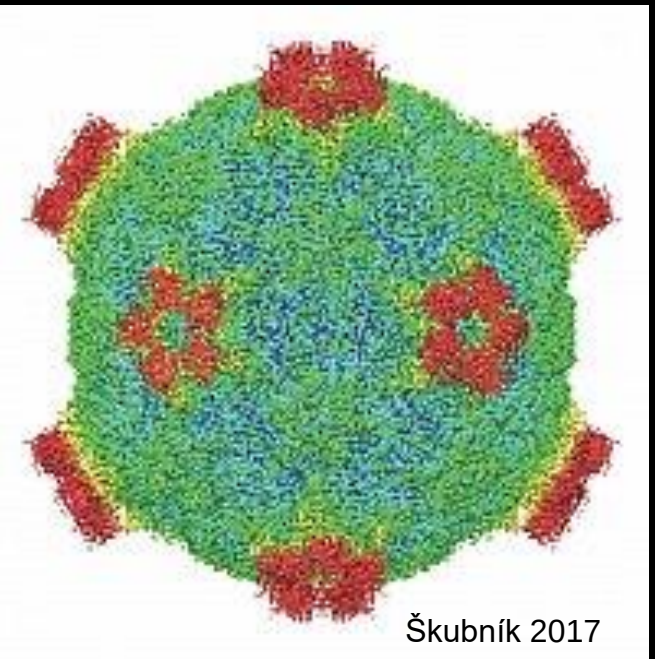
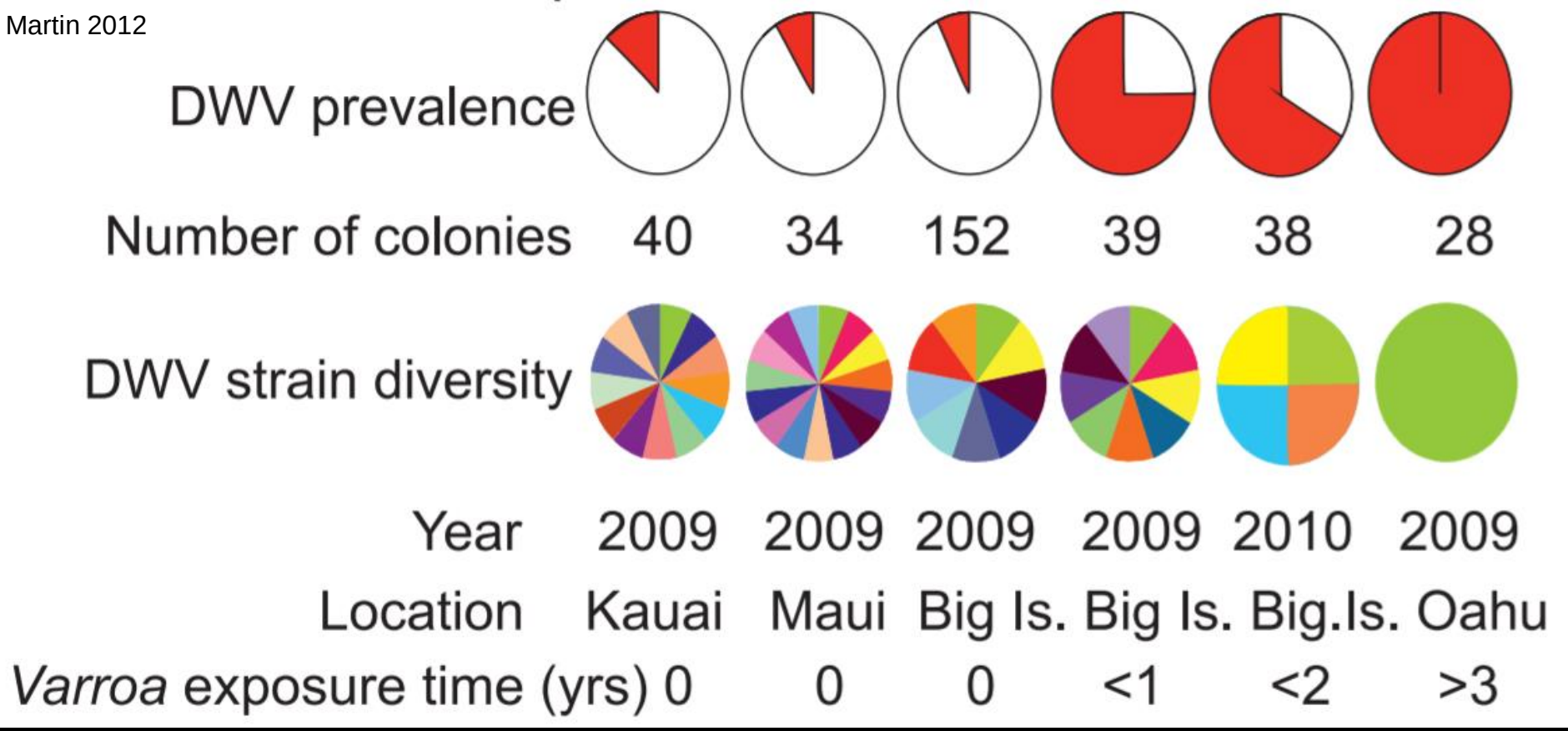
The evolutionary effects of beekeeping practices upon the coevolution of the varroa/DWV *“Monster.”*

Four species are involved in this coevolution



Martin 2012



DWV is able to rapidly evolve to take advantage of varroa and beekeeping practices to better reproduce and disperse.

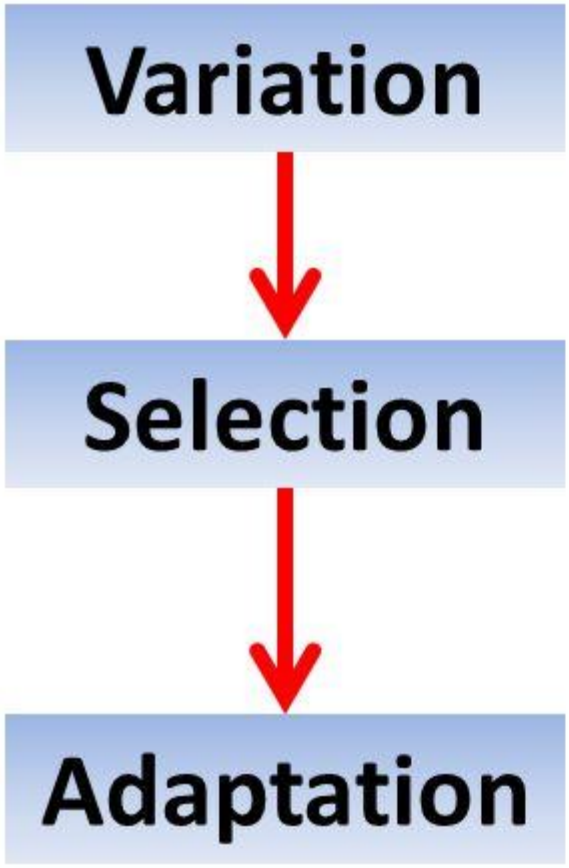

Deformed Wing Virus
(DWV)


First signs of an in-hive
DWV epidemic


PMS

Beekeeper practices created *The Varroa Problem…*
But we don’t need to perpetuate it.

The Process of Evolution



Because of **mutation and recombination** of genes, there is variation in a population

Selection occurs when some heritable variations allow organisms to **survive and reproduce** more

Adaptation has two meanings: 1. The process by which an organism becomes **better fit** to its environment due to selection, and 2. A characteristic of an organism that makes it more fit in its environment.

Reproduction is about increasing the number of genetic copies. Both varroa and DWV are very good at reproduction.

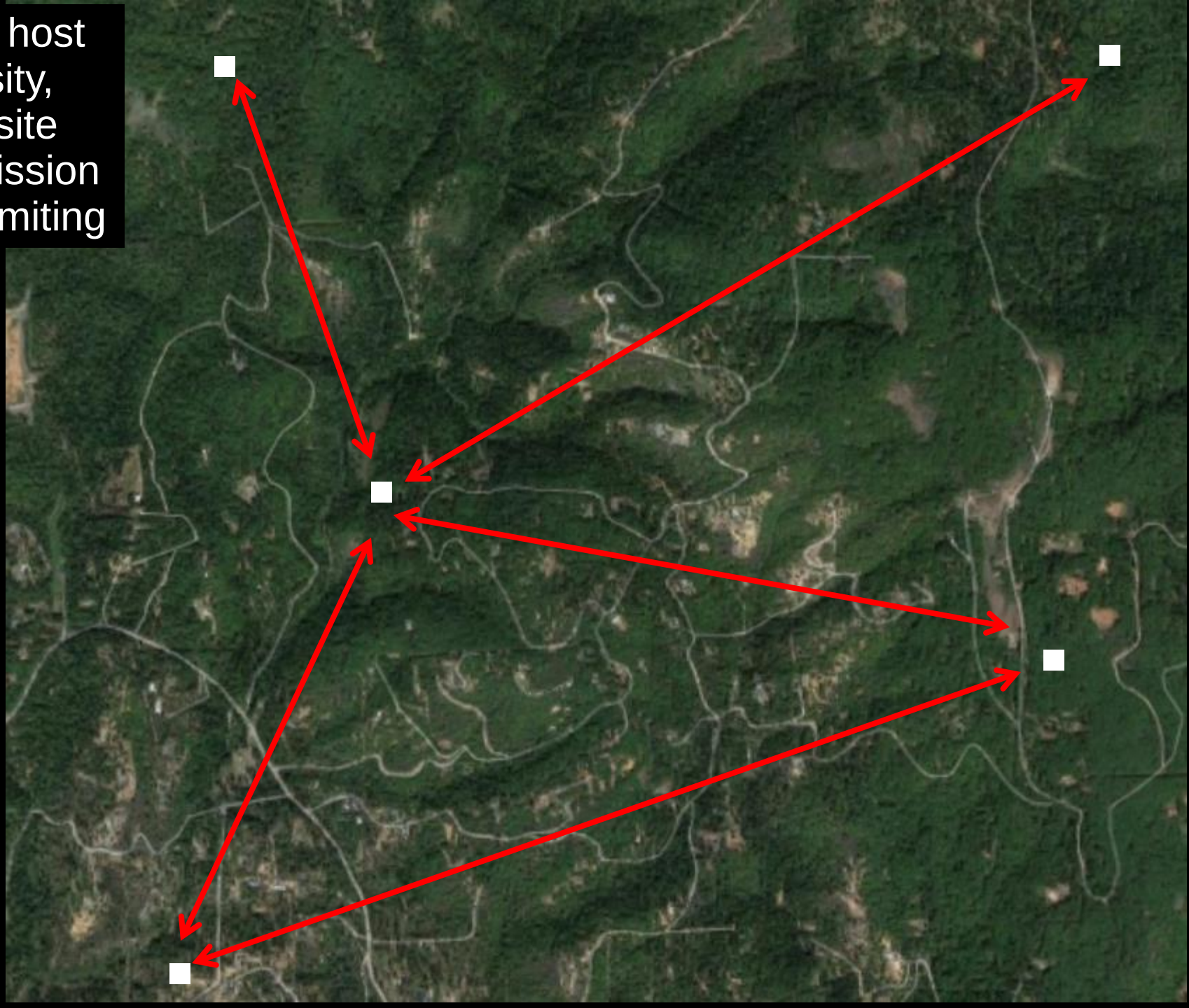
Dispersal **is about moving those copies to the next generation of hosts.**

Evolution is a shift in the proportions of genetic variants in a breeding population.

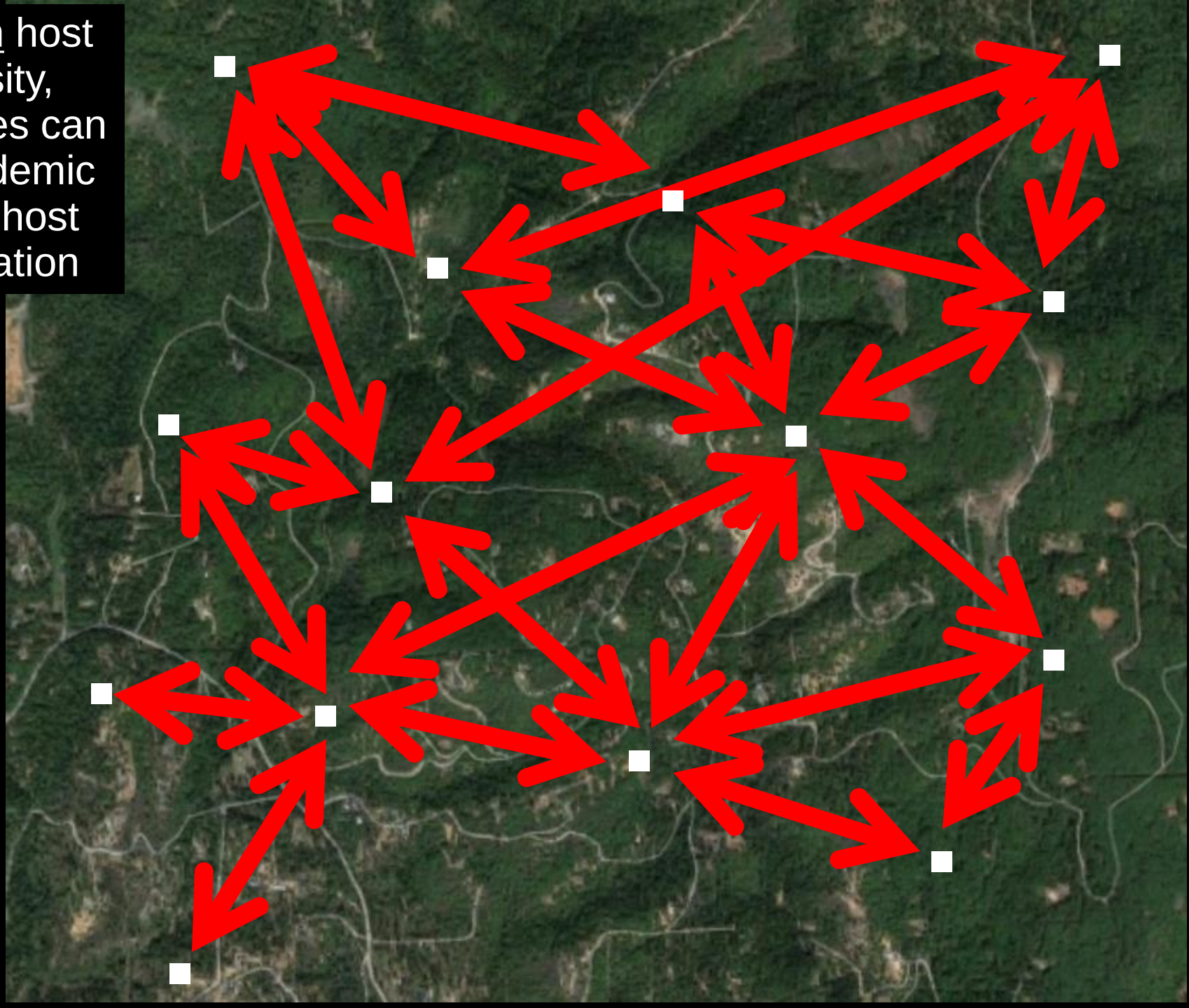
The Varroa Problem is all about *dispersal*.

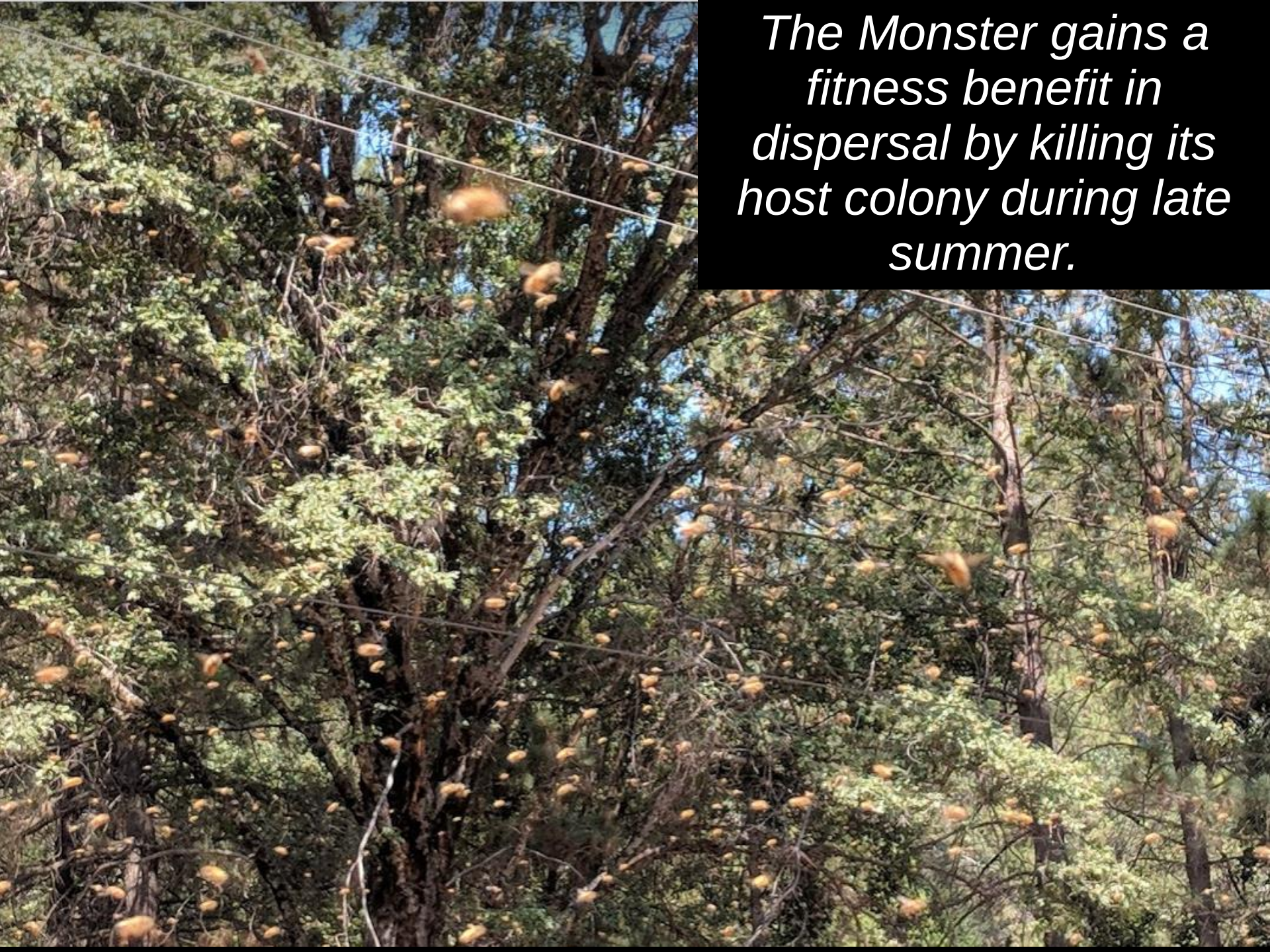
The varroa/DWV “Monster” is perpetuated by beekeeper-assisted dispersal.

At low host density, parasite transmission is self limiting



At high host density, parasites can go epidemic in the host population



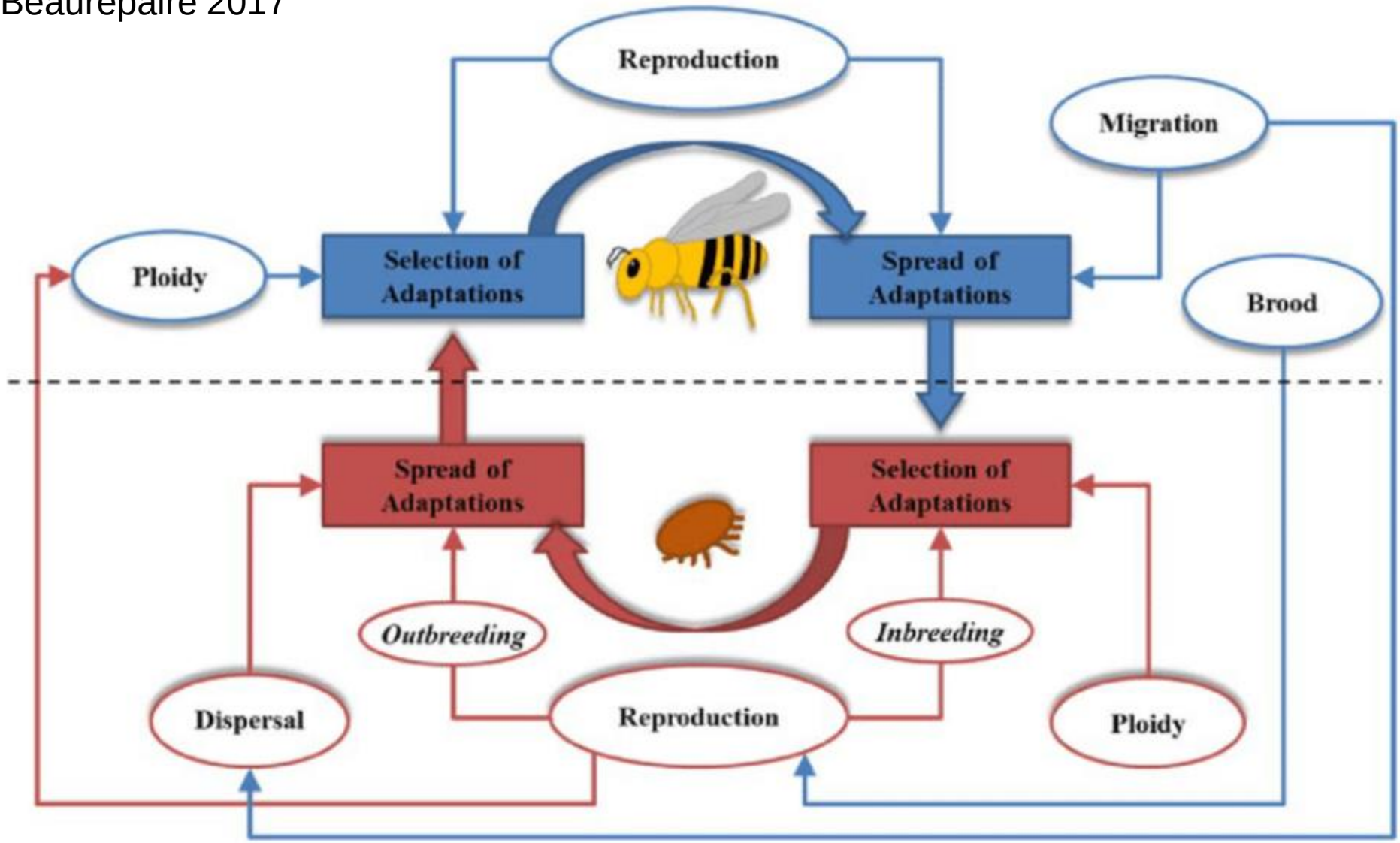

The Monster gains a fitness benefit in dispersal by killing its host colony during late summer.

It is <u>unnatural</u> to increase the density of the host, especially with domesticated stock.

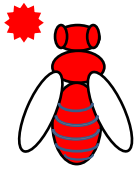
THE QUESTION:

Are you, as a beekeeper, part of *The Solution* or part of *The Problem*?

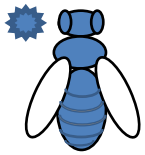
Beaurepaire 2017



In order to be part of *The Solution*, your actions must affect the breeding populations of the bee and DWV.

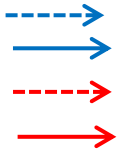


Virulent virus, non-resistant bees

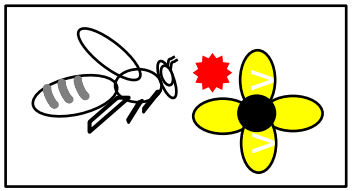


Avirulent virus, resistant bees

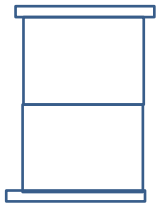
Varroa



Genetic flow--**BLUE IS GOOD,**
RED IS BAD

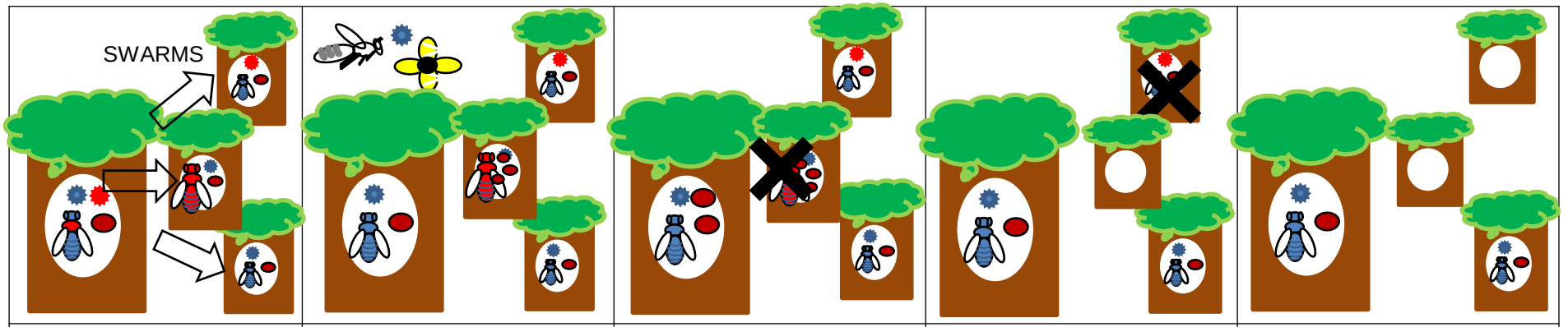


Virus transmission via flowers

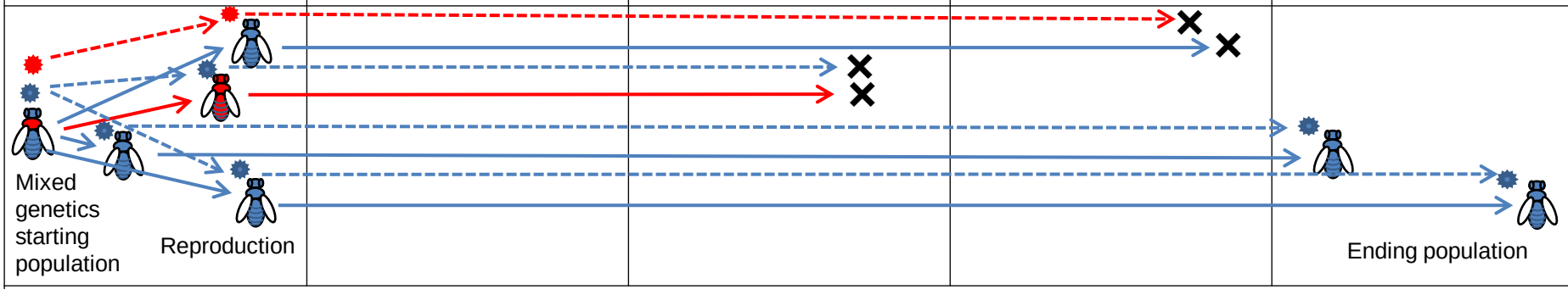


Managed hives

Wild-type colonies



SPRING: mites and virus strains get vertically transmitted via swarms from healthy colonies.	SUMMER: swarming reduces mite levels. Minimal mite or virus buildup in or between resistant colonies.	FALL: High-mite colonies die, but little dispersal due to distance between nests.	WINTER: winter applies strong selective pressure against virulent virus strains.	SPRING: resistant bees and less-virulent viruses exhibited greater "fitness." The cycle then repeats.

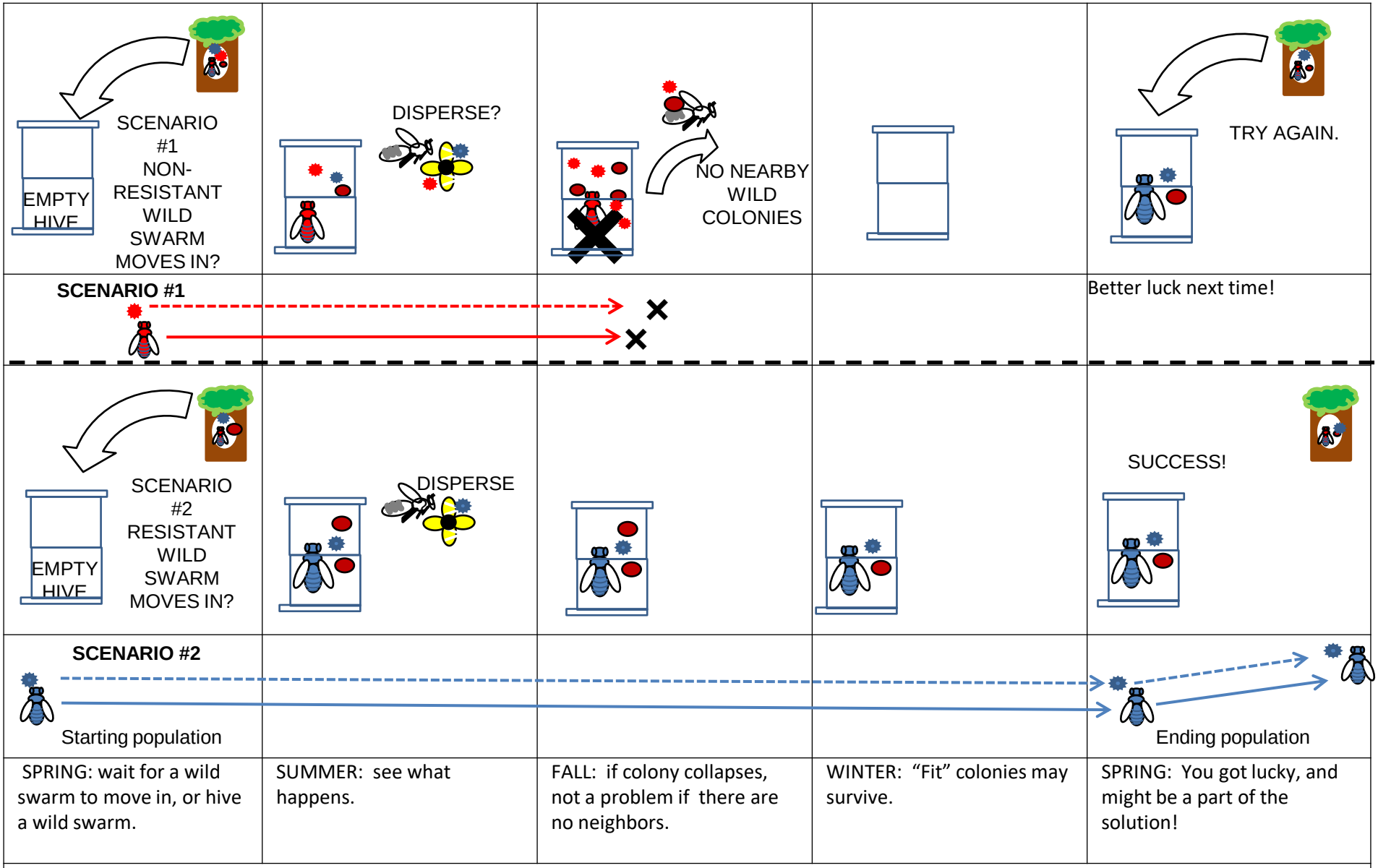


UNMANAGED WILD TYPE, PARTIALLY RESISTANT BEES, MIXED DWV STRAINS. This is an example of a wild-type population evolving a stable host-parasite relationship between the bees, the mite, and DWV.

Net genetic effect: Strong selective pressure upon the breeding population that weeds out nonresistant bees and virulent virus strains.

Pros: This is happening naturally in areas with little human introduction of managed hives.

Cons: These wild-type bees may not be desirable or adaptable to beekeeping or honey production.

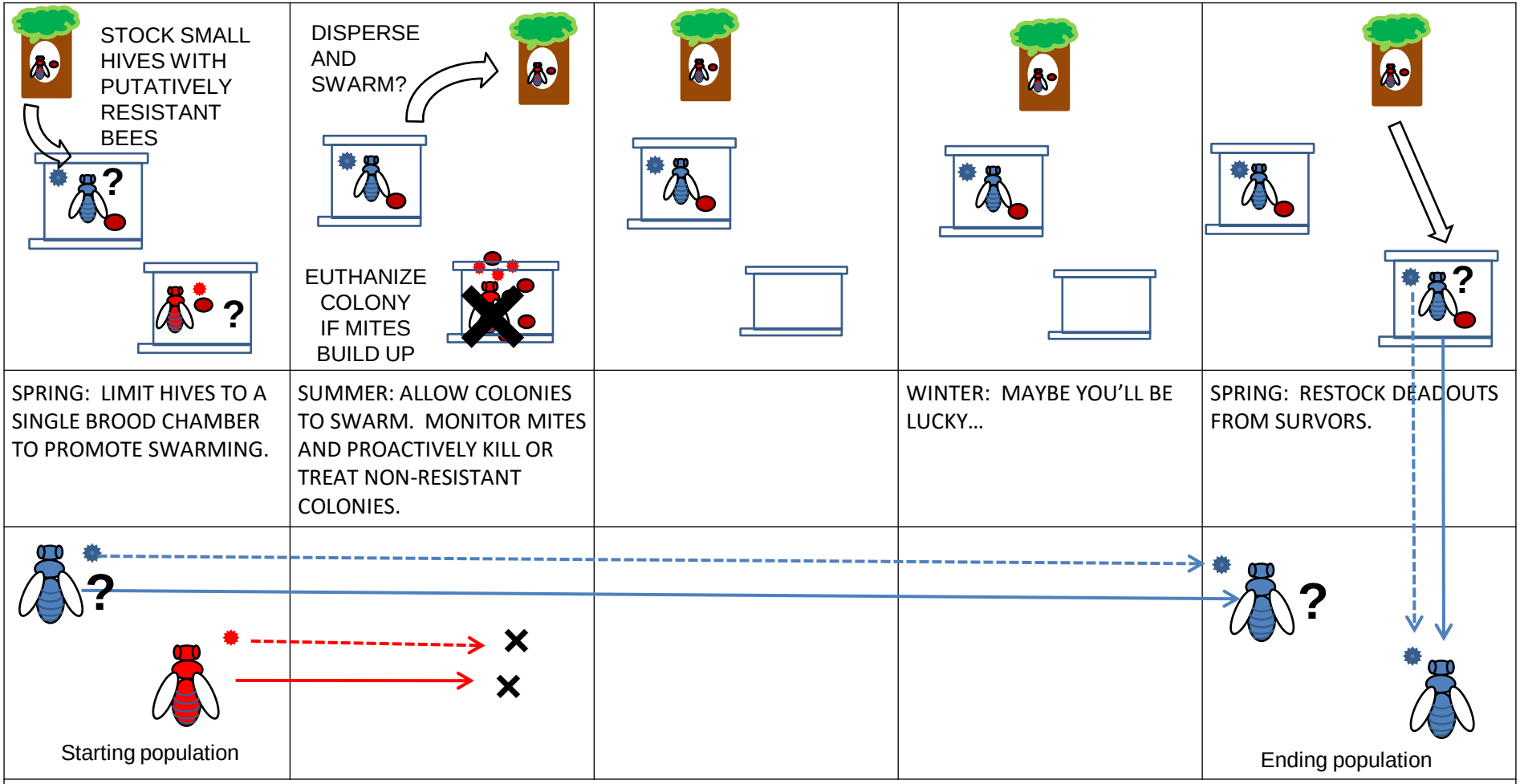


"NATURAL" BEEKEEPING—*ONLY PROVIDING A CAVITY* FOR A WILD-TYPE SWARM TO OCCUPY--*ISOLATED* SINGLE HIVES.

Net genetic effect: weeds out non-resistant bees and virulent DWV.

Pros: Similar to providing bird houses for birds to nest in—no other bee-keeping involved.

Cons: *Installation of package bees negates these scenarios*. Only justified if there are few other colonies within flight range.

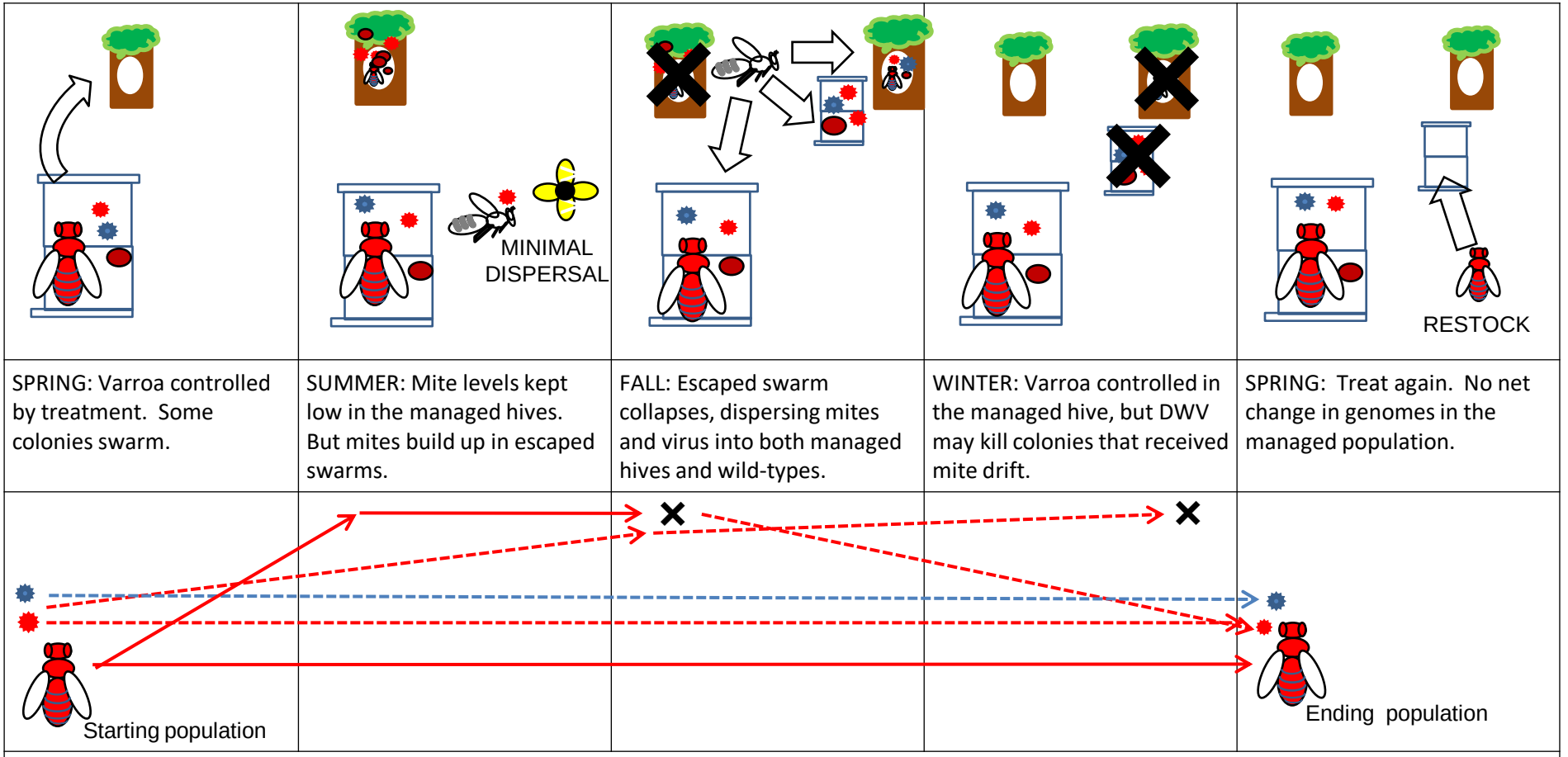


Darwinian beekeeper: starting with stock believed to be mite resistant, <u>beekeeper willing to euthanize the colony to prevent mite and virus drift.</u>

Net genetic effect: favors resistant bee genetics and benign DWV, but no honey yield due to small hives.

Pros: Little management involved. Small colonies swarm frequently.

Cons: Will not work if there are managed apiaries in the vicinity. No honey production. Bees may not be pleasant to work. Reality check: it's hard to imagine Darwinian beekeepers who will monitor mites and euthanize failing colonies.



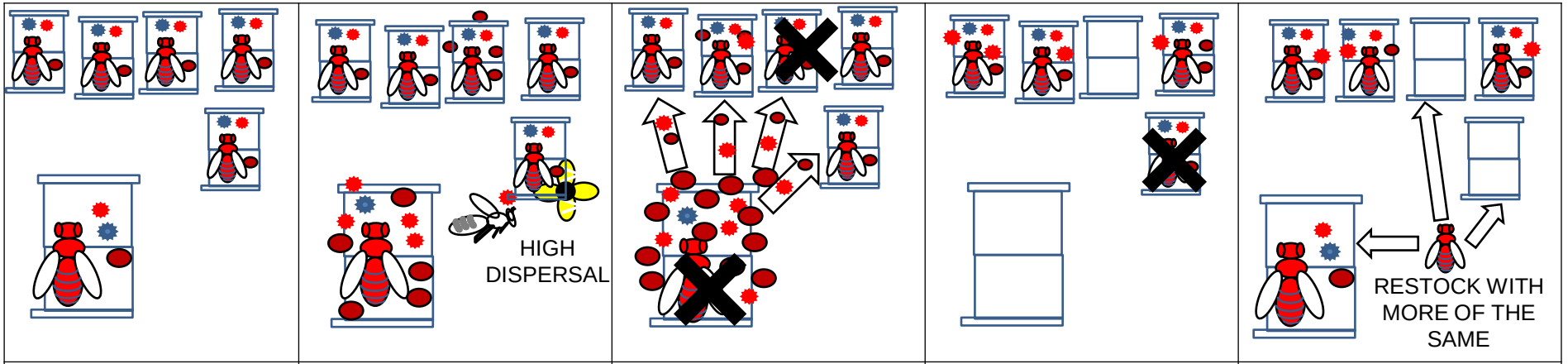
SPRING: Varroa controlled by treatment. Some colonies swarm.	SUMMER: Mite levels kept low in the managed hives. But mites build up in escaped swarms.	FALL: Escaped swarm collapses, dispersing mites and virus into both managed hives and wild-types.	WINTER: Varroa controlled in the managed hive, but DWV may kill colonies that received mite drift.	SPRING: Treat again. No net change in genomes in the managed population.

MANAGED BEES, MIXED VIRUS, VARROA CONTROLLED: The biggest problem is escaped swarms of nonresistant bees carrying virulent DWV.

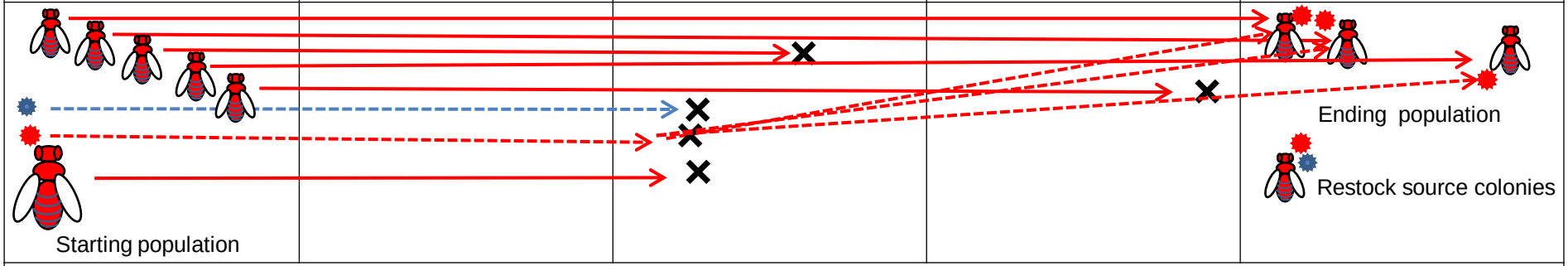
Net genetic effect: Very little net change in the bee genome. Some advantage to virulent DWV.

Pros: Bees are kept as livestock (similar to chickens or cattle). Beekeeping can be profitable if best management practices are followed.

Cons: Until beekeepers demand mite-resistant stock from the queen producers, varroa will need to be managed, and The Monster will likely continue to evolve.



SPRING: Mixed virus strains. Varroa poorly controlled. Lots of managed hives in the vicinity.	SUMMER: Mite levels build up. Treatments applied too late.	LATE SUMMER/FALL: The Monster takes its toll—massive drift of virus-carrying mites to other hives in the vicinity.	WINTER: Poor winter survival of the remaining hives, due to DWV.	SPRING: Surviving hives preloaded with virulent DWV. Restock the rest with more of the same. Repeat each season.

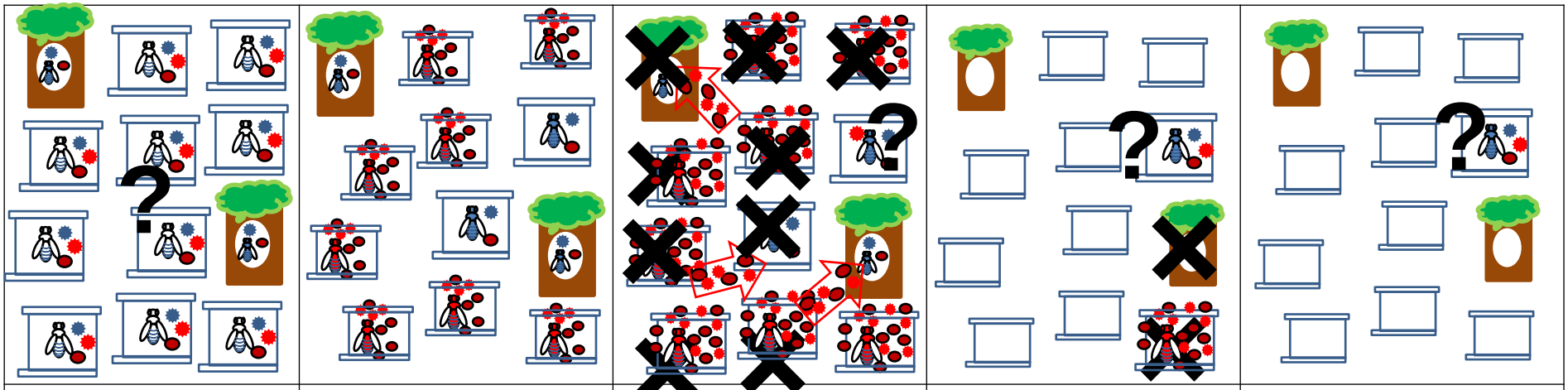


NON-RESISTANT DOMESTIC BEES, MIXED VIRUS, VARROA POORLY CONTROLLED

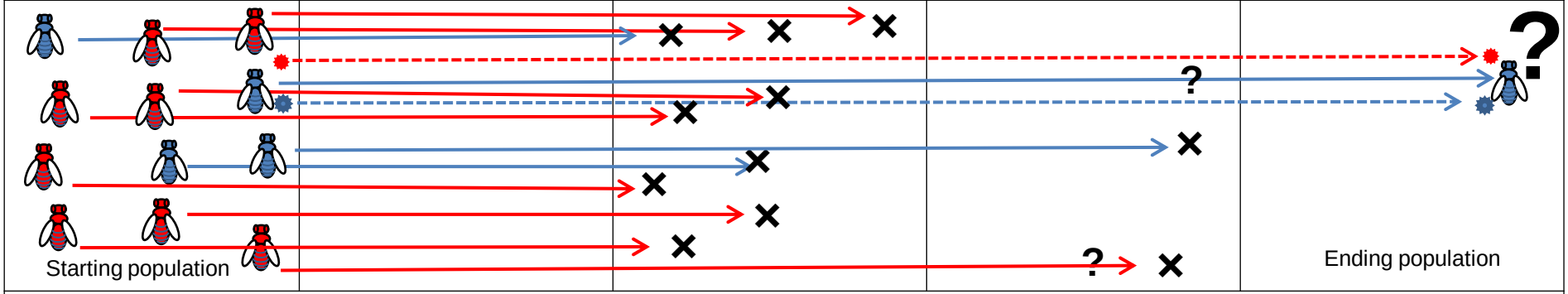
Net genetic effect: *rewards The Monster*. No net change in the bee genome, but strong selective pressure for mite/virus combinations that result in late-summer colony death.

Pros: You can claim that it was CCD.

Cons: Poor varroa management results in high losses. ***Not shown is the negative effect upon the wild-type population and neighboring beekeepers.***



SPRING: START WITH A POPULATION OF HIVES. SOME RESISTANT WILD COLONIES IN THE VICINITY.	SUMMER: GIVE VARROA (AND DWV) FREE REIN. LITTLE MITE BUILDUP IN RESISTANT COLONIES	LATE SUMMER/FALL: DRIFT OF MITES FROM COLLAPSING HIVES OVERWHELMS EVEN SOME RESISTANT BLOODLINES.	WINTER: PERHAPS A FEW EXTREMELY RESISTANT (OR LUCKY) COLONIES SURVIVE.	SPRING: RESTOCK FROM ANY SURVIVORS.



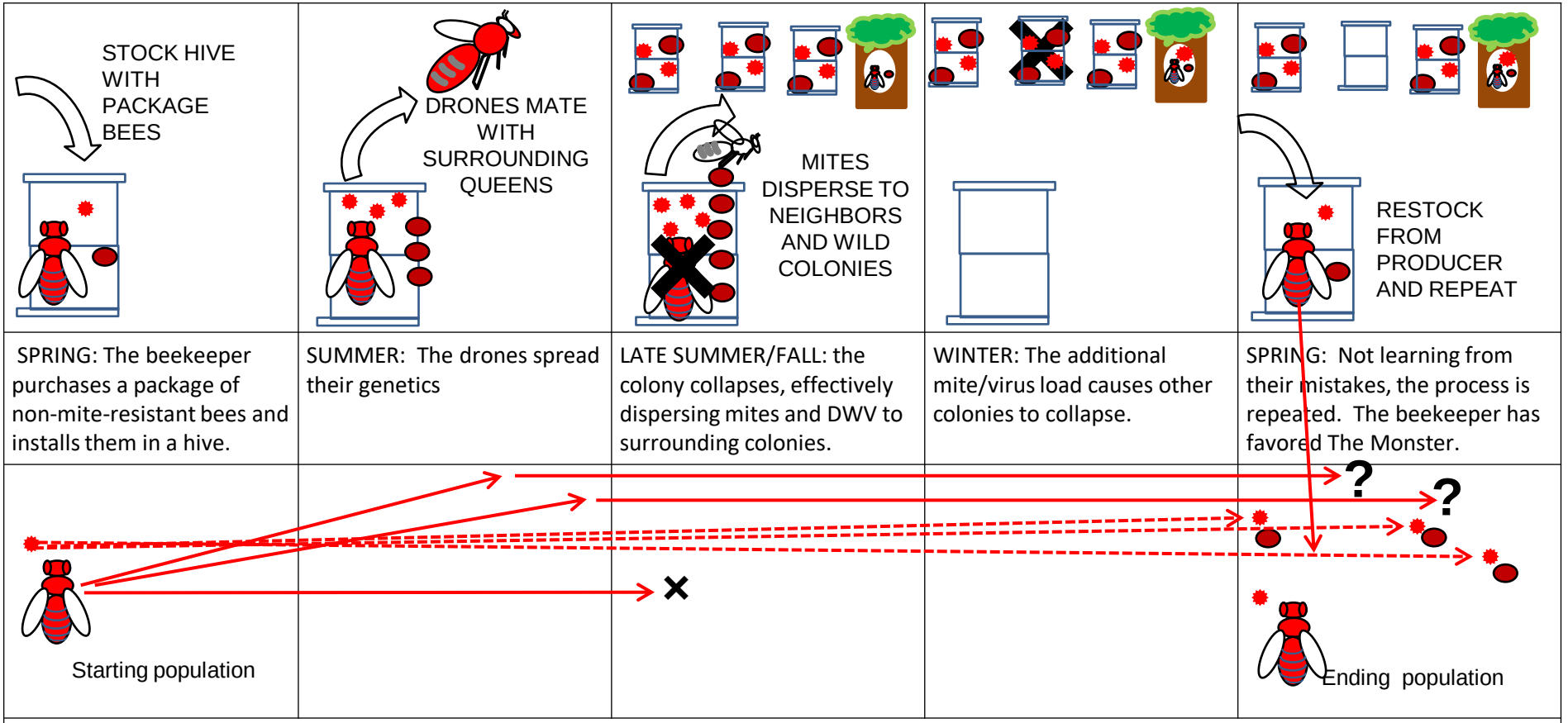
Bond selection (*Live and Let Die):* Stock a bunch of hives and allow The Monster to kill the "less fit." Breed from any survivors.

Net genetic effect: depends upon chance and diligence—you may get lucky over the long term.

Pros: Very hard selective pressure for mite/virus resistance. No mite monitoring or treatment necessary.

Cons: lots of **unnecessary colony deaths** involved; much labor to split and restock deadouts each season. Can overwhelm any evolving resistant bloodlines in both managed and wild breeding populations--**your neighbors will suffer.** Resulting resistant stock may have undesirable characteristics (defensiveness, frequent swarming, small colony size, poor production).

Roughly 60% of recreational beekeepers don’t manage varroa .



WELL-INTENTIONED AND WISHFUL "TREATMENT-FREE" BEEKEEPING: ***starting with commercial package bees*****, inadequate varroa management.**

Net genetic effect: Despite the best intentions, actually **favors The Monster.**

Pros: allows you to rationalize neglectful "beekeeping," free from the responsibility of varroa monitoring or treatment. You get to wear a "Treatment Free Beekeeper" hat. Rewards producers who supply the packages.

Cons: poor colony health, high colony losses, negative effect upon wild bees and neighbors.

Ways to improve: start with resistant stock (support your local breeders), monitor varroa, treat or euthanize mite-infested colonies before they collapse and spread mites and DWV strains to surrounding colonies. Explain the flaws of this dogma to others—*there is no reason to think that commercial stock maintained with miticides will suddenly evolve into resistant bees because you wear the "Treatment Free" hat.*

We all want to be "treatment free" beekeepers again.

To be part of *The Solution*, ground your beekeeping practices in biology rather than upon someone's dogma.

There is no benefit to allowing colonies to die in a breeding program--

you only need to replace any queens that don’t make the grade!

ETHICAL CONSIDERATIONS FOR ANIMALS UNDER ONES' CARE

Formal Recommendation by the
National Organic Standards Board (NOSB)
to the National Organic Program (NOP)

"The producer must not accept the presence of pests, parasites, or disease without initiating efforts to restore the health of the colony."

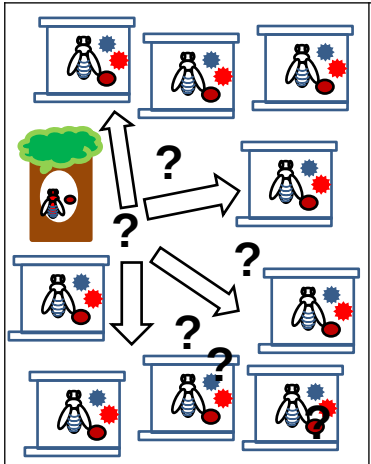
This puppy is suffering from a mite infestation

BE REALISTIC

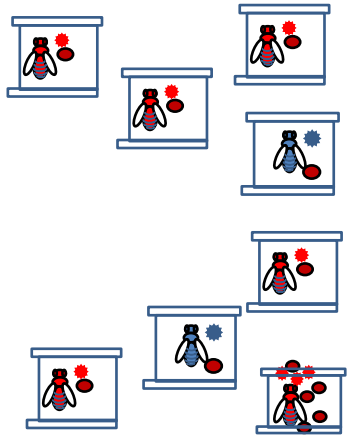
Commercial package bees will die without treatment.

Monitor all hives for mite buildup!

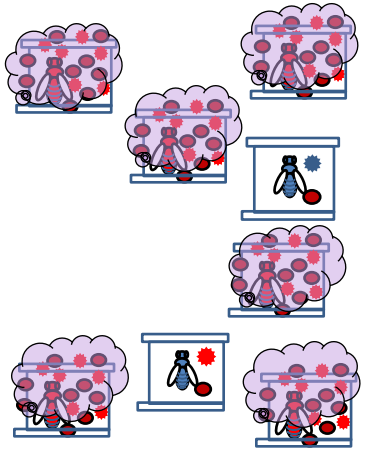
Treat or euthanize them prior to their collapse.



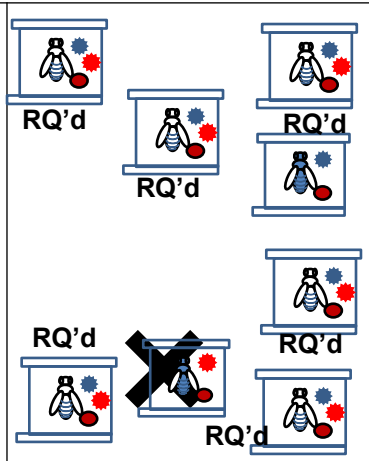
SPRING: START LOTS OF HIVES WITH PUTATIVELY RESISTANT BEES.



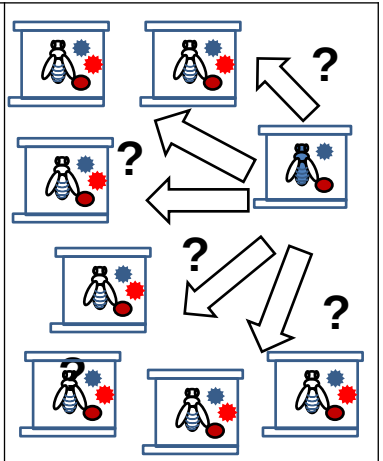
SUMMER: MINIMIZE SWARMING AND ***MONITOR VARROA.***



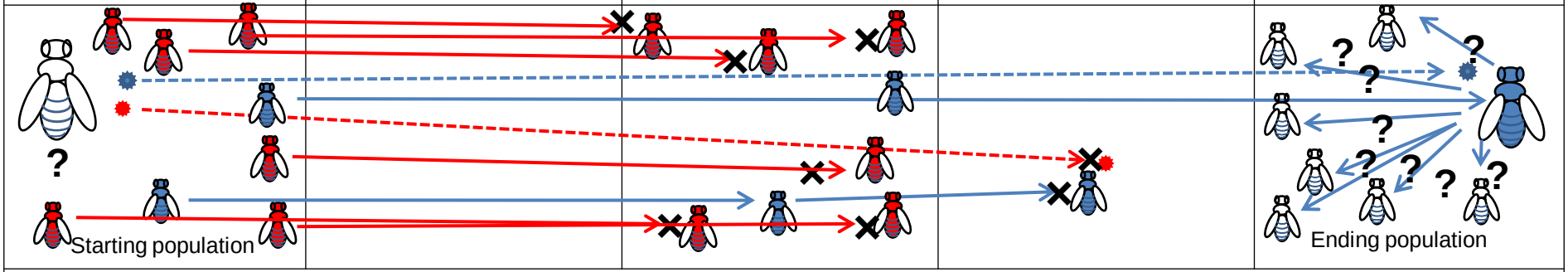
LATE SUMMER/FALL: DON'T ALLOW DISPERSAL OF MITES! FORMIC BLAST ANY HIGH-MITE HIVES; REPLACE THEIR QUEENS.



WINTER: ALLOW NATURE TO SELECT FOR WINTER SURVIVAL AND WEED OUT VIRULENT VIRUS STRAINS.



SPRING: RESTOCK ALL HIVES WITH DAUGHTERS FROM THE MOST MITE RESISTANT COLONIES—SHARE THE BEST.



One way to be part of The Solution (Modified Bond Method):

1. **Start with stock (preferably local) believed to be mite resistant (*not package bees*)—support progressive breeders!**
2. **Monitor hives for varroa increase, and treat with *a formic acid "blast"* if necessary prevent mite and virus drift.**
3. **Replace any nonresistant queens—do not allow them to rear drones next spring. *No need to punish the workers.***
4. **Next spring, *propagate and disperse* daughters from the most mite-resistant colonies. *There is no substantive benefit if you don't rear queens and spread the good genetics!***

Net genetic effect: favors resistant bee genetics and benign DWV, selects against mite-susceptible bloodlines.

FORMIC BLAST TO KILL MITES UNDER THE CAPPINGS, WITHOUT COMB CONTAMINATION

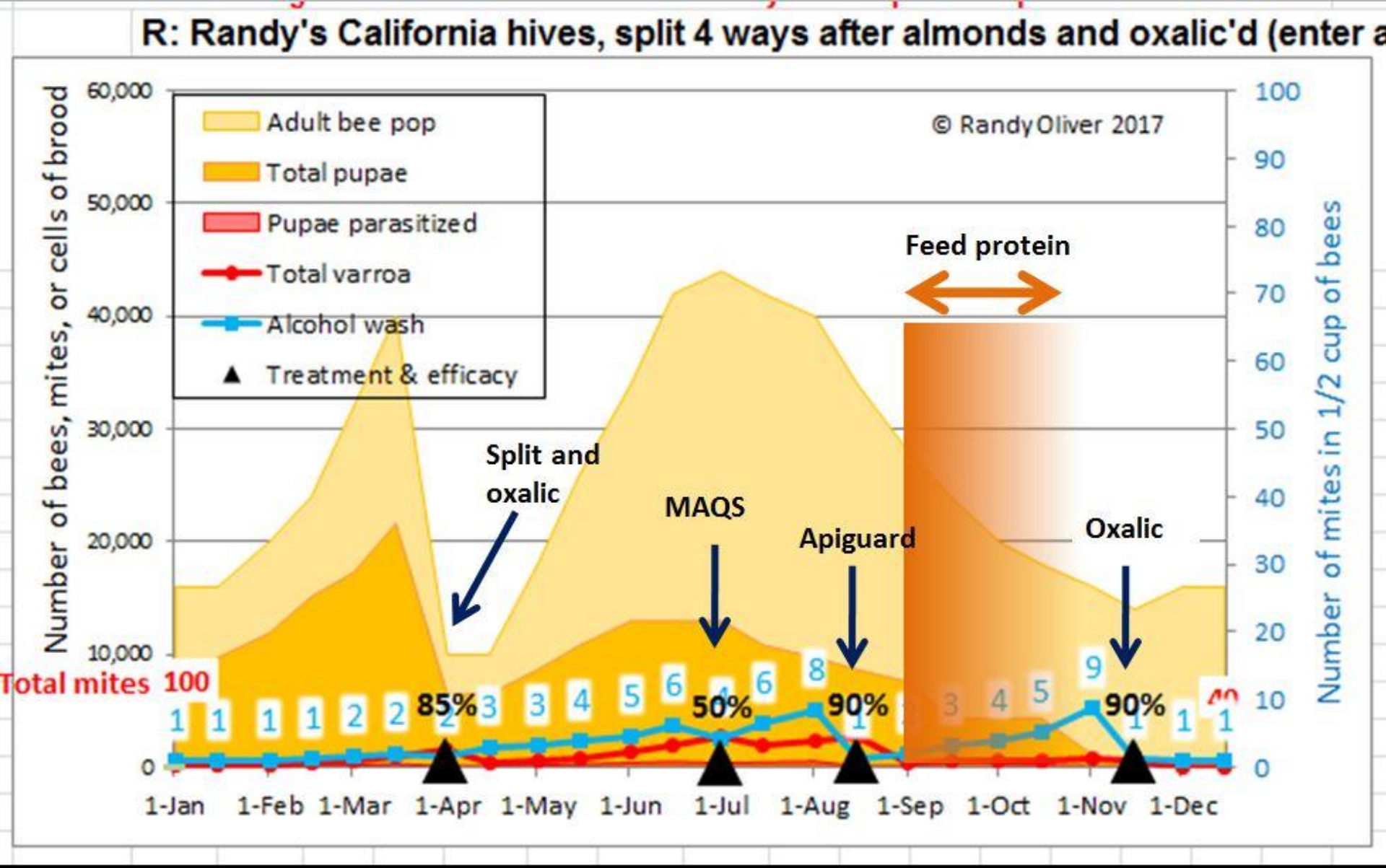
300mL of 65% formic acid, slow release, over singles (MiteAway II pads).

Seldom kills more than 100 bees; doesn't kill sealed brood. Requeen afterwards.

★★★★★

No synthetic miticides since 2001.

We love our bees and take care of them!



Typical mite management, our operation

Effective, no residues, no resistance, easy on bees