

A vibrant garden scene featuring a stone path leading through various plants and flowers. In the foreground, there are large green leaves and clusters of orange and yellow flowers. The path is bordered by a low stone wall on the right and a dark fence on the left. The background shows a house with a grey roof and more greenery.

Resilient Gardens for a Changing Climate

Linda Gilkeson

www.lindagilkeson.ca

The climate emergency is here

- Impacts on ecosystems, human health, economy, agricultural productivity, national security.... some effects are occurring sooner than predicted
- Widely felt now in this region: Forest fires, drought, floods, variable and extreme weather

A14 BRITISH COLUMBIA THE GLOBE AND MAIL | SATU

The province is caught in a grim climate cycle

Water levels are dropping, people face health risks: What will it take for B.C. to call it a climate emergency?

JUSTINE HUNTER
COWICHAN VALLEY, B.C.

Mark Worthing, a conservation campaigner for Sierra Club BC, stands in the unseasonably low Holt Creek riverbed, where it enters the Cowichan River. JAMES MACDONALD/THE GLOBE AND MAIL

B.C. drought levels
As of June 13

LEGEND

- Dry
- Very dry
- Extremely dry

MURAT YÜKSELİR / THE GLOBE AND MAIL. SOURCE: GOVERNMENT OF B.C.

Two weeks ago, I was up to my waist here," Mr. MacDonald observed his knees. The technical team from the province's water-management department was here to chart water pressure, depth and the rate of flow: Even without their FlowTracker equipment and atmospheric gauges, it was plain that the Chemainus is unseasonably low and lazy.

There are coho and steelhead fry in here, some trapped in isolated pools left behind as the water levels dropped. Typically, these young salmon and trout will spend the summer in the river before making their way to the ocean, but right now, their survival is in doubt.

Across British Columbia, this spring has set the stage for drought. June is usually wet, but everywhere is dry, vast swaths of the province are very dry, and in some places, including the Chemainus River, the drought rating is extremely dry. Environment Canada has warned of more hot weather to come. For the farmers who tap into this river to irrigate their crops just steps away from where the technical team conducts their measurements, that is

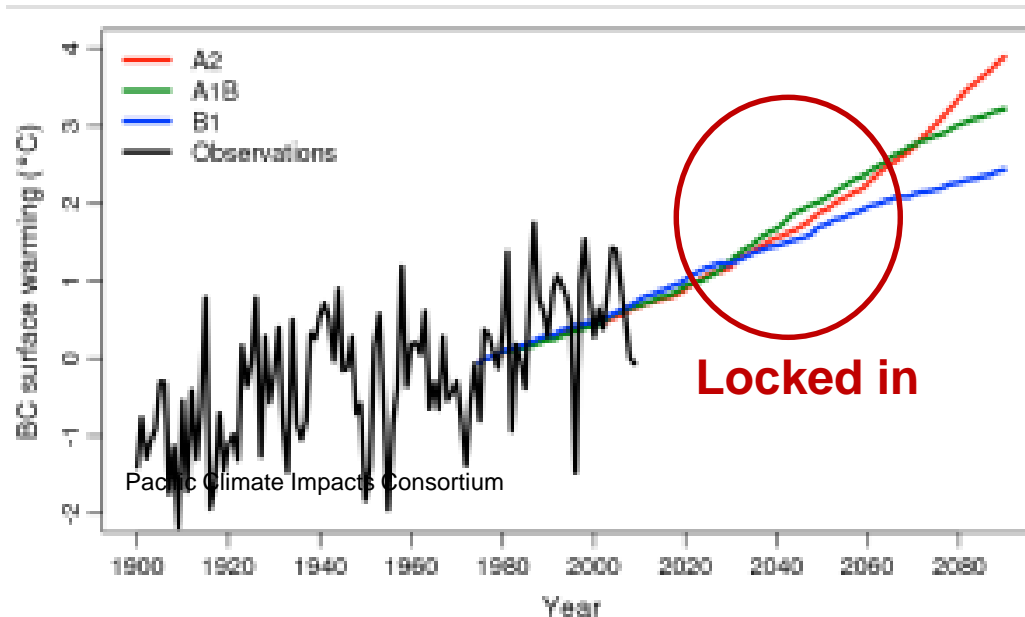
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Globe & Mail
June 22, 2019

Temperatures in BC—so far...

- Temperatures have increased 0.8-2.0°C over last century (global average is 0.85°C)
- Night time lows have warmed more than daytime highs
- Warming has been more rapid in last 35 years



2016 was the hottest year on record globally

The hottest 17 years on record occurred in the last 18 years

We are now in the warmest period of the last 1400 years

Effects of climate change

- Higher average temperatures = greater extremes of heat
- Slowing polar jet stream = extended periods of extreme weather, including polar outbreaks of extreme cold
- Changes in winter rainfall patterns = increased flood risk & waterlogged soils
- Less rainfall in the summer = longer dry period & more stress on water resources
- Increasing storm intensity = wind damage
- Increase in number of days warm enough for plant and pest growth (growing degree days)

Coastal BC climate by mid-century

Middle figures from climate model projections for 2050's*

- Average annual temperature increase: 1.3°C to 2.3°C
- Extreme heat days 3 times more common
- Average summer rainfall lower by 5-30%
- Total winter precipitation 2-12% higher; decreasing amount falling as snow

But, averages are not the whole story
2015 was a preview of the predicted 'average' summer by
mid-century (that's only 30 years away!)

*Compared to 1961-1990 averages: From Pacific Climate Impacts Consortium [Plan2Adapt](http://www.pacificclimate.org/analysis-tools/plan2adapt) calculator:
www.pacificclimate.org/analysis-tools/plan2adapt

Weird weather is the new normal

- 2018 had unprecedented extremes of weather globally: storms, heat waves, rainfall, drought, floods, fires and wind damage:
 - BC had the worst fire season in history [13,000 km² of forest burned], surpassing previous record set in 2017
 - Nov. 2018: BC Hydro reported the number of storms they responded to has tripled over past 5 years [this was before the record-breaking Dec. 20 windstorm]
- The number of prolonged cold & heat waves per year has increased 70% since 2000
 - Feb. 2019 was the coldest on record in Lower Mainland yet 2019 is expected to be one of the warmest years on record globally (several days in March set high temperature records)

How Does Weird Weather Affect Plants?

Climate change disrupts seasonal adaptations

- Growth rates increase, but hardening off may be delayed
- Risk of late spring frosts remains; they are more damage when buds break earlier in the season
- Risk of winter injury from unusually early or late cold snaps



Effects of temperature extremes

High temperatures:

- Growth slows or stops: photosynthesis stops above 35°C
 - E.g., Tomato growth peaks at 30°C
- Extreme heat disrupts cellular processes, causing death of cells
- Plants use up sugars from photosynthesis faster than they can be replaced = poor or bitter flavours

Low temperatures:

- Photosynthesis slows, stops below 5°C
- Frost damage, especially to plants that are not acclimatized

Plants can adapt to high or low temperatures, but not to rapid fluctuations between high and low

High temperatures ruin pollen

- Tomato pollen is sterilized above 30-32°C
→ flowers drop or fruit is distorted
- Greenhouses regularly get too hot for cucumber, pepper & tomato flowers



Warmer summers = more generations of some pests

- Species that have multiple generations per year fit in more generations each season:
 - E.g., Codling moth, carrot rust fly, cabbage root maggot, aphids, fruit flies, beet leafminer
- Numbers can be extremely high by fall



Codling moth



Spotted wing Drosophila

Effects of drought

Plants can tolerate moderate, but not severe, drought:

- Dehydration disrupts cellular processes
- Plants close leaf pores (stomata) to avoid water loss
- In dry soil, nutrients cannot pass into roots without a film of water around roots; root hairs die back

This occurred in cold weather and plants recovered completely →



Heat + Drought = Devastation

When stomata close:

- No cooling from evaporation → leaf temperatures rise by 5°C → leaf cells are killed by extreme heat
- Photosynthesis stops → no food for plant growth
- Movement of water from roots stops → no nutrients from soil

Plants can adapt to moderate heat OR drought stress, but not when they occur together.



We see a lot of sunscald now



Photo: E. Savory

Flowering disorders

- Temperature extremes for the season: hot or cold, rapid changes between extremes
- 'Blind' heads in cabbage family, premature flowering



And growth anomalies



Effects of precipitation changes

Both summer drought and winter waterlogging kill and injure roots, making plants:

- Less able to take up nutrients and water
- More vulnerable to drought the next season
- Susceptible to root diseases (e.g., *Phytophthora*)

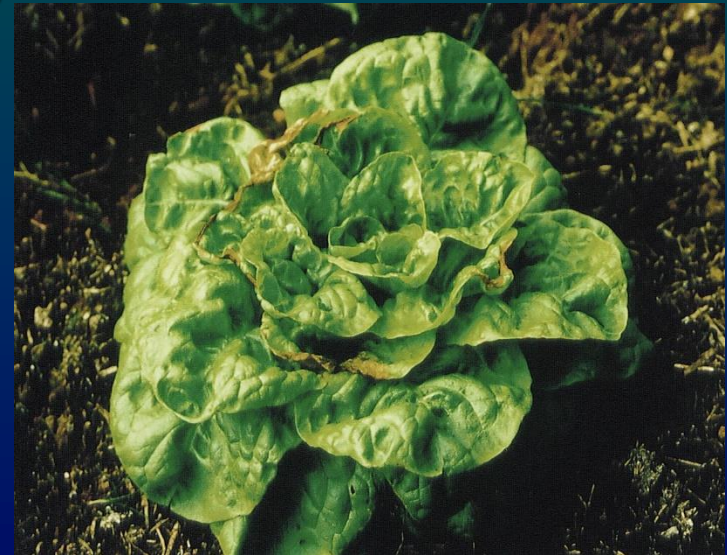
Trees are more likely to blow down, especially those carrying fruit or burdened by ivy, clematis, wisteria or other climbers

Root damage plays a key role in nutrient deficiencies, poor growth rates, susceptibility to diseases & pests

Some metabolic disorders are made worse by heat & drought

- Interaction of plant metabolism, weather, irrigation, soil nutrients & cultural methods → influences nutrient levels in leaves, flowers & fruit
- Plant tissues are most often deficient in **calcium**
 - not necessarily due to soil deficiency
 - heat/drought stressed plants can't get calcium from soil

These are often mistaken for diseases



Common tomato disorders

- Blossom end rot: Calcium deficiency in tissue, usually from irregular watering
- Green/yellow shoulder: Heat of direct sunlight inhibits ripening

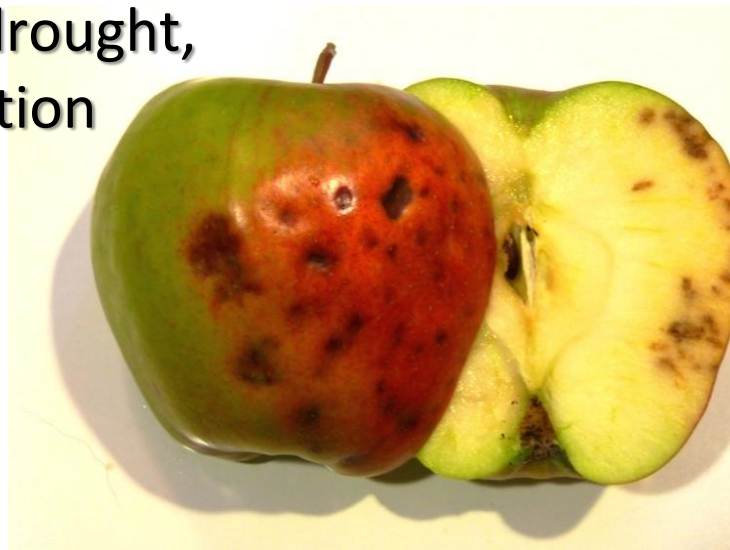


Common apple disorders

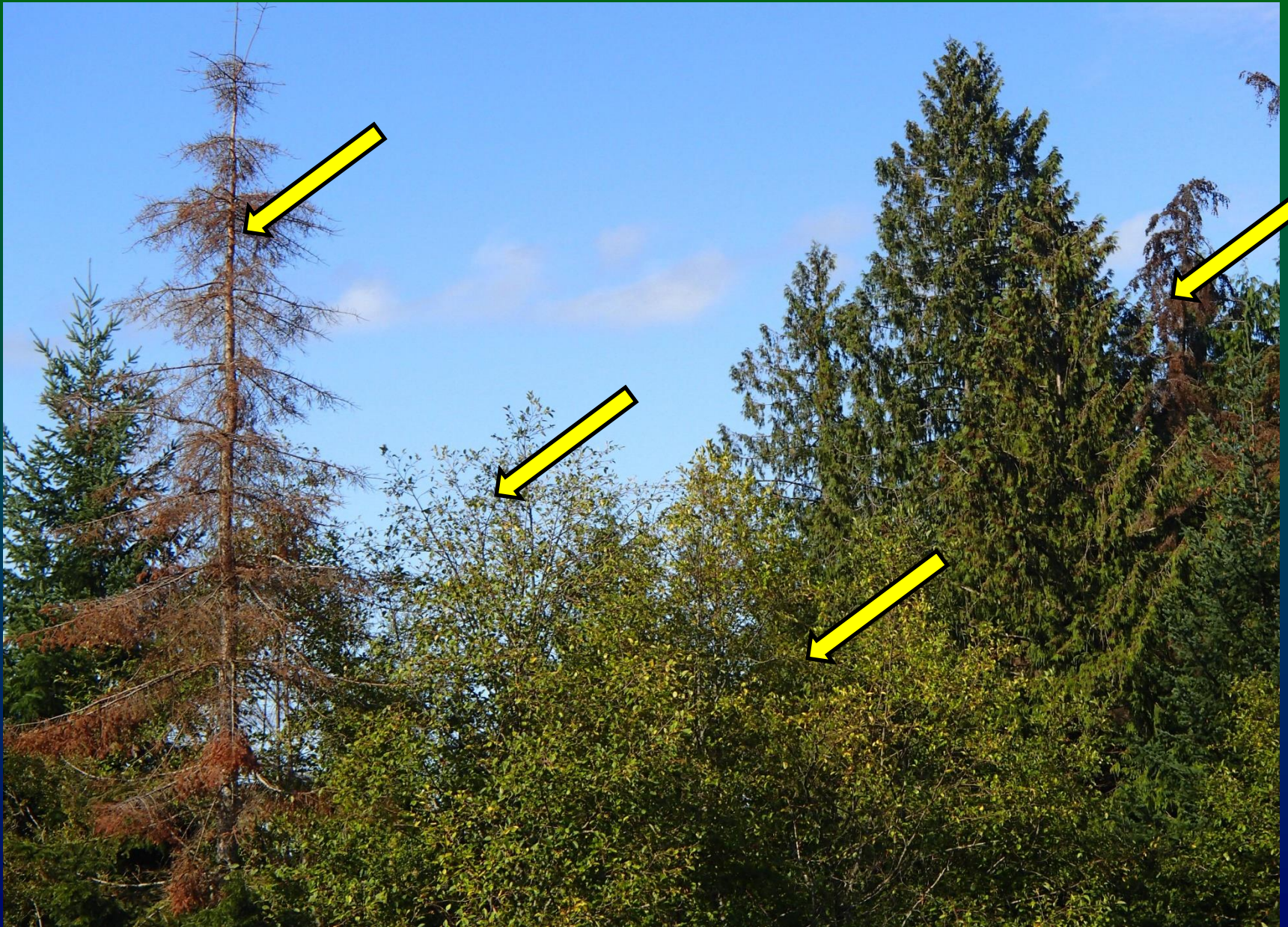
- **Watercore:** High temperature, low calcium, high nitrogen, excessive fruit thinning



- **Bitter Pit:** Calcium deficiency in fruit tissue from drought, excessive fertilization

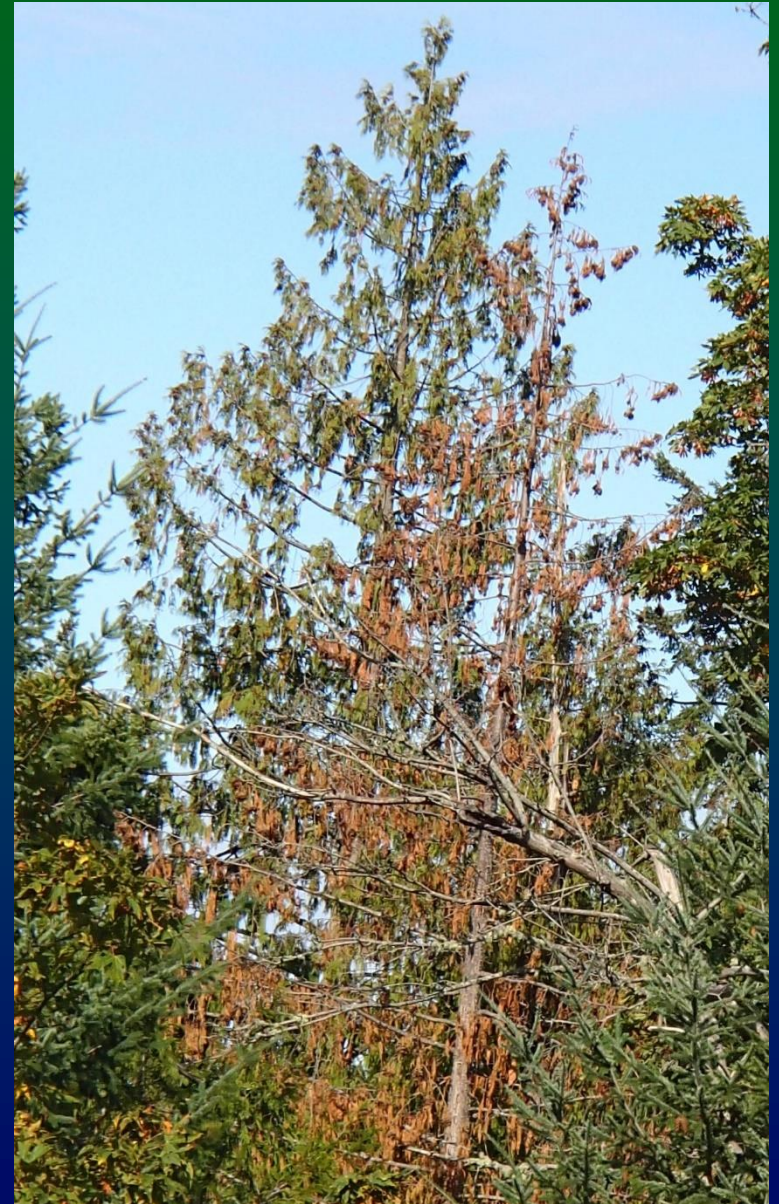


Tree stress is widespread



Impact on woodland

- W. Red Cedar is first well-known species likely to disappear due to lack of moisture (dry, rocky sites die first)
- Maples are also suffering
- Salal dieback now thought to be due to climate stress



Plant stress opens the way for insect attack

- Borers attack trees weakened by poor growing conditions
- Aphids thrive on drought-stressed plants



*How Can We Make
Gardens More Resilient to
Climate Change?*

Your observations, knowledge and skills are key

- Learn how 'weird weather' affects growth, flowering & fruiting, pest & disease life cycles
- Design protected gardens & choose resilient plants
- Keep records, especially of cultivars that perform well in drought, extreme temperatures
- Plan for long-term changes to improve plantings, irrigation systems, water storage

Design sheltered gardens

- Plants protected by windbreaks, walls, solid fences are less exposed to wind and cold injury



Choose resilient plants

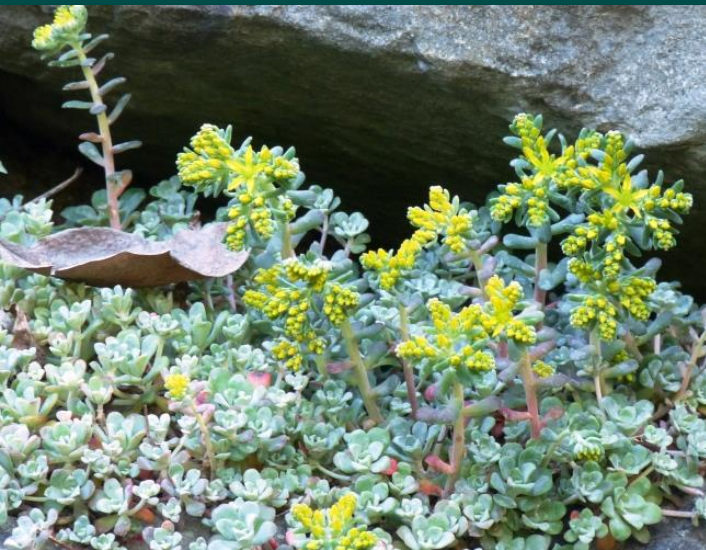
- Choose plants likely to survive unusual winter cold & summer heat rather than plants at the edge of their range (“if it grows in Winnipeg....”)
- Plant perennials rather than annuals: Once established, they are less vulnerable to variable weather & need less water
- Plant species with low summer water requirements



Include resilient native species

Choose species adapted to dry conditions*

- Goldenrod (*Solidago*)
- Red flowering currant
- Oregon grape (*Mahonia* spp.)
- Stonecrop/Sedum



*These also feed beneficial insects

Landscape Trees

- Choose species well adapted to soil & site; improve drainage so roots don't sit in waterlogged soil in winter
- Cedars, maples, hornbeam are suffering most now after several drought years (spruce, fir, junipers, oak least affected so far)
- Avoid species susceptible to breaking: Willow, box elder, poplar, silver maples



Landscape trees with a future

- Choose small trees: Need less water, have better wind stability, are easier to prune
- Plant very young stock for best establishment
- **Ensure roots do not encircle root ball:** Reduces water uptake & makes tree roots unstable →



Resilient lawns

- Grasses are adapted to go dormant in summer without water
- Deep-rooted lawns stay in good condition with watering once a month & can survive well without irrigation

To grow deep-rooted grass:

- Set mower to cut at 6-9 cm
- Taper off [*or don't start*] irrigation
- Leave clippings on lawn to mulch & feed grass
- Apply lime for acidic soils to raise pH

Lawns on shallow soils won't survive without
Irrigation—consider other groundcovers?



More resilient groundcovers

- Drought tolerant ground covers: creeping thymes, coastal strawberry, bellflowers, low Oregon grape
- Fleur de Lawn® developed at OSU: Mix of English daisy, fescues, yarrow, perennial ryegrass, strawberry clover

BONUS: Flowers also feed pollinators and attract beneficial insects that control pests



Fleur de Lawn® OSU

Choose disease resistant plants

- Diseases of wet spring weather: Choose scab resistant apples and pears; black spot resistant roses
- Diseases of dry summer weather: Choose powdery mildew resistant grapes, peas, cucumbers, roses, delphiniums & other flowers



Resilient food gardens

Grow several varieties of each crop:

- There are notable differences in tolerance for heat, drought, frost & adverse conditions in vegetables and fruit
- E.g., In 2015 there were big differences between how well onion, tomato, squash cultivars fared in the drought



Brandywines are OK but grow small-fruited tomatoes too



'Blind' head in 1 variety of cabbage due to late frost

E.g., Winter survival of chards after severe cold (winter 2016/17)

Survived fine:

'Leaf Beet'

'Lucullus'

Winter killed:

'Bright Lights'

'Fordhook'

'Silverado'



Avoid cultivars prone to disorders

Tomatoes:

- Prone to blossom end rot, green shoulder: Paste & large-fruited types, especially Brandywine, Roma, San Marzano
- Least affected are cherry tomatoes, varieties with small & medium-sized fruit

Potatoes:

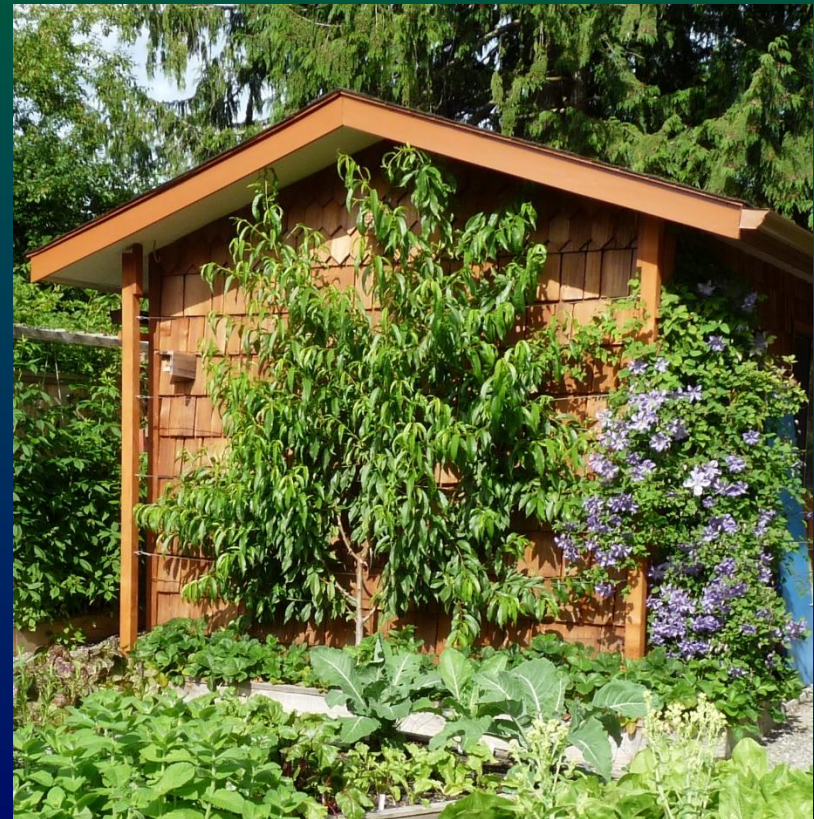
- Prone to hollow heart: Russet Burbank, Yukon Gold, Norgold Russet



Choosing tree fruit

- Choose late flowering varieties least likely to be damaged by late spring frosts
- Choose self-fertile varieties to improve chance of pollination in poor weather
- Avoid apples prone to:
 - Bitter Pit: Gravenstein, Jonagold, Golden Russet
 - Watercore: King, Fuji, Delicious, Granny Smith

Grow peaches, nectarines against buildings for frost protection →



Plant cold hardy crops to reap spring harvests

- Overwintered plants grow fast, survive poor weather, late frosts & spring pests much better than spring sown seedlings
- Lots to eat March to June!



That means planting early enough to fill your 'living refrigerator' by late October...



Adapt seeding methods to fit current conditions

Spring or **cool** weather:

- Wait until soil is 15°C to sow
- Warm soil with clear plastic before sowing

Summer or **hot** weather:

- Sow seeds slightly deeper
- Always shade seed beds until germination

Soil can be **too warm** to germinate lettuce, carrots, parsnips, corn salad →



*Be ready for heat waves **any time***

- Shade seedlings & mature plants on hot days
- Sprinkle fine mulch around seedlings to cool soil; maintain thick mulches around larger plants
- Increase irrigation if possible



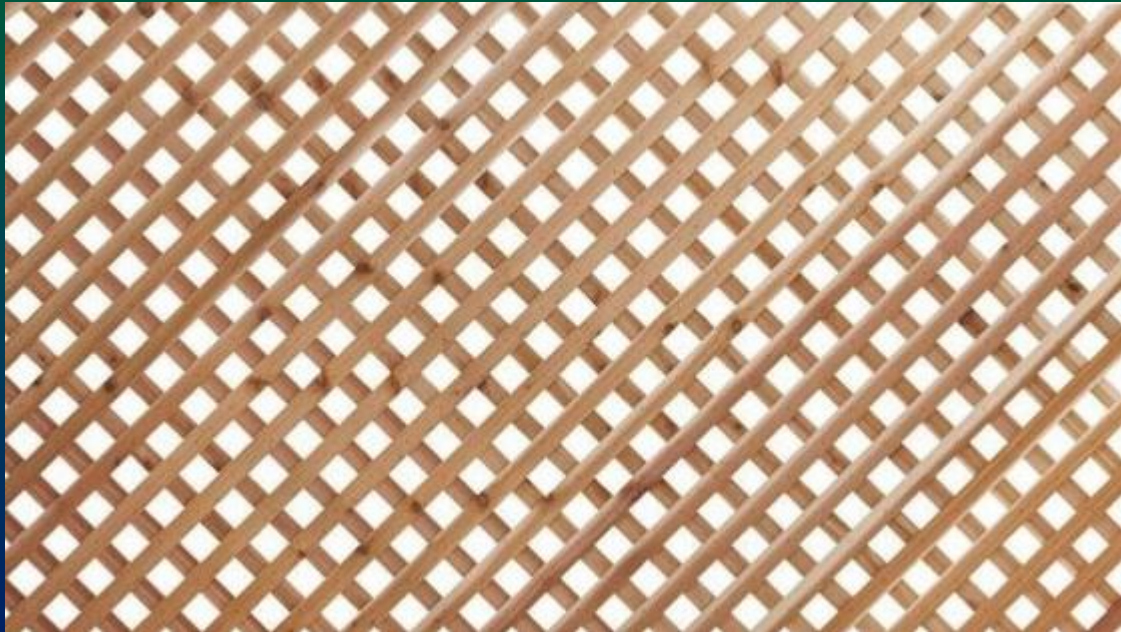
Invest in shade cloth

- 30-50% shade is ideal to cool while allowing light for growth
- Shading priorities: tunnels & greenhouse, seedling beds, cool weather crop (cabbage family, lettuce & greens, peas)



Or build lath covers

- Cut prefab cedar lath fence panels to fit your beds or design your own lath shade cover



Design to cool

Greenhouses & tunnels regularly get too hot in heat waves (the main cause of aborted fruit, metabolic disorders, sunscald)

- Open doors and vents wide; install more vents or use fans to move air
- Cover with **temporary** shading



Be ready for late spring frost

- Cover with plastic sheets, cloches, floating row cover, tarps



Prepare for Arctic outbreaks: Some will be colder, longer than usual

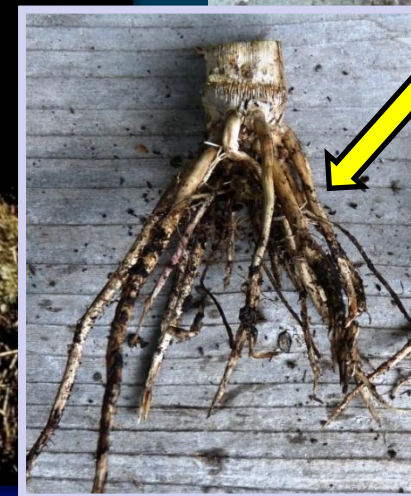
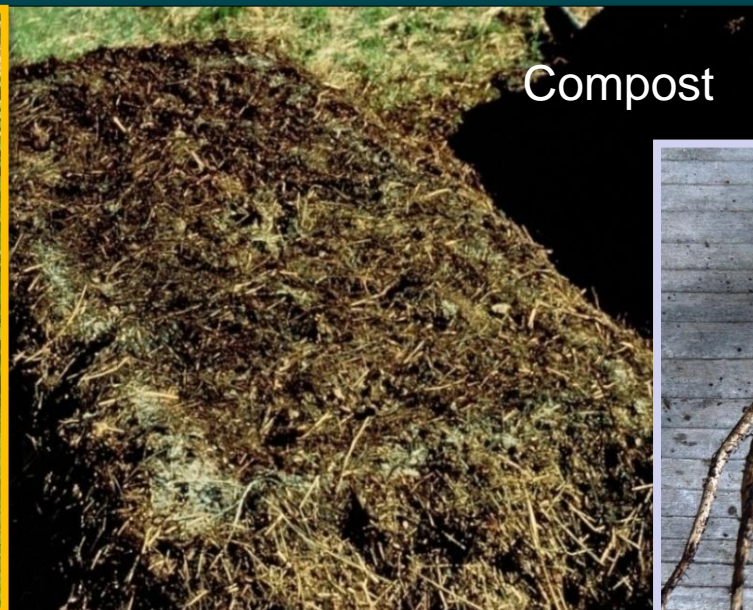
- Temporary: Plastic or tarps held down with rocks & boards
- Permanent frames: Low profile, sturdy, well-secured, wind resistant



Build soil organic matter

- Stores nutrients in a slow-release nutrient 'bank'
- Prevents nutrients from leaching away in heavy rains
- Increases water-holding capacity of soil

Humus (well-digested organic matter) improves soil structure, water-holding capacity, nutrient availability & **holds carbon** in the soil



Leave crop roots in the soil

Mulch all year round

- Keeps soil cooler in summer, warmer in winter
- Reduces evaporation in summer, protects soil from erosion & nutrient loss in winter rain
- Builds organic matter, feeds soil, controls weeds

Use: Leaves, straw, lawn clippings, crop residue, coarse compost, chipped garden trimmings, shredded paper....anything!



Plan for drier summers

- Install water conserving irrigation systems, collect household waste water
- Plant new trees & shrubs in the fall rather than spring: they will need less water in their first summer



Store winter rain

- There is no projected shortage of winter rainfall!
- A surprising amount can be collected from even a small roof area



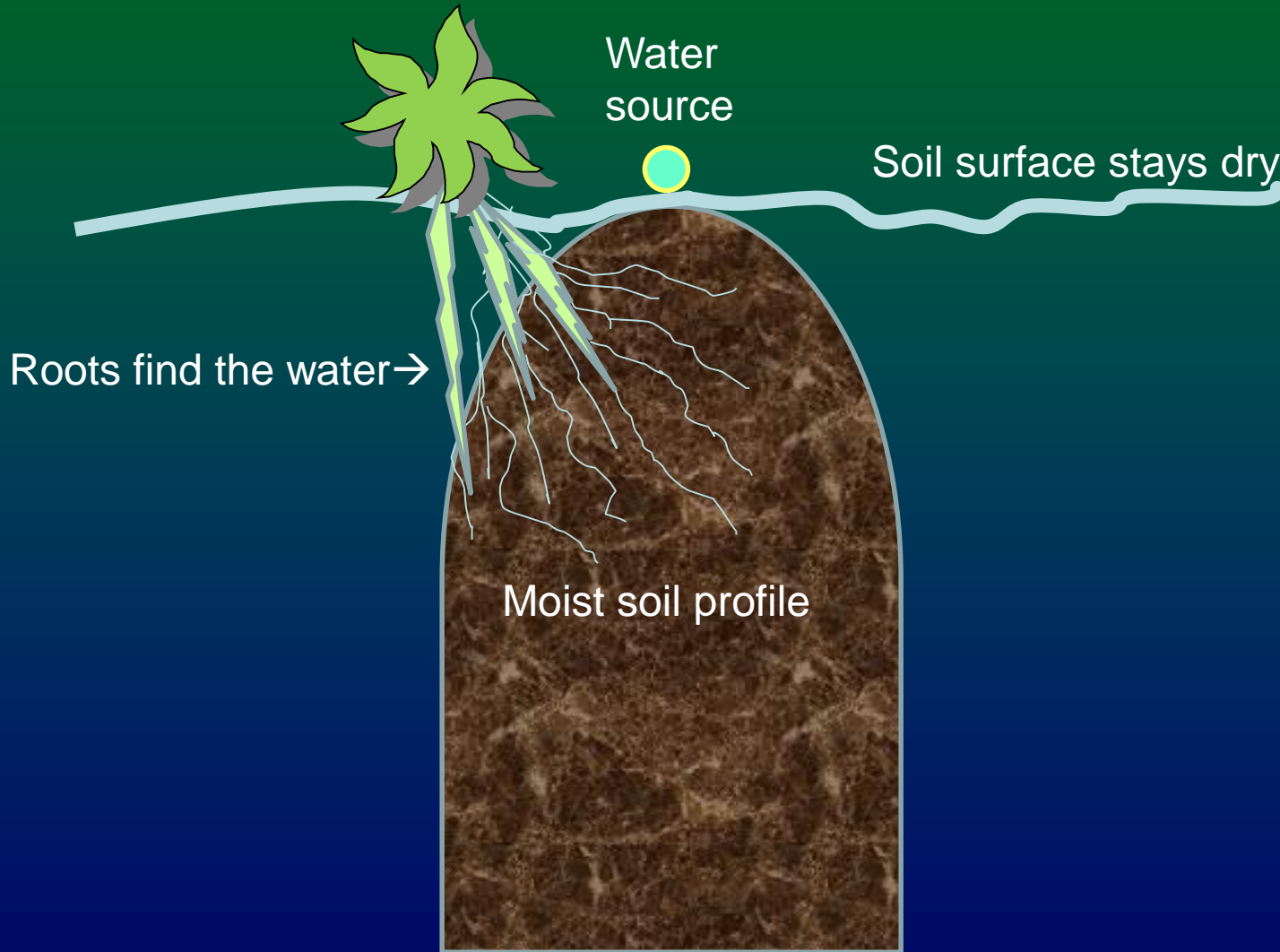
Irrigation tips

Infrequent, deep watering = healthy, deep-rooted plants

- Don't be on 'autopilot' with automatic systems: Check soil moisture to decide when to irrigate
- Tree bags provide slow release irrigation for new planting stock
- Calibrate your irrigation system to avoid wasting water



Where the water goes from a dripper or soaker hose



Checking drip or linear irrigation systems

- Let system run for defined period (e.g., 15 or 30 minutes)
- Check soil moisture a couple of hours later at root zone depth
- Adjust timing accordingly



Watering dwarf fruit trees

- Crop years: Monthly irrigation depending on weather & soil; every 1-2 weeks while fruit load is ripening
- With less irrigation fruit will be smaller
- But with no irrigation, drought stressed trees often lose **next year's** crop



Plan for heavy rainfall events

- Improve soil drainage to avoid water-logging, especially for trees, shrubs and perennials
- Build raised beds for winter vegetables, strawberries
- Keep soil surface covered with living plants & mulches to protect soil from erosion all winter



Brace for storms year-round

Loaded vines are very heavy & tall plants catch the wind:

- Support tall & top-heavy vegetables: Tomatoes, broccoli, cabbage, cauliflower, Brussels sprouts, corn
- Provide strong trellises for peas, pole beans, grapes, kiwi, climbing roses, clematis, wisteria & other vines



Storm-proofing Trees

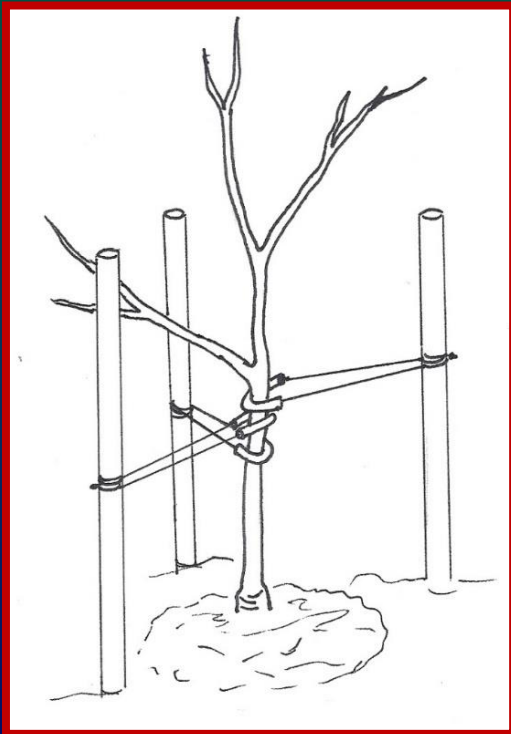
- Prune regularly to reduce storm damage: remove weak branches, thin branches or do spiral pruning
- Don't top trees or cut branches to stubs (new growth is usually poorly attached)
- Remove vines climbing trunks (especially ivy, *Clematis vitalba*) to reduce wind & snow load



Dwarf fruit trees need life-long support

Fully loaded dwarf trees tip easily due to small root system:

- Use 2 - 3 permanent posts or steel stakes
- Add temporary supports for branches while heavy with fruit



In summary:

Become a resilient gardener

- Know how to protect plants from heat & cold, drought, high rainfall, strong winds
- Choose plants & cultivars most adapted to variable weather
- Listen to weather forecasts & act promptly to moderate extreme weather
- Know which pests & diseases to expect & how to avoid damage
- Make long-term plans to improve plantings, soil drainage & organic matter, to conserve water & minimize irrigation

Be prepared for hot/dry weather, cool/wet weather, extreme cold, heat, rain, wind or whatever is coming next...

And for the long-term

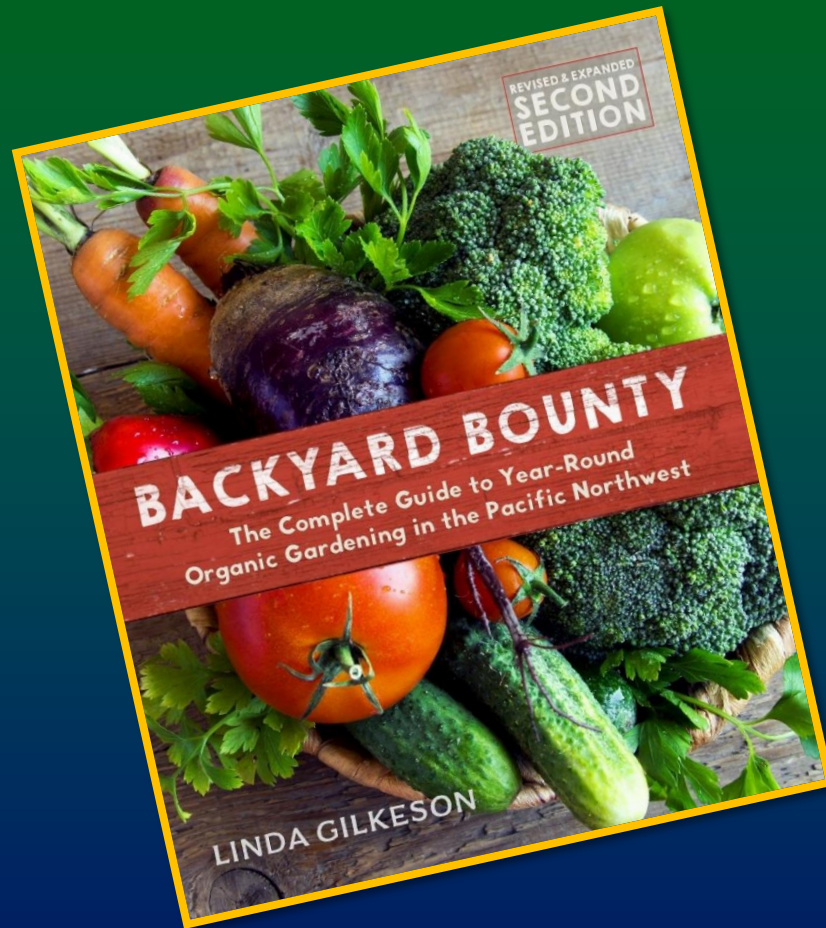
Join community, provincial and global efforts to reduce our output of greenhouse gases and adapt to a changing climate

Learn more:

- Pacific Institute for Climate Solutions www.pics.uvic.ca/
- Pacific Climate Impacts Consortium www.pacificclimate.org



Enjoy your resilient garden



For food gardening reminders join Linda's List: info@lindagilkeson.ca

Manage for optimum growth

This does not mean rapid growth

Trees growing too quickly:

- Have soft shoots, weak branches susceptible to wind damage
- Harden off late, which increases risk of cold injury in the fall
- Are more work to prune

Trees with a moderate, steady growth rate are able to harden off new growth before winter



Tomato example

- Hot, dry weather: Minimize pruning to shade fruit & avoid green shoulders; pay attention to watering; mulch soil; use shade cloth to prevent loss of flowers >90°F
- Cool, wet weather: Prune foliage for good air circulation & promote ripening; grow plants in greenhouse or tunnel; keep leaves dry to prevent late blight & other diseases



It was all too much for
this tomato

Cauliflower example

- Hot, dry weather: Use shade cloth to cool plants; pay attention to irrigation; use deep mulches; harvest before heads become “ricey”
- Cool, wet weather: Enjoy great cauliflower!
- Cold weather: Hope you planted a winter variety....



Button head from heat stress
or frost damage

What stresses plants?

- Mismatch in sun/shade requirements
- Extreme or unseasonal temperatures
- Drought, waterlogging
- Lack or imbalance of soil nutrients, wrong soil pH
- Poor planting and pruning practices
- Competition with weeds

Stressed plants are more susceptible to sucking and boring insects, also to diseases



Aphids thrive on drought-stressed plants

Resilient plantings

You can't change the weather, but with good plant choices and management you can reduce plant stress

Plants are stressed by:

- Extreme temperatures, mismatch in sun/shade requirements, drought, waterlogging, lack or imbalance of soil nutrients, wrong soil pH
- Poor planting and pruning practices
- Competition with weeds for water & nutrients

Stressed plants are more susceptible to sucking and boring insects, also diseases



Watering containers

- Frequency will increase with heat, low humidity, wind
- Roots don't tolerate as much heat as foliage can
- Check each pot individually: Water consumption varies with the size of the plant (most water is sucked from the soil by the plant, rather than simply lost through evaporation)



Climate Emergency

- 2019: A growing list of cities have declared a state of emergency focused on resolving the climate crisis: Vancouver, Victoria, the CRD and Islands Trust
- Government of Canada declared a climate emergency June 2019 (but then approved an oil pipeline...)

Plants adapted to dry summers

Trees: *Arbutus*, pine, evergreen oaks (Garry Oak)

Shrubs: Strawberry tree, *Artemisia*, *Ceanothus*, Western redbud, rockrose, smoke tree, *Cotoneaster*, *Juniper*, *Mahonia*, heavenly bamboo, *Pyracantha*, *Ribes*, *Rosa rugosa*

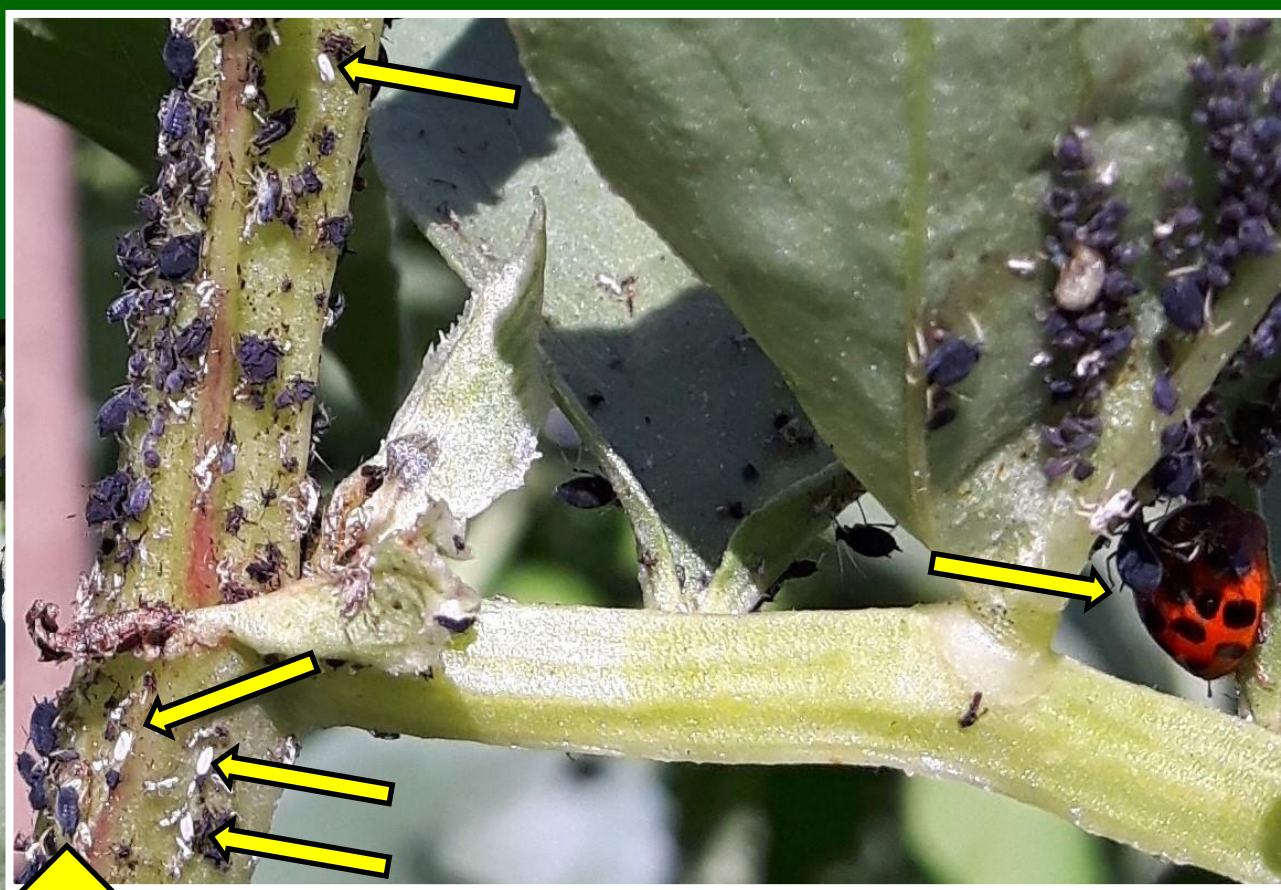
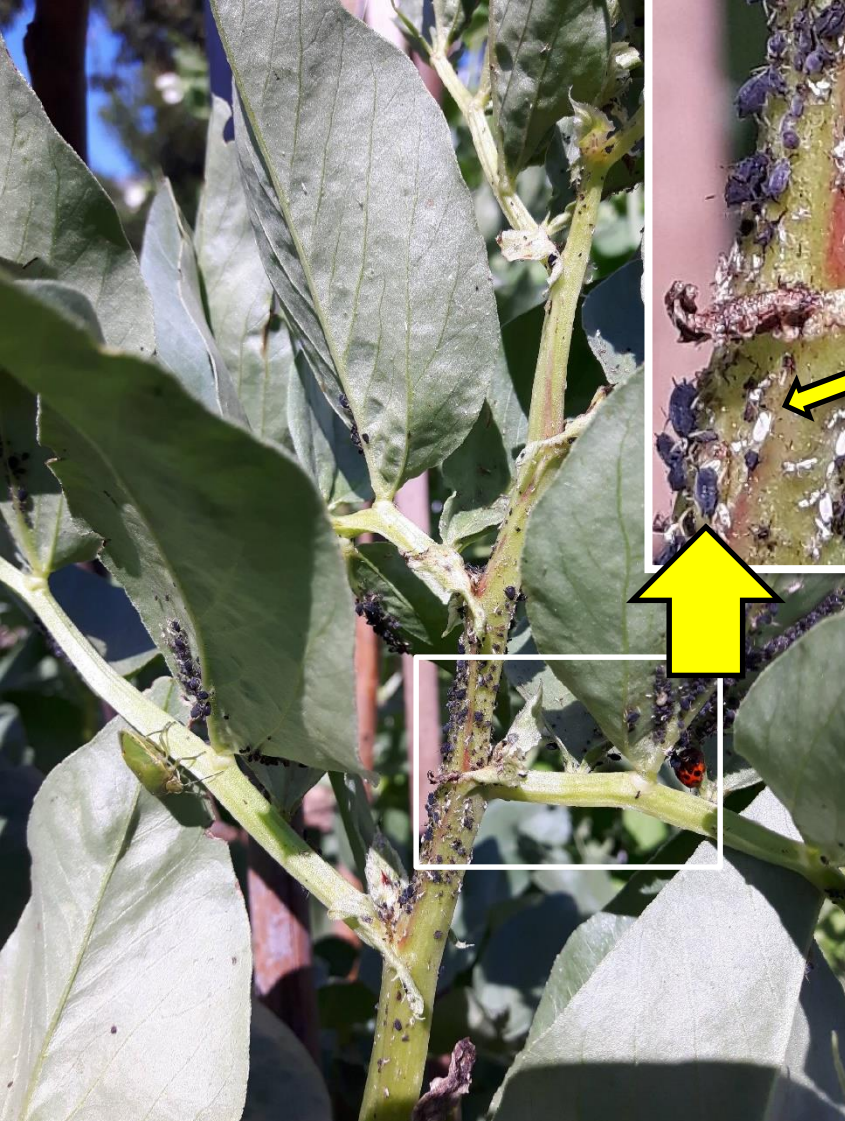
Herbs: Lavender, rosemary, sage, santolina, thyme

Annuals: Yarrow, *Agapanthus*, *Armeria*, Calamint, *Centaurea*, *Erigeron*, *Euphorbia*, bearded iris, narcissus, evening primrose, *Penstemon*, *Romneya*, *Sedum*, *Stachys*, *Verbena*

Ground Covers: Kinnickinnick, salal, snow-in-summer

Many of these are native plants





*Not just aphids!
Syrphid eggs,
ladybeetle*