Successful Biological Orcharding

with

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from

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Fascinating biological connections make for a healthy orchard ecosystem. All insect pests and fruit tree disease ï whether fungal or bacterial ï have launching points and particular timing. Healthy trees address these challenges first and foremost *from within*. Growers utilizing an ongoing investment in soil nutrition and biodiversity set the stage for gentler organic sprays to grow a successful fruit crop. The challenges you face at your locale will become far more manageable as you build a holistic system that keeps trees and berry plantings healthy from the get-go.

Healthy Plant Metabolism

Photosynthesis efficiency
Protein synthesis
Fats, essential oils, and phenolics

Fungal Duff Management

Forest edge ecology
Mycorrhizal boon
Tree root cycles
Ramial wood chips
Fungal design notions

Orchard Soil Health: Food Web Interaction & Fertility Ratios

Compost wisdom
Stocking the pantry
Nutrient density

Ecosystem Connections
Understory fertility loop
Root space, light space
Biodiversity to the nth degree
…Beneficial mathematics
Pollinator habitat
Braconid inspiration
Spider glory

Disease Progression
Staging areas
Fungal timing
Bacterial opportunists

Integrating Holistic Tenets into Orchard Practice
Phytochemical pathways
Stimulating induced resistance
Fatty acid nutrition
Competitive colonization
Cuticle defense
Genetic resistance mechanisms

OUT TO THE TREES AND GARDENS!

Holistic Alternatives to Fungicides
Systemic acquired resistance
Mixing pure neem oil
Effective microbes
Windows of opportunity
Stirring the biological stew

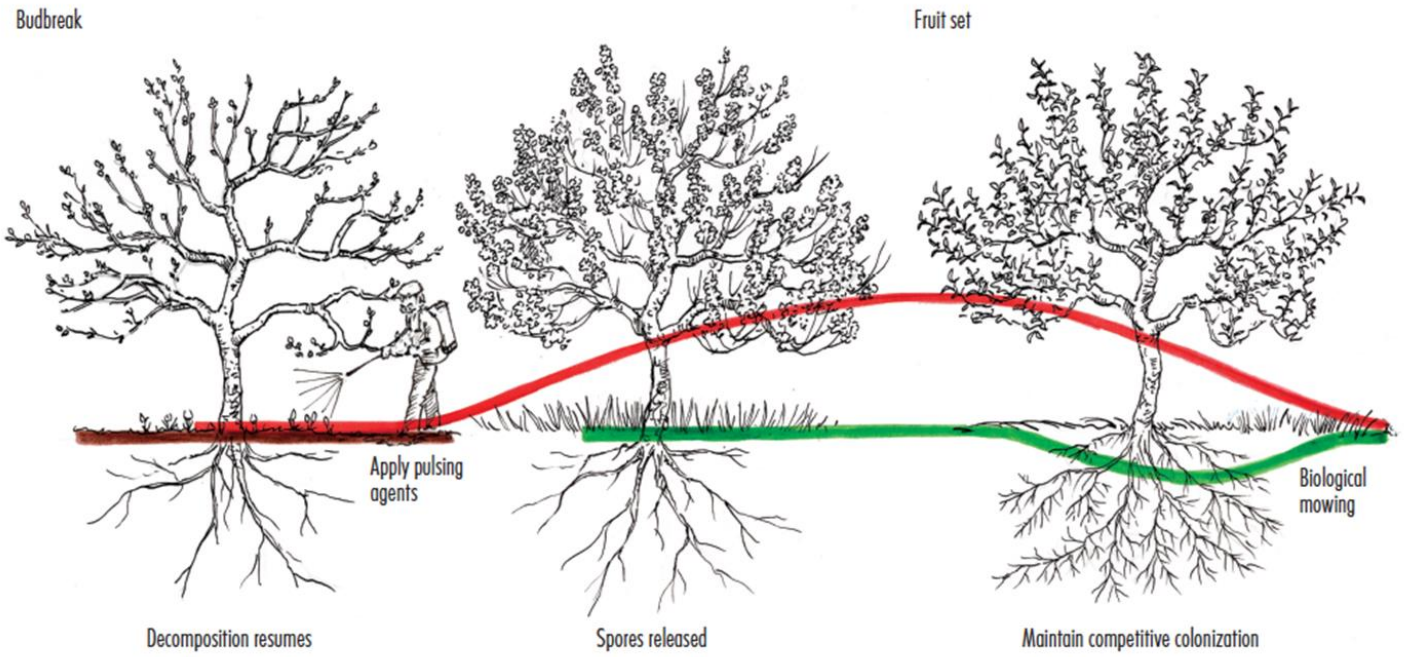
Insect Finale
Points of vulnerability
Nudging into balance
Organic tool box
Alternate inducements
No year will ever be the same

Your Turn
Ask those questions please!

The Fungal Curve

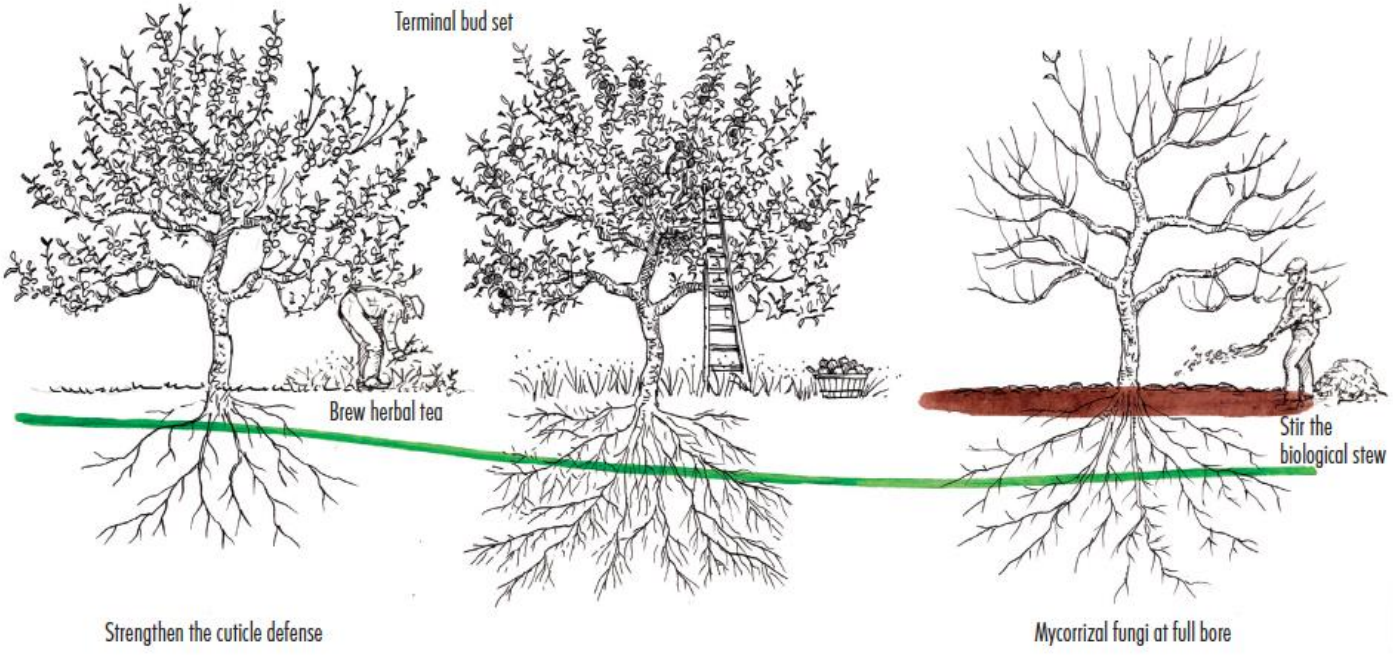
The growth cycle of feeder roots reveals the best timing for a number of orchard tasks. In a nutshell, the apple tree experiences two flushes of root growth that follows on the heels of observable green tissue growth above ground. The **"spring flush"** corresponds with soils warming up and the garnering of nutrients for fruit development and the formation of next year's flower buds. The **"fall flush"** kicks off terminal bud set, the expansion of the tree's permanent root system, and the all-critical storage of nutrients in bark tissues for spring.

Those wonderful drawings by Elayne Sears that show all this in the revised edition of the book are reproduced here so we can add yet another rhythmic layer to our understanding. The Fungal Curve is really a series of fungal happenings in the orchard that fruit growers need to recognize.



Bioactivity of numerous decomposers on the orchard floor is represented by the color brown - many of our practices aimed at reducing fungal disease inoculum in the understory are really about supporting the decomposers, which includes numerous species of beneficial fungi.

We address our "fungal fears" when we consider the red portion of the curve. Biodynamic orchardist Hugh Williams rightfully calls this space the "fungal zone" when describing how fungal disease spores arise from the ground surface to infect tender apple tissues. The primary infection period for diseases like apple scab, rust, and an assortment of rots corresponds perfectly with this red curve. Beneficial fungi and bacteria also arise and establish on the foliar surface during this outreach time of the "fungal being". The successful employ of biological reinforcement, induced systemic resistance, and minimal sulfur (on susceptible varieties) in holistic disease management all tie in directly to recognizing our allies.



The intricate interactions of the soil food web are what make animated life above the ground possible. The green portion of the fungal curve amounts to celebrating and abetting the role of mycorrhizal fungi in the orchard ecosystem. The fall flush of feeder roots is trumped a hundred times over by the hypha reach of these symbiotic fungi. Nutrient balance for the apple tree very much depends on the health of this life-support system.

Ramial Wood Chip Primer

There are white rots and there are brown rots related to decomposition. The first support a deciduous environment; the latter deal with high tannin content and thereby define the evergreen forest. Let's talk about ramial wood chips as the main course for feeding mycorrhizal and saprophytic fungi in an orchard food web that in turn supports our trees.

Defining Ramial Wood

- Consists of twig wood less than 7 centimeters in diameter– being not much more than 2½ inches around at the large end of the branch
- Species for chipping should mostly be deciduous, as here lays the soluble lignin advantage use by white rots to produce humic and fulvic acids
- Coarse pieces are preferable, including the prunings from fruit trees.

Understanding Ramial Nuance

The proportion of essential twig nutrients in wood chips increases as average branch diameter decreases. Nitrogen, phosphorus, potassium, calcium, and magnesium are found in the green cambium where leaf photosynthesis production and root nutrition come together to make a tree . . . which we in turn can redirect to build ideal soil in our own orchards to make fruit trees.

Size of the branches being chipped matters yet again when we consider the immediate impact on soil life. The carbon-to-nitrogen ratios in ramial-diameter wood averages 30:1, going no higher than 170:1 as we consider the larger end of the recommended branch. These ratios rise dramatically in stem wood, running 400:1 to as much as 750:1, thereby creating that soil dynamic where nitrogen becomes unavailable to the plant until such "log mulch" has significantly been broken down.

Soil fungi are adept at creating humus from a lignin source. Soil that has been built from the top down through fungal action undergoes humic stabilization– such soil has staying power and maximized nutrient recycling. Fruit trees belong in such soil. Ongoing soil health results from soil structure being managed by soil organisms. Fungal hyphae physically bind soil particles together, creating stable aggregates that help increase water infiltration and the soil's water-holding capacity. This accumulation of acid-rich organic matter as humus results from the decomposition of ramial wood chips.

Decomposing fungi can be classified into two subgroups. The *white rots* use enzymatic chemistry on lignin-rich hardwood to produce fulvic and humic. The *brown rots* transform softwood cellulose to produce polyphenols and allelopathic compounds specifically relied upon by evergreen species to suppress deciduous species.

Practical Applications of Ramial Wood Chips

- A mixed chipping containing no more than 20 percent softwood will favor white rots and thus can be spread freshly chipped.
- Steer away from solely softwood wood chips for orchard purpose. That said, aging a homogenous pile for a year overturns the allelopathic impact of brown rots. Mix with mature compost to create rich woodsy mulch for berry plantings.
- Diversity is always good. Dump ramial wood chips thickly in piles on different sides of bearing trees over the years. Young trees can be ring mulched.
- Leaves in full green make for higher nitrogen content. "Summer chips" heat up beyond the desired fungal influence. This is fine for the initial phase of composting but not something to apply directly as orchard mulch.

Diversity Cannot Be Overplayed

Perennial Genus	Common name	Family	Ecosystem Niche
Achillea millefolium	Yarrow	Aster	beneficials, medicine
Allium tuberosum	Garlic Chives	Onion	beneficals, odor confusion
Alnus rubra	Red Alder	Birch	N-fixer, chop&ncirc;nôdrop
Antennaria spp.	Pussy Toes	Aster	beneficial accumulator
Anthriscus sylvestris	Woodland Chervil	Parsley	beneficial accumulator
Arctium spp.	Burdock	Aster	taproot, bumbles, medicine
Ceanothus americana	New Jersey Tea	Buckthorn	spiders, myco accumulator
Chrysogonum virginianum	Green and Gold	Aster	shade tolerant
Coreopsis spp.	Coreopsis, Tickseed	Aster	beneficial accumulator
Cornus stolonifera	Red Osier Dogwood	Dogwood	beneficials, chop&ncirc;nôdrop
Cryprotaenia canadensis	Honewort	Parsley	beneficial accumulator
Echinacea purpurea	Purple Coneflower	Aster	bumblefest, bird immunity
Eupatorium perfoliatum	Boneset	Aster	beneficials, medicine
Euphorbia esula	Leafy Spurge	Spurge	vole deterrent
Foeniculum vulgare	Fennell	Parsley	beneficial accumulator
Gaillardia spp.	Blanket Flower	Aster	beneficial accumulator
Helianthus spp.	Perennial Sunflowers	Aster	wasps, bumblefest
Helianthus tuberosum	Jerusalem Artichoke	Aster	late bloom, people food
Inula helenium	Elecampane	Aster	bumblefest, medicine
Levisticum officinale	Lovage	Parsley	beneficials, taproot
Lupinus spp.	Lupine	Pea	N-fixer, bumblefest
Melissa officnalis	Lemon Balm	Mint	beneficials, winter haven
Monarda spp.	Bee Balm	Mint	bumblefest, tea herb
Myrrhis odorata	Sweet Cicely	Parsley	beneficials, taproot
Pulmonaria officinalis	Lungwort	Borage	bumble queen casbah
Pycnanthemum spp.	Mountain Mint	Mint	beneficial accumulator
Rheum rhabarbarum	Rhubarb	Knotweed	beneficial accumulator, pies
Sambucus canadensis	Elderberry	Honeysuckle	wasps, medicine
Senecio spp.	Ragwort, Groundsel	Aster	beneficial accumulator
Solidago spp.	Goldenrods	Aster	wasps, spiders
Spirea alba	Meadowsweet	Rose	beneficial accumulator
Symphytum x uplandicum	Russian Comfrey **Bocking 14 cultivar**	Borage	taproot, bumblefest, calcium, winter haven
Tanacetum parthenium	Feverfew	Aster	beneficial accumulator
Thymus spp.	Thyme	Mint	wasps, myco accumulator
Tussilago farfara	Coltsfoot	Aster	spring pollinators
Viburnum trilobum	Highbush Cranberry	Honeysuckle	beneficials, spiders

Orchard Fertility

Based on Rational Ratios for Health!

BASIC SOIL VALUES

Seems like a whole lot of shaking going on here with this soil testing business, eh? Each orchard soil has parameters established around organic matter content, cation exchange capacity, and the geological reality of the place you be.

Some simple basic values can be articulated for those not quite ready for the full monty of soil considerations. Keep in mind that these generalized guidelines aren't necessarily as optimal as it gets for a particular situation. The purpose here is simply to give your trees "ground to stand on" with a reasonable chance of success.

- Get that pH in the 6.3-6.7 range.
- Do this in the context of cation balance based on the CEC number for your soil.
- Organic matter fuels the biology. Get OM to 3% at a bare minimum.
- Phosphate and potash readings on a CEC test of at least 200# of each

This checklist defines clear goals for the soil build-up phase in preparing your home orchard. **Organic methods are not going to work as well if the basics of mineral nutrition in your soil are not up to snuff.**

> Here's the *ace up the sleeve* offered by vibrant soil biology: Mineralization is a two-way street. Those soluble nutrients produced by the microbes but not taken up immediately by the roots go right back into the next generation of microbes. There's rhythm here—a responsive beat—a tidal sensibility even. Plant roots in turn exude carbon that keeps microbe diversity and the immobilization/mineralization balance humming right along. It's this nature of the life portion of the soil that introduces and enforces the whole concept of balanced nutrition as opposed to the overstocked flooding of the reductionist chemical approach.

Soil Testing

Our role in starting an orchard is simply to check that pantry basics are essentially in balance. A soil test emphasizing biological parameters is the tool by which to gauge this. Certain soil amendments will likely be called for to achieve a proper starting gate for the biology.

Organic Matter

A diverse understory of plants is the principal means of replenishing organic matter from one growing season to the next. Orchard compost and/or a variety of haphazard mulches contribute here as well. The soluble lignins in ramial wood chips fuel the biology to produce the best type of organic matter of all: Stable humus provides for long-term nutrient storage that will be expressed as cation exchange capacity (CEC) on soil tests. Humic and fulvic acids made available through "humus banking" are what improve micronutrient assimilation across the board.

Cation Balance

Magnesium serves to pull soil particles closer together whereas calcium will spread the particles further apart. See where we're going with this? Slightly more magnesium is called for in a porous soil whereas clay requires higher levels of calcium to improve drainage and aeration. The percentage of base saturation for each of these elements provided on a soil test is how we compare the relative levels of each. The Ca:Mg ratio for a sandy soil can be targeted at 5:1 (noting the structural need for magnesium may skew this even lower). This same ratio for the *soil of your dreams*– that fine textured loam– should be close to 7:1. The heaviest clay soils benefit from even more calcium, so now a slightly higher Ca:Mg ratio becomes appropriate. The calcium pushes soil particles apart– that's good for clay. The magnesium pulls soil particles together– that's bad for clay but ever so good for sandy soils that lose water too quickly– which is when a higher proportion of magnesium is desirable. You determine which ratio range to use based on where the CEC number falls for your soil.

Potassium enters in here as well, tagging along on the heels of calcium at no greater than a 14:1 ratio. The percent base saturation numbers that represent "cation balance" for loam soil with respect to Ca:Mg:K are on the order of 70:12:4-5. These numbers shift for sandy soil to more like 65:16-18:3-4 and for heavy clay soil to more like 76:10:4-5.

Phosphorous – P

Phosphate (chemically notated as P_2O_5) requires time to get functioning organically. Ecological ag people have suggested that a phosphate-to-potash ratio of 2:1 is necessary to sustain crop refractometer readings above 12 brix (this being the measure of soluble solids in plant tissue indicative of overall health). Yet often the reverse is true in most biologically-managed soils, as potassium levels are constantly renewed by decomposing organic matter. Indigenous soil properties vary widely across the North American continent as well. Getting the P:K ratio to toe the line nearer to 1:1 can be challenging enough.

Potassium – K

Potassium is needed to renew what has gone into the fruit and to increase tolerance to winter cold and spring frosts. This mineral also strongly influences fruit color and fruit size. A huge heaping of organic matter, whether through generous composting and/or aggressive mulching, may nudge potassium levels too high relative to Ca and Mg, especially in dryland soils. Orchardists with shallow soils are the ones most likely to run short on the K score. *Potash* (being potassium oxide, KO_2) is often used to refer to various mined salts that contain the element potassium in water-soluble form.

Micronutrients

The essential soil nutrients that plants need in very small amounts are iron (Fe), manganese (Mn), boron (B), molybdenum (Mo), copper (Cu), zinc (Zn) and chlorine (Cl). These micronutrients are sometimes referred to as *trace minerals*. Soil tests may reveal a strong need to supplement one or two of these throughout certain regions– that can be done– but for the long haul I prefer using broad-source "soil condiments" in my orchard and garden compost on an ongoing basis.

The soil food web in all its diversity and complexity trumps reductionist soil chemistry many times over!

Holistic Spray Plan for the Home Orchard

Every orchard site faces its own array of challenges. Biodiversity of place sets the stage. Specific disease cycles need to be understood to determine if spray applications should be continued beyond the primary infection window. Rots in particular require additional action in the fruit sizing window. Commercial growers concerned with aesthetic diseases and nutrient density will likely continue spray applications into summer. Weave in the organic tool box for insect pressures as necessary ï knowing pure neem oil helps considerably here.

Growth Stage	Holistic Spray	Mix includes (per backpack)		Comments
Bud swell	Dormant Holistic (if needed)	20 oz. liquid fish 10 oz. neem oil 12 oz. effective microbes	**Winter's End**	Copper or lime sulfur are conventional organic means of addressing overwintering pathogens in buds and bark crevices
Quarter-inch green	Spring Holistic 1	Core Holistic Recipe w/doubled rates of liquid fish and effective microbes	**Primary Infection Window**	Thoroughly wet fungal duff zone and trunk/branch structure
Tight cluster to pink	Spring Holistic 2	Core Holistic Recipe		Add Bt to this spray mix if surface feeding caterpillars in evidence
Spring Feeder Root Boost				Organic blends with nitrogen boost for young trees, weak trees, and biennial bearers
Bloom	Competitive Colonization Boost	NO FISH NO NEEM 12 oz. effective microbes 1 oz. seaweed extract 4 oz. molasses		This spray made midway through the bloom period é if conditions warrant
Petal fall	Spring Holistic 3	Core Holistic Recipe		Timing to be averaged across varieties
Week of petal fall	Fruit set pests (eastern growers)	Surround for curculio Spinosad for sawfly		Base coat of kaolin clay to be applied in 2 to 3 layers
1st Cover (7 days later)	Spring Holistic 4	Core Holistic Recipe		Micronized sulfur can be considered as well in an exceptionally rainy year
Week of fruit set	Fruit set pests	Renew Surround for PC 1st generation moths	**Fruit Sizing Window** **Hand thin crop load within these 30 days**	
2nd Cover (10 days later)	Comprehensive Holistic 1	Core Holistic Recipe w/ herbal teas w/ sea minerals		Fermented teas begin when herb growth stage appropriate for brewing
Next week of fruit set	Fruit set pests	Renew Surround for PC 1st generation moths		
	Borer trunk spray	5 oz. neem oil		Adjust borer timing to the specific species at your site
3rd Cover (10 days later)	Comprehensive Holistic 2	Core Holistic Recipe w/ herbal teas w/ sea minerals		
4th Cover (10 days later)	Comprehensive Holistic 3	Core Holistic Recipe w/ herbal teas w/ sea minerals		

5th Cover (14 days later)	Summer Holistic 1	Core Holistic Recipe w/o liquid fish w/foliar calcium	**Fruit Ripening Window**	Comfrey tea provides a farm source of calcium. Products like Premier add a trace mineral component.
	Apple Maggot fly	Sticky ball traps		
	Borer trunk spray	5 oz. neem oil		Adjust borer timing to the specific species at your site
6th Cover (14 days later)	Summer Holistic 2	Core Holistic Recipe w/o liquid fish w/foliar calcium		See calcium note above.
7th Cover (14 days later)	Summer Holistic 3	Core Holistic Recipe w/o liquid fish w/foliar caclium		See calcium note above.
8th Cover (14 days later)	Summer Holistic 4	Core Holistic Recipe w/o liquid fish w/foliar calcium		If deemed helpful on later varieties.
Fall Feeder Root Boost			**Harvest Time**	Organic blends with appropriate cation balance, rock phosphate, and trace minerals.
Leaf drop in progress	Fall Holistic	20 oz. liquid fish 5 oz. neem oil 12 oz. effective microbes	**Post Harvest**	Non-aerated compost tea is a suitable microbe back-up if em supply is used up

Home Orchard Rates. This assumes a 4-gallon backpack sprayer is used to cover so many trees to the point of runoff. The numbers given are based on ñacreage rateò for each product, figuring a minimum of 100 gallons spray volume applied by tractor handgun. We®e simply dividing that acreage rate by 25 to specify backpack rates. The size of your trees and targeting the ground at certain times as well determines how far a single backpack will go. Once you know how many backpack tanks will provide sufficient cover each time you spray, it®s easy to figure how much product to purchase for the season ahead.

Core Holistic Recipe. Mix 2.5 ounces of pure neem oil with a generous teaspoonful of soap emulsifier to achieve a 0.5 percent neem concentration. Use 10 ounces of liquid fish and 6 ounces of mother culture of effective microbes for this backpack volume. Dissolve as much as a half cup of blackstrap molasses in warm water to launch those hungry critters. Backpack applications should also include 5 tablespoons of liquid kelp or half an ounce (dry weight) of the seaweed extract.

Enhancements to the Core Recipe.

- Sea mineral rate (when specified) is 2 ounces per tank.
- Continued use of liquid fish in the fruit sizing window is optional.
- Coconut milk is a vegan substitute for liquid fish.
- Raw cow milk (diluted 1:10 with water) helps with rots in the fruit sizing and fruit ripening windows. Experiment here and report in please.
- Aerated compost tea can be substituted for effective microbes. The ideal may actually be to use both in order to maximize species diversity. Some companies offer ñbiology in the jugò along with an array of good nutrients.

Beneficial Mathematics

Natural predators are too often judged to be insufficient at providing complete control of a pest problem. What an appropriate moment to say *poo pah*! Dismissing helpful allies in the orchard ecosystem for not providing a complete solution on a species basis is exceedingly shortsighted and frankly arrogant. How much better it is to understand that several partial solutions add up to substantial biocontrol. And that this might just be diversity's way of doing higher math.

Let's consider the codling moth… most anyone anywhere will deal with this pest of apples, pears, quince, and even some apricots and plums. Eggs are laid singly in proximity to the developing fruit, often on a nearby leaf if not on the fruitlet itself. Each female moth will deposit 30 to 100 pinhead-size eggs. These sit exposed for 6–14 days before hatching. Certain parasitic wasps can sense precisely where and will lay their eggs inside each moth egg to provide a feed for their young. Call that a 20 to 60 percent advantage. . . provided plenty of flowering diversity exists to support the presence of plenty of adult wasps.[1] Just-hatched codling moth larvae have significantly better odds than most moth caterpillars, as this internal feeding species bores into the fruit generally within 24 hours. A spined soldier bug or an especially astute chickadee might have ended this passage. Still other parasitic wasps lay their eggs in the larvae itself to provide a feed for their young.[2] Score that 5 to 10 percent given the short duration of exposure (the odds against surface feeding caterpillars rise astronomically, by the way). Codling larvae eat the seeds in the fruitlet and then exit some 3 to 4 weeks later, either by dropping to the ground in a fallen fruit or crawling back towards the trunk. Yellow jackets gather such caterpillar meat for their young. . . spiders weave, pounce, and otherwise frolic. . . ground beetles never let creamy flesh walk on by. Let's take away another 5 to 20 percent. Surviving larvae spin a cocoon in which to pupate beneath bark scales on the trunk or in a sheltered place at the base of the tree. Woodpeckers and nuthatches work this situation; tachinid flies aren't averse to sticking an egg within that cocoon to facilitate a pupal feast. That puts codling moth down another 10 to 20 percent.

Beyond *letting all this happen* by fostering biodiversity, our job on the insect balance front should be considered blessedly small in comparison! The advantages spoken of here apply to all pests to varying degrees. Spend some time getting to know your friends and revering their "limited contributions" in the big scheme of things.

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[1] Trichogramma wasps can be purchased from beneficial supply houses and timed for release into commercial orchards just as codling moth egg laying initiates. Research indicates as much as a 60 percent decrease in pest numbers as a result. The braconid wasp *Ascogaster quadidentata* does similar work.

2 Charles Darwin once wrote about ichneumonid wasps: "I own that I cannot see as plainly as others do, and as I should wish to do, evidence of design and beneficence on all sides of us. There seems to me too much misery in the world. I cannot persuade myself that a beneficent and omnipotent God would have designedly created the *Ichneumonidae* with the express intention of their feeding within the living bodies of caterpillars." Keep in mind that the father of evolutionary thought was not an apple grower!

Seeking Lepidoptera Balance

Many species of fruit moths, active at different points in the season from green tip on through harvestð and multi-generational to bootð make for significant challenge. Organic orchardists have an array of approaches in seeking balance with the Lepidoptera complex. Keep in mind two important caveats as you determine the most effective course of actions for your site. One, never rely solely on any one approach even for a single species. And two, a good job of control with the first generation is critical to limiting the next round of egg layers.

Organic options	**Species**	**Comments**
Bacillus thuringensis	All	Short residual of three days can be enhanced with fish oil. Larvae must ingest this biological toxin, thus internal feeders can quickly reach relative safety.
Surround	CM OFM LAW	Suppresses 1st generation egg-laying provided thick coverage is maintained those first weeks following petal fall. Female moths sense clay on upper leaves. . . then go on to look for ñright treeò
Summer oil	All	Stylet oil offers an organic formulation. Deters female from laying eggs as well as smothers eggs.
Granulosis virus	CM OFM	Virosoft and Cyd-X are commercial formulations. Baculoviruses are semi-specific to each species.
Mating disruption	CM OFM OBLR	Twist ties (200ï 400 to the acre) placed in trees. Different placement strategies for different species. Lures for OFM apparently work for LAW. Not recommended for windy sites and blocks less than 1 acre.
Grandevo	All	Naturally derived from a newly discovered bacterium, which produces compounds that contribute to complex modes of action. Control of moths and mites is achieved through repellency, oral toxicity, reduced egg hatch, and reduced fecundity (ability of pest to reproduce)
Entrust (Monterey or Bullôs Eye are backyard formulations	All	Biologically derived from the fermentation of a naturally occurring soil organism, *Saccharopolyspora spinosa.* Species resistance can follow overuse of spinosad. Best reserved for summer generations where 7ï 10 day residual overlaps a multi-species window.
Pure neem oil	All	Four holistic sprays of spring include neem oil. Insect growth regulator aspect affects eggs and larvae. Summer use will help with 2nd generation pressures.
Trichogramma minutum	All	Beneficial habitat (source of nectar) a must! Releasing 400,000 parasitized eggs per acre over several consecutive weeks gives approximately 60% CM control. Numbers dwindle, making annual release necessary.
Cardboard bands	CM	Larvae crawl into cardboard corrugations to pupate. Bands work best on smooth-barked trunks. Remove after 1st generation and then again post-harvest.