

Where Have All the Insects Gone? *[...When Will We Ever Learn...]*

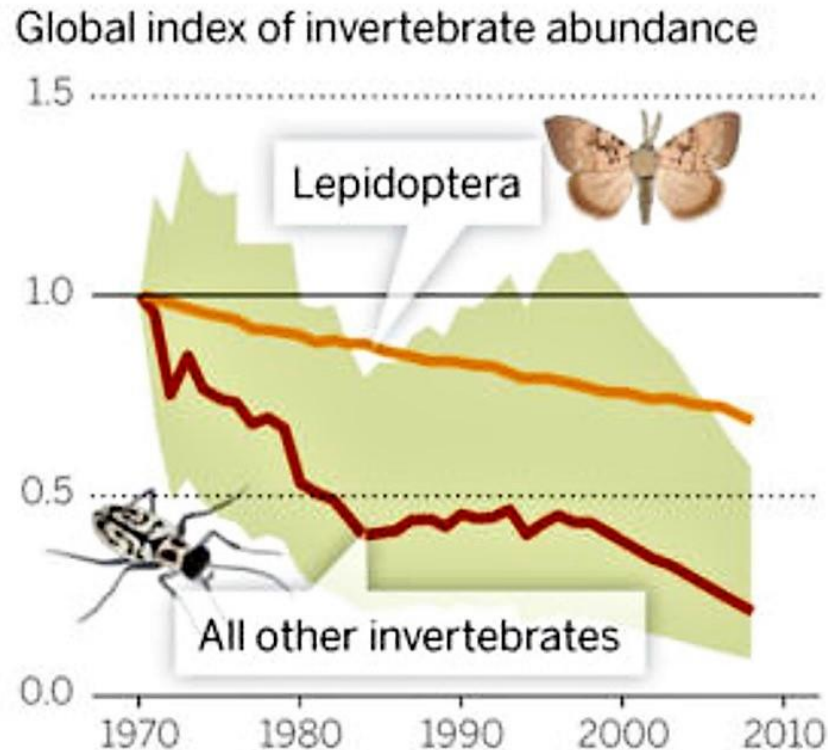


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[Very] bad news about insects

Over last 30-40 years insect populations around the world have dropped precipitously:

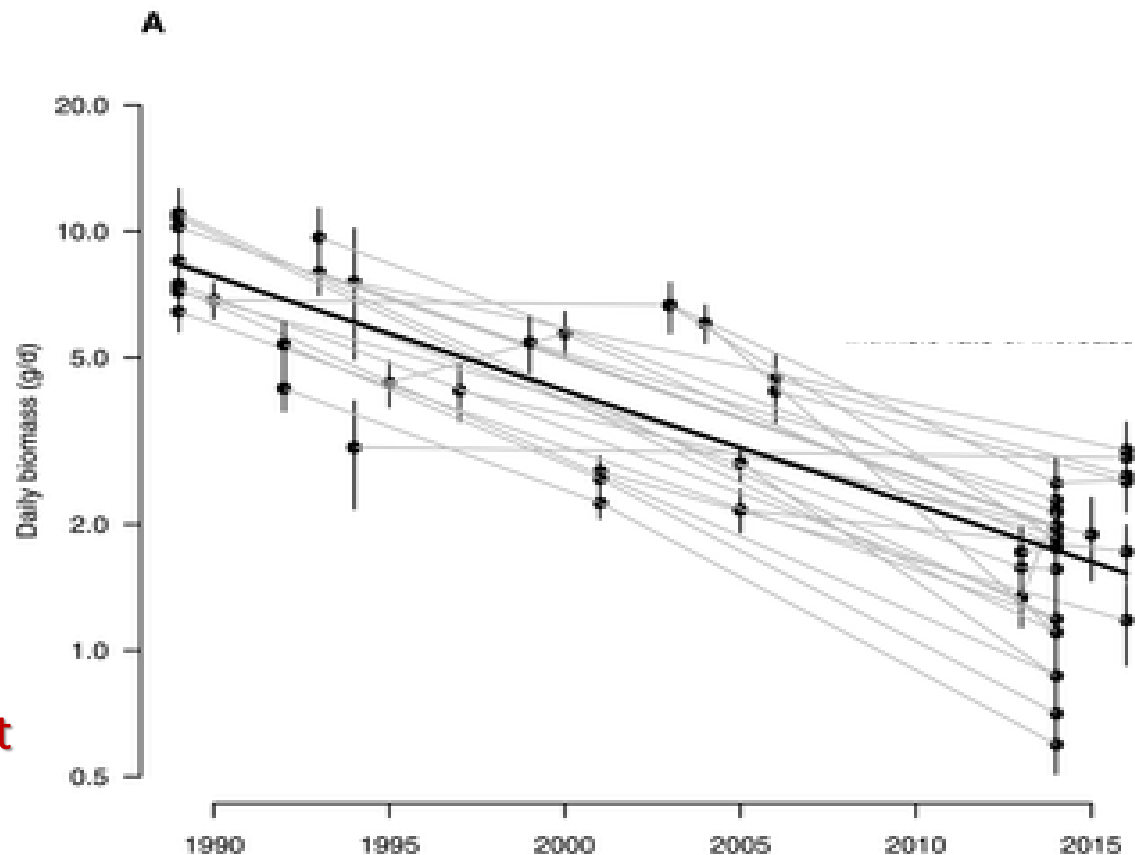
- Global monitoring of 452 species showed 45% drop in insect populations since 1970s [R. Dirzo, et al, *SCIENCE* July 24, 2014]



*2017 wakeup call: A German study**

- 76% decline in average airborne insect biomass (up to 82% in midsummer) over 27 years in protected natural areas in Germany (63 sites)
- Causes? Habitat loss, land use change not considered likely
[C. Hallmann, et al, PLOS, Oct. 18, 2017]

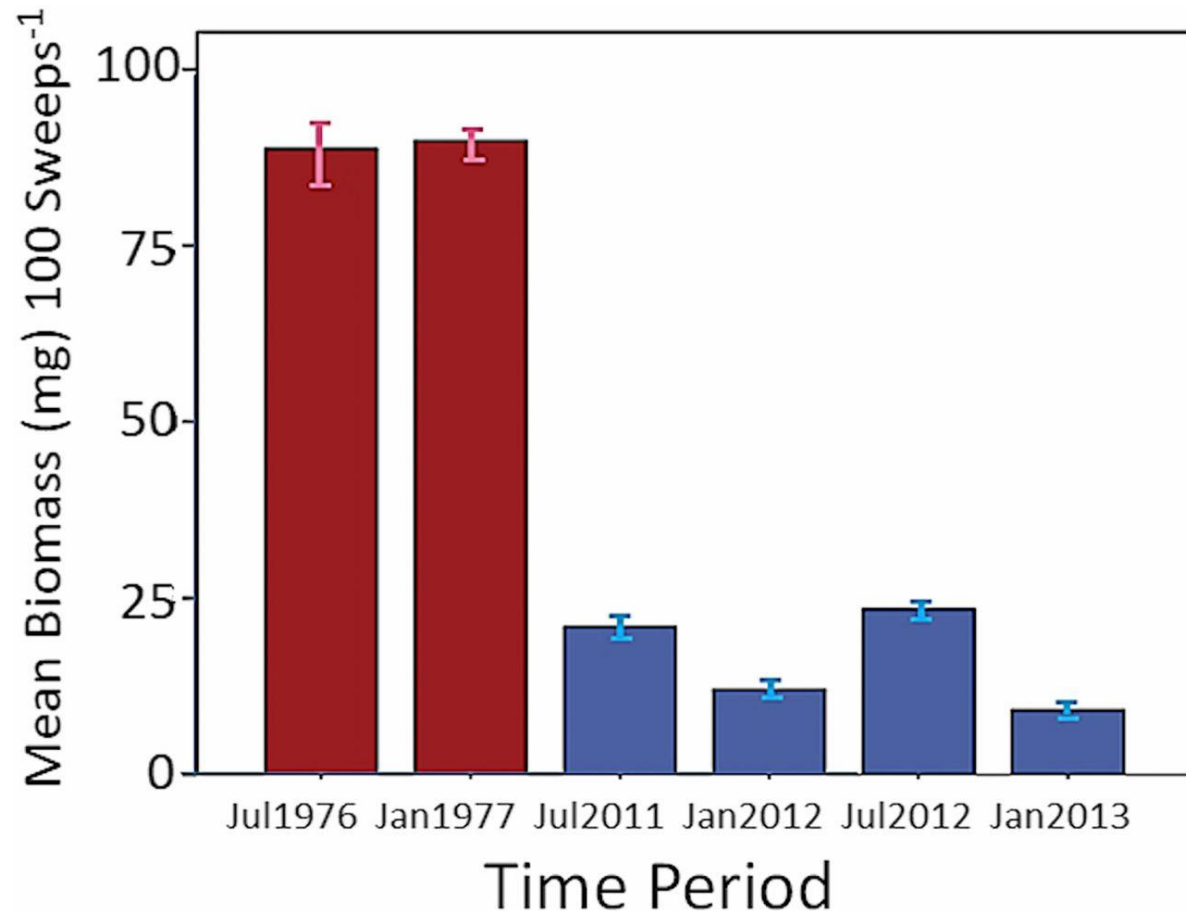
* This paper got worldwide attention: it was the 5th most cited paper in 2017



And then this: 2018

- Average dry-weight of arthropods caught in a Puerto Rican rainforest: same sample areas 1976, 1977 compared to 2011, 2013
- Decline thought to be related to higher temperatures due to climate change
- Parallel decrease in insect eating lizards, frogs, birds

[B. Lister & A. Garcia, PNAS
115(44) Oct. 30, 2018]



And now this: April 2019

- A review of 73 studies worldwide found “dramatic rates of decline” may lead to extinction of 40% of insect species over next few decades
- Extinction rate for bees, ants, beetles is 8 times higher than for mammals, birds, reptiles
- Four groups of aquatic insects have already lost a high proportion of species
- A few adaptable, generalist species are expanding

[Sánchez-Bayo & Wyckhuys. Biological Conservation 232:8-27. Apr. 2019]



Photo: E. Cronin

Why should we care?



- Estimated 2 million-30 million species globally (most unknown)
- Estimated 0.01% to 1% of those species are “pests”

So what are all these non-pests doing?



Honey



Silk



Pollination

Photo: E. Cronin



Dye

Value of pollinators

Vital for native plant reproduction, agricultural crop yields & crop seed production

- Over 85% of flowering plants depend on pollinators to reproduce
- 1/3 of all human food plants: >100 food crops in Canada
- 24% of birds & mammals have fruit & seeds as a major part of their diet



Pollinators?

Much more than bees

Thousands of species of **flies, wasps, moths, beetles**:

- Equal in value of contribution by bees: 25-50% of all flower visits
- Better at pollinating some plants
- Even where bees are present, pollination improves when other pollinators also visit flowers
- Often visit different parts of flowers & different flowers on plants than bees
- Some carry pollen farther than bees

Flies: The second largest group of pollinators →



Predators & parasites *of pests*



Photo: E. Cronin



Thousands of native species attack aphids, caterpillars and others pests

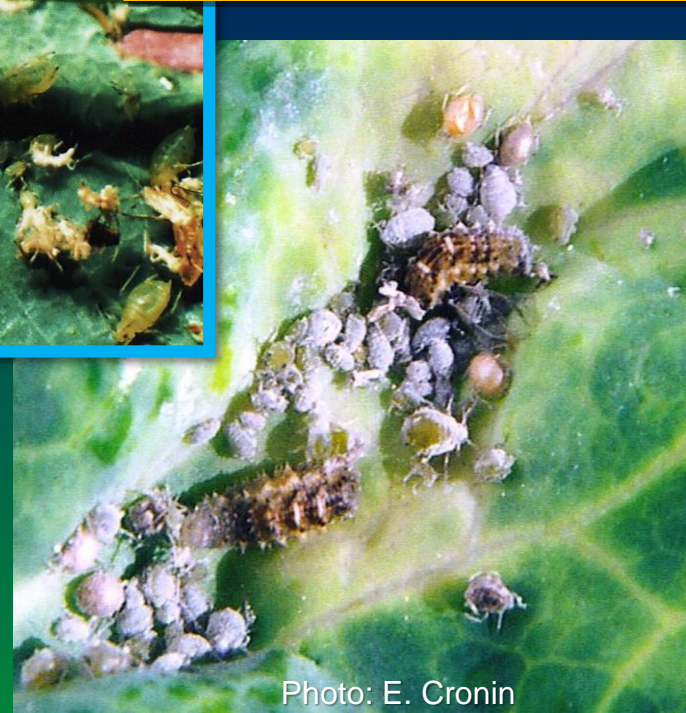


Photo: E. Cronin

Food for wildlife

- Majority of bird partially or totally depend on insects in their diet
- Insectivorous birds are showing stronger declines than most other bird groups [NABCI Canada 2012]
- Widespread declines in North America started in mid-1980's; linked to decline in populations of flying insects [S. Nebel, et. Al. Avian Conservation & Ecology. 2010]
- And don't forget fish, frogs, lizards and other wildlife....



Photo: Darren Clark



Photo Jess Findlay



Photo: D. Sherony

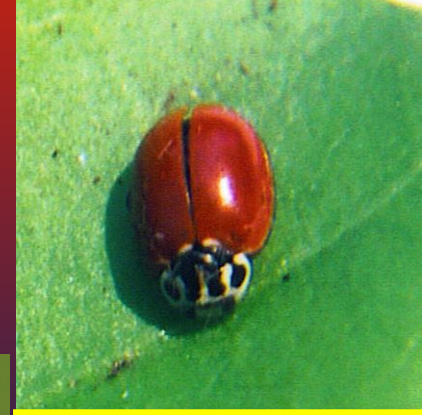
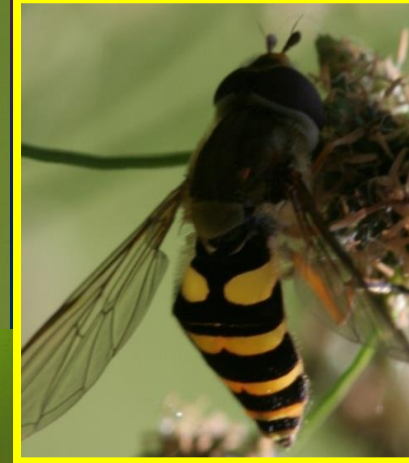
Insects provide other ecosystem services

- Soil building and aeration
- Nutrient cycling, decomposing
- Water purification



Carrion & dung beetles are important!

*Most of the insects you
see are **not** pests*



How human activities affect insects

As for other animals and plants, the most pervasive, worldwide impacts are from:

- Destruction of natural habitat from agriculture, industry and urbanization
- Pesticide use

Some activities affect species in some places more than others:

- Climate change
- Light pollution
- Air & water pollution

Loss of habitat

- Paving and cultivation remove insect forage plants, wipe out nests and pupation sites
- Establishment of non-native plants removes habitat for native species
- Deer are a major consumer of insect forage in this region

A virtual desert for insects
(if they don't eat lawns) →



Pesticides kill (duh!)

Includes insecticides, miticides, fungicides, herbicides:

- Widespread adoption of neonicotinoids is our latest chapter in a long history of mass killing with insecticides
- Herbicides remove forage plants for pollinators, butterfly caterpillars
- Fungicides change the 'scent' of plants, also kill some species
- Dormant oil sprays kill overwintering beneficial insects and predatory mites



Photo: E. Cronin

Rising global temperatures

- Direct effect: High temperatures kill insects
- Indirect effects: De-synchronizes insects with host plants & prey insects

Recent study found high temperatures can sterilize sperm of male beetles:

- Exposure to 1 heat wave reduced fertility; exposure to second heat wave virtually sterilized males
- Effects carried to next generation, with reduced fertility, lifespan of offspring

[K. Sales, et al., Nature Communications Nov., 2018]



Photo: E. Cronin

Rising atmospheric CO₂ levels

- Research shows there has been a 30% drop in protein in goldenrod pollen since 1874
- Greatest drop occurred after 1960, correlated with rising CO₂ levels
- Poor quality pollen resulted in
 - Shorter lifespans in bees
 - Altered behavior and vigor

“Pollen is becoming junk food for bees”

[L. Ziska, et al. PROC. ROYAL SOCIETY, April 13, 2016]



Artificial light at night

- Over 60% of insects are nocturnal
- 2018 German study found that regions with sharpest decline in flying insects have high levels of light pollution

[M. Grubisic, et al, Ann. Appl Bio. 2018]

Effects of night lighting:

- Attracts insects away from ecosystem to die from exhaustion or predation
- Disorients, desynchronizes internal clocks essential for seasonal and day/night adaptation



Effect of night lighting on pollination

Recent study showed importance of night-time pollinators—even when daytime pollinators were also present

- Artificial lighting reduced night visits to plants by 62% compared to dark areas, resulting in 13% lower fruit set

[E. Knop, et al, Nature. 548(7666). Aug. 2017]



Woollybear moth Photo: Leslie Cox



Smerinthus sp.
Photo: P. Minvielle

Studies on pollution effects

- Air pollutants disrupt flower scents: Scents insects could detect kilometres away now travel as little as 200 m; some break down in minutes rather than lasting hours. **Increases foraging time as insects are less able to detect scents.** [J. Fuentes, et al. *Atmospheric Environment*. Vol. 141, Sept. 2016]
- 69 drugs were found in insects near Australian water-ways: Accumulated in aquatic stage of flies & beetles, also found in insects & spiders that eat them **[then to birds, bats, frogs?]** [Richmond, et al., *Nature Communication*. Vol 9: 4491, Nov. 2018]
- Mosquito larvae eat microplastic particles in water; some particles stay in their bodies as they mature to adults. **Effects unknown.** [R. Al-Jaibachi, et al., *Biology Letters*. Vol. 14, Sept. 19, 2018]

What can we do?



Perennial / Pollinator Bed

This is a very new bed, so its purpose is still evolving, but right now it's dedicated to insects, primarily of the flying kind: bumble bees, honey bees, mason bees, hoverflies, beetles, and moths.

Why insects? Well, they bring a lot of benefits to the garden. I don't think people realize how important insects are. They provide significant pest control. They provide pollination for all those fruits and vegetables we're growing. If you look around at people's yards, you'll see that insects often get short shrift when it comes to habitat, food sources, and nesting sites. People also like to spray them with all kinds of crap. I want to make sure that my garden provides habitat, food, and protection for the insects in the neighbourhood (people's pollinator corridors). You'll be astounded what happens when you grow a lot of flowers in the garden; the bad bug control is phenomenal. Plus, the sound bees make as they're buzzing around in the flowers rivals the sound of the ocean. Try it.

Just remember, it's not only about forage plants (ie. pollen-rich plants for bees). It's also critical to provide an assortment of larval food plants, so you keep the insects IN your garden, laying eggs and seeing that life cycle all over again.

My favourite website for pollinator information is the Xerxes Society (xerxes.org).

What beneficial insects need

- Food for adults (pollen, nectar) and host plants for larvae
- A safe environment, without pesticides, night lighting, bug zappers
- Drinking water in dry months
- Nesting places, protected sites for pupation & overwintering



Improve insect habitat on your property

Increase food supply: pollen, nectar and larval host plants

- Adult bees drink nectar; pollen is the main diet of bee larvae
- Most adult predatory and parasitic insects eat only pollen or nectar; it is their larvae that eat other insects
- Adult butterflies only drink nectar; their caterpillars eat leaves of native plants



Photos: E. Cronin

Vancouver Bee Study

- Found lowest numbers in traditional landscapes: mowed lawns, non-native flowers (e.g., petunias, pansies, tulips, roses, heathers)
- Highest numbers were in gardens with mixed native & non-native plants
- **Untended, wild & weedy areas had the most species**



Provide a variety of flowers

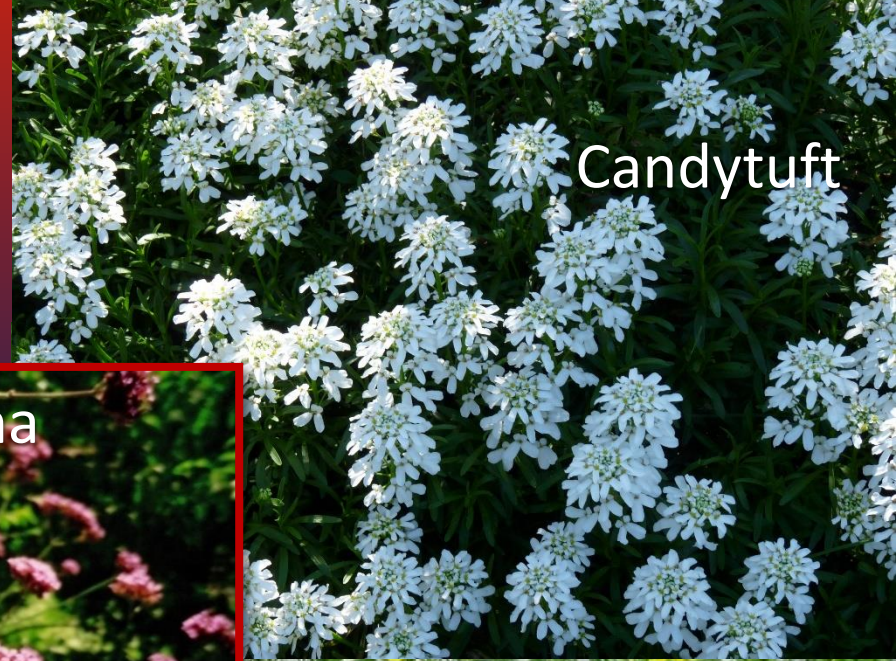
Insect species are so diverse that flowers must also be diverse:

- Tiny parasitic wasps need tiny nectar-rich florets; they drown in nectar pools in large flowers
- Beetles & flies with a short proboscis (syrphids, tachinids) visit open, flat or cup-shaped flowers
- Moths, butterflies, bumble bees can drink nectar from deep trumpet flowers



Photo: E. Cronin

*Tiny flowers fit the
mouthparts of small
insects*



Candytuft



Verbena



Dill



Cilantro,
Arugula

Deep or tubular flowers

Large, nectar-rich flowers suit large bees, butterflies, moths

- *Vaccinium*, *Ribes*, foxglove, bee balm, fireweed, lobelia, *Mahonia*, *Ceanothus*, rhododendron, red clover



Photo: E. Cronin

Flower diversity = pollen diversity

Especially urgent due to decreasing protein content in pollen:

- Bees don't seem to recognize or compensate for poor quality pollen by taking in more
- BUT, studies show they can compensate by foraging for a greater variety of pollen sources with complementary amino acids

Especially important in late summer & fall when pollen sources are most limited



Plant for bloom all season long

- Spring is the only time on SSI with plenty of forage for many insects:
 - Native plants & trees provide pollen & nectar
 - Fruit trees and many early ornamentals are excellent insect forage
- Concentrate on increasing the number of forage plants that flower from late June to October
 - Late summer and fall forage is critical for bumble bees, social wasps and insects with several generations per season

Spring: Native plants

Trouble-free, easy to grow, need little water:

- Arbutus, maples, native willow, *Arctostaphylos* spp., ocean spray
- Oregon grape, salmonberry, salal, red-flowering currant
- Stonecrops, sea blush, spring gold



Late summer-fall: Native plants

- Douglas aster, goldenrods, pearly everasting, *Helenium* spp.
- Common snowberry



Late summer-fall: Perennial ornamentals

- Shasta daisy, Sea holly, *Sedum* species ('Autumn Joy'), Stachy 'Hildago', asters



Annuals for a fast fix

- Useful first year, before perennials from seed mature
- Borage, calendula, annual coreopsis, cosmos, California poppy, sunflowers, sweet alyssum, forget-me-nots, *Phacelia*, sea blush, spring gold, crimson clover, mustards, buckwheat



Pollinator plantings

- Aim for at least 50% native plants
- Plant in masses: Over 1 square meter of each kind of flower or 5-10 plants of most perennial flowers
- Grow many different plants: More insects visit where at least 8 species of flowers are present



Biological control plantings

- Dill, cilantro, parsley: Attract lady beetles, lacewings
- Calendula, other yellow daisies: Syrphid flies
- Many species visit sweet alyssum, goldenrod, asters, yarrow, candytuft, forget-me-not, thymes, daisies, mustard/cabbage family (allow overwintered vegetables to flower in spring)



E.g., Sweet alyssum

- Planted in Ontario strawberry fields to attract pirate bugs that control thrips
- Widely used in California lettuce fields to attract aphid predators
 - Research on alyssum inter-planting found 204 beneficial insects for every pest insect counted in the lettuce crop



Butterfly plantings

- Native plants are essential: Adults drink nectar from many flowers, but caterpillars feed on leaves of native plants

E.g., Stinging nettle is the host for West Coast Lady, Painted Lady, Milbert's Tortoiseshell, Satyr Comma, Red Admiral



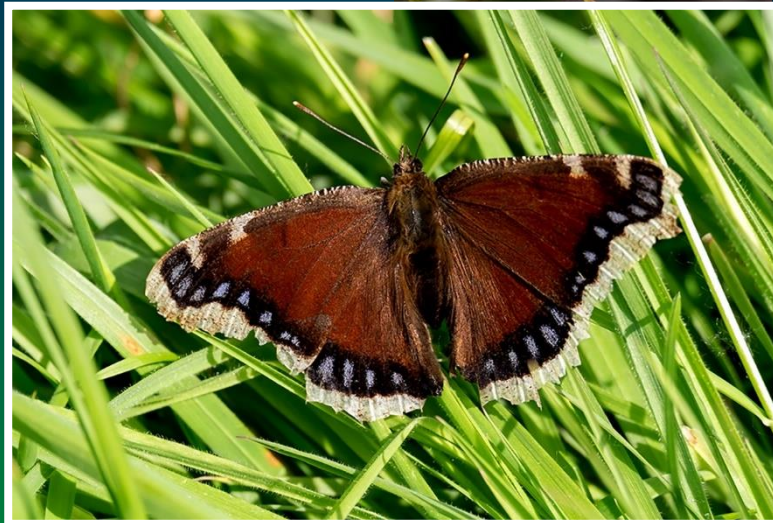
Red Admiral



Photo: E. Cronin

Butterfly host plants

- Lorquin's Admiral: Willow, poplar, chokecherry, *Spirea*
- Mourning Cloak: Willow, cottonwood, aspen
- W. Spring Azure: *Spirea*, *Ceanothus*
- Cedar Hairstreak: W. Red Cedar
- Moss's Elfin: Stonecrop



Photos: S. Henson

Choose least modified flowers

Grow 'wild-type' or least manipulated cultivars: highly modified and hybrid flower cultivars are often less valuable to insects:

- Many have little or no nectar or pollen
- Double flower mutations can prevent insects from reaching nectar
- Insects often don't recognize unusual or new colours

Suntastic,
Sunrich,
Solar Flash
sunflowers
are bred to
be pollenless



E.g., Echinacea

Unimproved prairie native *Echinacea purpurea* is more attractive to bees than selected cultivars

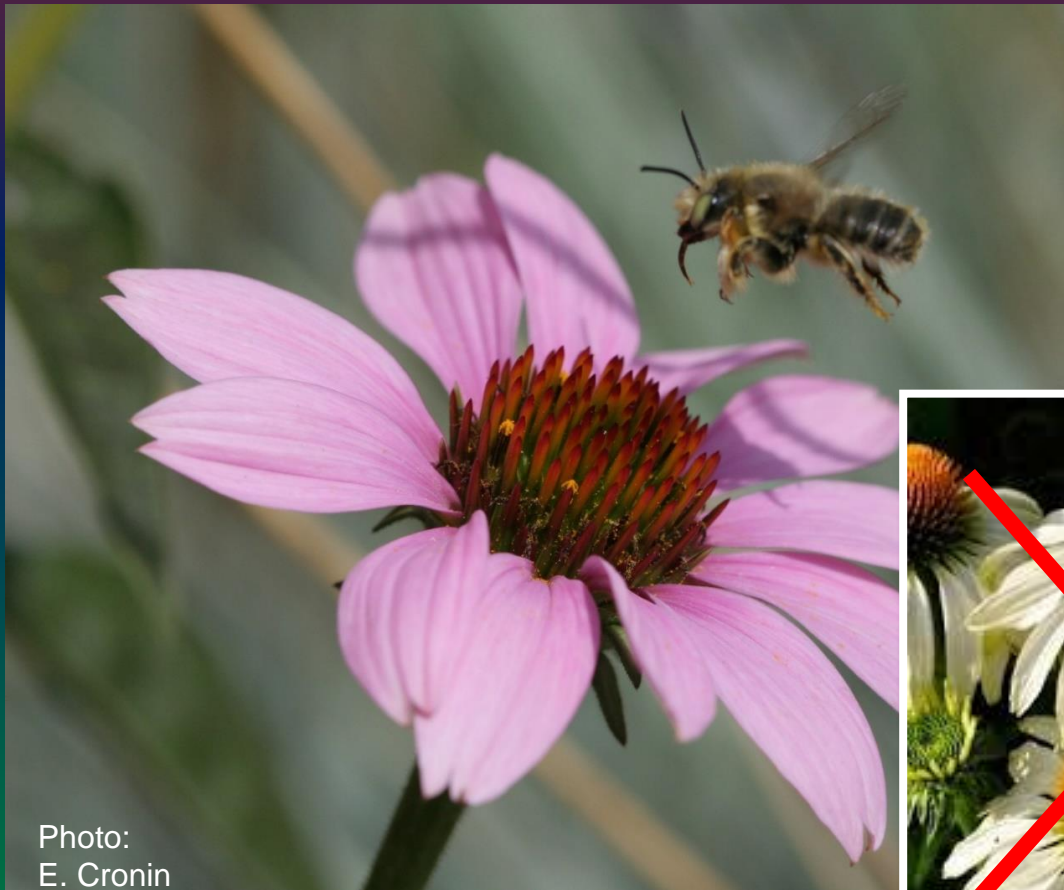


Photo:
E. Cronin

If you already have these, don't
remove them--just plant better ones→



'Cherokee' hybrids



'White Swan'

Appearances can be deceiving

- Himalayan blackberry flowers hum with bees, but it is mainly bumble bees & honey bees
- Yarrow is of little interest to honey bees or bumbles, but is one of the most valuable plants for other native bees & many non-bee pollinators

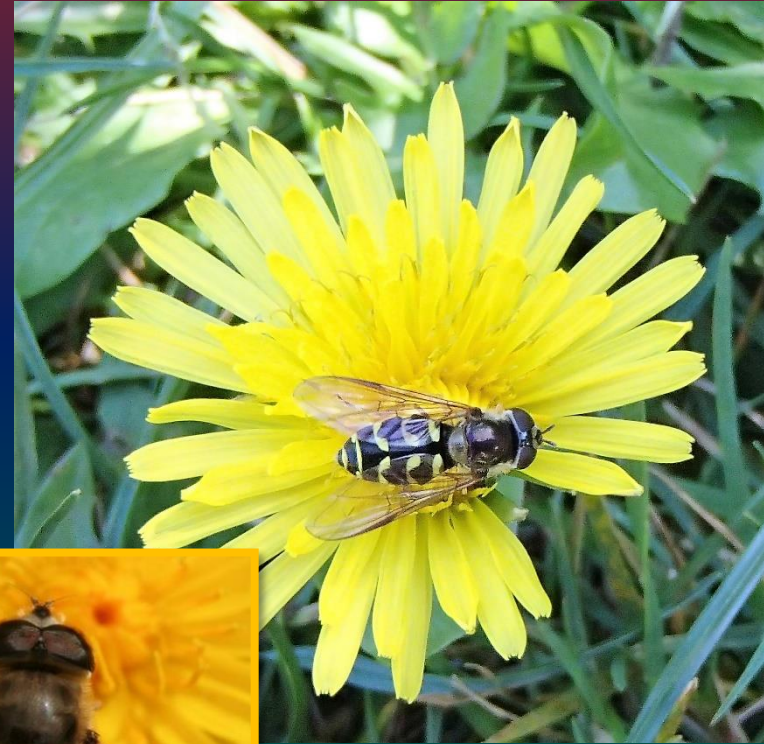


A very odd-looking native hover fly on yarrow →



Insects love weeds

- Dandelions are the most visited of all urban plants
- Wild carrot/Queen Anne's lace
- Mustard family weeds



Avoid invasive plants

Invasive plants of concern in BC:

- Butterfly bush (*Buddleia*)
- Bachelor buttons, “cornflower” (annual & perennial)
- Baby’s Breath (*Gypsophila*)

Sumac appears on many pollinator lists, but it will take over your yard! Best left in its native habitat

*There are many other excellent
forage plants to grow*



Other problem plants for this region

- Viburnum: Attacked by Viburnum leaf beetle
- Japanese Andromeda (*Pieris*): Attacked by Andromeda lacebug
- Lupines: Toxic lupanine in pollen can affect bumble bees



Where to plant?

- Replace lawns and landscape plants with insectary plants
- Interplant between existing plants, add groundcovers
- Plant in rockery, along road and edges of driveways
- Waste areas, vacant lots, temporarily bare sites, on septic fields



Insectary Lawns

Replace grass with:

- Low maintenance mixes of flowers and grasses: English daisy, sheep fescue, yarrow, perennial ryegrass, strawberry clover
- Red, white Dutch or MicroClover
- Perennial flowering ground covers: creeping thymes, coastal strawberry, bellflowers, low Oregon grape



Large-scale insect ‘pastures’

- Agriculture: Field borders, hedgerows, fallow areas, rotation crops
 - Plant a variety of species, mixed or in alternating strips
 - Include flowering and native shrubs and trees in hedgerows
- Road shoulders, utility rights-of-way: Low maintenance & native species, requiring little or no mowing



UBC hedgerow demo



Richmond, BC

Provide a safe water supply

- Insects that don't eat leaves rely on water bodies & dew (there is no dew in our driest months)
- Lack of water sources in dry summer weather shortens life span & reduces the number of eggs beneficial insects lay



Photo: E. Gronin

Make sure insects can't drown

- Sand or stones in water allow insects to crawl out (do this for bird baths too); unglazed pottery works well
- Place out of reach of small children, pets
- Dump water regularly to prevent mosquitoes from breeding



A sloping rock island makes this trough safe

Don't use pesticides...

...on crops, gardens, landscapes, lawns, weeds, roadsides, including insecticides, miticides, fungicides, herbicides

Even pesticides allowed in organic certification programs are **NOT** safe for non-target insects:

- Pyrethrins (from *Pyrethrum* daisies) are fast-acting, broad spectrum nerve toxins
- Soaps and oil sprays kill any insect contacted by the spray



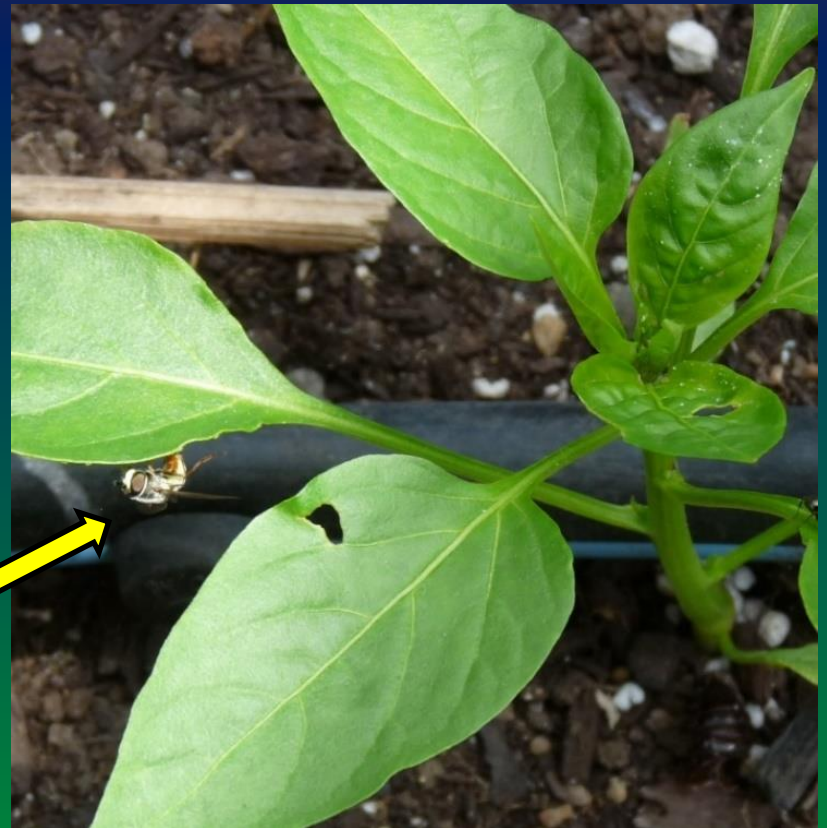
Photo: E. Cronin

Are home-made sprays OK?

Nope!

- If a substance kills “pests”, it will also kill pollinators, predators, butterflies
- May also damage leaves or kill plants (especially soap, detergent, oils, borates, alcohol)
- Illegal under the Canada *Pest Control Products Act*

Hover fly laying eggs beside aphids on a pepper plant: give her time to do her job...



Don't use pesticides inadvertently...

Neonicotinoids are still in use in the nursery trade

- Canada is phasing out outdoor uses of neonicotinoids by 2021, but greenhouse uses remain
- Chemicals may still be present on plants from US nurseries, “big box” stores
- Buy nursery plants from organic or local sources you can ask about their production methods
- Or grow your own from seed



Beware of other controls

- “Bug-zapper” electrocution devices kill huge numbers of harmless & beneficial insects. One study found over 2 weeks, 6 zappers killed 13,789 insects—but **only 31 were mosquitos!** [T. Frick, D.Tallamy *Ent. News* 107(2): 77-82. 1996]
- Sticky traps also catch beneficial insects:
 - Yellow traps outdoors catch parasitic wasps
 - Limit use of winter moth tree bands to the Nov.-Feb. emergence period
- Open slug traps with liquid baits drown ground beetles (slug predators) if not designed to prevent them from falling in



Turn **OFF** outdoor lights

- Never leave yard or pathway lights on all night
- Install sensor lights that illuminate outdoors only when needed
- Replace incandescent, CFL & halogen lights with **warm** LED lights or use yellow incandescent bulbs in conventional light fixtures



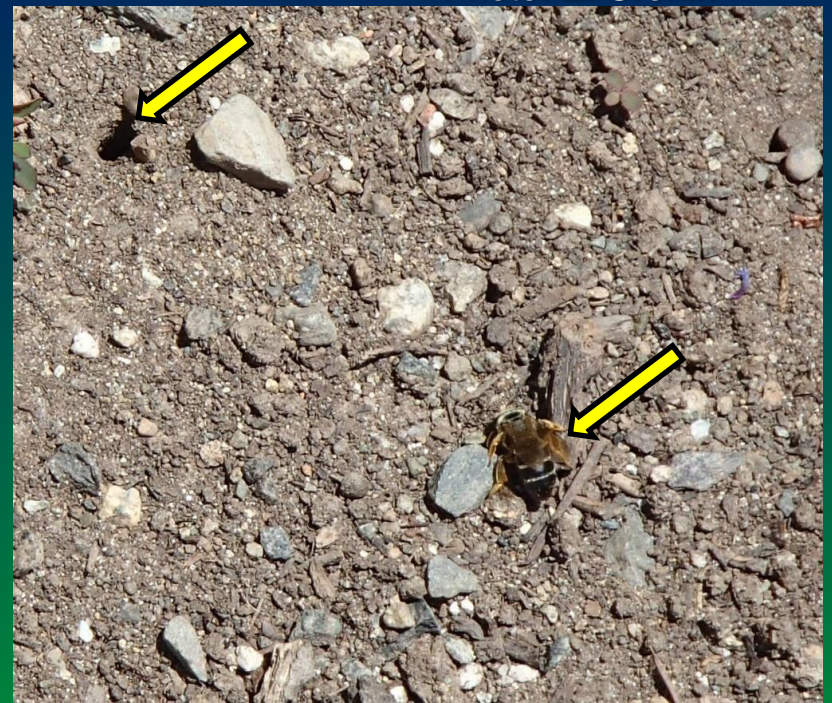
Photo: E. Cronin

Minimize soil disturbance

- 70% of native bee species nest in the ground
- Many predatory insects pupate in the top layer of soil
- Ground beetles need undisturbed refuges



Photo: E. Cronin



Preserve bee burrows

Leave bare soil at the base of
rock walls, on sunny banks for
bee nests

Burrows of a bee colony on a
septic field on SSI →



Provide native bee nest sites

30% nest in tunnels (beetle holes, hollow twigs, canes, straws)



Minimize cultivation

Protect the pupae of syrphid flies & aphid midges and burrows of native bees:

- Use mulches to control weeds & cover soil between perennials
- Use 'no-till' methods for annual beds as much as possible

British gardeners get the message at RHS Wisely →



Help address global environmental issues that affect all living things

Destruction of natural habitat

Climate change

Air, water and light pollution

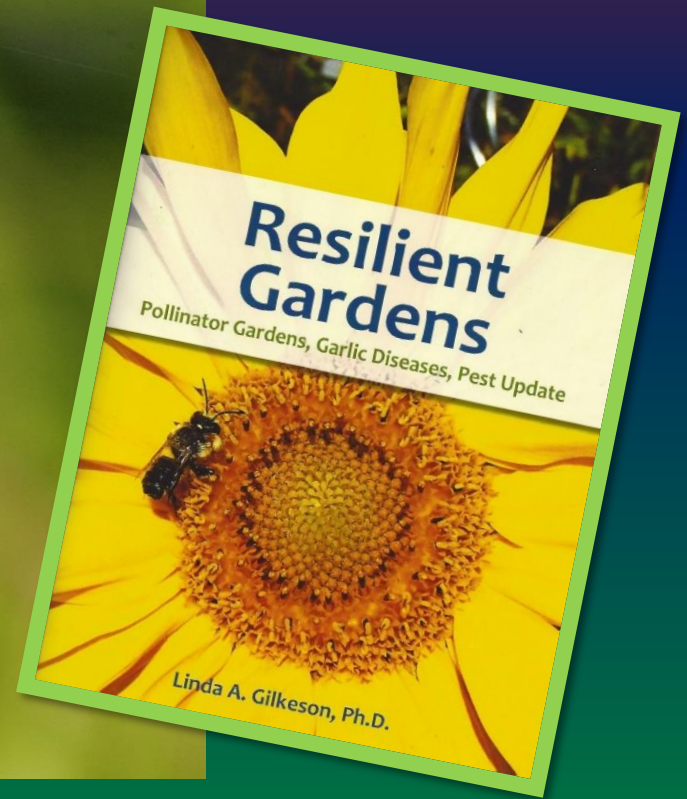


Photo: NASA

Enjoy the beneficial insects in your garden!



Photo: E. Cronin



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