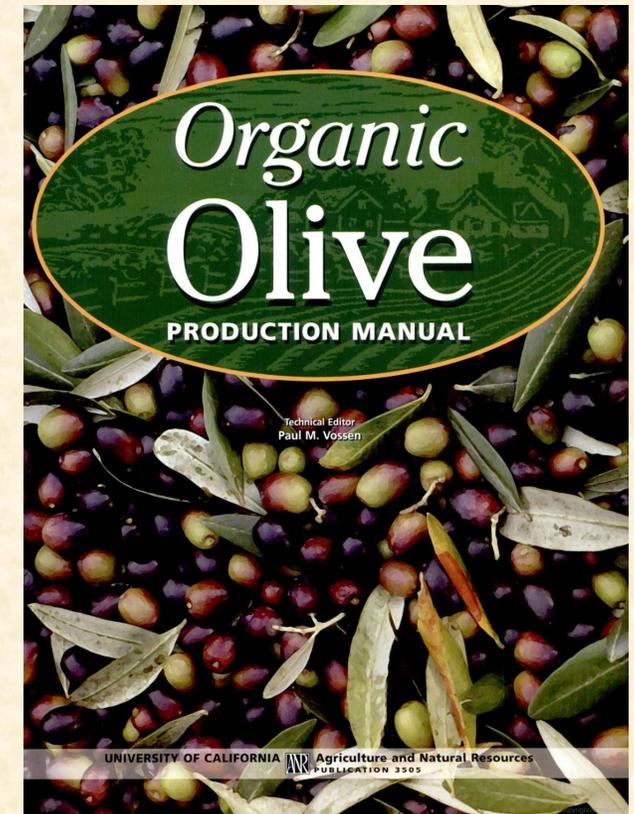
Common Legume Cover Crops

- Bell beans & vetch:
 - often seeded in the fall, terminated in spring
 - can supply as much as 200 lb/ac N
- Clovers & other legumes
 - can contribute ~25-30 lb/ac N as clippings decompose



Common Legume Cover Crops

- Subterranean clover
 - comes back from seed every year
 - many organic growers find it fulfills most of the olive orchard's N needs without excess
- Can supplement cover crop N with applications of other materials if needed



Cover Crops Examples

Winter annual grasses



Blando soft brome:
intermediate height,
matures early, re-
seeds, uses low water



Zorro fescue:
short, reseeds well
early in the spring,
uses low water



Annual ryegrass:
aggressive, easy to
establish, matures late,
uses more water, good
erosion control



Grain barley:
3 ft tall, competes
well with weeds, lots
of biomass, mow &
throw onto tree rows

Cover Crops Examples

Annual grasses

- produce a lot of biomass
- can mow & throw in tree row for weed control
- require some nitrogen for a good stand
- help with erosion control



Annual ryegrass



Barley



Oat

Cover Crops Examples

Winter annual legumes



Subterranean clover:
low-growing, tolerates
mowing, competes with
weeds, reseeds readily,
matures early, low water



Rose clover:
low-growing,
seeds early,
low water



Crimson clover:
a bit taller, slightly
more aggressive,
matures later,
needs high
moisture to reseed



Burr clover: native medic
clover, can be mowed short,
reseeds early, little water use



Berseem clover: produces the
most biomass, can be mowed
several times, uses more water

Cover Crops Examples

Annual legumes



Bell bean or fava bean:
tall, can fix a lot of
nitrogen in low-N soils



Lana woolypod vetch:
prolific N fixer, grows
well in cold weather,
best choice when
seeding late



Common vetch & purple vetch:
grow well in winter, cold tolerant

Cover Crops Examples

Annual legumes



Field pea:
grows like garden pea,
remains almost dormant in
cold weather, growth surges
in spring



Hairy vetch:
good in sandy
soils, cold tolerant,
slow growing in
winter



Fenugreek:
can germinate in cold
conditions

Cover Crops

Benefits	Tradeoffs
<ul style="list-style-type: none">• Improve soil function: soil organic matter, increase water infiltration, reduce runoff• Nutrients: legumes fix nitrogen• Weed suppression: can compete with weeds• Beneficial insects: promotes pollinators, pest predators	<ul style="list-style-type: none">• Frost: may lead to cooler temperatures which can increase frost damage• Gophers: may improve pest survival such as gophers• Water: likely not be feasible without rainfall• Nitrogen: if it's not a legume, might need a little nitrogen

Competition with Young Trees

- Minimize competition from alley plants when trees are young
- In mature orchards, cover crops & resident vegetation is often allowed to grow near trees because they don't compete much
(olives are low feeders)
- As area under canopy becomes shaded, ground cover thins out



CDFA FREP

Intercrops

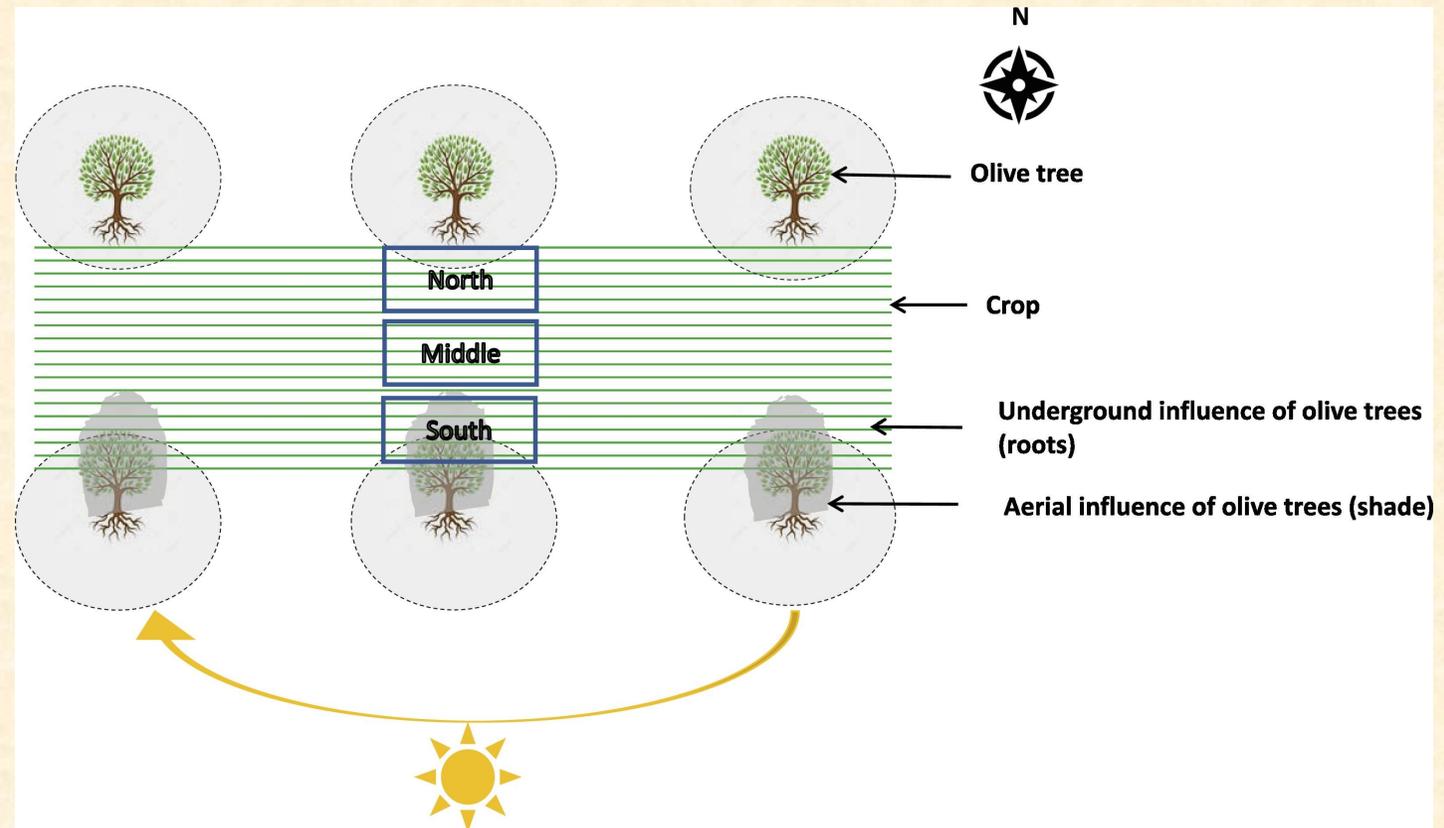
- Secondary plants between tree rows intended to be harvested
 - forage for animal grazing
 - vegetables
 - cereals or legumes
- Use space in alley for secondary products
- Can increase farm profitability & sustainability



Durum wheat variety trial in olive orchard.
Agforward, EU, France.

Intercrops

- Common in Mediterranean countries
- Historically, planting cereals or legumes was widespread in Mediterranean olive orchards to increase land productivity



Intercrops Goals

- Promote interactions between plants, microbes, arthropods, mammals, birds
- Improve soil plant health, biodiversity, pest management
- More efficient use of space, water, sunlight



Intercrops Goals

- Help build a more stable crop ecosystem
- Soil health benefits: living roots in soil helps reduce erosion, increase root exudates which enhance soil biology



Intercrops

- Choose plant species & varieties that do well in olive orchard conditions
 - benefits from some shade
 - relatively low water use
 - won't host olive pests



Durum wheat variety trial in olive orchard.
Agforward, EU, France.

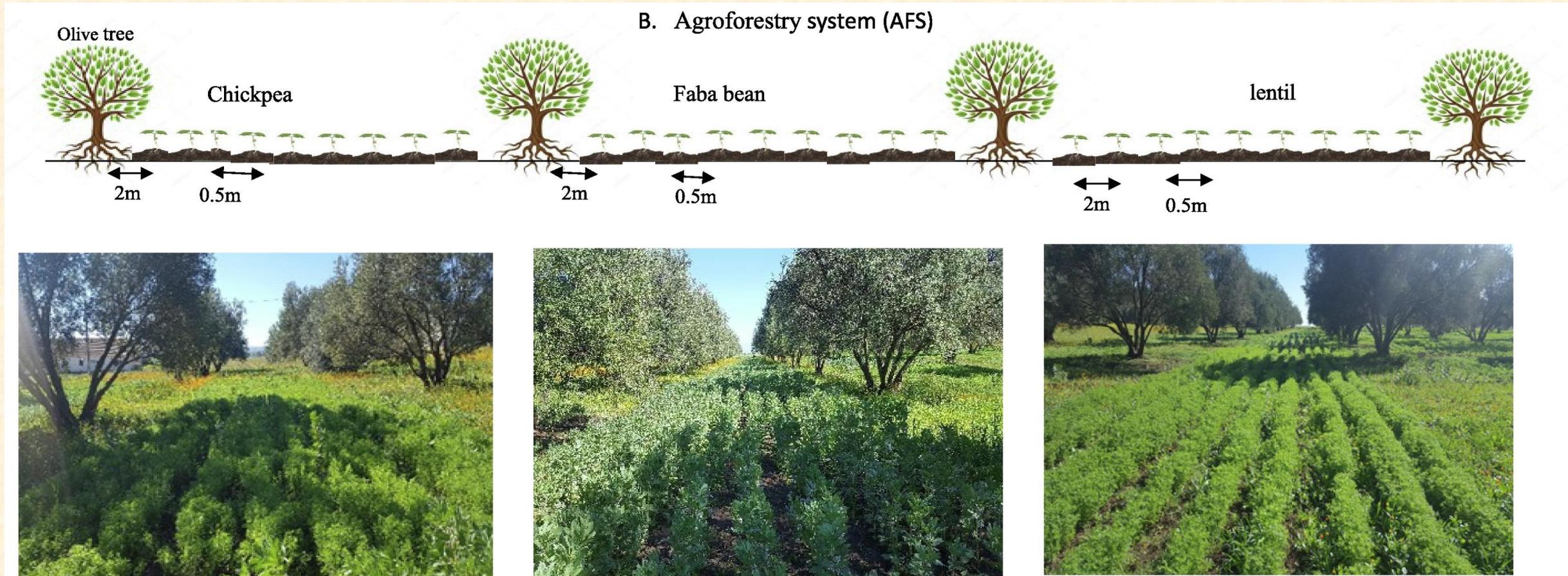
Intercrops Examples

- Forage for grazing animals: sheep, cattle, goats, chickens, etc.
- Wheat or other cereals, beans, alfalfa
- Vegetable crops such as potatoes, melons, beans, onions



Durum wheat variety trial in olive orchard. Agforward, EU, France.

Intercrops Examples



Intercrops

Benefits	Tradeoffs
<ul style="list-style-type: none">• Income: more per area• Stability: can help offset low income during alternate bearing• Soil: Help reduce soil erosion & runoff• Weed suppression• Capture more sunlight: efficient use of space• Beneficials: habitat for beneficial predators• Temperatures for intercrops: trees help moderate extremes for intercrop	<ul style="list-style-type: none">• Complexity & logistics• Equipment: may require new equipment• Rain: likely won't work without some winter rain• Pests: can host pests• Yield: likely lower yield than monocrop system

Field Edges Niche: Hedgerows



Photo from CAFF Hedgerow Manual 2018

Hedgerows

- Rows of vegetation on edges of ag fields for natural resource conservation goals
- Trees, shrubs, perennial grasses, forbs, rushes, sedges, etc.



Photos from CAFF Hedgerow Manual 2018

Hedgerows Goals



ATTRA Sustainable Ag's Pictorial Guide to Hedgerow Plants for Beneficial Insects

- Increase biodiversity
- Habitat for pollinators, natural predators of pests, beneficial insects, wildlife
- Reduce soil erosion, improve sediment trapping
- Increase carbon storage in plant biomass and soils

Hedgerows Goals

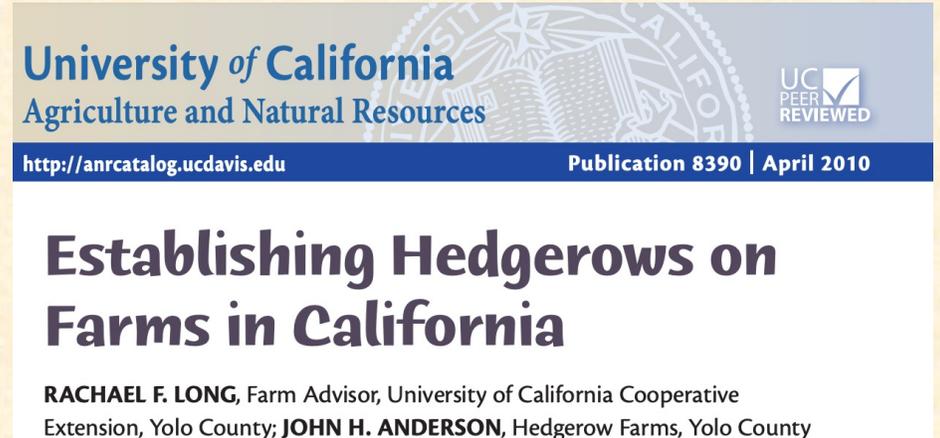


ATTRA Sustainable Ag's Pictorial Guide to Hedgerow Plants for Beneficial Insects

- Create barrier: dust, chemical drift, weed seed dispersal, noise, etc.
- Create a living fence, delineate boundaries, windbreak
- Smother & outcompete weeds

Hedgerow Species Selection

- Consider plants that are
 - well suited for your soil & site conditions, climate, conservation goals
 - low-water use species
 - California native plants
- Avoid species that
 - host insect pests or diseases for olives or other nearby crops
 - spread rapidly beyond the desired area



Hedgerows

Making a Difference
for California

University of California
Agriculture and Natural Resources



<http://anrcatalog.ucdavis.edu>

Publication 8390 | April 2010

Establishing Hedgerows on Farms in California

RACHAEL F. LONG, Farm Advisor, University of California Cooperative Extension, Yolo County; JOHN H. ANDERSON, Hedgerow Farms, Yolo County



Large shrubs (15 ft spacing)

Toyon
Western redbud
Coyote brush
Ceanothus
Elderberry
Coffeeberry

Smaller shrubs and forbs and plugs (7.5 ft spacing)

California buckwheat
Yarrow
Milkweed
Aster
Goldenrod
Mugwort
Phacelia
Gum plant

Native grass mix

Purple needlegrass
Nodding needlegrass
California oniongrass
Squirrel tail
One-sided bluegrass
Blue wildrye
Creeping wildrye
Slender wheatgrass
Meadow barley

Trees (20-30 ft spacing)

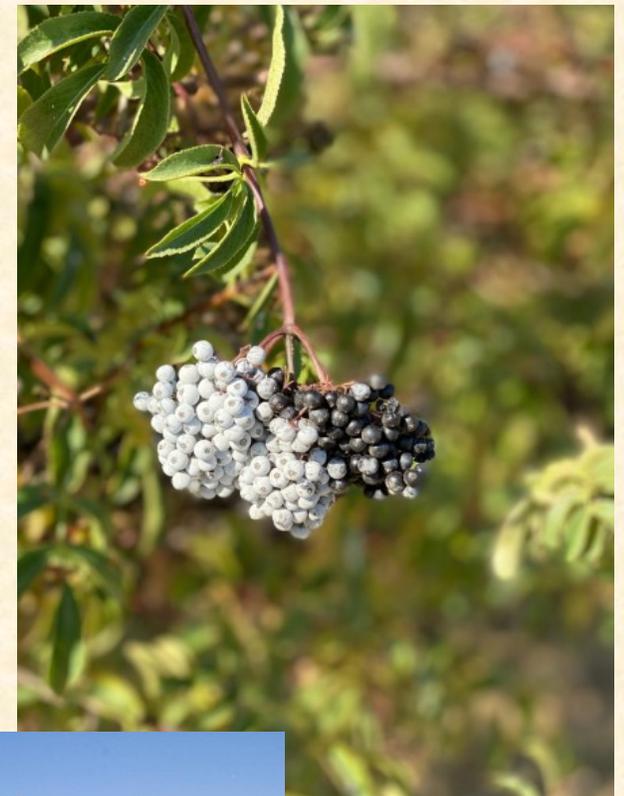
Willow
Cottonwood
Oak
California buckeye
California sycamore

Forb strip seed mix

Lupine
Clovers
Tarweed
Vinegar weed
California poppy
Gum plant
Phacelia

Hedgerows

- SAREP Elderberry Project, Sonja Brodt
 - including a harvestable high-value crop can help offset the cost of establishing a hedgerow
 - elderberries are native to California
 - field boundaries, windbreaks
 - habitat for birds, insects, natural enemies of pests
 - build soil structure



UCCE Advisor Rachel Long and a grower standing in front of an elderberry hedgerow

Hedgerows

 **ATTRA Sustainable Agriculture**
NCAT A program of the National Center for Appropriate Technology • 1-800-346-9140 • www.attra.ncat.org

A Pictorial Guide to Hedgerow Plants for Beneficial Insects

By Omar Rodriguez and Rex Dufour, NCAT Agriculture Specialists
Published Oct. 2017

This publication provides a straightforward pictorial guide to several of the most beneficial hedgerow plant species used in farmscaping for native pollinators and insect predators and parasites in California. It provides plant names, bloom times, heights, and descriptions that note considerations for selection and establishment.



California buckwheat in bloom. Photo: Rex Dufour, NCAT



Assassin bugs are generalist predators with a wide host range. Photo: Rex Dufour, NCAT



Deergrass in a farm hedgerow. Photo: Rex Dufour, NCAT



Lady bird beetles overwintering in deer grass. Groups of beetles emit an aggregation pheromone that attracts additional lady bird beetles. Photo: Rex Dufour, NCAT

Hedgerows



Flannel bush in full bloom. Photo: Rex Dufour, NCAT



Ceonothus in full bloom. Photo: Rex Dufour, NCAT



Elderberry in a hedgerow. Ideal as windbreak, dust barrier, and bird habitat, but may need some pruning of multiple stem base. Photo: Rex Dufour, NCAT



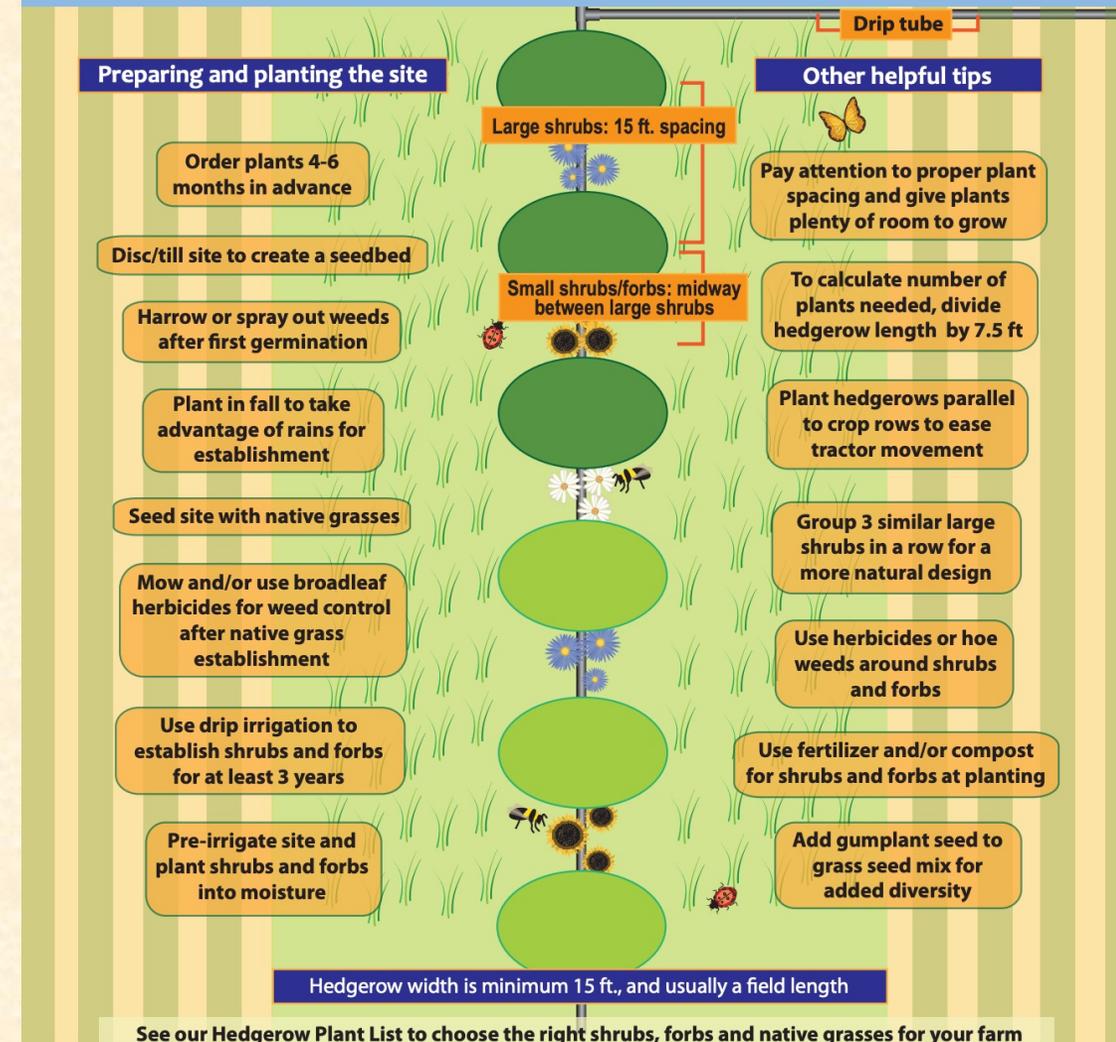
Coyote bush in bloom. Photo: Rex Dufour, NCAT

Hedgerows

- Requires good planning & management:
 - Make a plan
 - Select, analyze, design, & prepare site for planting
 - Choose appropriate plants

Inside Hedgerows

The Dynamics of a Hedgerow Planting



 University of California
Agriculture and Natural Resources
University of California Cooperative Extension
70 Cottonwood St., Woodland, CA 95695
530-666-8734 (office) | <http://ceyolo.ucdavis.edu>



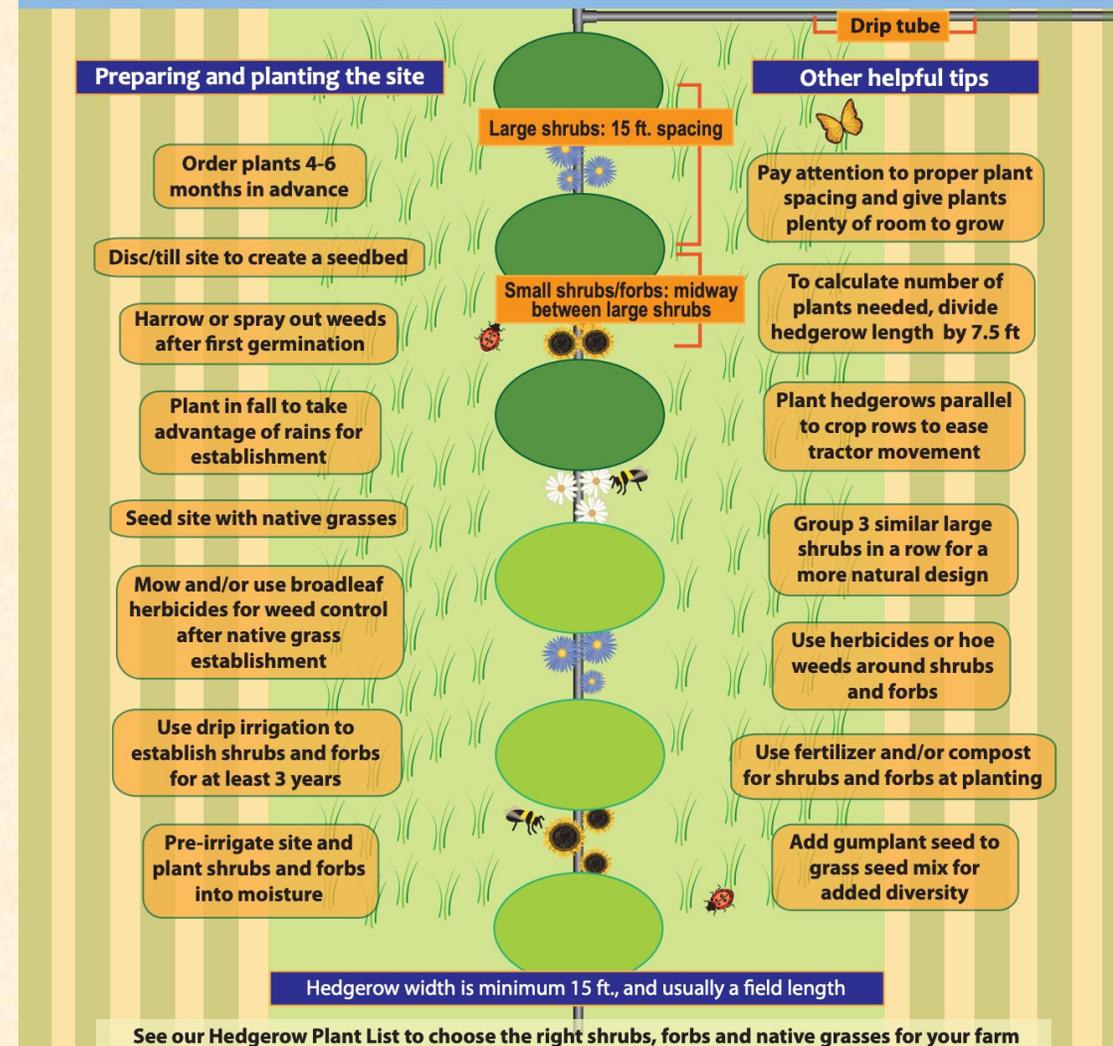
For more information:
Establishing Hedgerows on
Farms in California
<http://anrcatalog.ucdavis.edu>
(publication #8390)

Hedgerows

- Requires good planning & management:
 - Implement IPM plan for weed and rodent control
 - To promote rodent predators, could consider installing owl boxes in hedgerows
 - Might need to irrigate young plants to promote establishment

Inside Hedgerows

The Dynamics of a Hedgerow Planting



Hedgerows

Benefits	Tradeoffs
<ul style="list-style-type: none">• Biodiversity: promotes habitat for beneficials• Soil: reduce erosion, runoff• Barrier: a living fence, windbreak• Carbon: increase carbon storage in plant biomass and soil• Weeds: competition with weeds on edges	<ul style="list-style-type: none">• Cost of establishment• Cost of ongoing maintenance & weed management in hedgerow

Hedgerows Resources

- Hedgerow planning: for more info & assistance, reach out to your local
 - Extension advisor
 - NRCS office
 - RCD office
- Funding: ask about the NRCS EQIP program to help fund hedgerow installation



Hedgerows

UC Cooperative Extension
UC CE Pest Management

Enter Search Terms



UCCE Capitol Corridor Home Pest Control Notes newsletter

- Home
- Alfalfa
- Dry Beans
- Hedgerows**
- Seed Crop Production
- Water Quality
- Cost Studies

Hedgerows

Benefits of Hedgerows include:

- *Pest control
- *Wind breaks
- *Air and water quality protection
- *Soil protection
- *Wildlife habitat
- *Enhanced populations of beneficial insects & pollinators

Hedgerow Information:

[Hedgerows on field crop edges increase soil carbon to a depth of 1 meter](#)

University of California
Agriculture and Natural Resources

UC PEER REVIEWED

<http://anrcatalog.ucdavis.edu> Publication 8390 | April 2010

Establishing Hedgerows on Farms in California

RACHAEL F. LONG, Farm Advisor, University of California Cooperative Extension, Yolo County; JOHN H. ANDERSON, Hedgerow Farms, Yolo County

ATTRA Sustainable Agriculture
NCAT A program of the National Center for Appropriate Technology • 1-800-346-9140 • www.attra.ncat.org

A Pictorial Guide to Hedgerow Plants for Beneficial Insects



HEDGEROWS AND FARMLANDSCAPING FOR CALIFORNIA AGRICULTURE

A RESOURCE GUIDE FOR FARMERS
2ND EDITION



CAFF | FARMERS GUILD
COMMUNITY ALLIANCE WITH FAMILY FARMERS

Organic Weed Management

- Weed ID: who is there?
- What are their growth & reproductive habits?
- Monitoring & record keeping: species? location? timing?



UC IPM / Agriculture / Olive / Common and Scientific Names of Weeds 

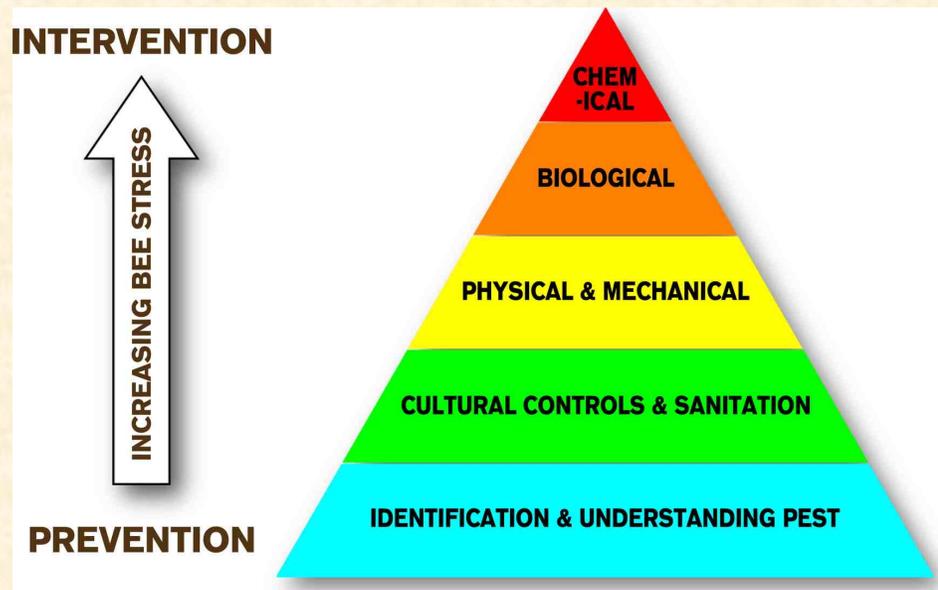
Agriculture: Olive Pest Management Guidelines

Common and Scientific Names of Weeds

Common Name	Scientific Name
Asparagus	<i>Asparagus officinalis</i>
Barley, Hare	<i>Hordeum murinum ssp. leporinum</i>
Barnyardgrass	<i>Echinochloa crus-galli</i>
Bermudagrass	<i>Cynodon dactylon</i>
Bindweed, Field	<i>Convolvulus arvensis</i>
Blackberries	<i>Rubus</i> spp.
Bluegrass, Annual	<i>Poa annua</i>
Bromegrasses	<i>Bromus</i> spp.
Canarygrass	<i>Phalaris canariensis</i>
Catsear, Common	<i>Hypochaeris radicata</i>
Chickweed, Common	<i>Stellaria media</i>

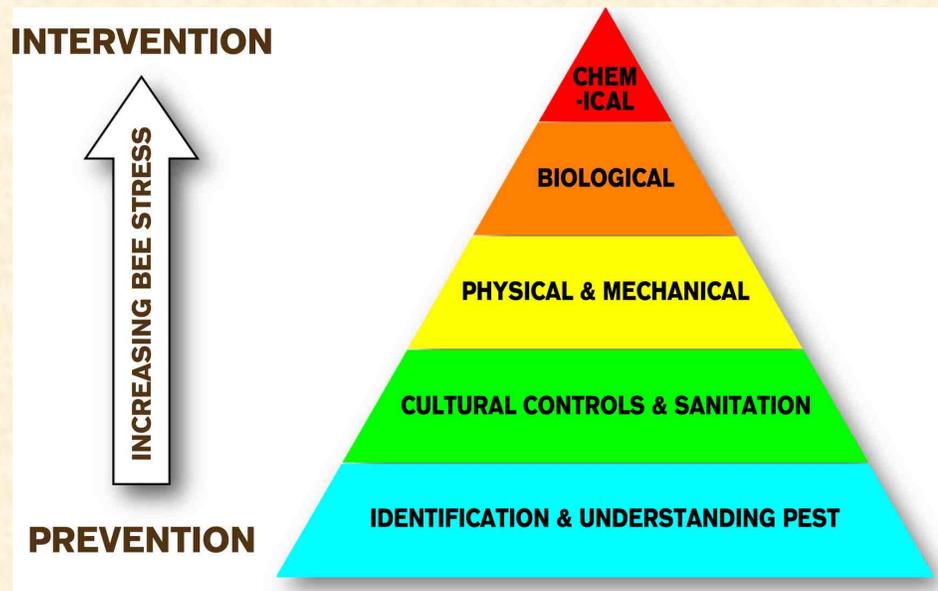
Plant Ecological Principles

- Integrated Pest Management (IPM) is an ecosystem-based framework
- a problem-solving process that minimizes risks to people & environment
- toolbox of strategies



Plant Ecological Principles

Food for thought: how could plant ecology enhance your IPM approach?



Consider

Niches

alleys: cover crops, intercrops
edges: hedgerows

Biodiversity & Multifunctionality:
species selection



Consider

Niches

alleys: cover crops, intercrops

edges: hedgerows

Interactions & Trophic Chains:

IPM & natural predators,

building soil organic matter

Cost & Benefits

profitability, resiliency, stability

Biodiversity & Multifunctionality:

species selection

Timing: planting, flowering,
life cycle, nutrient availability



Consider

How can different plant species enhance my...?

- Integrated Pest Management Plan
- Water conservation
- Nutrient management
- Soil functioning
- Climate adaptation strategies
- Crop system stability
- Profitability & income stability



Conclusion

- Strategic plant ecological management can provide many services in olive orchards
- Choose practices that make sense in your unique context (no “one-size-fits-all”)
- Can experiment on a small scale first



Thank you!



Questions? Anecdotes?

