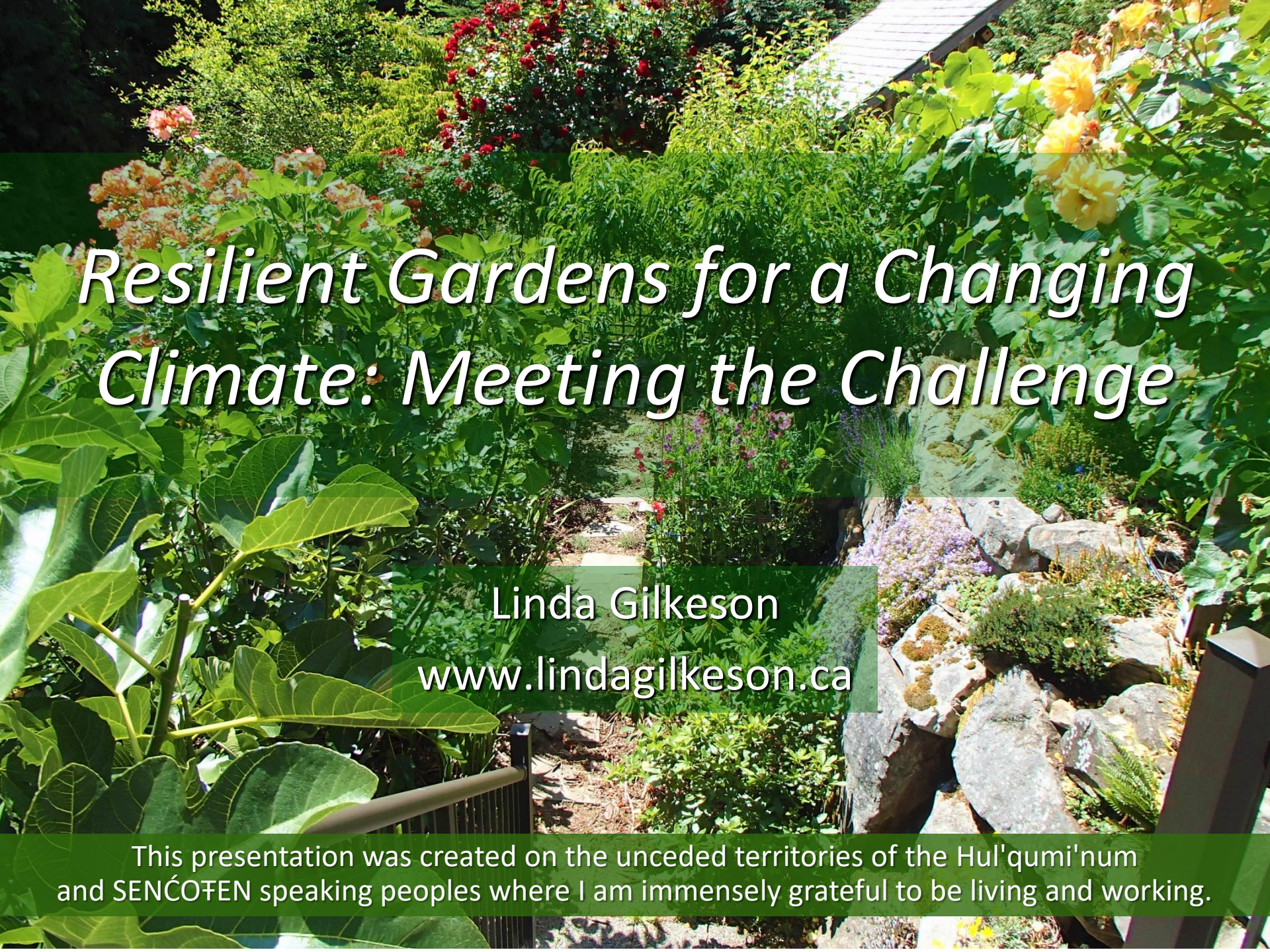

Resilient Gardens for a Changing Climate: Meeting the Challenge

Linda Gilkeson

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

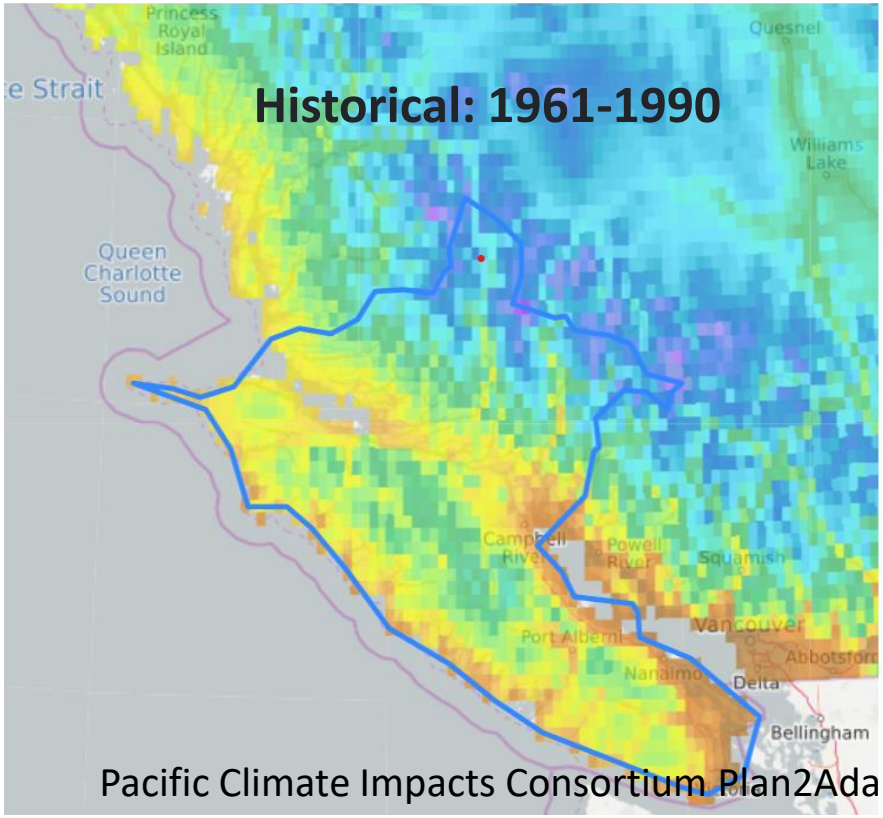
How is the climate changing in BC?

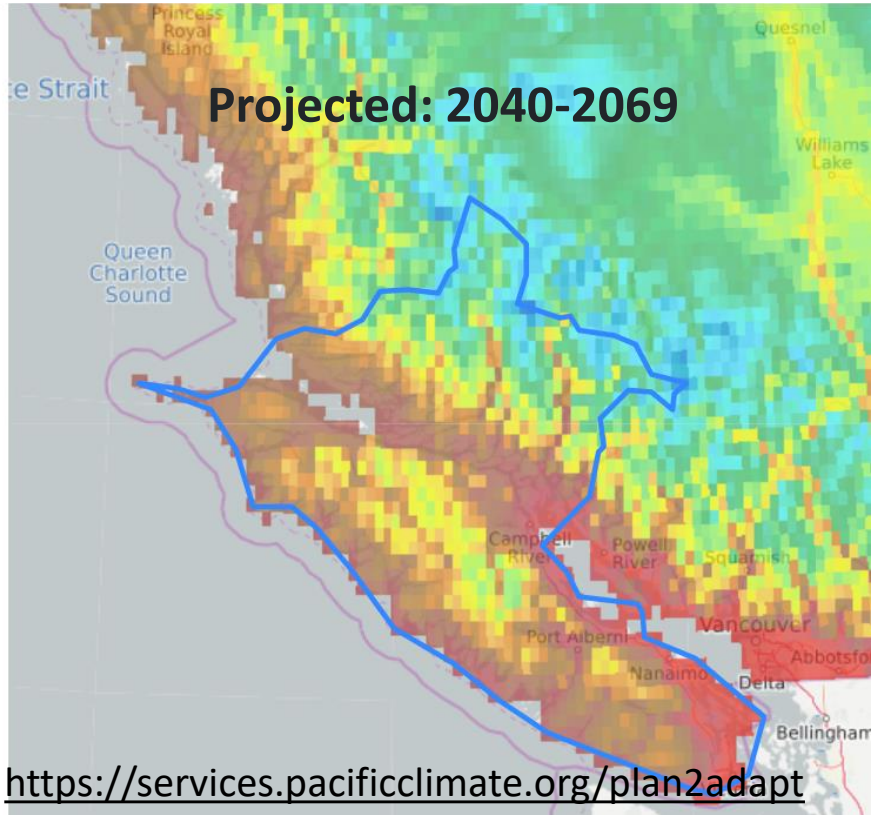
- Higher average temperatures for all seasons & higher night temperatures; projected increase up to 2.3°C within 25 years*
- Increasing frequency and intensity of extreme weather events
- Increasingly variable frost timing in spring and fall
- Winter precipitation higher, summer with longer dry periods; more extreme rainfall events
- Increasing storm intensity, more wind damage

2024 was the first year that global average temperature rise exceeded 1.5°C over pre-industrial levels: it was the warmest in year globally in over 100,000 years

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

Projections of rising average temperatures for BC have certainly been coming true…

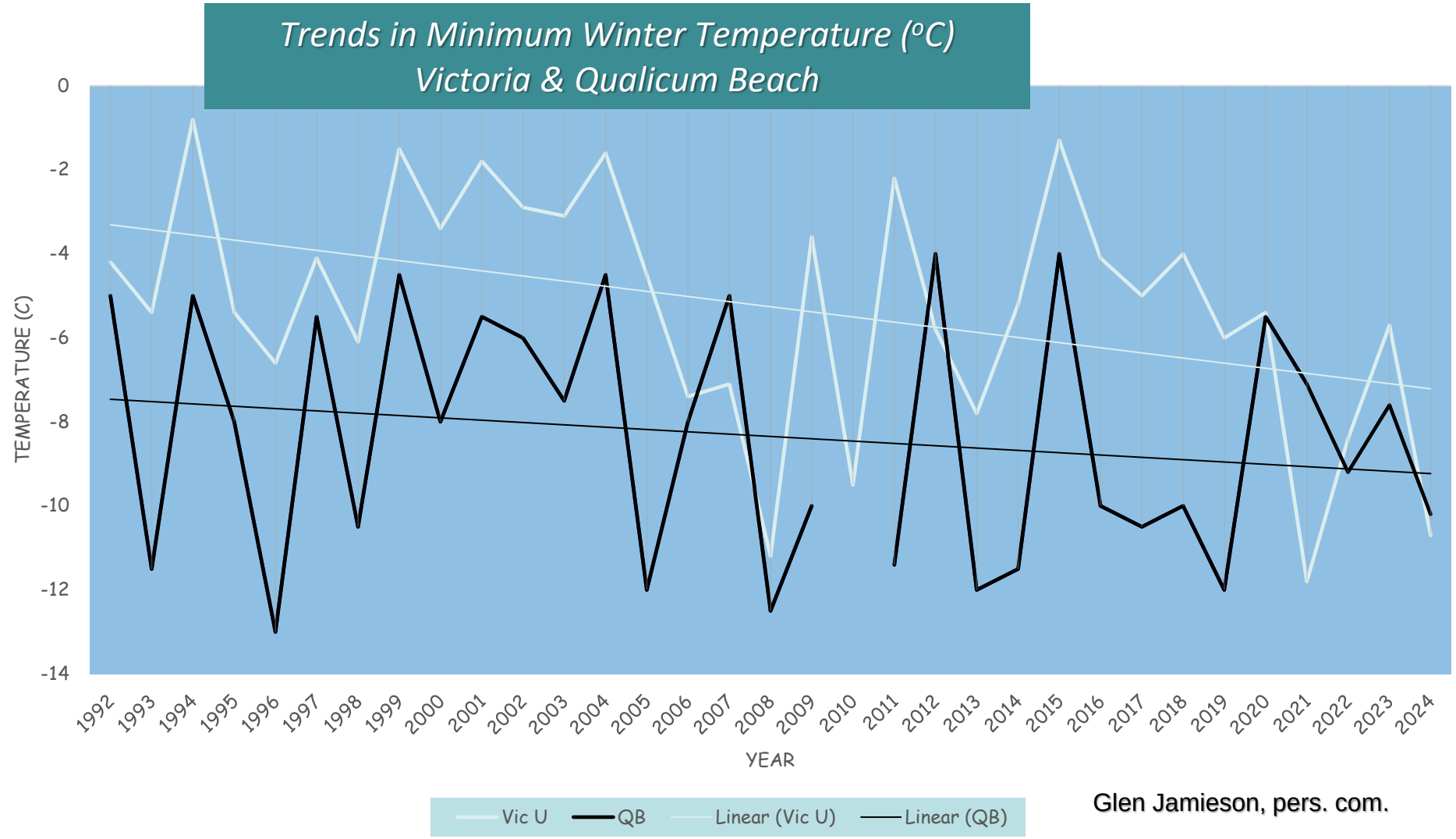




Pacific Climate Impacts Consortium Plan2Adapt https://services.pacificclimate.org/plan2adapt

BUT that isn't the whole story…

Winter minimums have decreased locally, even as average winter temperatures have increased



Glen Jamieson, pers. com.

Hopes of growing novel plants in a warming climate have been dashed by increasingly variable weather

4-days of extreme cold last January damaged or killed many established crop and landscape plants


How the Changing Climate is Affecting Plants and What We Can Do About It

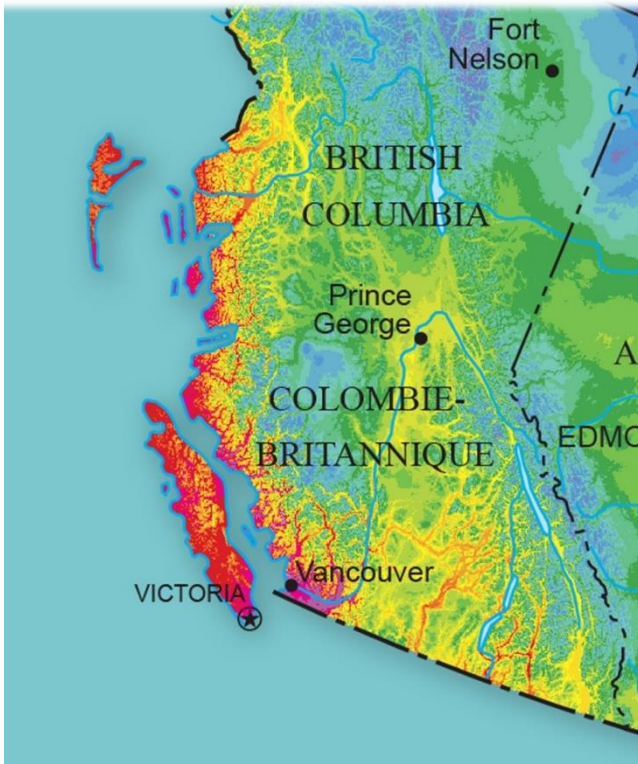
Effects of cold weather on plants

- Cold injures or kills plants, especially if:
  - A temperature drop is sudden or unseasonal
  - Plants have not hardened off yet or if hardening off is delayed by high fall temperatures
  - Plants have resumed growth in mid-winter due to warm weather
- Spring frost kills fruit flowers and leaf buds, injures growing points of vegetables
- Note: Winter injury can take awhile to be visible if roots are damaged; death of plants may not show until early summer

Don't "push" plant hardiness zones

- Choose hardy plants, likely to survive occasional winter cold rather than plants on the edge of their range or climate zone
- Horticultural zone maps are updated to reflect changing climate, but complex coastal geography has always made it difficult to apply zones to coastal BC--and increasingly variable weather is making it even harder
- Lower minimum temperatures are likely to be an important limit

Weather extremes, not averages, will determine what we can grow



Avoid stimulating late season growth

When winter cold occurs unseasonably early or late, woody plants are more vulnerable to winter injury

- Don’t fertilize trees or shrubs after peak growth period (early July)
- Encourage trees to harden off by reducing irrigation as daylengths shorten
- Don’t do summer pruning after mid-August as it can stimulate succulent new growth that is late to hardened off

Leaves killed on tree by an early November cold snap

Avoid losing flower buds to spring frost

Due to warmer average winters, buds break earlier: ornamental and fruit tree flowers are now at greater risk than ever of being killed by a late spring frost

- Choose the hardiest, latest blooming varieties
- Plant in areas with good air circulation, where cold air can drain downslope, away from trees

Tip: To avoid planting in frost pockets, check where the ground frost forms when overnight temperatures drop to freezing

Early blooming varieties are most at risk from spring frost

Stay alert for late spring frosts: They are not going away

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

Prepare for longer, colder Arctic outbreaks

Cover vegetables, half-hardy herbs & other plants in cold snaps:

- Temporary covers: Light tarps, well weighed down; supports underneath help shed rain, prevent crushing by heavy snow
- For protection all winter: Covers should be low profile, sturdy, well-secured, wind-resistant

Effects of hot weather on plants

- Growth slows as temperatures rise; photosynthesis stops above 25^{o}-35^{o}C, depending on the plant
- Extreme heat kills leaf & fruit cells
- Plant stress and growth disorders increase
- The more hot days, the longer it takes for some crops to mature
- Vegetables & fruit are less sweet or have poor flavours
- More irrigation is needed to keep plants in good condition

Very hot days are also lost growing days, just as cold days are

High temperatures sterilize pollen

- Tomato pollen is sterilized above 30-32°C causing flowers to drop
- Greenhouses now regularly get too hot for cucumber, pepper & tomato flowers
- Peas have short pods due to heat-killed pollen

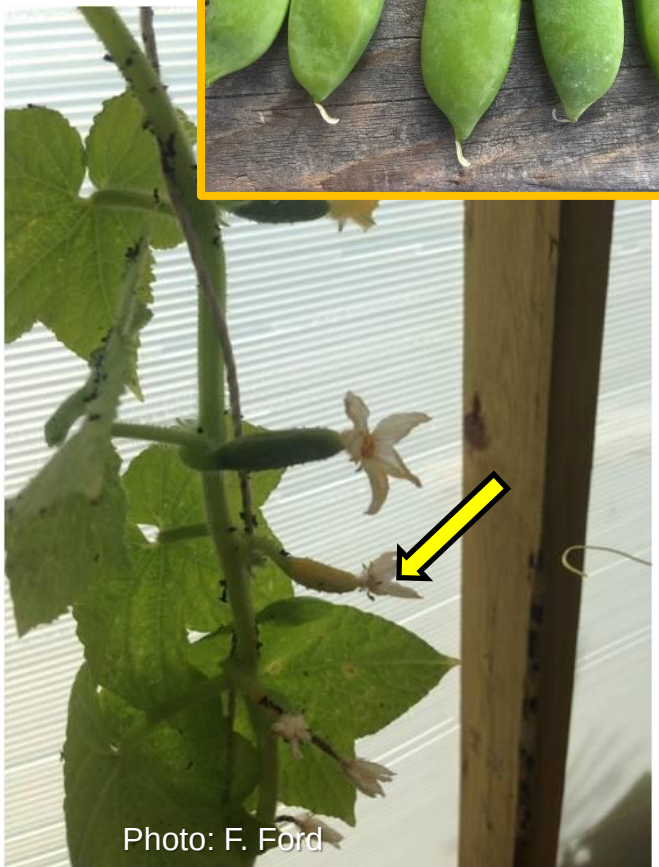
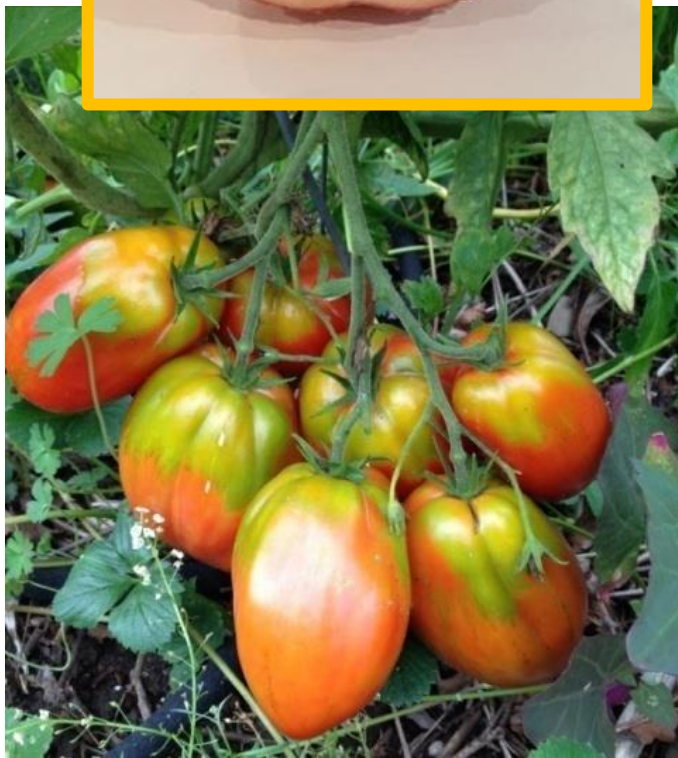


Photo: F. Ford

High temperatures cause growth disorders

- Premature flower formation in leafy greens, disruption to flower development, ‘unisex’ flowers in squash
- ‘Ricey’ or premature heads in cauliflowers
- Green shoulders that never ripen on tomatoes
- Potato tubers with internal browning



Sunscald can be mistaken for disease

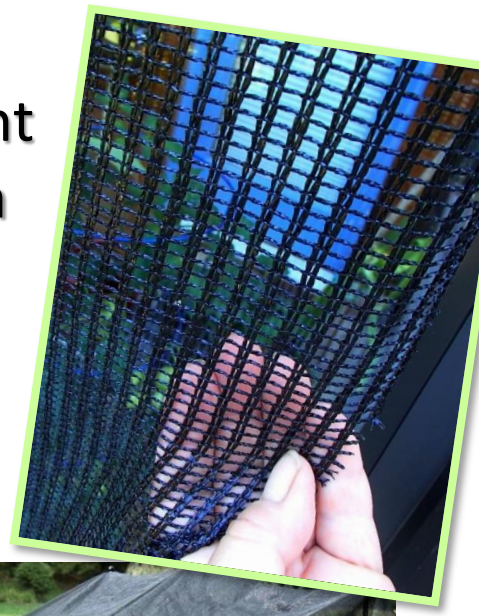
Be prepared to shade plants in heat waves

- The younger or more delicate the tissue, the more easily it is damaged; injury is worse in spring or after a period of cool weather
- Be alert to forecasts & deploy shade materials over vulnerable plants; if possible, increase irrigation and mulching
- Priorities: Seedlings, cool weather crops (cabbage family, lettuce & greens, peas)

Heat kills!
Shading just slows growth…

Every vegetable gardener should now have shading materials

- 30-50% shade cloth cools while allowing enough light for growth; choose knitted polyethylene rather than woven polypropylene
- Lace curtains & tablecloths, old bed sheets work for short periods; if possible, remove material daily to allow plants to receive early & late direct sun



Invent other ways to shade vegetables

- Dual purpose hoops can carry shade fabric or insulating covers according to the season
- Lath makes sturdy shades on beds
- Use tall crops to grow shade in place

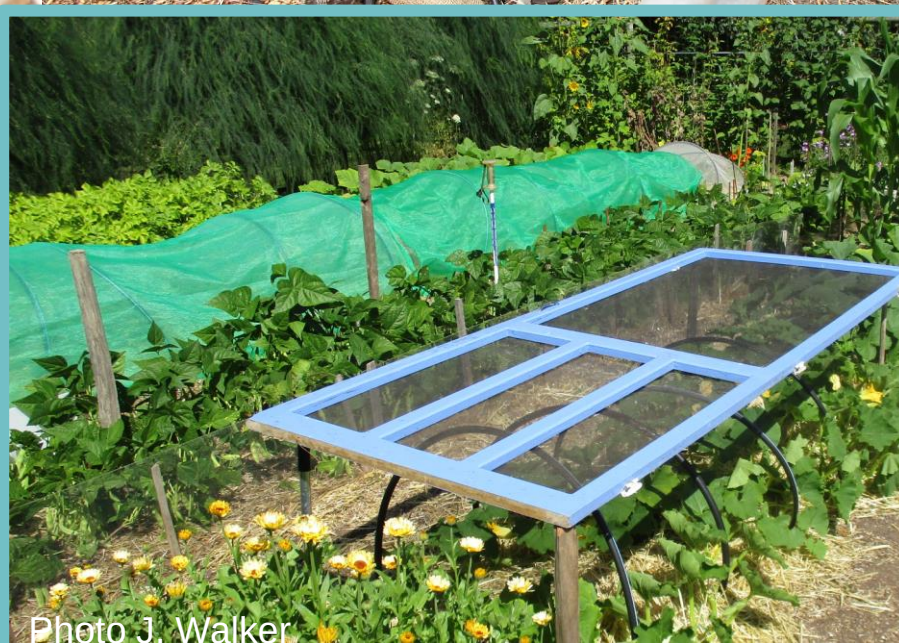


Photo J. Walker

Protect maturing fruit in heat waves

- As fruit nears full size it is readily damaged by heat and direct sun
- Shade cloth over plants or opaque bags on grape bunches and other fruit prevent sunscald (don't use clear or translucent bags)
- Minimize pruning for tomato plants: Leaving foliage to shade fruit prevents green shoulders (and improves flavour)

The hot greenhouse problem

Greenhouses, tunnels, hoop houses now get too hot, causing aborted fruit, metabolic disorders, sunscald

- Glass traps the most infra-red radiation
- Home/hobby greenhouse are usually not well-designed for heat waves or energy conservation

Conventional hobby greenhouses overheat without modifications

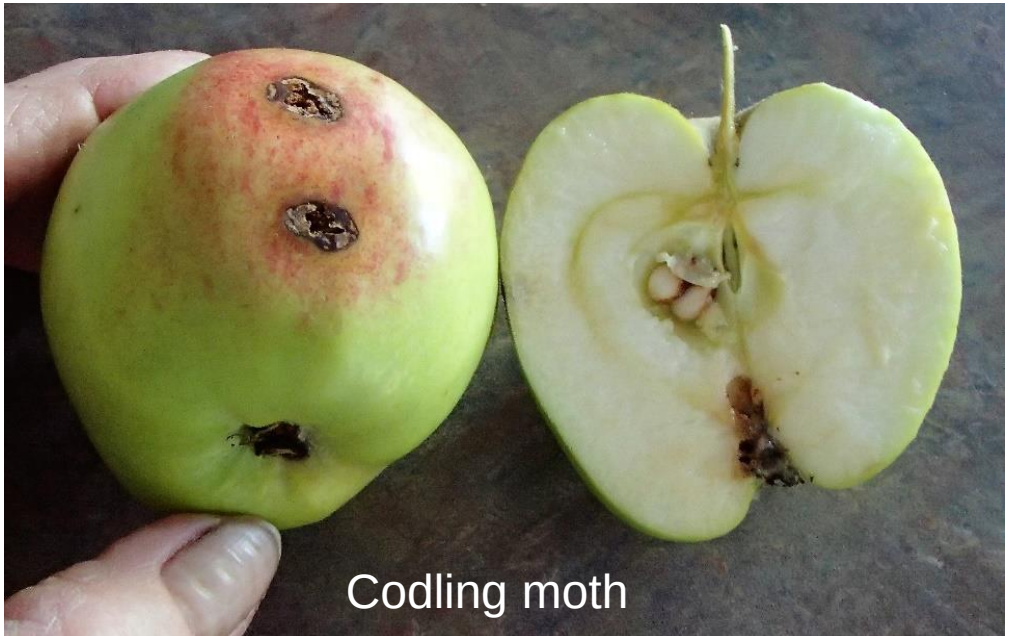
Heat injury to leaves of greenhouse tomato

Cooling greenhouses, tunnels

- Install more vents, open up sides of structure
- Part of a greenhouse can be covered with 50% shade cloth to reduce temperatures without impairing yields
- Replace glass or poly glazing with light diffusing/insulating materials
- Use high speed fans to move air
- Install mist cooling system

Warmer average temperatures = more generations of some pests

- Species with several generations per season have more generations in warmer years:
  - E.g., Codling moth, carrot rust fly, cabbage root maggot, fruit flies, beet leafminer
- Numbers in the late generations can be extremely high by fall


Codling moth


Spotted wing Drosophila

Improve the survival of beneficial insects

Pollinators & insects that control pests have been hit hard by heat waves and other pressures:

- Include pollen & nectar plants in gardens and landscapes to support pollinators and natural enemies of pests
- For BC coastal region, late summer & early fall flowers are critical for bumble bees, parasitic wasps, hover flies, pirate bugs
- Grow a mix of native & introduced ornamentals; aim for at least 50% native species

Bumble bee numbers in North America are down by half: linked to increasing frequency of extreme heat days

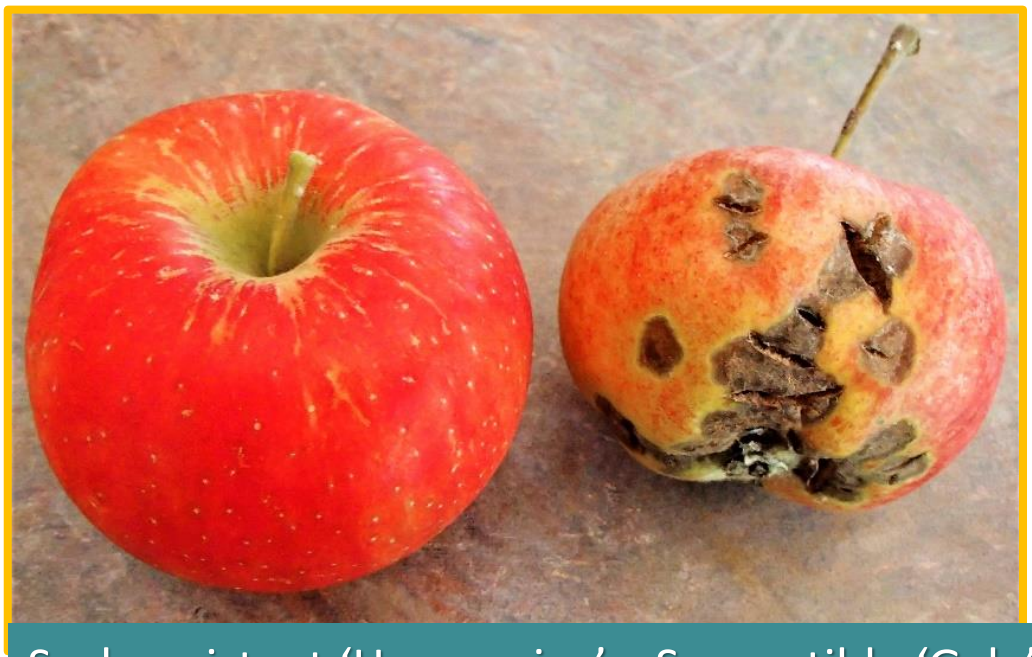
Warmer average temperatures = increase in some plant diseases

- Fungi and bacterial pathogens have more generations in warmer conditions
- Powdery mildew infections increase in drier, warmer summers, especially with warmer nights
- Drought stressed plants succumb earlier to root rot & stem diseases

Choose disease resistant plants

- Avoid diseases of dry weather: Powdery mildew resistant varieties of grapes, peas, squash, cucumbers, roses; choose ornamentals that are not susceptible to powdery mildews
- Avoid diseases of wet weather: Scab resistant apples & pears; downy mildew resistant vegetables; botrytis resistant tulips; early blight resistant tomatoes

Tulips resistant to *Botrytis*



Scab resistant 'Honeycrisp' Susceptible 'Gala'

Effects of drought on plants

Plants can temporarily tolerate moderate, but not severe, drought:

- Dehydration disrupts cellular processes
- Root hairs die back, more roots die if drought is prolonged
- Nutrients cannot pass into roots without a film of water around roots
- Plants close leaf stomata to avoid water loss: transpiration stops

Drought during fruit development is particularly damaging

When transpiration stops:

- No cooling from evaporation → leaf temperatures rise >5°C → leaf cells are killed by high temperatures
- No photosynthesis → no food produced in plant cells
- No movement of water from roots → no nutrients come from soil and sugars, protein, oils, plant hormones can't move within plants

Photo D. Dukart

Long-term effect of drought/heat stress

Trees & shrubs stressed by repeated periods of starvation due to heat/drought stress have smaller leaf areas, store less food in their tissues

- With less stored food, plants are less able to withstand poor conditions or resist pest or pathogen attack
- Borers attack trees weakened by stress; aphids thrive on drought-stressed trees and other plants

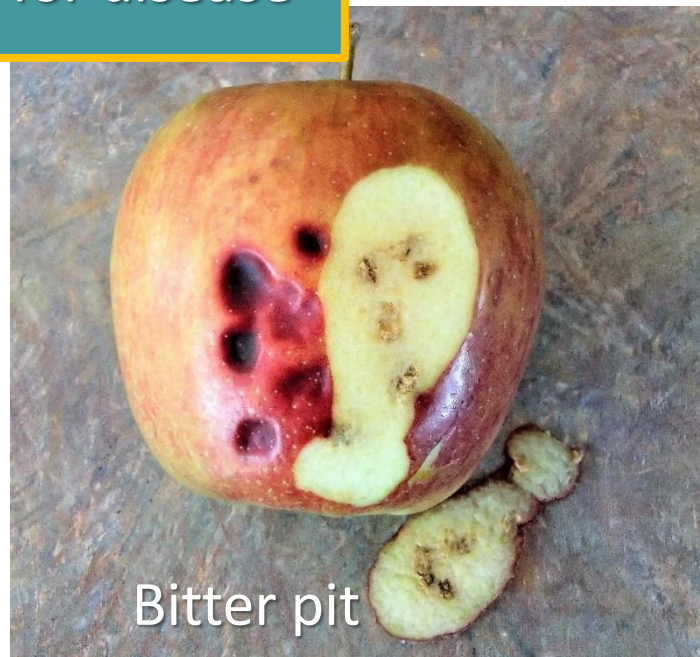
Metabolic disorders in plants

- Arise from interaction between plant metabolism, weather, irrigation, soil nutrients, cultural methods → influence nutrient levels in leaves, flowers & fruit
- Calcium disorders in crop plants are most common: Heat/drought stressed plants can't take up calcium from the soil

Disorders are often mistaken for disease

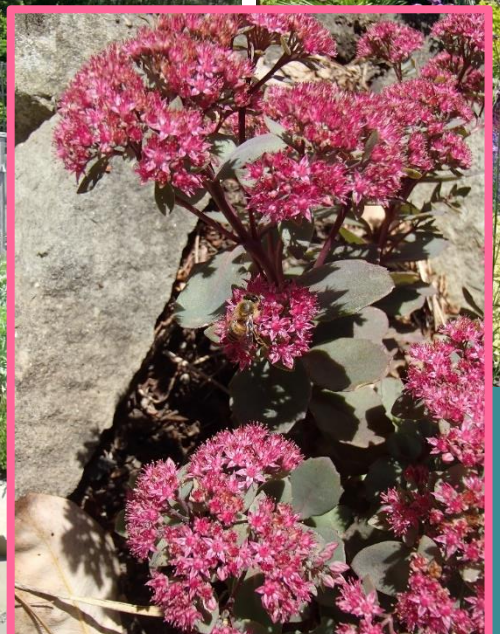

Blossom end rot


Hollow heart


Bitter pit

Choose drought tolerant landscape plants

- Choose hardy species with low summer water requirements
- Include native flowers, bulbs that go dormant in summer
- Focus on perennials: Once established, they need less water than annuals & are usually less vulnerable to variable weather



There are many interesting *Sedums* & other succulents that need no water

Incorporate resilient native plants

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

- Ocean spray, Oregon grape, salmonberry, red-flowering currant
- Goldenrod (*Solidago*), Douglas aster, Stonecrop/Sedum

Bonus: Ecologically valuable habitat for insects, wildlife

Plan for even drier summers

- Install water conserving irrigation systems
- Collect household water for use on plants
- Plant new trees & shrubs in the fall: they will need less water in their first summer
- Reduce (or, even better, stop) irrigating lawns

Irrigate efficiently

- Water infrequently & deeply according to root depth of plants
- Take the time to calibrate an irrigation system:
  - Lawn sprinklers: Use tuna tins to measure depth of water delivered
  - Drip & soaker hose systems: Dig down into root zone to check moisture after a period of irrigation; surface soil can be dry yet sufficient water is present
- Don’t leave automatic systems on the same schedule all season: water requirements start low in May/June, peak in July, tail off in September

Effects of precipitation extremes

Both drought and waterlogging injure and kill roots, setting up a cycle of increasing root damage year after year

Trees, shrubs, other perennials:

- Are less able to take up nutrients and water in the growing season
- Become even more vulnerable to drought the next season
- Are more susceptibility to root diseases (e.g., *Phytophthora)*

"Zombie" trees are increasingly likely to blow down in wind storms

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

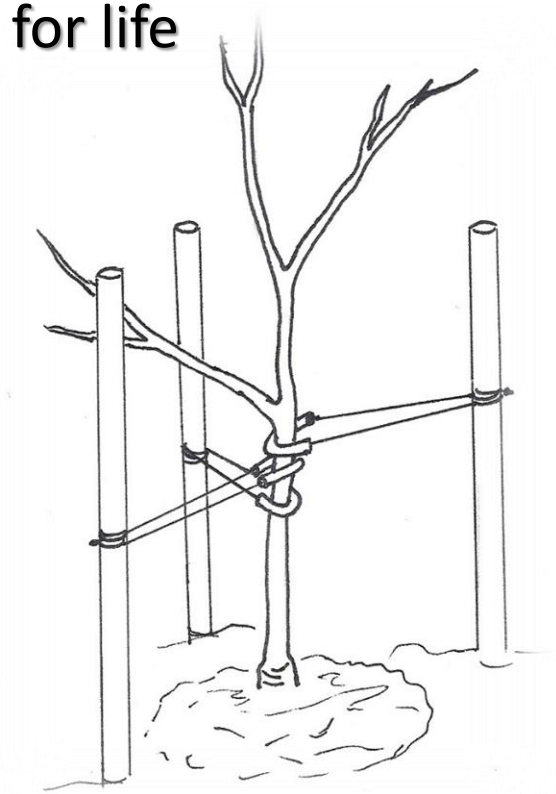
Be prepared for heavy rainfalls year round

- Improve site and soil drainage to avoid periodic water-logging, especially for trees, shrubs and perennials
- Build raised beds for winter vegetables, strawberries where soil is poorly drained in winter
- Keep soil surface covered with living plants & mulch to protect soil from erosion


Other Resilient Gardening Tips

Brace for wind storms (& heavy snows)

- Support top-heavy vegetables: Tomatoes, broccoli, cabbage, cauliflower, Brussels sprouts, corn
- Provide strong trellises for climbing roses, clematis, wisteria & other vines, pole beans, peas, kiwi fruit, grapes
- Support branches loaded with fruit; securely stake dwarf fruit trees for life



Storm-proof woody plants

- Remove vines climbing on tree trunks to reduce wind & snow load
- Prune regularly to reduce storm damage: remove weak branches, thin branches or do spiral pruning
- Cut back bulk of climbing roses, grapes, other climbers before winter to protect arbors & trellises from weight of ice, snow and high winds (finish pruning in February)

Diversify landscape plantings

- Plant a variety of species, cultivars, native & introduced plants: If some plants are damaged, others are likely to look fine
- Wild-type & non-hybrid plants are more genetically diverse = some may survive extreme weather better than others
- Nursery trade cultivars are mostly cloned (genetically identical) = less potential for survival of hardier individuals

As the weather becomes more extreme it is more important than ever to choose plants suited to microclimates

Plant several varieties of each crop

- There are notable differences between varieties in their tolerance for heat, drought, frost, variable weather (keep good records)
- Especially sensitive to adverse weather: Cauliflower, Brussels sprouts, cabbage, sweet corn, large-fruited tomatoes

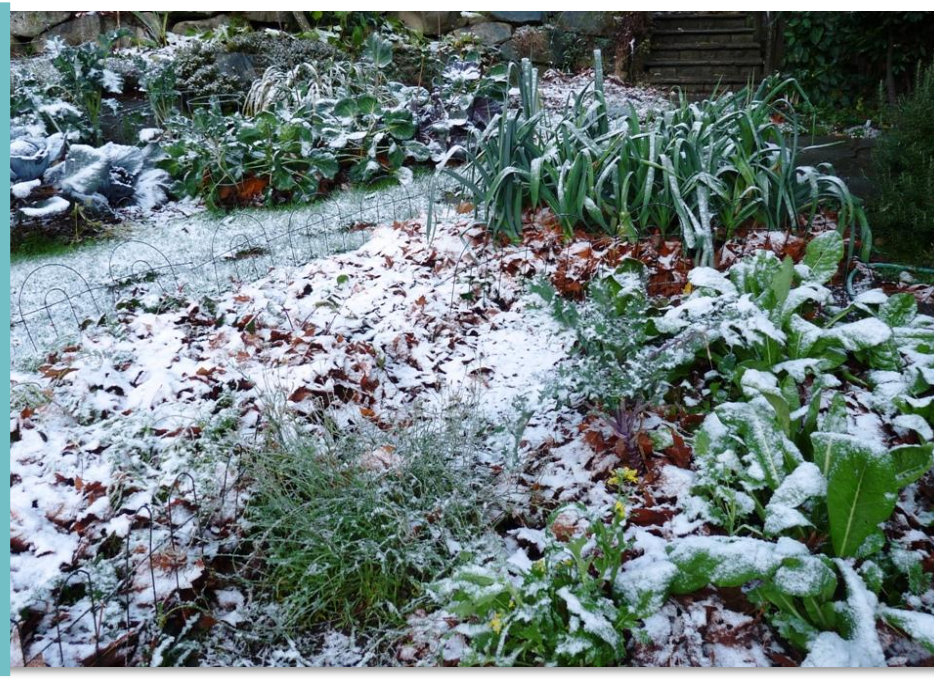
Brandywines are nice, but small-fruited tomatoes are more reliable

Photo: J. Standen

'Purple Moon' cauliflower handles heat—who knew!

Mulch everything, everywhere, all year-round

- Keeps soil cooler in summer, warmer in winter, prevents frost heave damage to crowns & shallow roots
- Conserves water: reduces evaporation in summer
- Protects soil from erosion & loss of nutrients in winter
- Builds soil organic matter and soil carbon, increases soil fertility
- BIG BONUS: controls weeds



What to use as mulch

- Beds where soil disturbance occurs (vegetables, annual flowers, strawberries): Leaves, straw, crop residues, yard waste, coarse compost, grass clippings, shredded paper
- Perennials where soil isn't disturbed (fruit & landscape trees, shrubs): Wood chips, all of the above

Avoid landscape bark mulch, which is flammable

Rethink raised beds

- They provide good drainage, soil warms earlier in spring—but they need more summer irrigation & soil is warmer in heat waves
- Permanent beds are excellent, but not necessarily raised beds

Permanent, but not raised, beds →


Gardens Can Help
Mitigate Climate Change

Deep soil carbon is deposited by plant roots

Deep rooted plants, especially trees, hold carbon in the roots; create channels that move dissolved organic carbon meters deep in soil where it bonds with mineral particles; held for 10 to 1000 years

Increasing the carbon held in the soil removes it from the atmosphere

Carbon is sequestered in plants, roots, humus, soil microbes & deep in the soil profile

- Maximize the amount of living roots throughout the soil year-round
- Add more plants, in greater variety to landscapes and gardens
  - Increase density of plantings
  - Add vines & climbers along fences
  - Grow ground covers, bulbs under established shrubs, trees
  - Replace turf with deep-rooted perennials

Build soil organic matter

Carbon is held in *humus* (completely decomposed organic matter) for 1 to 50 years; humus improves soil structure, water-holding capacity, nutrient availability

- "Chop & drop" crop residues, use sheet composting, leave prunings & pulled weeds on the soil surface
- Plant roots add masses of organic matter: Leave roots in the soil whenever possible
- Amend soil with compost

Surface mulches build soil organic matter faster than digging in compost

Leave the leaves

- Where leaves have been left on the soil every year to decompose, soil holds 30% more carbon than areas where leaves are removed
- Nutrient levels in the soil are also higher & decomposition rates are higher (due to healthier soil microbial community)
- Find permanent places in landscapes to deposit mulches of leaves removed from lawns, sidewalks, driveways
- Light leaf fall on lawns can be left to decompose or mowed to shred the leaves in place

Minimize soil disturbance

Cultivation speeds release of soil carbon, disturbs soil organisms

- Use no-till methods or infrequent, shallow cultivation (under 7 cm)
- Plant without cultivating before the next planting when possible
- Control weeds by smothering under organic mulches

Cauliflower transplanted into a bed after peas were cut down

No need to remove corn roots before sowing fall greens


Reduce the area planted to annuals & lawns
Use the extra space to plant trees & shrubs, restore perennial native vegetation & wildlife habitat, perennial flowers for pollinator forage

Maximize the harvest from a smaller food garden

- Grow crops intensively, using interplanting, succession planting
- Plant for harvest year-round to produce the most in a smaller space

Rethink lawns

- Convert to low maintenance practices: Leave clippings to feed soil; don't irrigate: allow grasses to go dormant in summer = much less mowing
- Replace with alternative lawn mixes or ground covers (e.g., creeping thymes, coastal strawberry, bellflowers, low Oregon grape)

BONUS: Flowers feed pollinators & attract beneficial insects

Better yet…

- Replace lawn with deep-rooted perennials, especially drought tolerant native flowers, trees and shrubs to conserve water, increase the carbon held in soil and roots
  - Convert a strip of lawn every year, propagating new plants from old ones to keep costs down

- Convert lawn to a food garden: It won't save water, but food grown locally generates ¼ of the greenhouse gases of imported food for the same diet, improves ood security, saves money, is tasty, healthy, fun…..


Questions?
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