Where Have All the Insects Gone?

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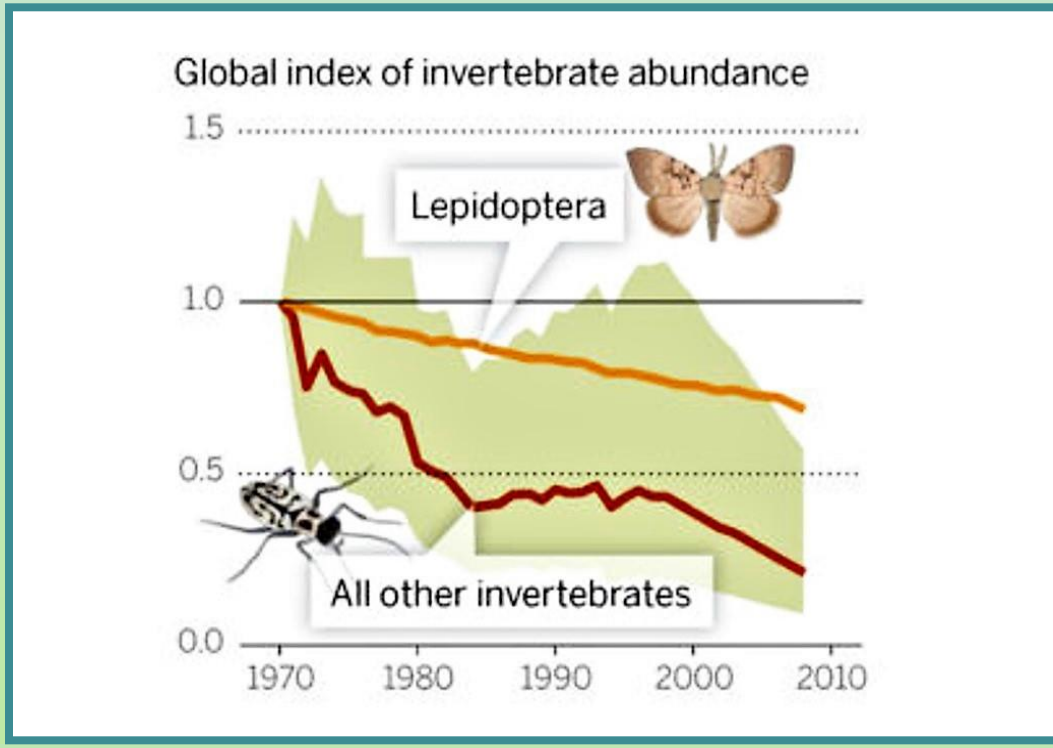
This presentation was created on the unceded territories of the Hul'qumi'num and SENĆOŦEN speaking peoples where I am very grateful to be living and working.

Bad news about insects just got worse….

- Over 40 years, global monitoring of 452 species showed 45% drop in insect populations
- 27 years of records from 63 protected natural areas in Germany showed an 80% decrease in airborne insect biomass
- Possible extinction of 40% of insect species projected over next few decades; extinction rate for bees, ants & beetles found to be 8 times higher than for mammals or birds
- 2020: Summary of 166 studies showed abundance of terrestrial insects declining 9% per decade
- *2024: Published re-analysis of above database showed insect decline had been underestimated*



Why should we care?

"If insects were to vanish, the environment would collapse in chaos"

- E.O. Wilson

"Insects are the primary means by which the food created by plants is delivered to animals"

- D. W. Tallamy

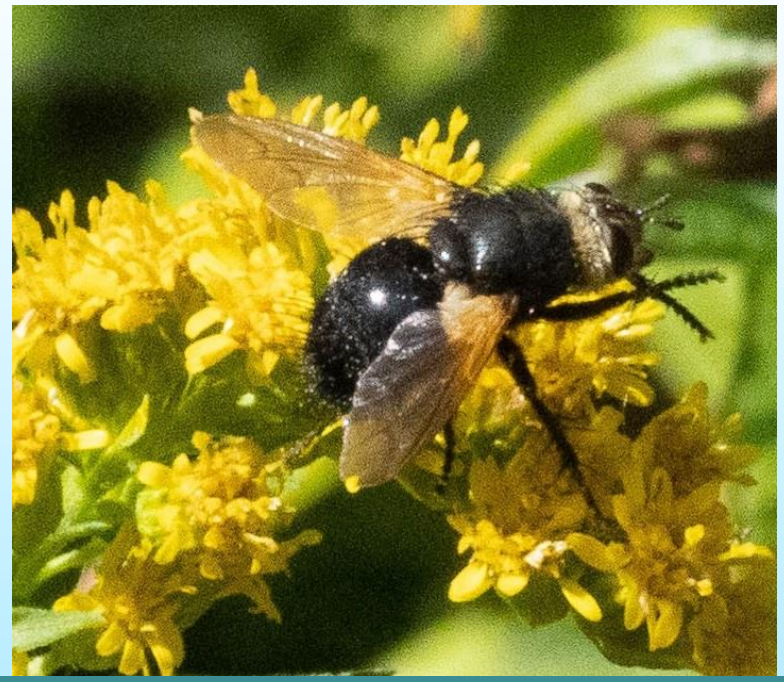
Insects pollinate flowers

- Vital for survival of most plants: 87% of all plant (90% of flowering plants) depend on pollinators to reproduce
- Up to 5% of fruit, vegetable & nut production globally is lost due to inadequate pollination
- 1/3 of all human food plants require pollination: >100 crops in Canada
- Fruit & seeds from insect pollination are a major part of diet of 24% of birds & mammals

Pollinators are not just bees

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

- Equal in value to 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, flowers on different parts of plant, and carry pollen farther than bees
- Moths pollinate at night



Flies: The second largest group of pollinators

Thousands of other species are predatory or parasitic on pests

A few of the thousands of native aphid predators

But these are just a tiny fraction of insects at work

?

There are 10-30 *million* insect species globally (most unknown)

Less than 0.1% of those species are “pests”

What are all of those non-pests doing?

Vital, but unseen, insects provide "ecosystem services"

In every ecosystem on the planet they are key players in:

- Soil building & aeration
- Decomposition & nutrient cycling

Carrion & dung beetles are essential recyclers

Insects purify water

- Larvae of aquatic insects clean water in lakes & streams: filter feeders consume algae & micro-organisms, turning them into biomass eaten by fish & birds

Photo: J. Gathany. Creative Commons Attribution 2.5 Generic license.

Yes, even mosquitoes are valuable…

Insects make the existence of animals possible

Through plants, the sun's energy becomes plant material; as insects digest plant material and are eaten by other animals, they are the pathway for nutrients to reach the wider food web:

- e.g., Caterpillars are rich in fat, protein & carotenoids, an essential nutrients for the development of baby birds (only plants make carotenoids)
- 96% of terrestrial birds depend on insects (mostly caterpillars) to feed their young
- Insectivorous bird numbers are declining faster than other bird groups, with a 59% decline in Canada since 1970's

It takes > 9,000 caterpillars to rear 1 nest of chickadees to the fledgling stage

Photo: D. Tallamy

Photo: Darren Clark

Insects make the existence of plants possible

- Insects decompose living and dead plant material, making nutrients available to the soil microbial community, which in turn makes nutrients available to plants
- Insects aerate soil, speed soil enrichment
- Insect pollination enables plants to reproduce
- Insects control pests on plants

Thinking about caterpillars:
Nasty little plant pests?
OR
Conveyers of essential nutrients from plants to the wider food web?

Human impacts on insects: Loss of habitat

Where development, agriculture, forestry, landscape ornamentals & invasive plants have replaced native plants, there are far fewer insect species, including pollinators, and smaller populations of native insects

Building, paving and cultivation eliminate:

- Native pollen & nectar forage flowers
- Host plants for larval food
- Nesting, pupation, overwintering sites

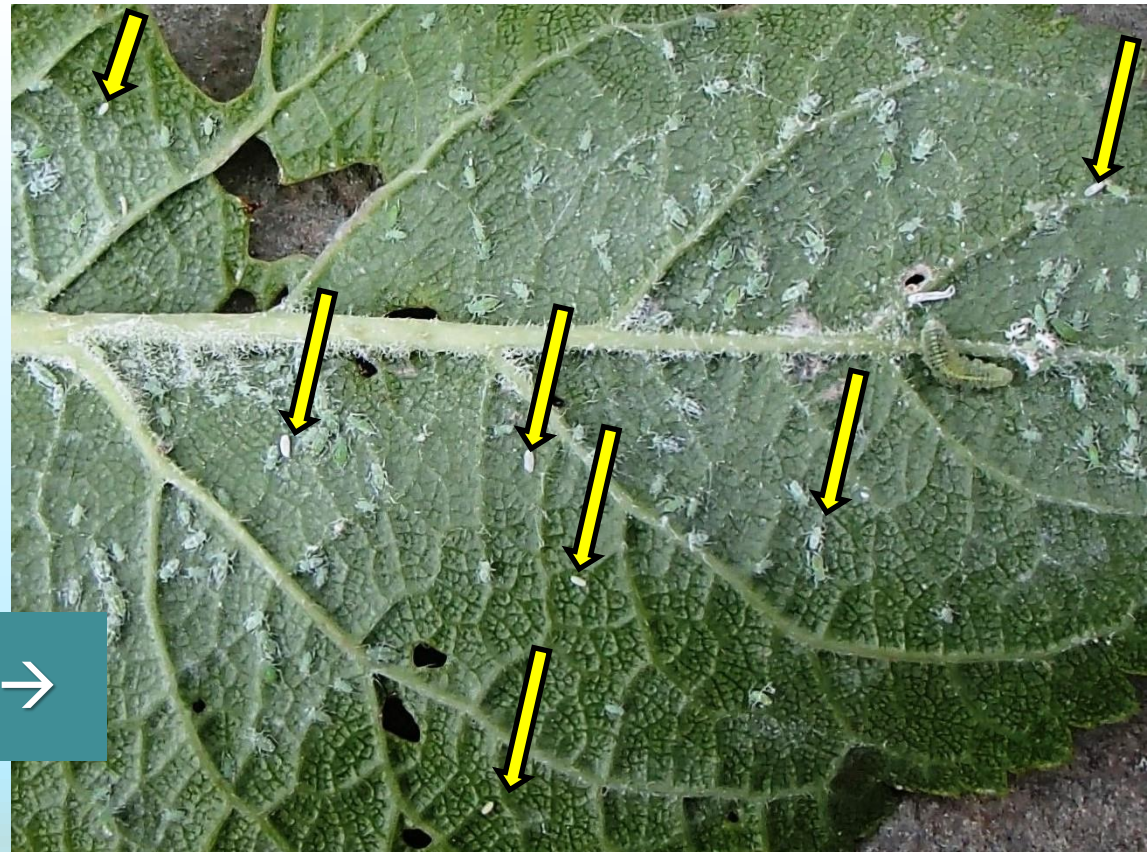
Loss of native plants may be the greatest contributor to decline of insect populations

[D.W. Tallamy, et al. 2021. *Ecological Entomology*. Vol 46:729-742]

Impacts: Pesticides kill

Includes insecticides, miticides, fungicides, herbicides:

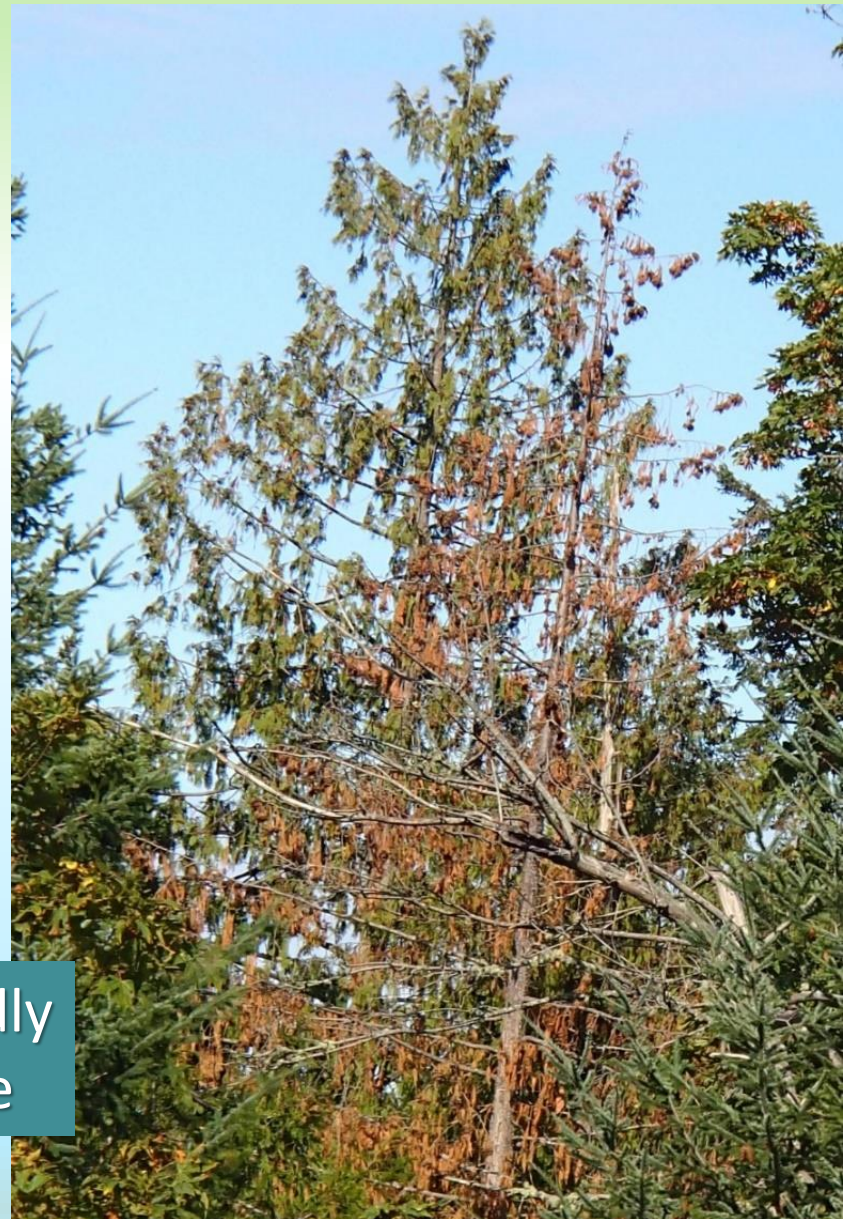
- Widespread adoption of neonicotinoids was our latest chapter in a long history of insect extermination (that particularly backfired on bees)
- Fungicides change the 'scent' of plants, also kill some insects & mites directly
- Herbicides remove host plants, pollen & nectar sources
- Even least toxic pesticides (e.g., soap) repel predatory insects from searching for prey or laying eggs on treated leaves



Syrphid fly eggs: Insects have very acute senses→

Impacts: Rising average temperatures

- De-synchronizes insects with seasons & daylength, with host plants & with the emergence of their prey insects
  - E.g., Spring leaf emergence is earlier, affecting leaf-eating insects and the insects & birds that prey on them
- Changes the distribution of host plants
- As summers become drier and warmer, dries up nectar & pollen sources prematurely
- Increase losses of native trees, habitat from forest fires



Western Red Cedar is a high-profile native plant rapidly disappearing from this region due to climate change

Extreme temperatures

- High temperatures directly kill insects

  e.g., Bumble bee populations in North America are half what they once were, linked to increasing frequency of extreme heat days

- High temperatures sterilize insects

  e.g., One heat wave reduced fertility of male beetles; a 2nd heat wave sterilized them

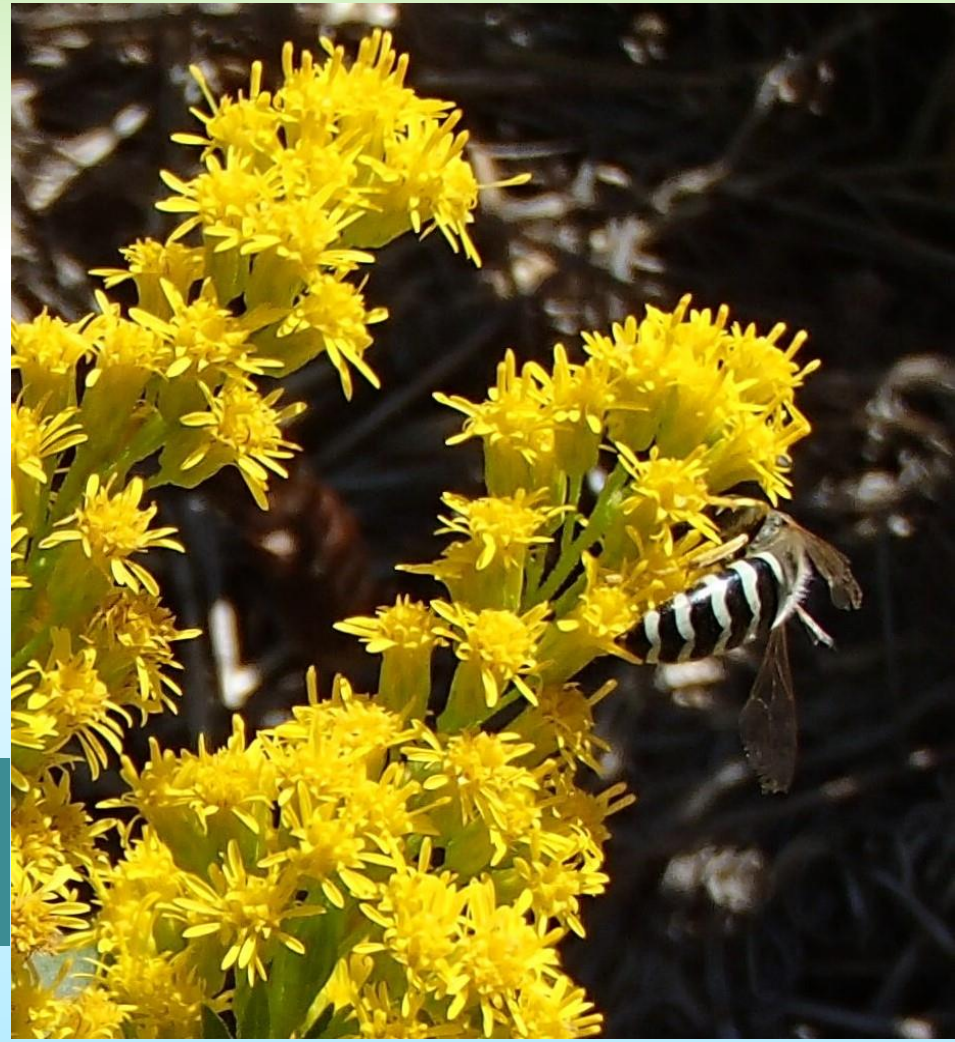
- Extreme winter cold reduces survival of insects overwintering

  In exposed sites:

  e.g., Jan 2024 extreme cold may have caused the large drop in numbers observed in local butterfly species

Rising carbon dioxide in the atmosphere

- Protein content of goldenrod pollen has dropped 30% since 1874
- Greatest decline occurred after 1960, correlated with rising atmospheric CO_2 levels
- Poor quality pollen resulted in:
  - Shorter lifespans in bees
  - Altered behavior and lower vigor



According to one of the researchers:

"Pollen is becoming junk food for bees"

Artificial light at night

Over 60% of insect species are nocturnal. Night lighting:

- Attracts insects away from natural ecosystems to die elsewhere from exhaustion or predators
- Disorients & desynchronizes insects' internal clocks that are essential for adapting to the seasons and to regulate day vs. night behaviour
- Affects insect abundance, number of species present, and impairs movement of pollen

Light at night prevents aphid predatory midges from entering diapause (insect hibernation) for winter

Night lighting decreases pollination

Studies show value of moths as pollinators & impact of night lighting on pollination:

- Artificial lighting reduced night visits to plants by 62% compared to dark areas
- Resulted in 13% lower fruit set even though daytime pollinators were also present

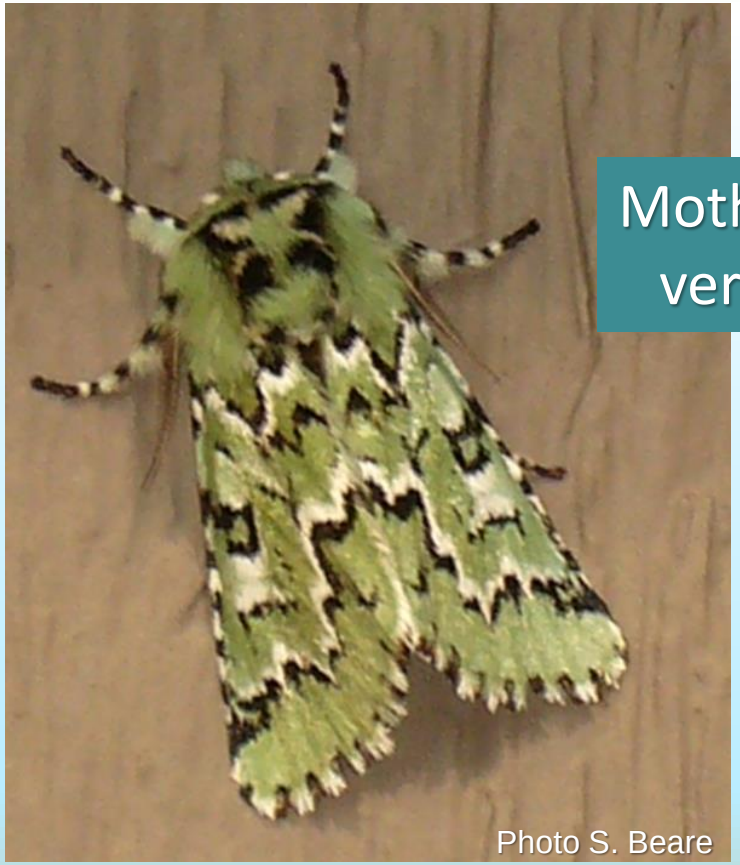


Photo S. Beare

Moths are now recognized as very important pollinators

Photo: P. Minvielle

Artificial light at night

- Regions with the sharpest decline in flying insects have the highest levels of light pollution
- Areas in UK with street lights were found to have half the number of caterpillars compared to similar areas without lights
- High impact on moths, whose caterpillars are the main food birds need to feed their chicks

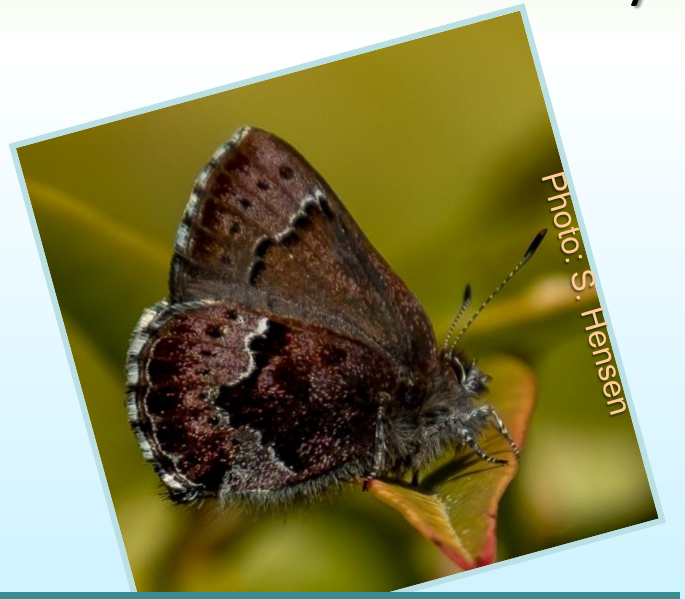
Photo Jess Findlay

NASA/GSFC/Craig Mayhew and Robert Simmon

What can we do?

Local conservation actions matter!

The good news: Because insects live in such small worlds, improving even small spaces can make a big difference in insect biodiversity and survival



Planting native sedum in my rock walls brought this rare native butterfly, Moss's Elfin, to live in my yard

Sedum spathulifolium

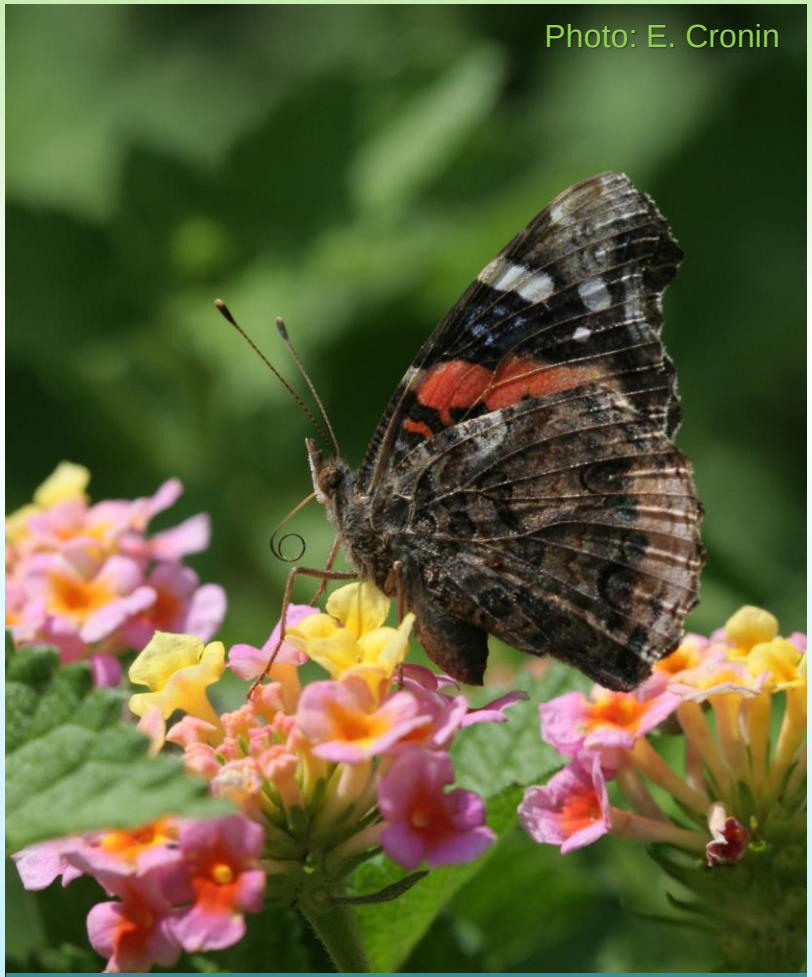
What insects need

- Pollinators, butterflies, moths, predatory & parasitic insects need nectar & pollen to feed the adults; bees need pollen to feed larvae
- Larvae of moths, butterflies, beetles & other insects that eat leaves, need host plants
- All insects need:
  - A safe environment, without pesticides, bug zappers, night lighting & other hazards
  - Protected places to nest, pupate & to spend the winter
- Non-leaf eating insects need drinking water in dry months

Diets for entire insect life cycles

- Red Admirals visit many flowers for nectar, but without stinging nettles to feed the caterpillars there can be no adult butterflies →

- Predatory & parasitic wasps drink nectar, but without caterpillars to host their larvae, there won't be another generation (and without native trees leaves to eat, there are fewer caterpillars)



5 species of local butterflies need stinging nettles to feed their caterpillars

Effect of non-native plants

- Most insects that eat vegetation feed on only 1 or a few closely related plants
- Native insects don't recognize leaves of non-native plants as food so planting non-native plants and spread of invasive plants removes recognizable food & natural habitat
- The more inedible food there is in the landscape, the fewer moths, butterflies, beetles and others can survive there
- Non-native trees & shrubs may have the greatest negative impact

70% of caterpillar species feed on a single plant family

Native + non-native plants?

- Adults of many insects feed on nectar or pollen; many can forage in flowers of both native and non-native plants:

  e.g., Adult butterflies can take nectar from many kinds of garden plants, but their caterpillars must have leaves of their native host plants

  e.g., Many bee species can take pollen from a wide variety of plants, but pollen specialization on particular native flowers is also common in native bees

- Vancouver bee study: Highest numbers of bees were in gardens with mixed native & non-native plants

- Some native plants support far more insect species than others: they are considered keystone species for local ecosystems

Keystone native plants*

- Especially valuable trees: Native oaks (*Quercus*), cherry *(Prunus*), willows (*Salix):*
  - e.g., Caterpillars of 436 moth species use Garry Oak as a host plant in the PNW
- Many trees provide leaves for caterpillar diets as well as pollen
  - e.g., 448 species feed on willow leaves & many others species, including pollinators and aphid predators collect willow pollen
- Goldenrods and Douglas Aster are keystone perennial flowers in this region:
  - Many insects use nectar & pollen, also to build up body reserves for overwintering
  - Bees nest in hollow stems of goldenrods
  - More bees may visit when both are present than when each is grown alone

*See: *Nature's Best Hope* by Douglas W. Tallamy. 2021.

Keystone Plants by Ecoregion: https://homegrownnationalpark.org/

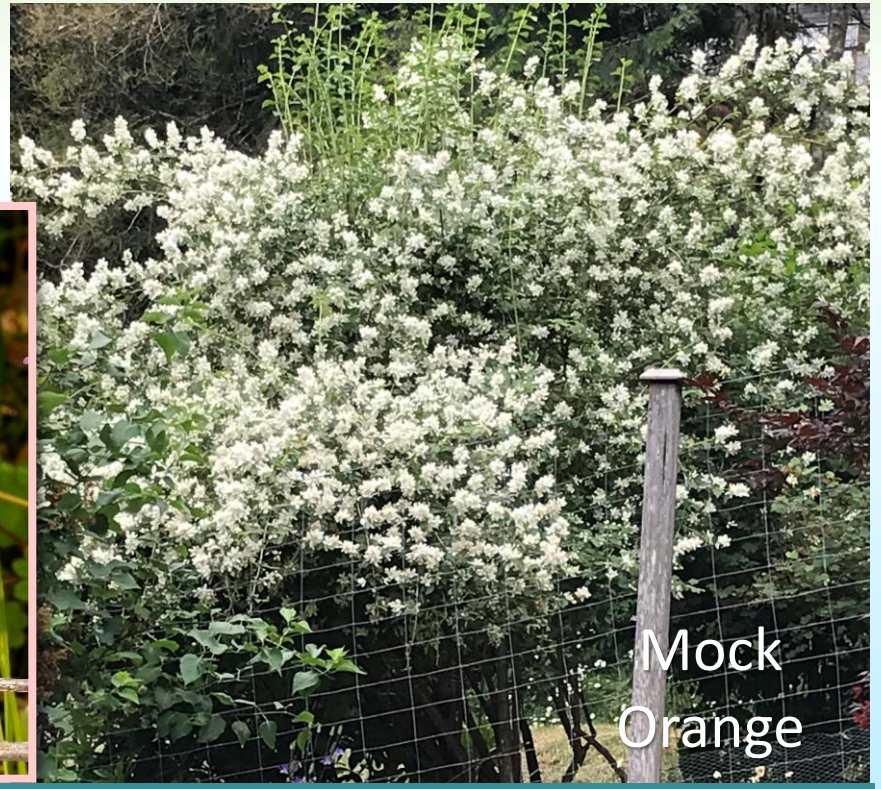
Landscape with native trees, shrubs & flowers

Many species are trouble-free, easy to grow & need little or no summer irrigation:

- Arbutus, *Arctostaphylos* spp., Ocean Spray, Mock Orange
- Oregon grape, Salmonberry, Salal, Red-flowering Currant
- Stonecrops, Sea Blush, Spring Gold, goldenrods, asters


Red-flowering currant


Seablush


Mock Orange

"Native" means to S. coastal BC & suited to the soil & micro-climate in your area

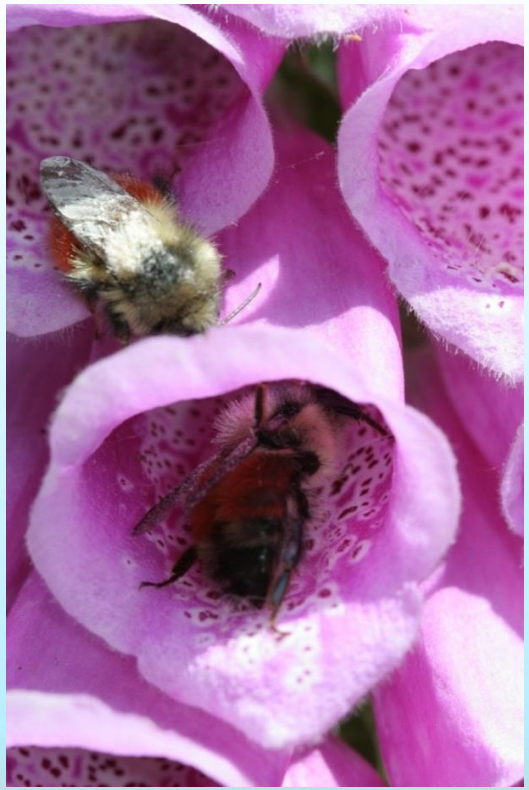
Plant for bloom all season long

- Continuity of food supply is essential: Late summer & fall flowers are critical for bumble bees, parasitic wasps, hover flies, pirate bugs & others with several generations per season
- Concentrate on increasing number & variety of native plants blooming during periods when the least insect forage is available: Goldenrod, Douglas Asters, sedums Pearly Everlasting, Common Snowberry, other late summer flowers

Plant a variety of flower shapes

Insects are very diverse so flowers must be diverse:

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



Flowers that feed adult predatory & parasitic insects

- Lady beetles, lacewings: Dill, cilantro, parsley
- Hover flies: Calendula, marigold, yellow daisies, dandelions
- Many species: Sweet alyssum, goldenrods, asters, yarrow, candytuft, forget-me-not, thymes, daisies, mustard family plants

Many species visit sweet alyssum

Flower diversity = pollen diversity

This is especially urgent if decreasing protein content in pollen is widespread:

- Bees don't seem to compensate for poor quality pollen by taking in more food BUT they do compensate by foraging for a greater variety of pollen sources with complementary amino acids

Choose least modified flowers

Grow native, ‘wild-type’ and least manipulated cultivars; avoid ‘nativars’ of native species

Highly modified & hybrid 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 may not recognize unusual or new colours

Cutting sunflowers are bred to have no pollen!

Growing insect forage plants from seed

- Allow plants to self-sow or collect seeds and sow elsewhere outdoors in the fall (or by February) so seeds are naturally stratified by winter and sprout in the spring
  - e.g., Nodding onion, Camas, Shooting Star, Candytuft, lavenders, catmint, catnips, penstemons, Russian sage, Rudbeckia (most) Black-eyed Susan, *Sedum,* most tree seeds

- Many plants have seeds that require light to germinate so must be sown on the surface (protect seedbed from birds)
  - e.g., Yarrows, Pearly everlasting, coreopsis, cosmos, foxglove, Gaillardia, catmint, catnips, penstemons, sages, Sedum, goldenrods, asters (*Symphyotrichum* →)

Note: Many perennial flowers take 3-6 weeks to germinate at 20°C, even longer in cooler conditions

What to plant? Look at the wider landscape

Because they fly, neighbourhood vegetation is part of the insect 'foodscape':

- Urban/suburban areas with few wild or natural areas nearby: Planting native trees and shrubs, host plants for caterpillars & other leaf-eating insect may be most valuable
  - E.g., Oak, cherry, alder, willow, arbutus, manzanita, salal, stinging nettles

- Less developed or rural areas, with yards surrounded by wooded or wild areas: Planting flowers to provide pollen and nectar for adult insects all season may be most valuable
  - E.g., Support bumble bees by planting nectar-rich flowers with deep trumpets that can't be accessed by honey bees: *Vaccinium*, *Ribes*, foxglove, bee balm, fireweed, lobelia, *Mahonia*, *Ceonothus,* red clover

Replace lawns

- Plant flowering meadow mixes or ground covers (e.g., creeping thymes, coastal strawberry, bellflowers, low Oregon grape) where low vegetations is desired
- Planting perennial flowers, native trees and shrubs provides even better habitat to support more insects, provide nesting and overwintering sites
  - Convert a strip of lawn every year; propagating new plants from established plants keeps cost down

Provide a soft landing zone for caterpillars

- Caterpillars feeding on tree leaves need a safe place to pupate to complete their life cycle:
  - e.g., Leaf litter or loose soil beneath the tree for pupation & over-wintering sites
- Plant groundcovers, understory shrubs, ferns, or use leaves or wood chip mulches to provide pupation habitat under trees in landscapes

A mowed lawn is a barren zone for caterpillars:
This wood chip mulch helps, but understory plants under the tree would be even better

How much to plant?

- To support native bees & other pollinators:
  - Aim for at least 50% native plants
  - Plant in masses: Over 1 square meter of each kind of flower or at least 5-10 plants of most perennial flowers
  - Grow many different plants: More bees visit where at least 8 species of flowers are in bloom at the same time
- To support leaf-eating insects:
  - Aim for 70% native trees and shrubs
  - Native oaks, cherries, and willows top the list for supporting biodiversity (leaf and pollen eaters)

Native Nodding Onion is easy to grow from seed

Photo: E. Cronin


What else can we do?

Provide a safe water supply

- Insects that don't eat leaves rely on water bodies & dew (but there isn't dew in dry months)
- Low humidity is a severe stressor on all insects
- Lack of water in dry weather shortens life spans & reduces number of eggs insects lay
  - E.g., Aphid midges & parasitic wasps lay twice as many eggs when they have access to water

Tiny wasp drinking dew

Photos: E. Cronin

Make sure insects can't drown

- Stones in water allow insects to crawl out (put them in bird baths too); unglazed pottery containers work well
- Dump water regularly to prevent mosquitoes from breeding
- Place out of reach of small children, pets

A sloping rock beach makes this trough safe

Photo J. Kolot

Don't use pesticides…

…on crops, gardens, landscapes, lawns, weeds, roadsides

- Includes insecticides, miticides, fungicides, herbicides
- Effective alternative methods and tools are available to manage pests, diseases & weeds

Most pesticides allowed in organic production (e.g., pyrethrins, insecticidal soap) ALSO harm non-target organisms

What kills 'pests', also kills predators & parasitic insects, pollinators, butterflies……

Photo: E. Cronin

Pesticides as a last resort, not routine treatment

- Identify pests, learn life cycles & how to decide whether treatment is necessary:

  E.g., Is the number of leaf-eating caterpillars in a fruit tree high enough to affect tree health or harvest?

- Dormant sprays are often used on fruit trees for no reason or for pests & pathogens the sprays don't control (e.g., tent caterpillars, apple scab, pear trellis rust)

Dormant oil sprays kill over-wintering beneficial insects & mites

164 species of caterpillars can feed on apple leaves, most unnoticeable

Turn off or replace outdoor lights

- Don’t leave yard or pathway lights on all night
- Install sensor lights that turn on only when needed
- Replace incandescent, CFL, cool LED & halogen lights with warm LED light bulbs

Photo: E. Cronin

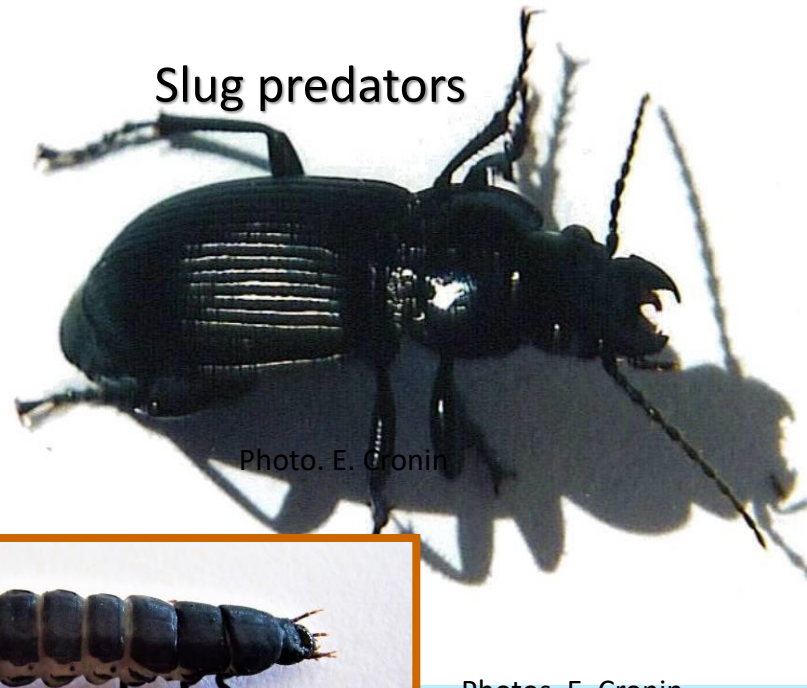
Never use bug zappers

Minimize cultivation

- Many beneficial insects (e.g., syrphid flies, aphid midges) pupate in the surface layer of soil and leaf litter; many also overwinter there
- The majority of native bee species overwinter in burrows in the ground
- Use organic mulches to control weeds (not plastic mulches or landscape fabric)
- Use ‘no-till’ methods for gardens, crops and flower beds

Protect ground dwellers

- Give ground beetles & other predators a stable refuge away from cultivated areas:
  - Leave undisturbed pathways, areas of perennials between annual beds
  - Leave permanent vegetation margins, “beetle banks” of grasses and perennials
- Minimize soil cultivation, cover soil with mulch or living plants, plant ground covers between shrubs & trees



Photos. E. Cronin

Protect wild bee nest sites

- 70% of native bee species nest in the ground: leave bare soil at the base of rock walls, preserve sunny banks, sandy areas
- 30% of native bees nest in tunnels: beetle holes, hollow twigs & canes: leave stumps, prunings, bundles of twigs for nest sites
- Bumble bees nest in burrows and cavities, birdhouses, sheds, hollow logs, brush piles, under tussocks of grass

Re-think fall clean up: Mess is best!

Twig-nesting bees and other insects overwinter in hollow twigs & canes; butterfly chrysalises are attached to woody stalks; many insects overwinter in leaf litter

- Leave stems standing OR cut stalks and lay them on the soil surface for the winter
- Don’t walk on garden beds, especially around host plants: insects are likely pupating or over wintering in the leaf litter

Delay spring cleanup

- Clean up debris as late as possible in spring to give overwintering insects time to emerge: e.g., after soil temperature >13°C for a few days
- Delay raking or mowing until May; leave areas unmowed & set mower to cut as high as possible for annual mowing of meadows
- When cutting back plants, “chop and drop” cut material in the landscape to build up seedbanks for natural regeneration
- Leave stalks with a hollow pith at least 20 cm high for twig-nesting bees

Rather than cutting ‘Autumn Joy’ sedum flush with the ground, leave short stems

Re-think horticultural practices

- Ecological gardening is based on working with natural cycles of plants and how they grow in mixed communities and in succession as sites change
- Appreciate the wilder appearance of natural plantings:
  - Combining a traditional, 'clean' border of familiar plants can make wilder, woody thickets in the background acceptable to the public
  - A single mowed strip along the edge makes a natural meadow look cared for
- Ecological practices also conserve water, sequester carbon to combat climate change, provide pest control for food crops, support birds and other wildlife

Use your own observations to question garden 'lore', imagine other approaches, try new ways to do things

Photo: E. Cronin