EXPERIENCE JOURNEYS

The Forest at Bar K-C

Dave Klepacki, PhD

July 9, 2021

Forestry and Forest Ecology

- Wikipedia Forest Management: *The management of forests is known as forestry, silviculture, and forest management…Techniques include timber extraction, planting and replanting of different species, building and maintenance of roads and pathways through forests, and preventing fire*.
- Wikipedia Forest Ecology… *The Scientific Study of…A forest ecosystem is a natural woodland unit consisting of all plants, animals and micro-organisms (Biotic components) in that area functioning together with all of the non-living physical (abiotic) factors of the environment.*

Difference in views of forests: exploitation verses ecological services.

- Glossary of Forestry Terms 1993, Published by Forestry Canada, Pacific and Yukon Region: mature: Trees or stands that are sufficiently developed to be harvestable.
- Canadian Forest Service Forestry Glossory: "Natural forest, the development of which has been virtually uninfluenced by modern human activity." …*there is probably little, if any, strictly natural forest remaining on planet Earth….As society and forest managers seek systems that safeguard ecosystem services such as biodiversity and minimize long-term environmental impact, it seems helpful to re-examine the concept of natural and its realization in reference sites. Bradshaw, "What is a Natural Forest?" 2015.*

What is a “natural forest” in the Bragg Creek area?

- Has a history of natural disruptions…in our area the 1863, 1910, 1919 fires. Followed by natural regeneration.
- Wide native biodiversity and structure: Mixedwood populations (Aspen/Balsam Poplar, Lodgepole Pine, White Spruce, rare Douglas Fir) with range of ages and canopy levels including understory of young trees and “refugia” of old growth trees 200-300+ yrs old.
- Nutrient recycling with snags, decomposition of deadfall from past insect or disease that support woodpeckers, insects, fungi and bacteria.
- Ecological Services: Water storage, filtration, flood control, airborne pheromones, pollination, functioning habitats populated by the natural variety of mammals, birds, and microbiota.

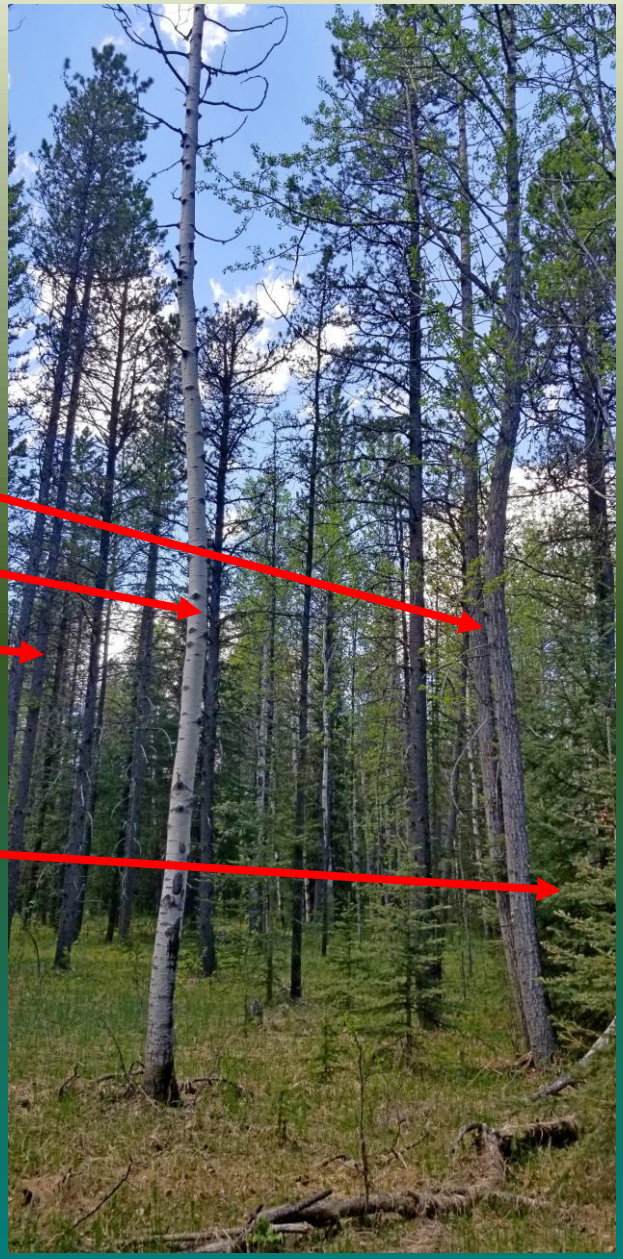
Foothills Montane South ecozone mixedwood forest composition

1. Balsam Poplar
2. Trembling Aspen
3. Lodgepole Pine

   (Douglas Fir)

4. White Spruce

Succession sequence: Balsam Poplar-Aspen-Douglas Fir/Lodgepole Pine-White Spruce.



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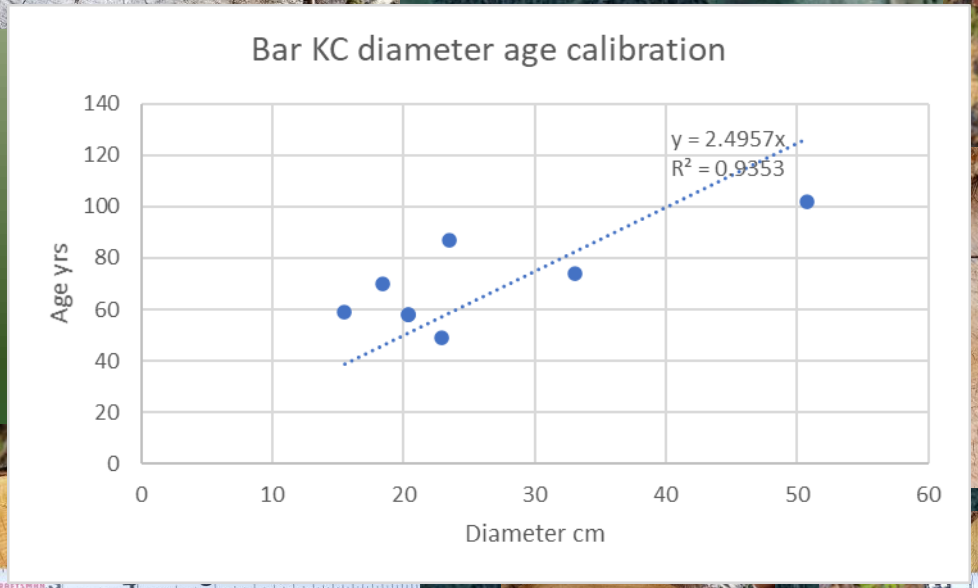
Forest types on Bar-KC

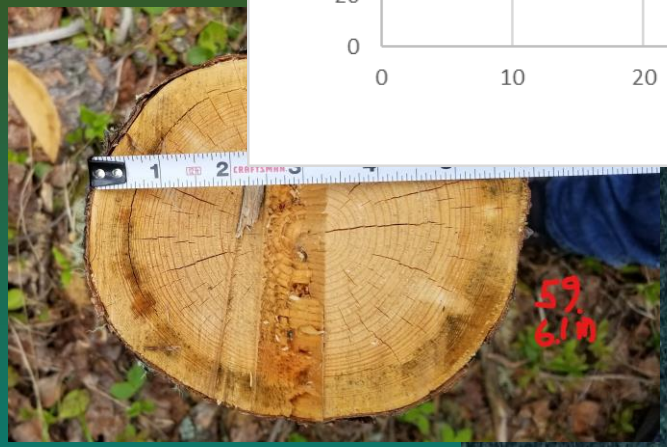

49yrs


58 yrs


Cowboy Trail
74 yrs
10m?


Bar KC diameter age calibration
Age yrs
Diameter cm
y = 2.4957x
R² = 0.9353
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60


102 yrs

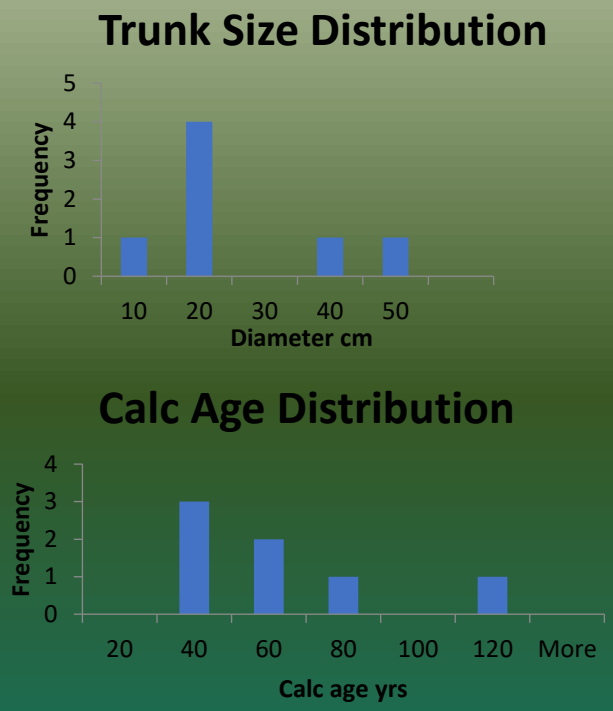

59
61m


87 yrs
975


70yrs
725m


E
© 2021 Google
Image © 2021 CNES / Airbus

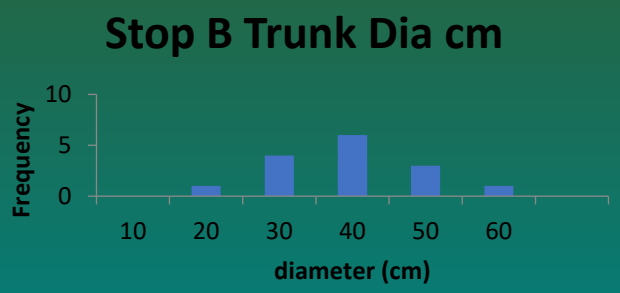
Stop A, SW Deer Lake

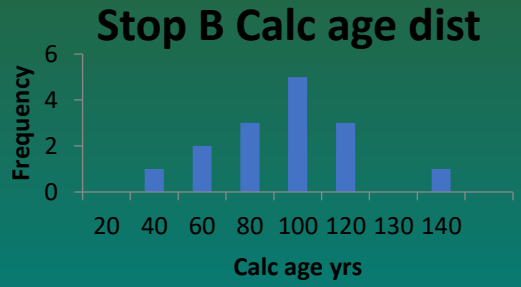


	# Stems	Percent
Aspen	21	48
Lodgepole	9	20
Spruce	7	16
Dead	7	16

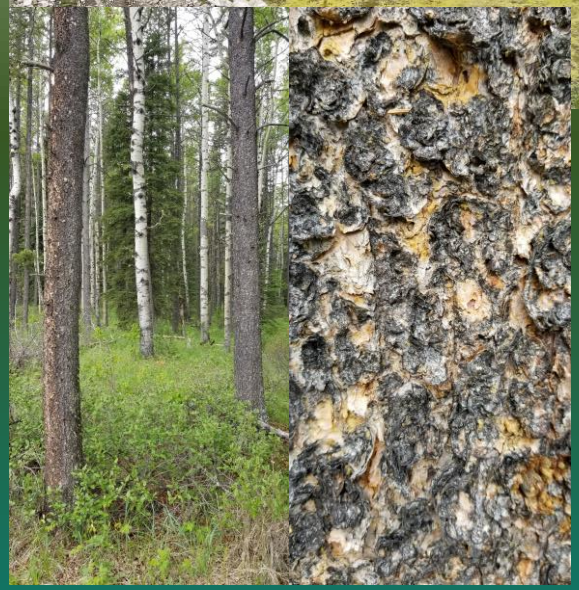
Douglas Fir sapling

Stop B Open-grown Lodgepoles with 5-30% old needle MPB damage but healthy new growth.

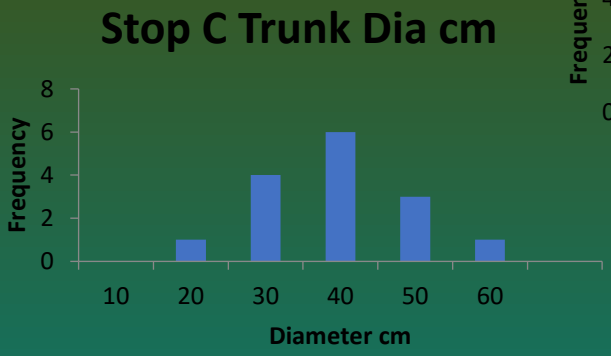


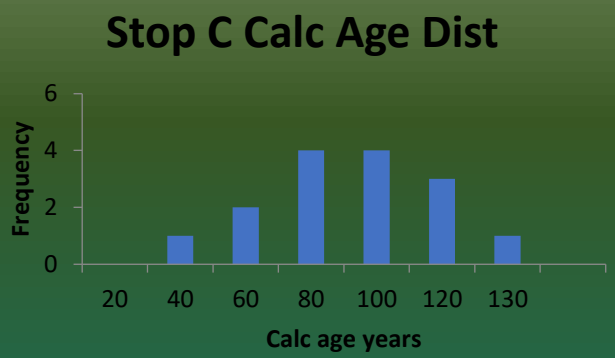


Stop C Lodgepole stand in mixed wood near dump. <5% red needles, new growth.



Note spruce and pine pollen in slough

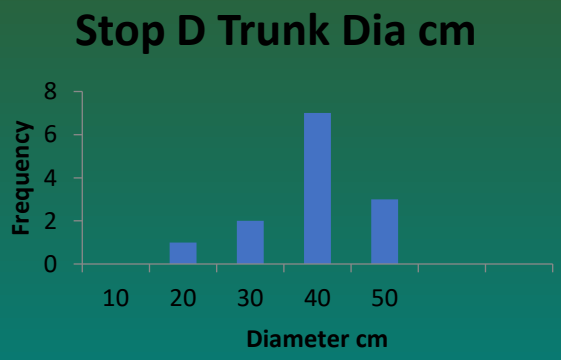


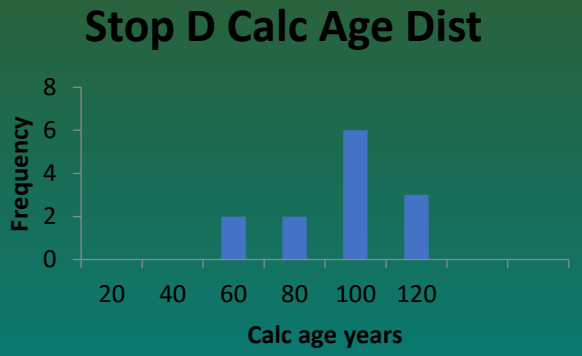


	# stems	%
Lodgepole	8	100
Dead		0

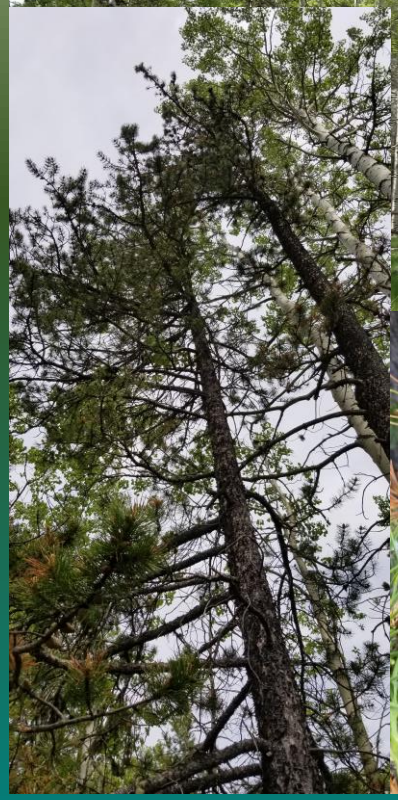
Stop D Mixedwood south of hay meadow

	# Stems	%
Lodgepole	10	77
Aspen	3	23
Dead	0	0

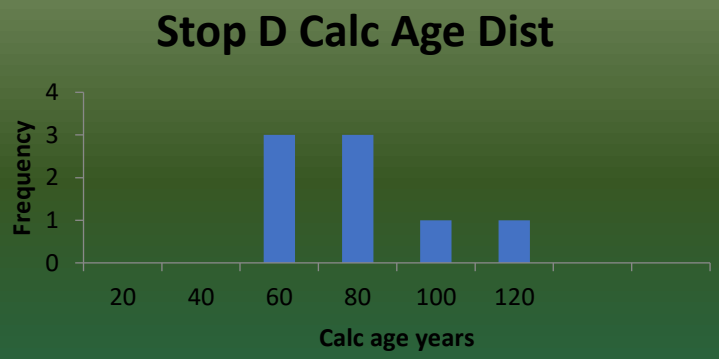


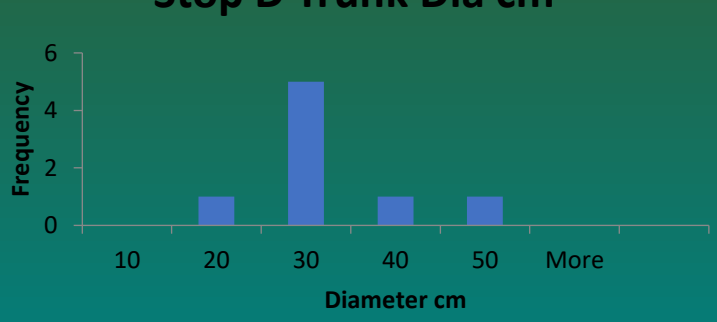


Mixedwood in southwest corner of Bar KC 5-10% old red needles surrounding new growth.



	# stems	%	
Lodgepole	3	17	
Aspen	8	44	
Balsam	3	17	
Dead	4	22	Aspen





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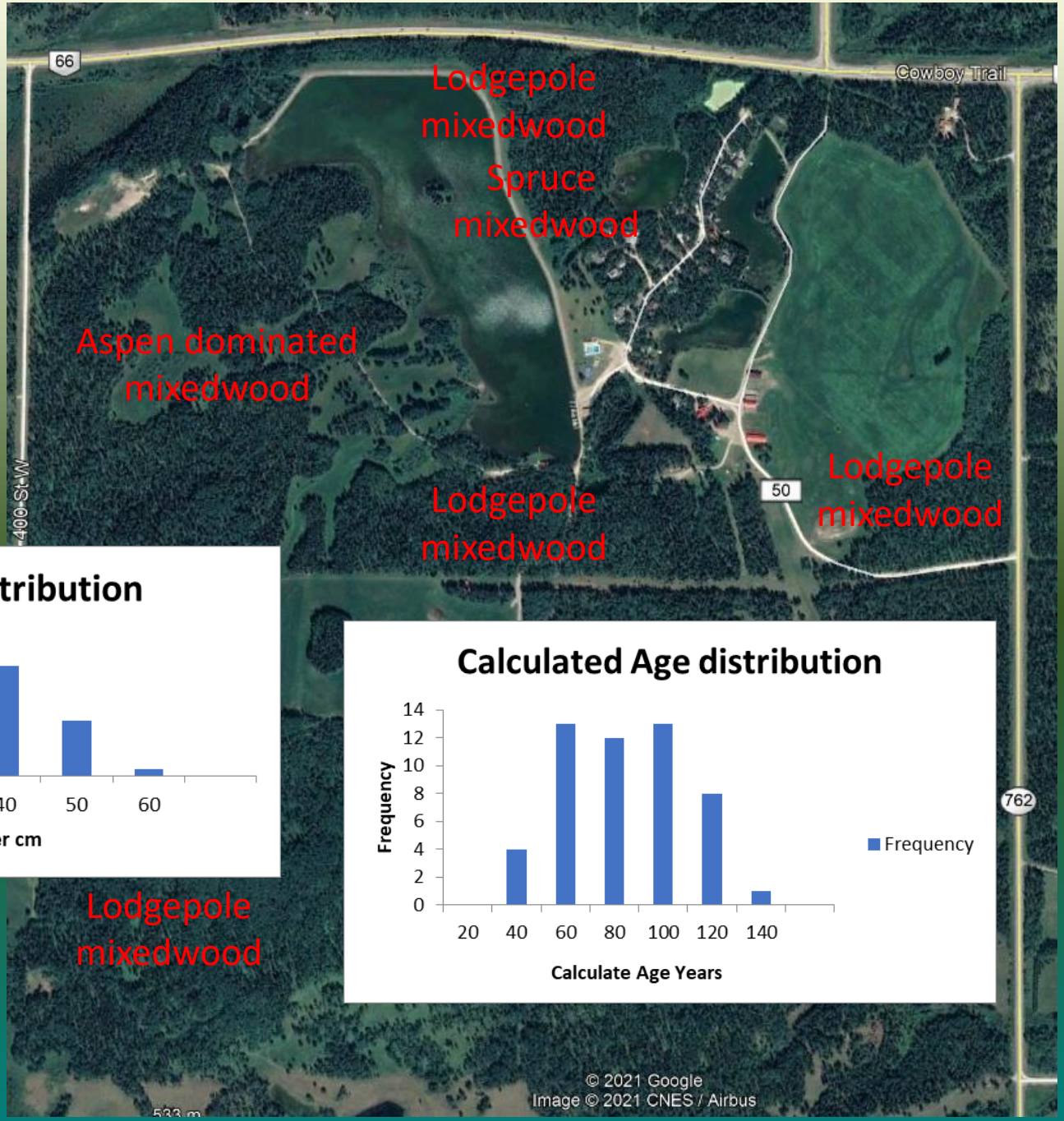
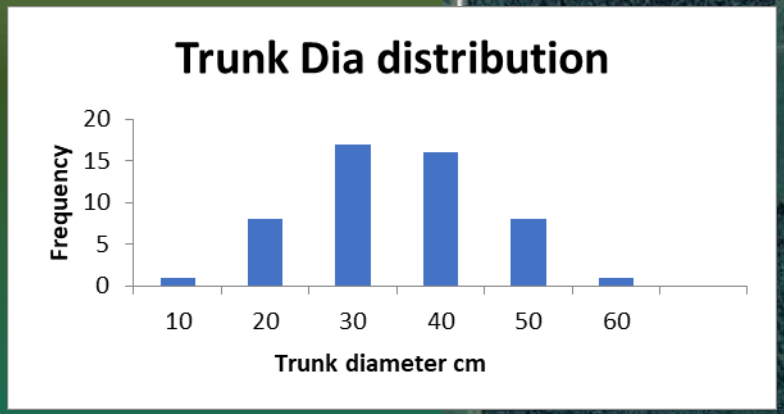
Total samples
N=51

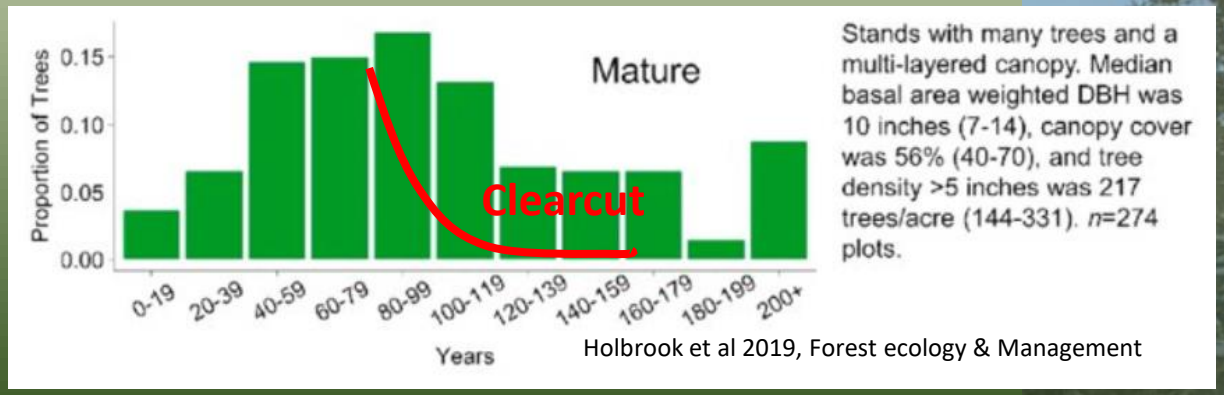




Forest Ecology Conclusions 1

- The forest at Bar KC is dominated by mixedwood: Lodgepole pine-Aspen-White Spruce. In wet areas Balsam Poplar and White Spruce dominate. This is an “adolescent forest” with 60-100 yr trees. Other forests in the area that have 200-300 yr components to age structure.
- Trees within pasture areas have more damage from Mountain Pine Beetle. Perhaps because of stress from livestock rubbing.
- New growth on Lodgepole Pine indicates trees are regaining resilience in this wet spell.
- Spruce Budworm infestation will need monitoring in April-May of next year to consider small scale Btk application in cabin area.

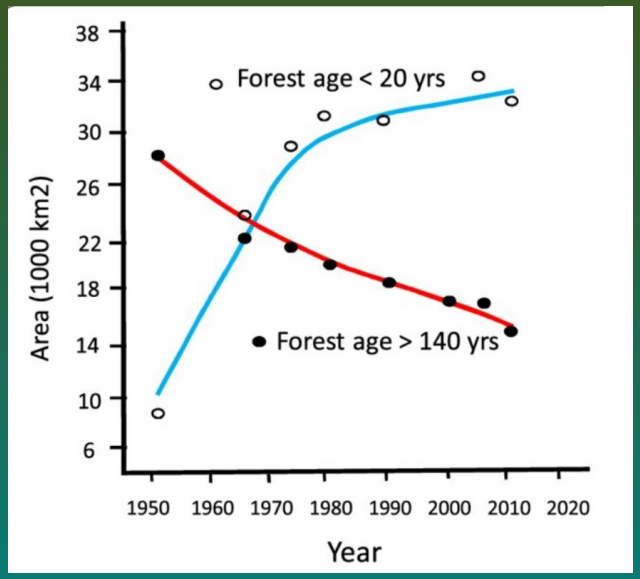
How clearcuts change the natural structure of a forest.



Stands with many trees and a multi-layered canopy. Median basal area weighted DBH was 10 inches (7-14), canopy cover was 56% (40-70), and tree density >5 inches was 217 trees/acre (144-331). *n*=274 plots.

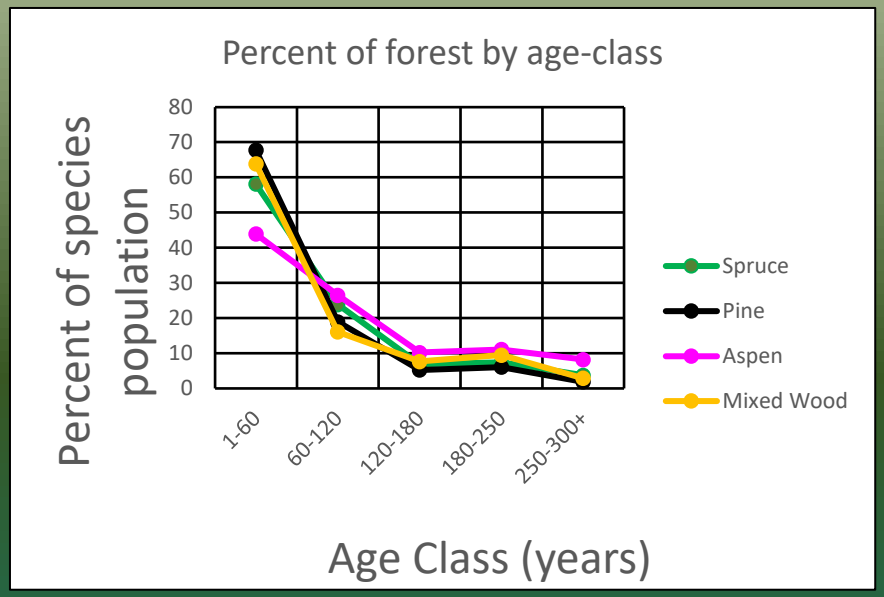
Holbrook et al 2019, Forest ecology & Management

Tree age distribution in a natural mature forest from USDA Forest Service Inventory and Analysis program.



The decline in old forest areas from harvesting in Finland . Kuuluvainen and Gauthier, Forest Ecosystems, 2018

Age structure of Lower Foothills forests. 20-30% of trees are >100-300 yrs.
"Mature forests" (150+ yrs) have about 200 trees/ha pine and 500 trees/ha spruce.



Age structure of Foothills FMU 10 from Rogeau Msc thesis 2013 written for SLS.

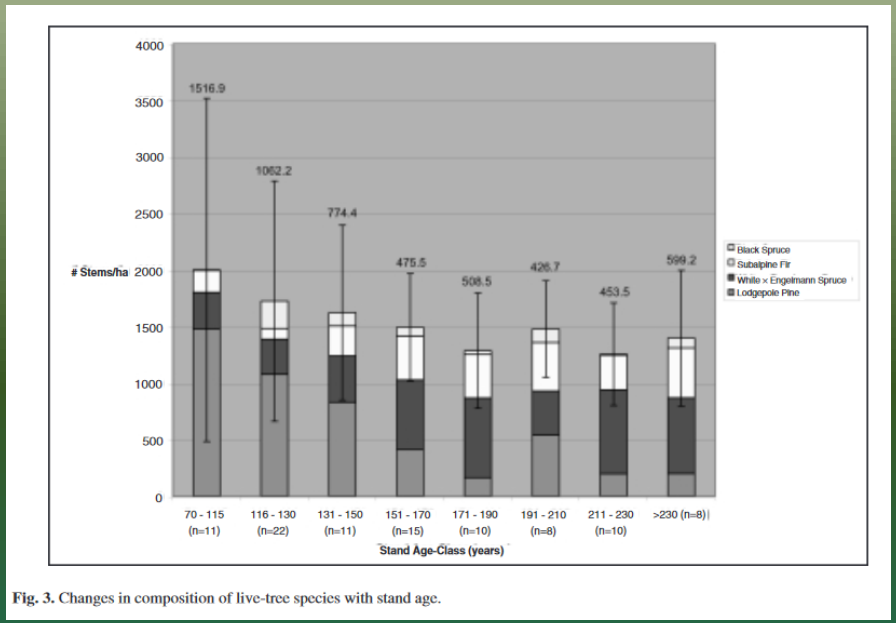
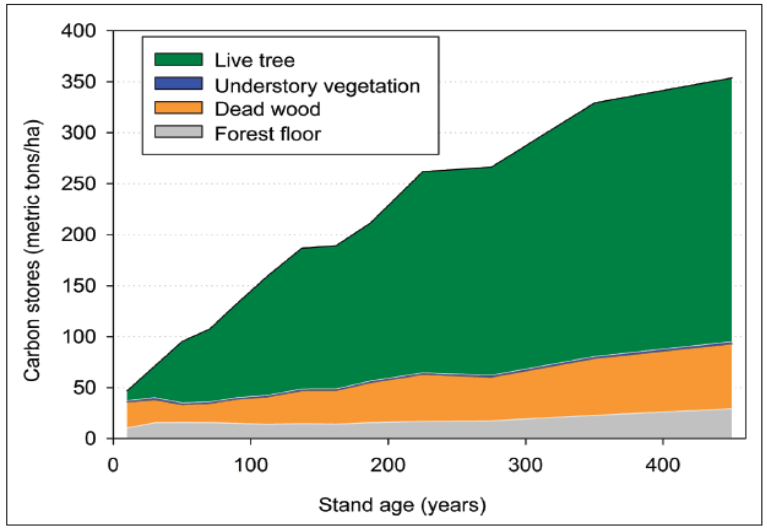


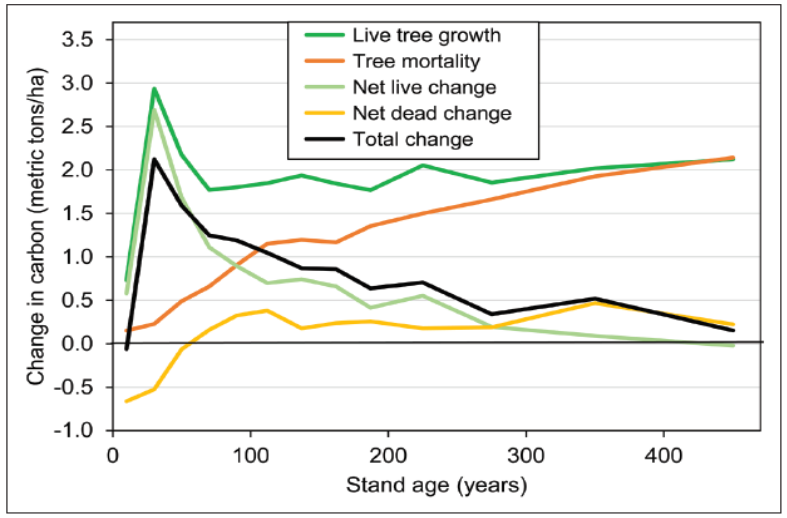
Fig. 3. Changes in composition of live-tree species with stand age.

Number of trees/hectare vs age from study area near Nordegg. From Morgantini & Kansas, 2003. (The Forestry Chronicle). Note

The importance of old growth forests for carbon storage in western forests. Watts, 2017



In Pacific Northwest forests, carbon accumulation increases more rapidly in stands that are younger than 200 years; carbon accumulation slows after 200 years. Most of the carbon in a forest stand is stored in live trees and dead woody debris.



The carbon storage capacity of a Pacific Northwest forest fluctuates throughout its lifetime because of tree growth and mortality. Live tree carbon storage rates peak early in stand development, but this growth is offset by tree mortality as the stand ages. In young stands, the amount of carbon stored in dead wood decreases, but it increases at low rates in older stands.

- Young forests quickly accumulate high biomass (carbon) at a high rate.
- Carbon sequestration rate declines with old age but the volume of carbon stored in large trees is very high.
- Immediately after disturbance previously forested areas are carbon emitters because organic materials decay quickly, more than very young trees can accumulate.

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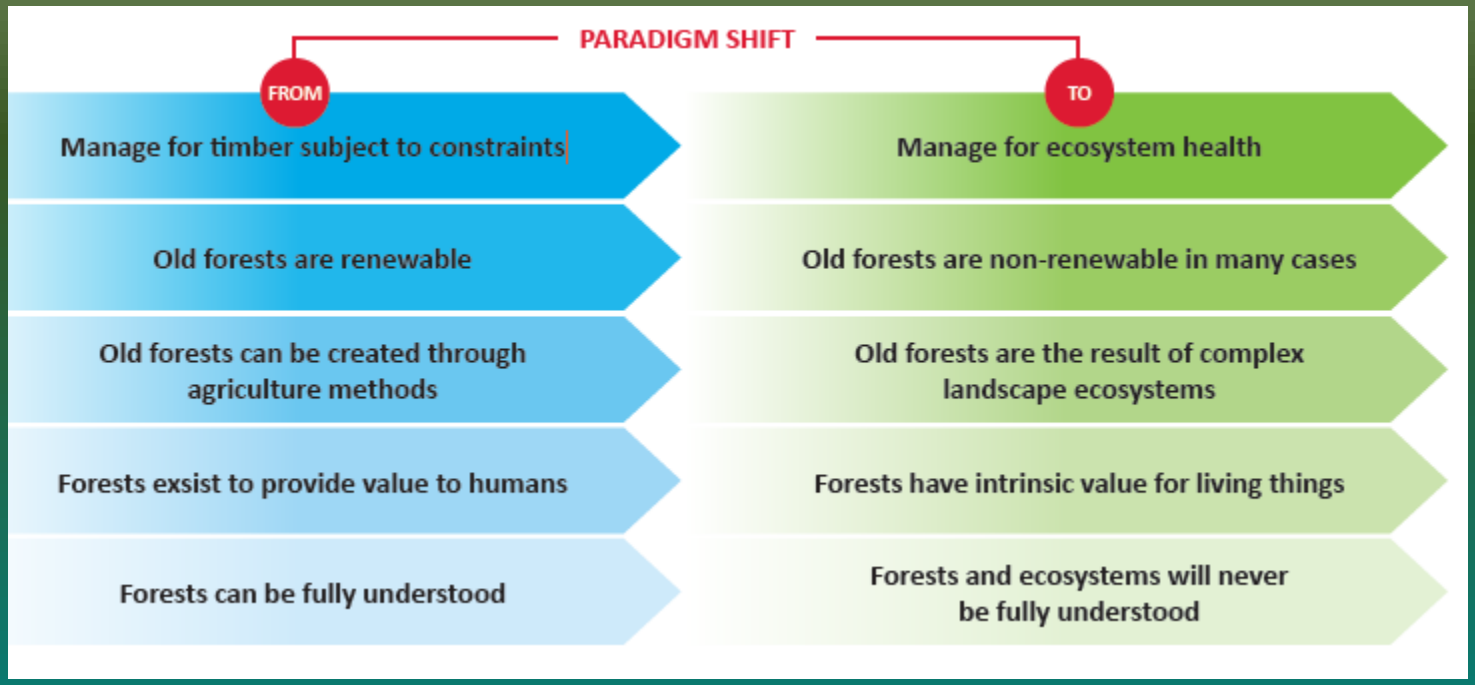
A NEW FUTURE FOR OLD FORESTS: *A Strategic Review of How British Columbia Manages for Old Forests Within its Ancient Ecosystems Gorley and Merkel, 2020*

Old Growth Forests are habitat for species like Pileated and Three-toed woodpeckers as well as many insect species unique to that ecosystem.



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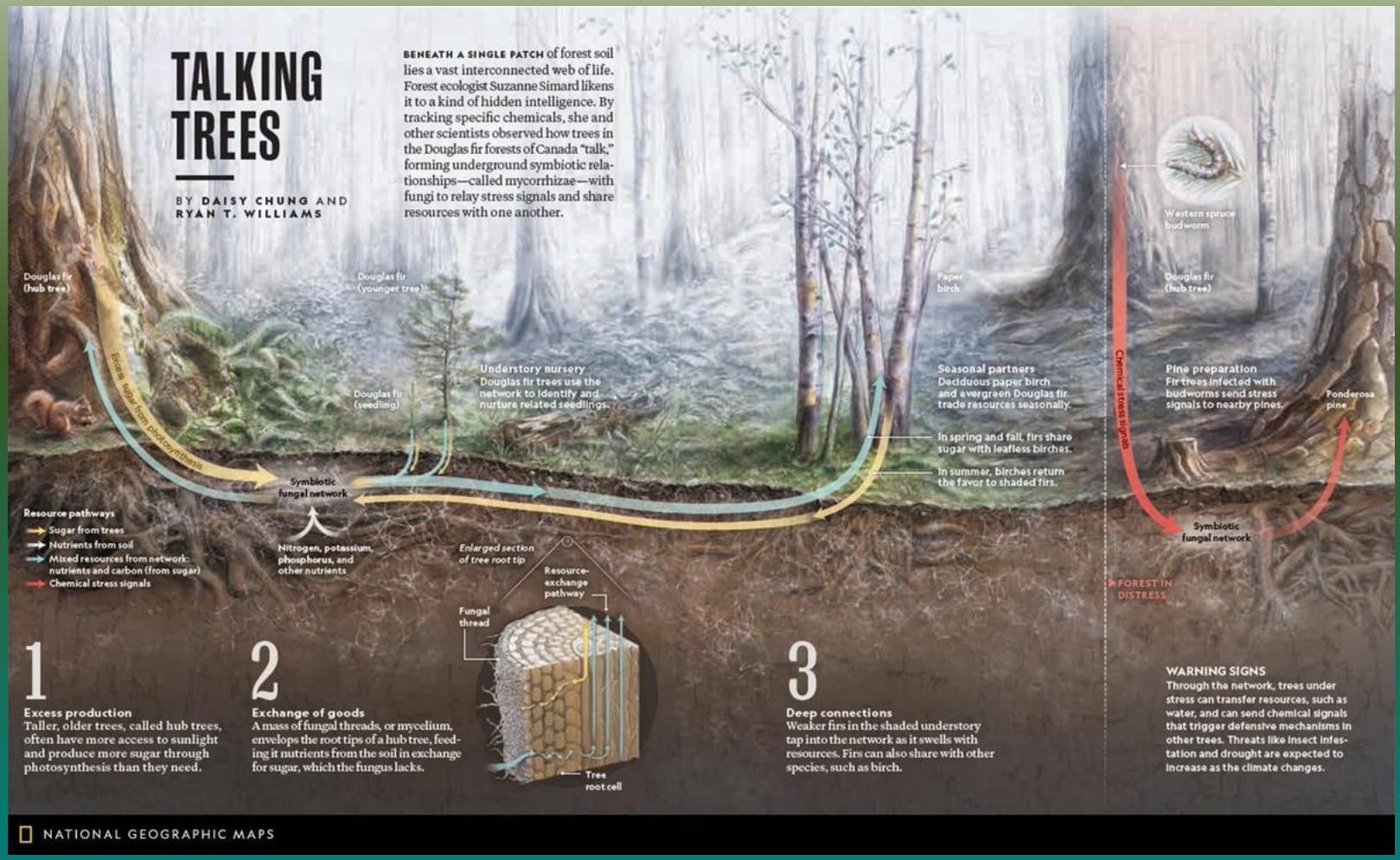
Old growth “mother trees” distribute nutrients and chemical instructions (including insect defense alarms) to offspring and neighboring trees through mycorrhizal fungal networks. An essential component of a functioning forest (UBC prof Suzanne Simard).



Suppression of offspring growth by mycorrhizal chemical signals

Tree diameter (DBH) does not correlate well with age. Rwegongeza, 2013

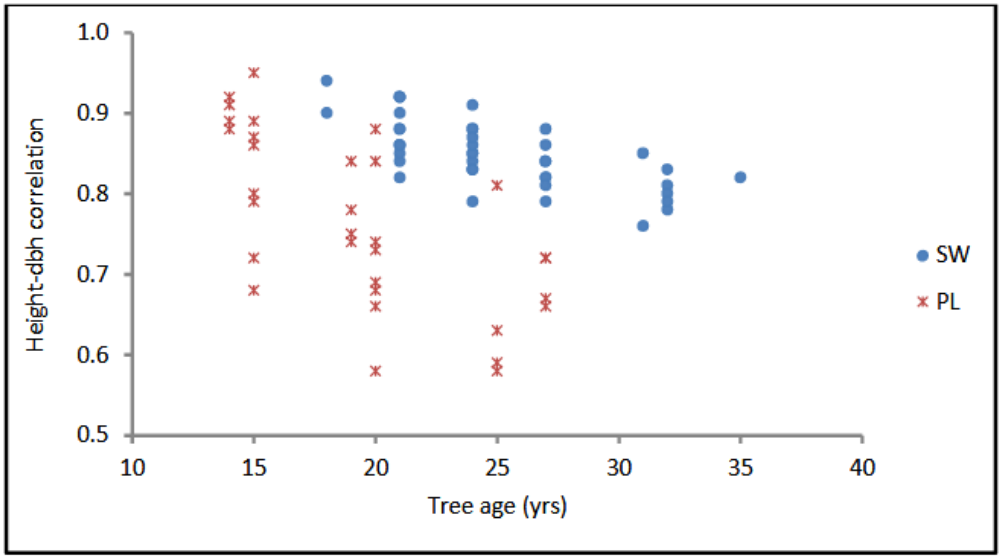
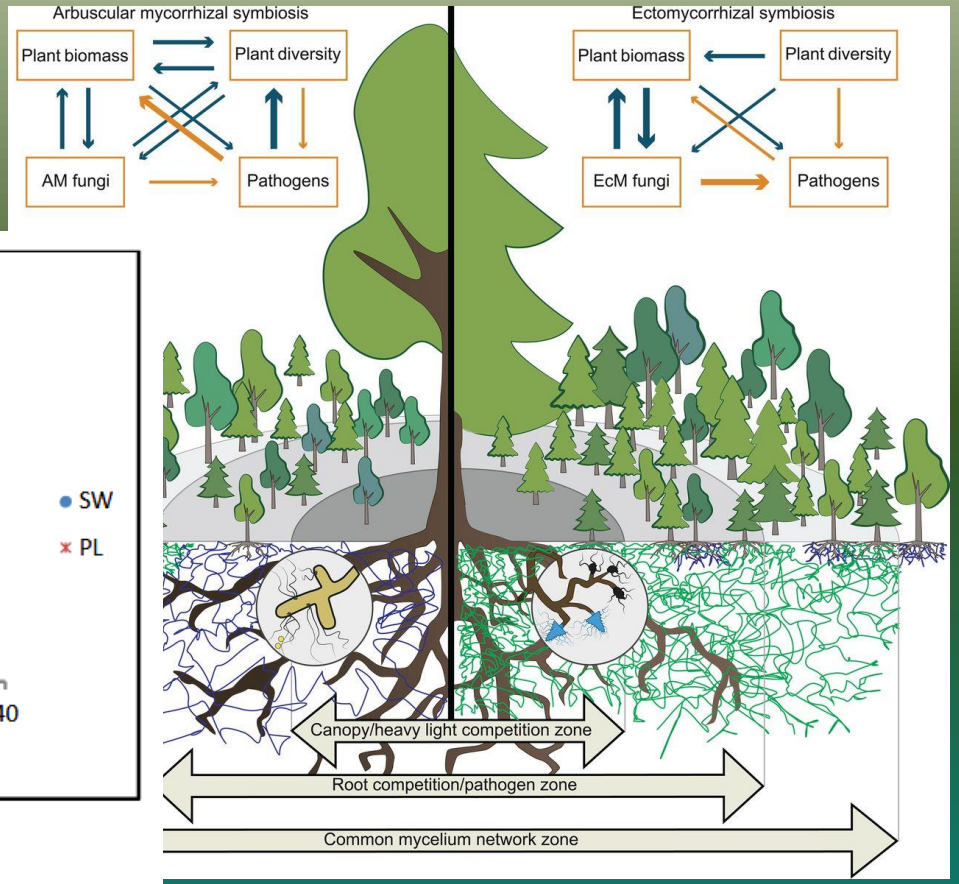


Figure 8: The decline of height-DBH correlation with tree age. PL (lodgepole pine, r = -0.66), SW (white spruce, r = -0.69).



Tedersoo, Brahram and Zobel, Science, 2020

Forest Disturbances

- Disturbance Scale: Stand replacement, patch, and canopy gap scale.
- Wildfire
- Wind: blowdowns
- Insect: Mountain Pine Beetle, Spruce Budworm, Spruce Beetle, White Pine Weevil, Sawyer Beetle, Aphids, Aspen Tortrix, Bruce spanworm, Leaf miner, Aspen Leaf Roller, Sawflies. Wood borer.
- Disease: Armillaria root disease, comandra blister rust, western gall rust, Spruce broom rust, marssonina, aspen leaf blight.
- Human
  - Linear features: Roads, seismic lines, OHV trails, hiking/biking trails
  - Logging: Produces unnatural age distribution, eliminates ecosystems, disrupts mycorrhizal network, increases wildfire hazard.

Insect infestations

- Mountain Pine Beetle

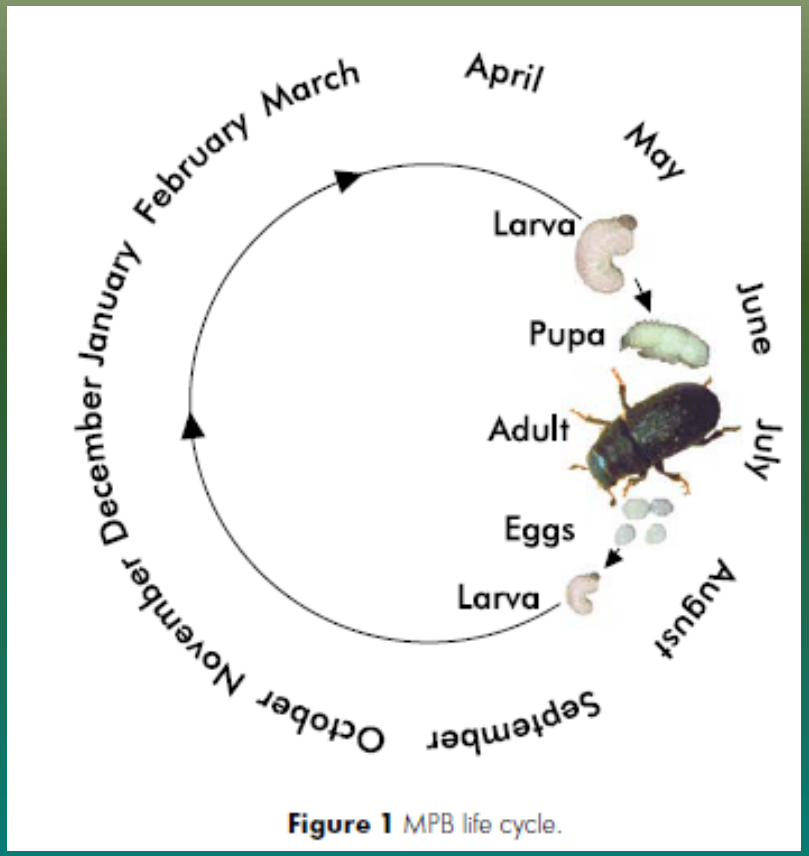


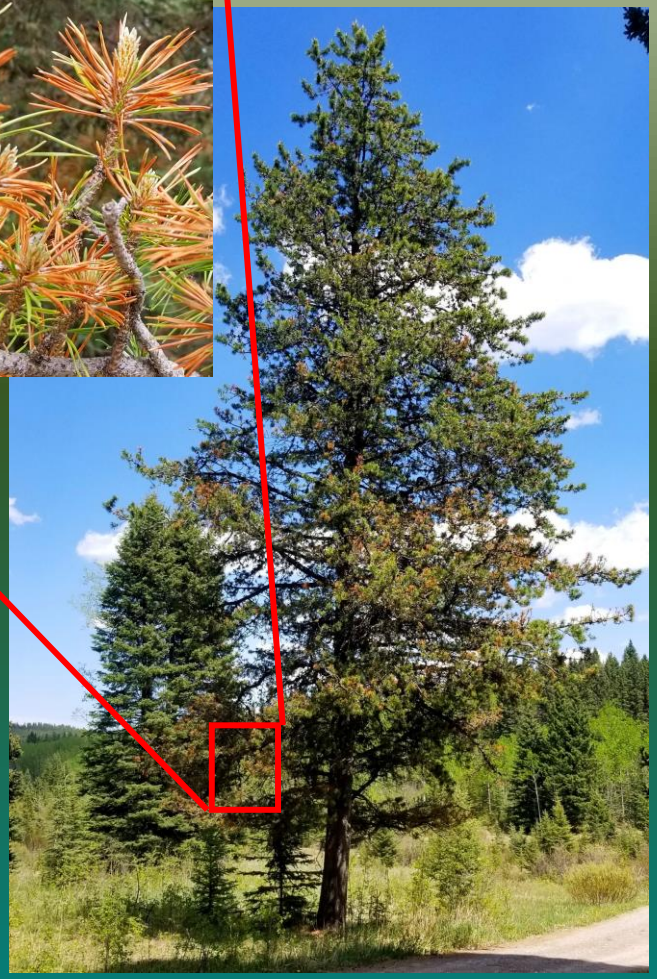
Figure 1 MPB life cycle.

Figure 3 Pitch tube on pine tree attacked by MPB.

Figure 4 Boring dust on the base of the tree.

Mountain Pine Beetle

Mild infestation and recovery. Folk Tree Lodge, Hwy 762, June 2021. Note new green needle candles indicating recovery.

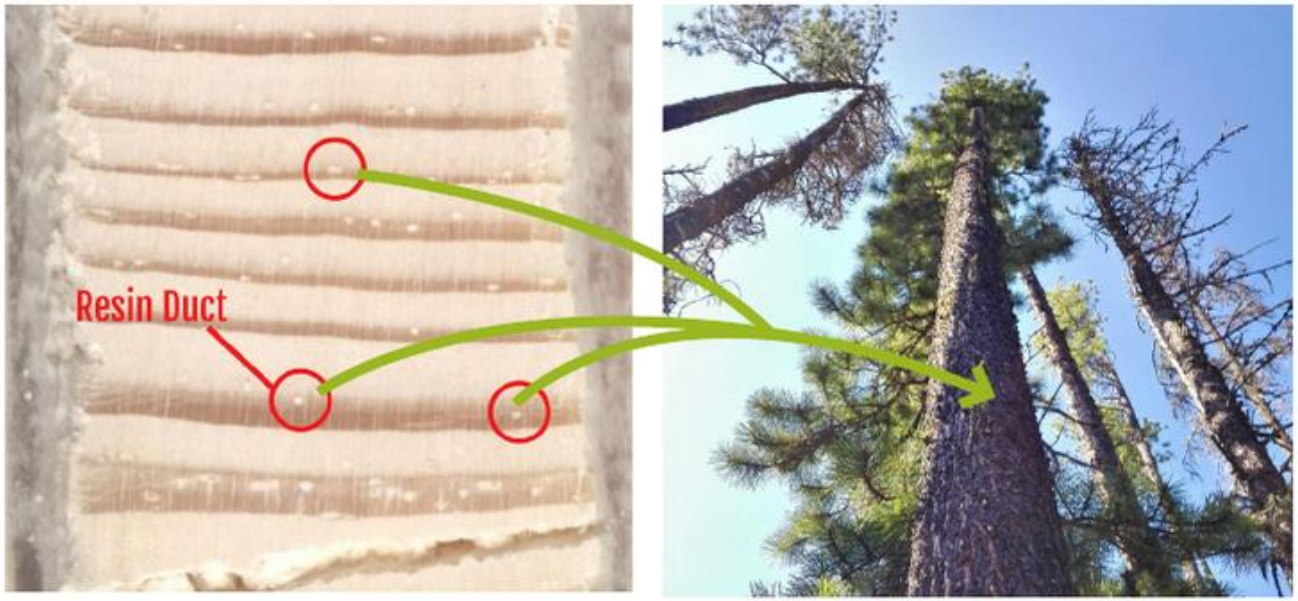


Stand replacement Infestation. Mt Kerkeslin, Jasper National Park, March 2019

Recoverable Pine Beetle infestation on BarKC. This tree will survive.

Lack of pitch tubes on trunks

Recovered trees are MPB resistant and will spread resistant offspring.



Residual trees remain green after MPB attack. Our team's research shows that these surviving trees had larger resin ducts compared to the trees that were killed.

The key implication from this study may surprise some foresters. **Despite the economic value of salvaging live trees in a beetle-killed stand, these green trees hold distinct value in helping promote future stands that are resistant to MPB.** If all surviving trees are removed during salvage operations, the forest may lose the genetics of these key MPB-resistant trees.

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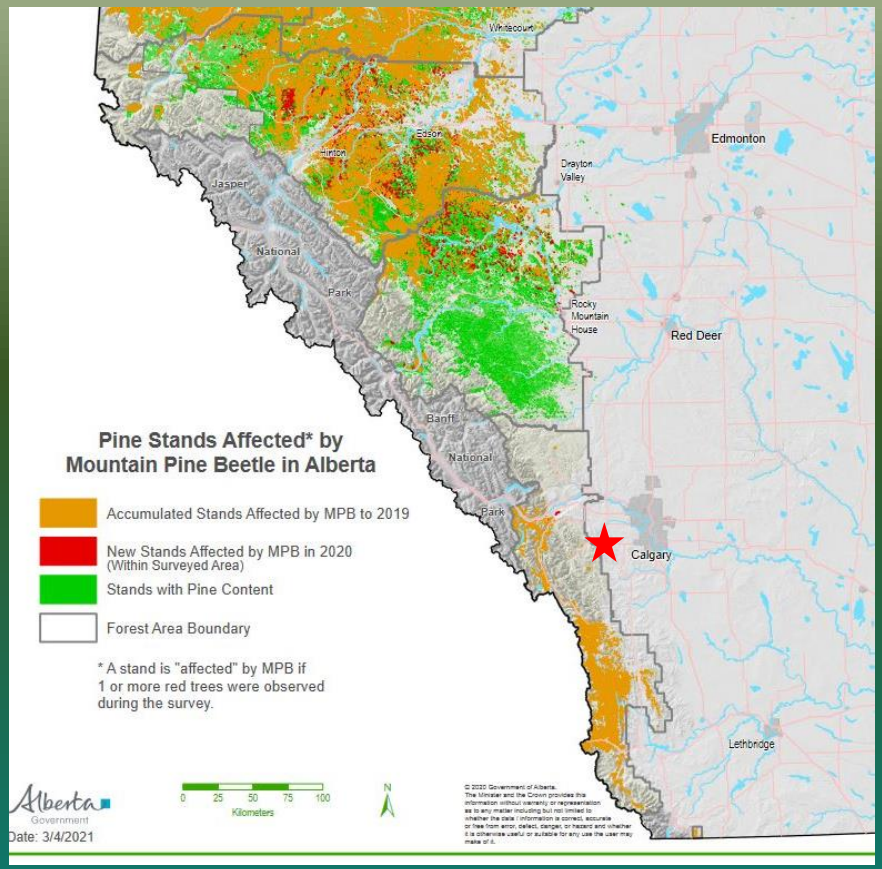
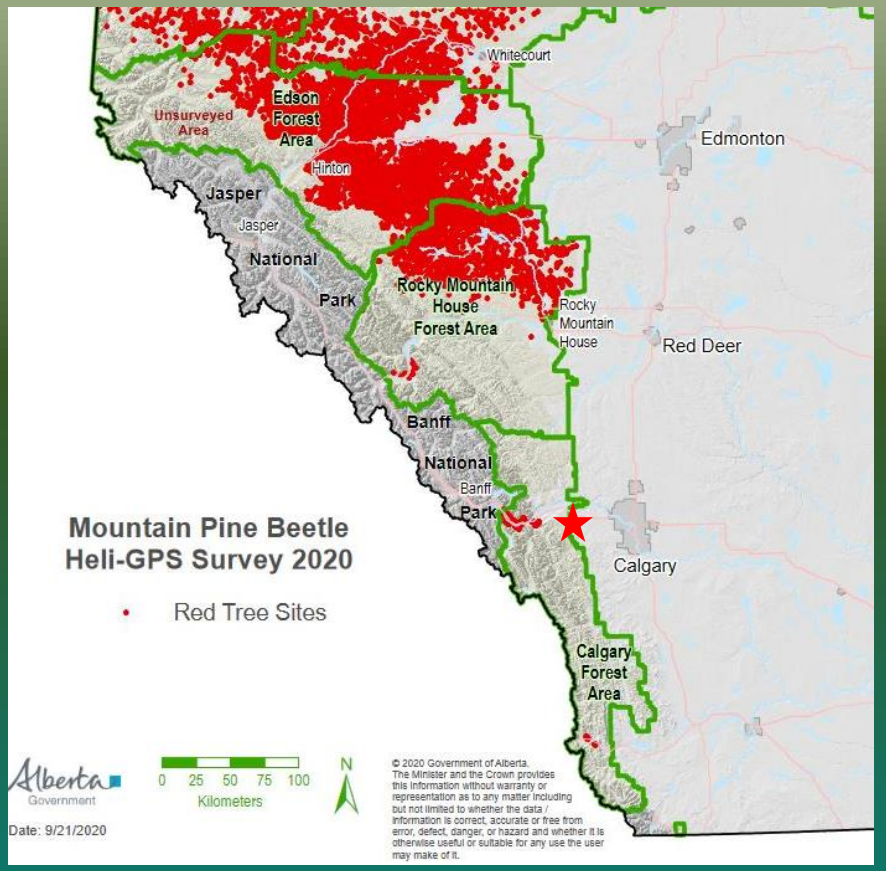
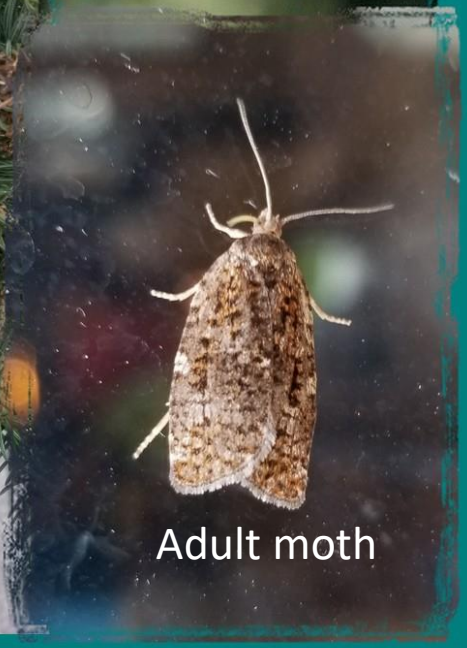
2020 Mountain Pine Beetle cumulative presence (left) and recent “red tree” (significant needle loss) observations. No nearby new infestations.





Spruce Budworm

Instar 5 larvae



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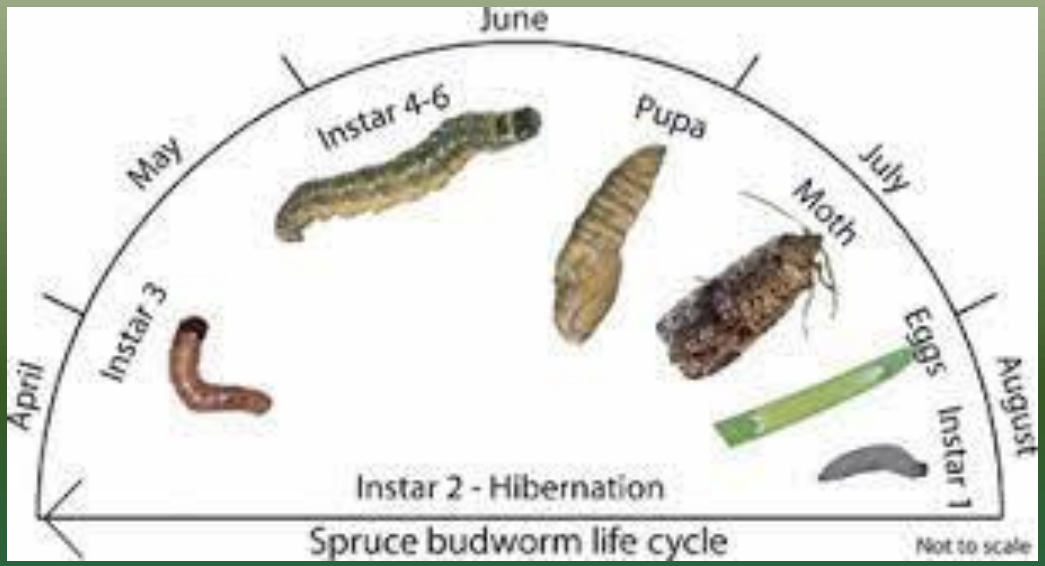
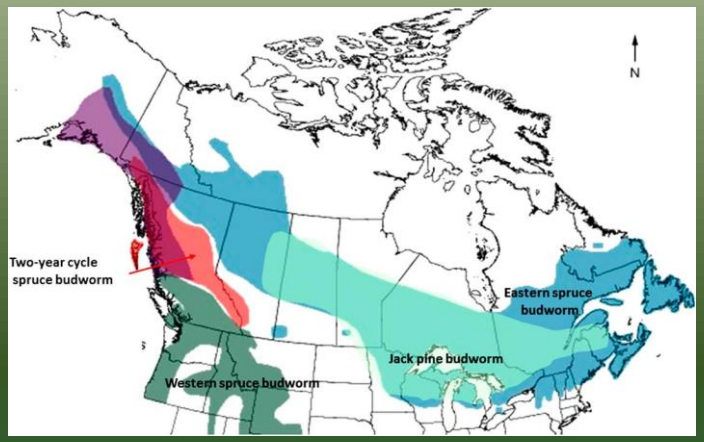
Spruce Budworm Choristoneura species lifecycle (Rauchfuss & Ziegier, 2011) Range from Nealis, 2015.





C. occidentalis affects white spruce, engelmann spruce, douglas fir, subalpine fir in western Canada; C. fumiferana affects balsam fir, white spruce, black spruce, red spruce in northern and eastern Canada and US.; C. pinus affects jack pine budworm in central Canada and US.; C. lambertiana affects ponderosa pine in Colorado and New Mexico.

Western Spruce Budworm Choristoneura occidentalis

- Affects White Spruce, Engelmann Spruce, Douglas Fir, Subalpine fir.
- Infestations reduce radial growth (wood volume) and stunts trees (top kill) deforming stems. Lumber industry.
- Migration of larvae spreads when 4 larvae/branch tip or ~25% defoliation of new growth occurs. Moth migration increases spread.
- Spruce trees mortality starts after 4-5 years of severe defoliation in mature stands, 7-8 years in immature stands. (MacLean, 1980).
- After 12 years of infestation, mortality in mature white spruce stands is 36%, and 13% in immature stands (MacLean, ibid).
- Budworm defoliation does not increase wildfire risk (Flower et al 2014, Miegs et al. 2015, 2016).

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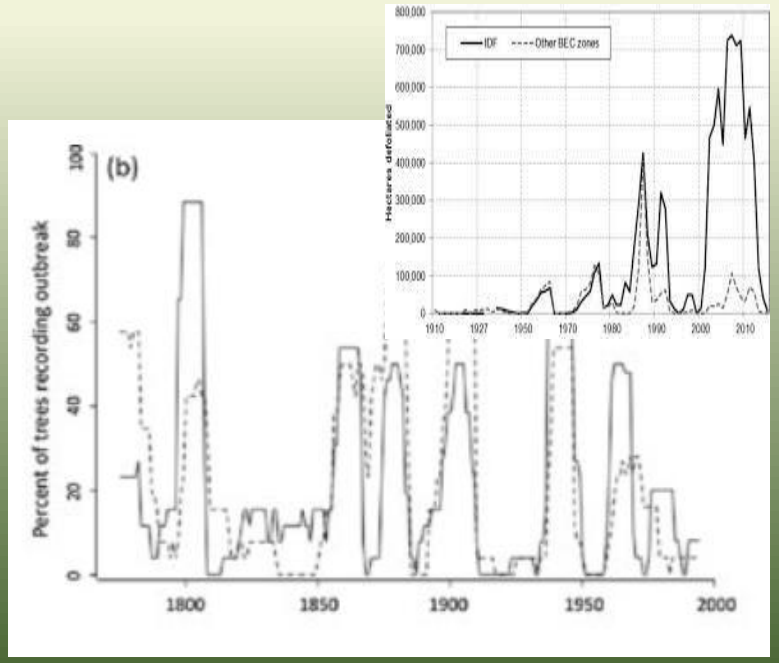
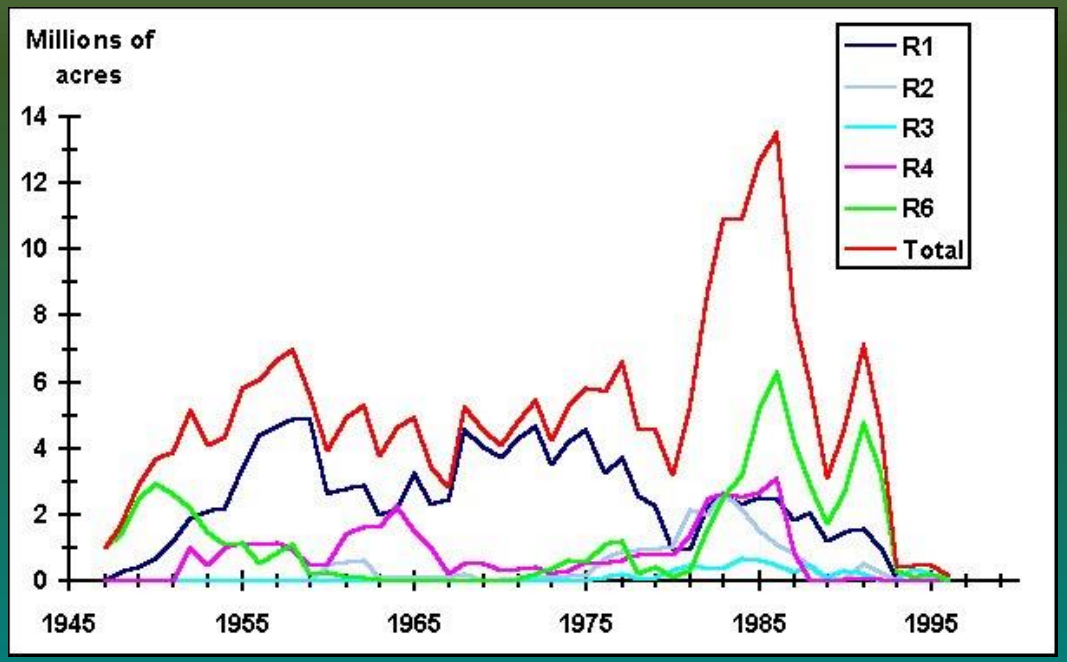
Outbreak peaks 25-35 years, duration 4-8 years.



Periodicity of western spruce budworm in Southern British Columbia, Canada. Alfaro et al. 2014

Western Spruce Budworm periodicity in Western United States by Majeed et al 1999, R1 is MT, ID; R6 is Pacific NW.



Insecticide Bacillus thuringiensis, variety *Kustaki* (Btk)

- Naturally occurring bacteria in our soils.
- Btk produce crystal proteins during sporulation, called insecticidal delta-endotoxins that form holes in the caterpillar's gut, which eventually leads to death over a few days.
- Must be sprayed on foliage when larvae are consuming needle growth.
- 70-100% mortality (Regniere et al., 2019)
- Only works in the alkaline gut of insects, does not survive in acidic gut of mammals.
- Used on Spruce Budworm, Lymantra dispar (gypsy moth), tent caterpillars, webworms, corn borers, cabbage looper, other vegetable worms.
- Btk reduces defoliation by 44% in white spruce (Fuentealba et al. 2014)
- Other pesticides are organophosphates (nervous system inhibitors) Dimethoate, Malathion and Trichlorfon. All toxic to other life forms.

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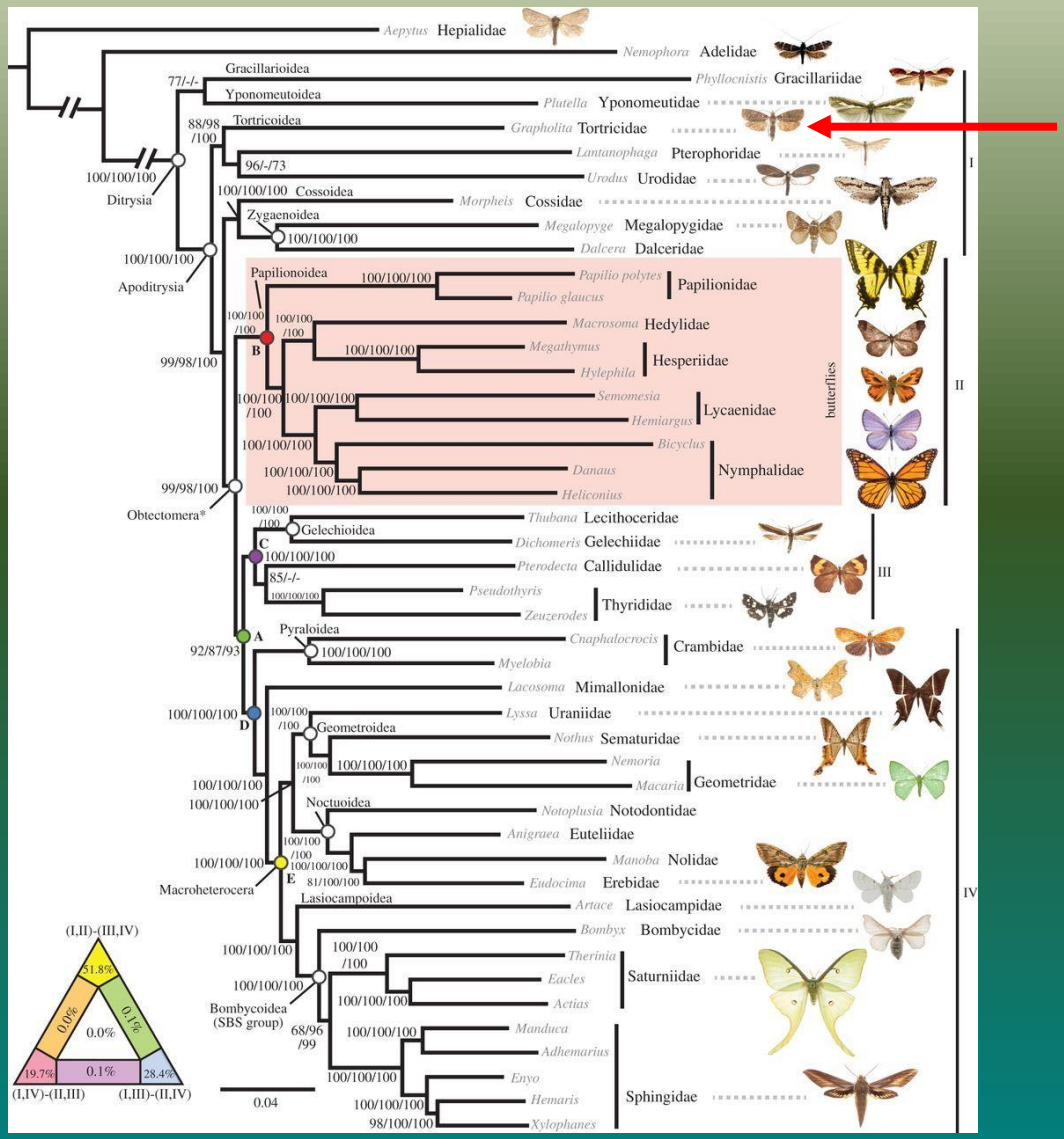
Phylogenetic tree of the order Lepidoptera. Spruce budworms, Choristoneura (budworms) is a genus in family Tortricidea.

In North America there are over 11,000 described species of Lepidoptera species, including 679 butterflies. Discover Life 2021

"Btk kills caterpillars of all butterflies and moths, although some species are partially resistant to it." Botanical Electronic News Apl 1998.



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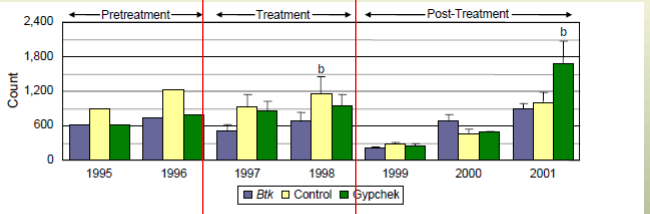


Figure 25. Total count[illegible]ed by treatment. Total count=15,883. Lower case[illegible]s significantly lower than the treatment count of th[illegible]. Error bars indicate one standard error.

All caterpillars

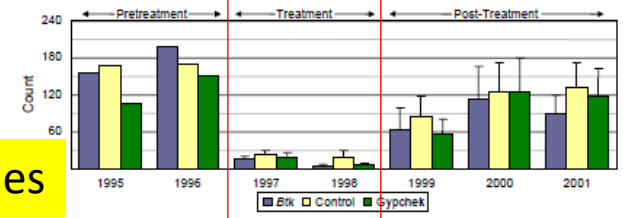


Figure 64. Total counts of *Tachinomyia* species known to attack macrolepidoptera taken with Malaise traps. Total count=1,951. Error bars indicate one standard error.

Flies

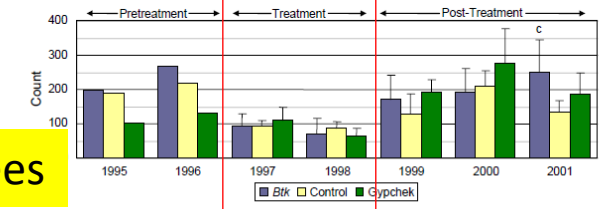


Figure 77. Total counts of bees (Apoidea) sampled with Malaise traps. Total count=2,800. Lower case letters (c=control) indicate a treatment count is significantly lower than the treatment count of the bar it is above for that year with $p<0.05$. Error bars indicate one standard error.

Wasps & bees

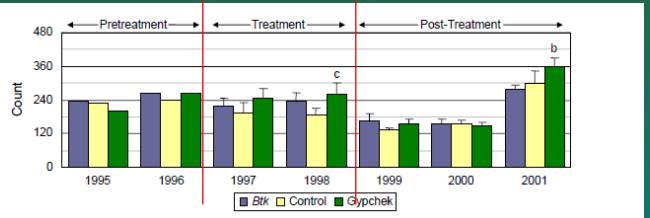
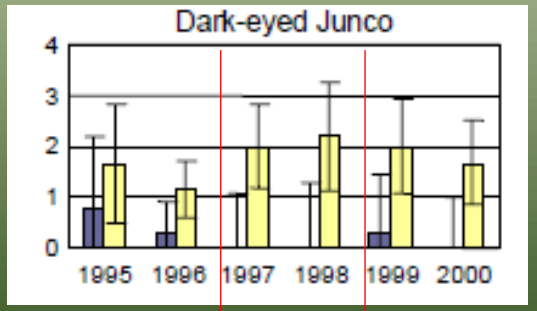


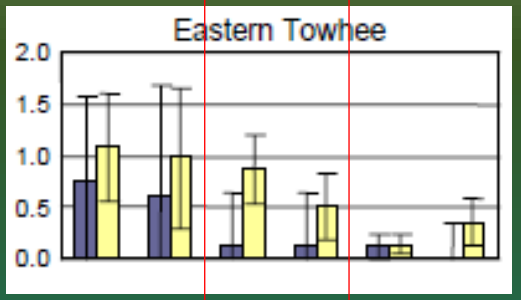
Figure 69. Total counts of adult spiders sampled from foliage. Total count=4,624. Lower case letters (b=*Btk*, c=control) indicate a treatment count is significantly lower than the treatment count of the bar it is above for that year with $p<0.05$. Error bars indicate one standard error.

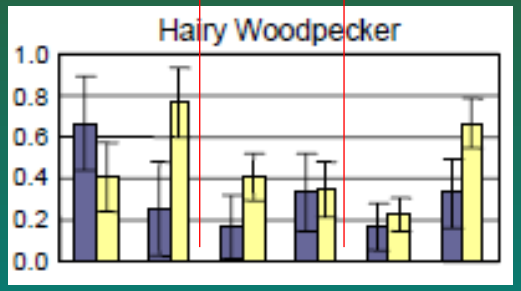
Spiders

Long Term Evaluation of the Effects of Bacillus thruingiensis kurstaki, Gypsy Moth Nucleopolyhedrosis Virus Product Gypchek, and Entomophaga maigaon Nontarget Organisms in Mixed Broadleaf-Pine Forests of the Central Appalachians. 143p.

Stazanac and Butler, Eds, 2005

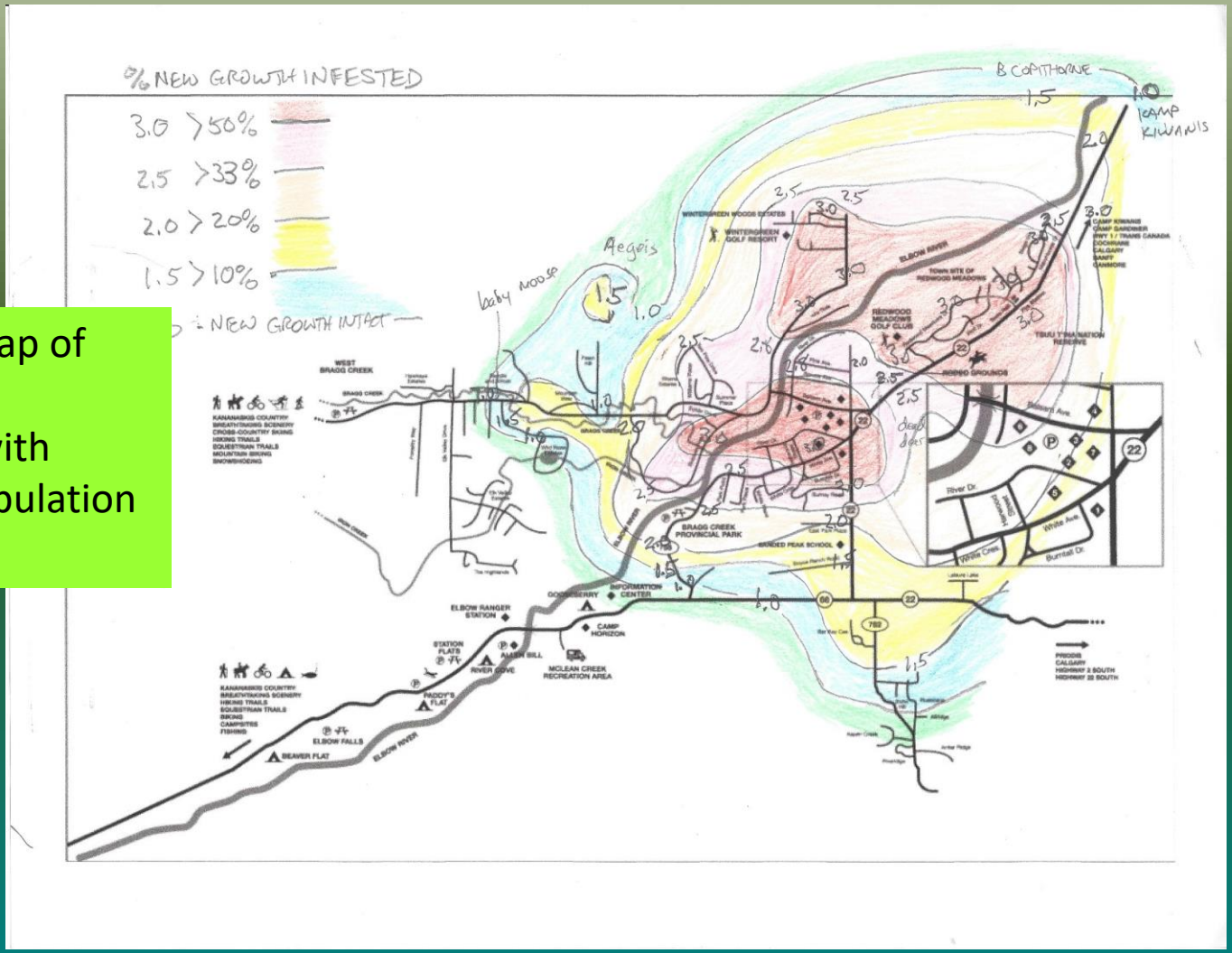






Spruce Budworm Infestation as of June 23.

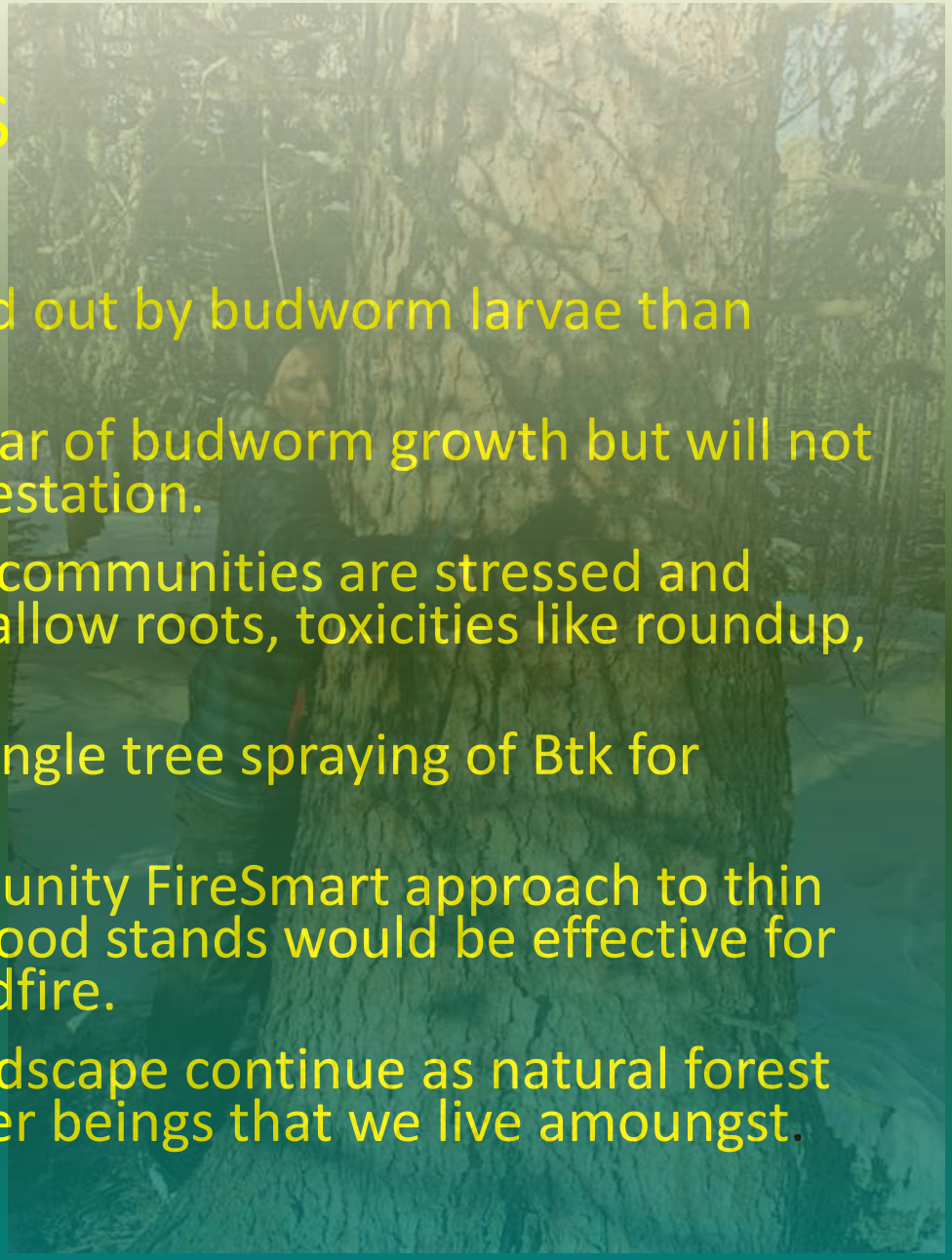
Note overlap of infestation intensity with human population centres



Limiting factors on spruce budworm populations.

- Healthy trees! No fungal infections or drought stresses.
- Choristoneura predators (Jennings & Crawford 1980) include wasps, beetles (esp ladybugs on eggs), flies (diptera), ants, spiders and birds especially Cape May and Tennessee warblers, Towhees, Siskins (eggs), although birds cannot significantly decrease outbreak populations (Venier & Holmes, 2010) .
- Spruce have a natural insecticide in needles, phenolic acetophones piceol and pungenol (Bauce et al. 2011) produced by gene betaglucosidase-1 (Bohlemann & MacKay, 2014). Surviving trees have natural resistance. Glucoside picein also plays an unknown role Lamara et al. 2018.
- Budworms susceptible to late summer dessication.
- Bad weather in spring prevent instar 3 migration and increase predation.
- Thinning (40%; Bauce & Fuentealba 2014) of spruce trees limits infestation. Forests with overlapping crowns, abundant current year buds, abundant pollen cones increases infestation.

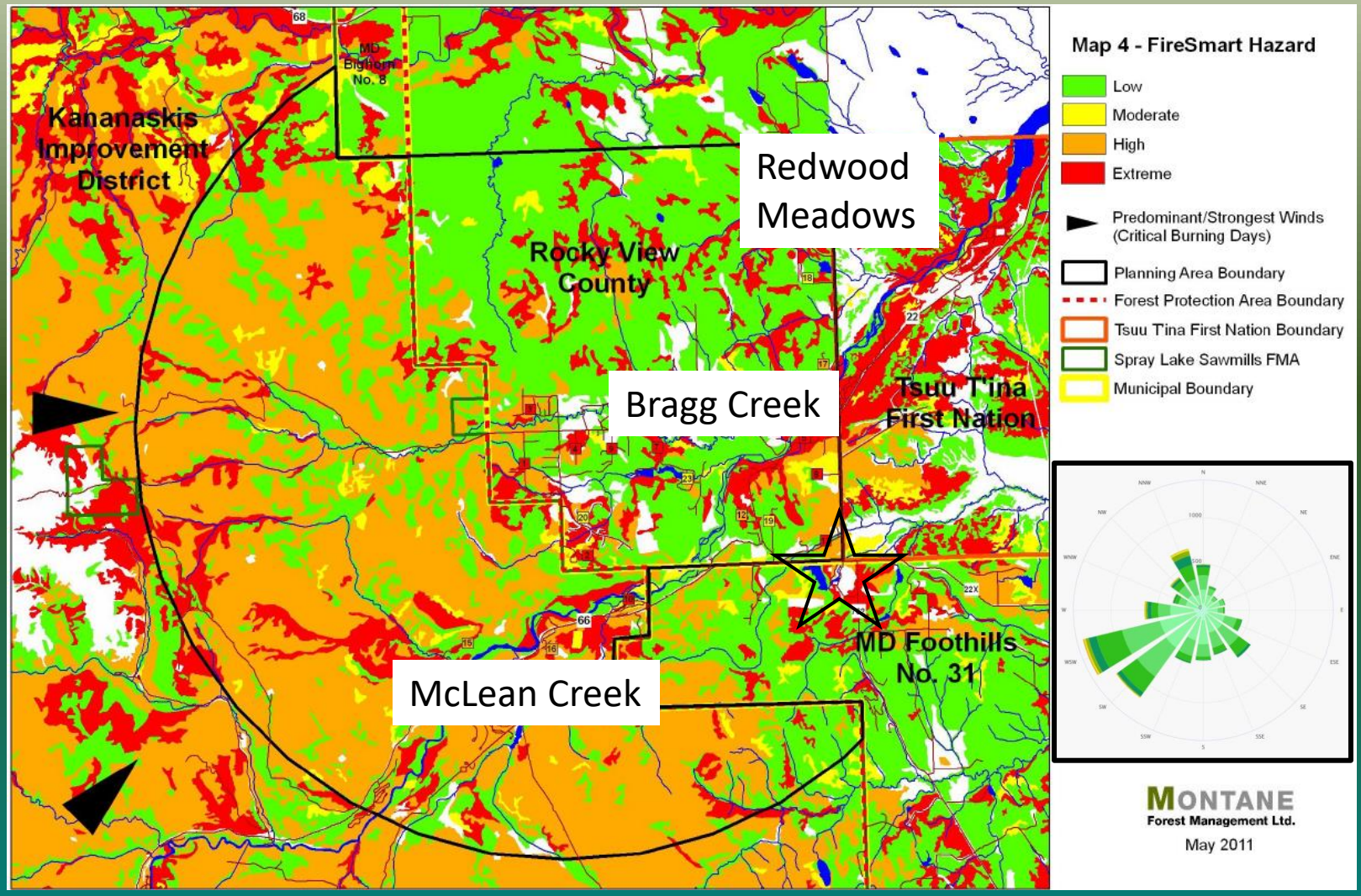
Conclusions



- Humans are more freaked out by budworm larvae than spruce trees are.
- Btk spraying reduces a year of budworm growth but will not eliminate widespread infestation.
- Spruce trees in our close communities are stressed and subject to infestation. Shallow roots, toxicities like roundup, overcrowding.
- I recommend selective, single tree spraying of Btk for (human) valued trees.
- A homeowner and community FireSmart approach to thin spruce trees and mixedwood stands would be effective for both infestations and wildfire.
- Let other parts of our landscape continue as natural forest ecosystem for all the other beings that we live amoungst.

EXPERIENCE JOURNEYS

Firesmart Hazard Elbow River Valley. Bragg Creek and Whitecourt are Alberta's highest risk communities for wildfire.



Champion Lakes fire set by exploding rifle targets in slash piles southern MacLean Creek Off-Highway Vehicle Forest Land Use Zone.

EXPERIENCE JOURNEYS

Fire history of the Elbow River Valley from “Fire regimes of southern Alberta, Canada. M-P Rogeau, 2016 PhD thesis, U of A. Note the principal historic Bar KC fire is 1910.
Calculated Fire Return Interval is 43yrs +80/-20

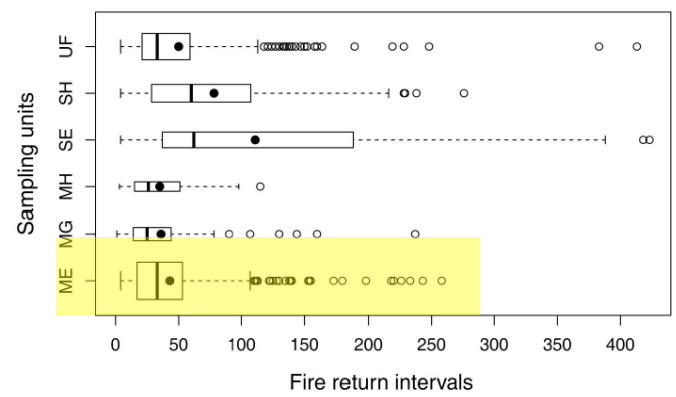
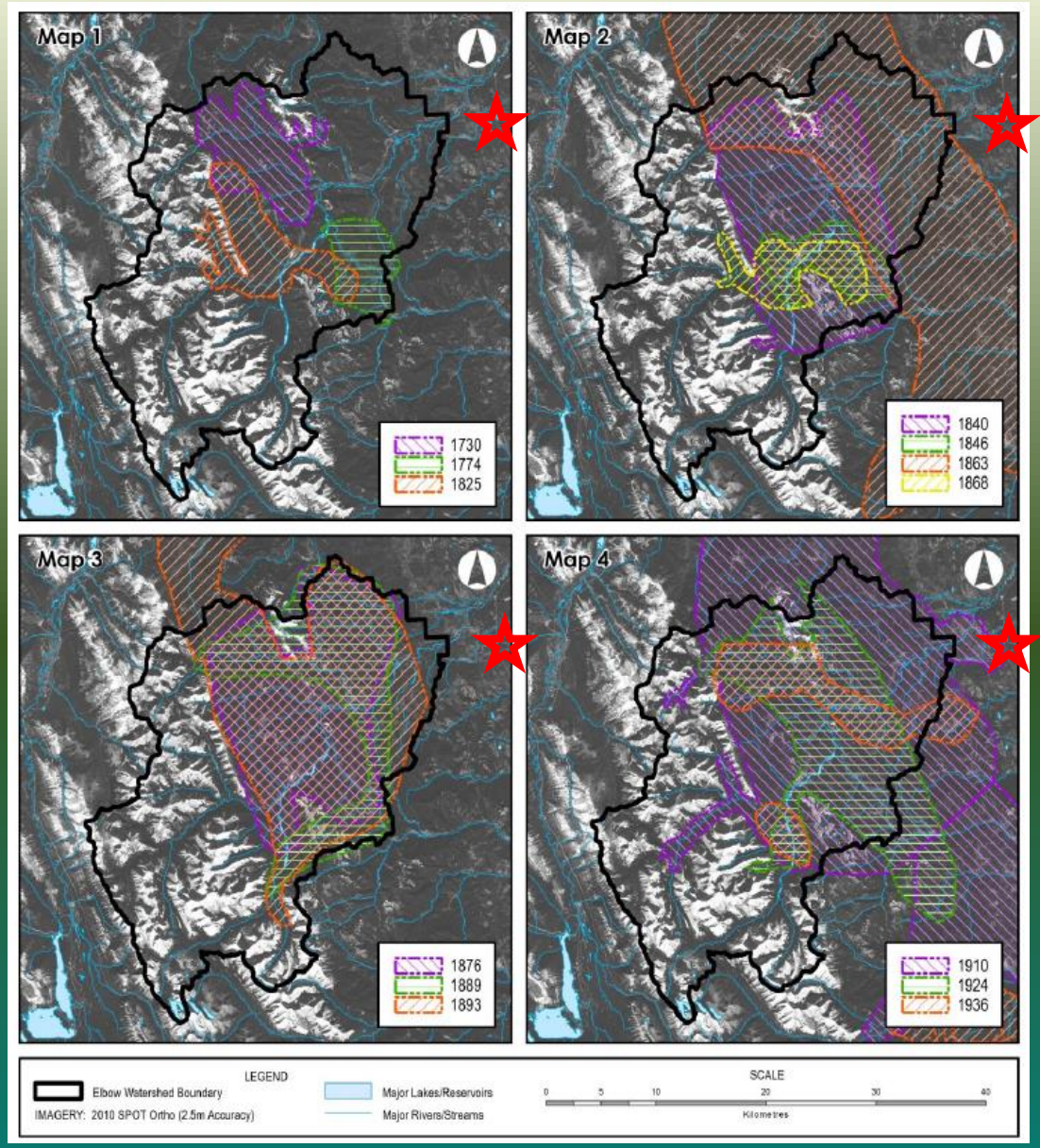


Figure 2-3 Boxplots showing the spread of fire return intervals for six sampling units in southern Alberta. Montane-East (ME), Montane-Ghost (MG), Montane-Highwood (MH), Subalpine-Elbow (SE), Subalpine-Highwood (SH), Upper Foothills (UF). The vertical line represents the median and the dark circle the mean. The width of the box is the square-root of the number of observations. The box bounds the top of the first quartile and top of third quartile. The whiskers represent the lowest and highest datum within 1.5x the inter-quartile range. Empty circles are outliers.



Elbow River Watershed logging footprint: 1984/2016

Unsustainable logging rate: More than 24% of harvestable forest logged in 31 years, for a 0.8%/yr deforestation rate.

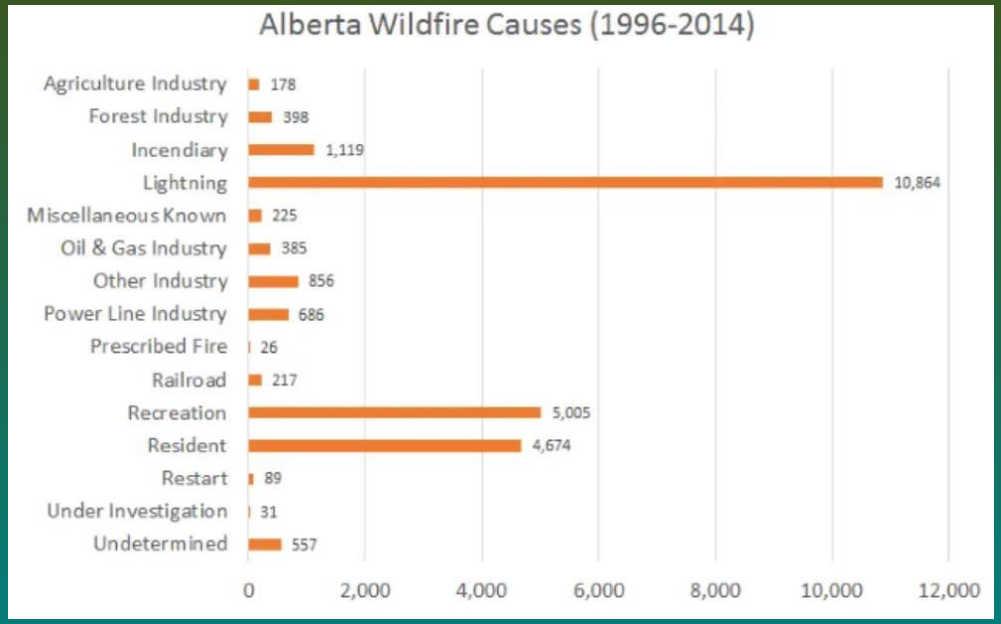
2001-2019 18 yr Deforestation rates: World 6%, Canada 10%, Elbow River 14%

Differences in clearcut logging and wildfire disturbances.

- Clearcut harvesting and wildfire affect biodiversity in different ways.
- Fire disturbances have many small disturbances and a few very large “stand replacement” disturbances.
- Soil chemistry and nutrient residues significantly differ.
- Fire return intervals are longer (20-500 yrs) than rotation intervals for merchantable timber (40-100 yrs)
- Regenerated forests in logged patches planted for merchantable pine rather than deciduous conifer mixed wood. Understory
- Forest harvesting does not emulate mosaic of stand types (age structure in refugias) of natural forests.

Principle causes of Wildfires

- Most significant factors in California wildfires *(Sidder, 2021, Uncovering patterns in California's blazing wildfires, Am Geophysical Union Eos March 2021)*
  - Climate, Vapour pressure deficit (low humidity).
  - Population density (low population more fire)
  - Fuel amount (heavily vegetated areas fire prone).



Alberta
Wildfire ignition sources
Mack Male, 2016

Fuel distribution is critical parameter for fire severity

In a forest where fires rarely happen, fuel builds up: There's **surface fuel** (grass, logs, woody debris, brush); **ladder fuel** (shrubs, small trees, snags); and **tree crowns**.

1. Surface fires spread quickly through brush and woody debris.
2. Ladder fuels allow the fire to move up toward the forest canopy.
3. Tree crown fires are so intense, they're difficult to control.

The effectiveness of Aspen trees as a firebreak. (Alexander, 2010, The Forestry Chronicle)

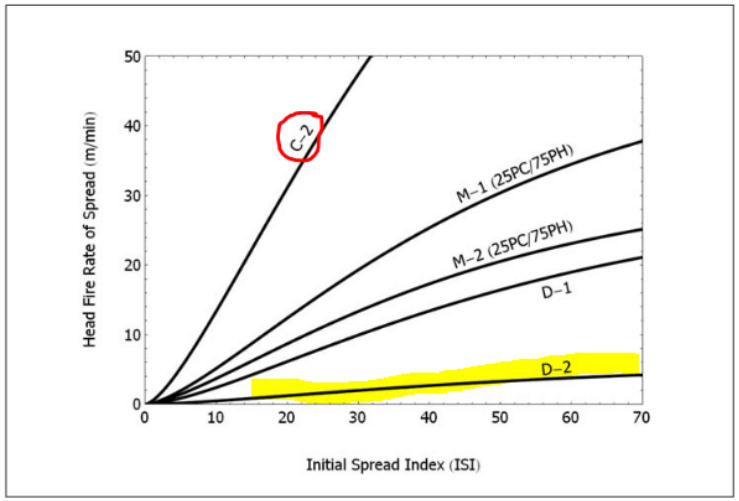


Fig. 3. Equilibrium head fire rate of spread (ROS) on level terrain as a function of the Initial Spread Index (ISI) component of the Canadian Forest Fire Weather Index (FWI) System for the Boreal Spruce (C-2), Boreal Mixedwood – Leafless (M-1), Boreal Mixedwood – Green (M-2), and Leafless Aspen (D-1) fuel types in the Canadian Forest Fire Behavior (FBP) Prediction System according to Forestry Canada Fire Danger Group (1992) in relation to the Green Aspen (D-2) fuel type. Both of the boreal mixedwood fuel types contained 25 percent conifer (PC) and 75 percent hardwood (PH). The Buildup Index (BUI) component of the FWI System was set at 70 for the purpose of the buildup effect adjustment on ROS found in the FBP System.

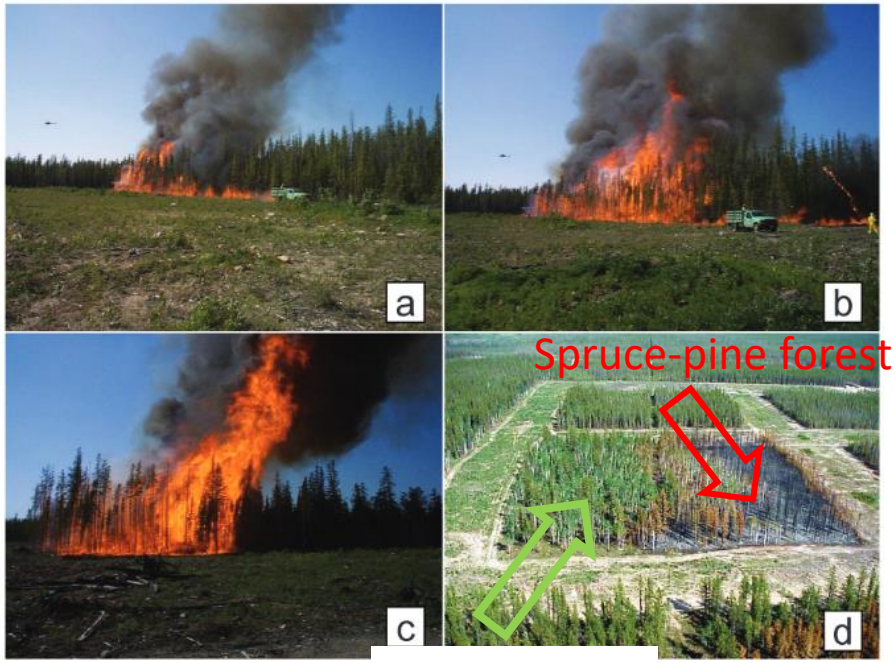


Fig. 5. Ground views of an experimental crown fire in a mixed jack pine – black spruce – trembling aspen plot (a–b) following ignition, (c) during the period of active burning, and (d) an aerial post-burn view. The high-intensity flame front associated with the onset of crowning in the conifer component of the plot following ignition of the plot edge failed to sustain itself upon entering the leafed-out hardwood portion of the plot.

Fire spread rate of leaved Aspen forest 1/10 that spruce forest.

EXPERIENCE JOURNEYS

US Forest Service Fire Effects Information System, Populus Tremuloides (Quaking Aspen) Feb 2021

Crown fires in coniferous forests often drop to the surface in quaking aspen, or may extinguish after burning into quaking aspen only a few meters [19,55,138]. Quaking aspen stands often act as natural fuelbreaks during wildfires [55], and fires sometimes bypass quaking aspen stands surrounded by conifers [138]. In an analysis of fires in quaking aspen in National Forests of the Intermountain West (USFS Regions 2, 3, and 4) from 1970 through 1982, Bevins [19] reported that wildfires that burned thousands of acres during extreme weather conditions usually penetrated less than 65 feet (20 m) into quaking aspen.

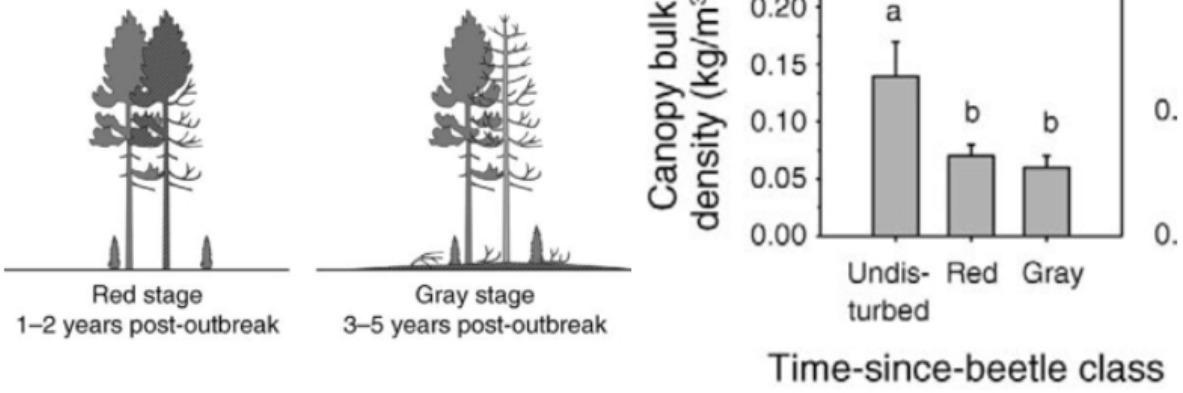
Young trees increase fire risk

- "..younger forests with spatially homogenized continuous fuel arrangements, rather than absolute biomass, was a significant driver of wildfire severity." *Zald and Dunn, 2018, Severe fire weather and intensive forest management increase fire severity in multi-ownership landscape. Ecological Applications 28(4), 2018 pp 1068-1080.*
- "Our data suggested that increased fire initiation was most pronounced in harvested stands up to a decade old, and there was some evidence that the effect might last as long as 30 years." *Krawchuck and Cumming, 2008, Disturbance history affects lightning fire initiation in mixed boreal forests: Observations and simulations." Forest Ecology and Management 257 (2009) pp 1613-1622.*

Mountain Pine Beetle infestation decreases fire risk in years following defoliation.

Are forests attacked by MPBs at increased risk of fire?

A study of canopy fuels in forests attacked by mountain pine beetles in Yellowstone National Park, USA



Conclusion: Risk of fire is ***decreased*** following attack by MPBs

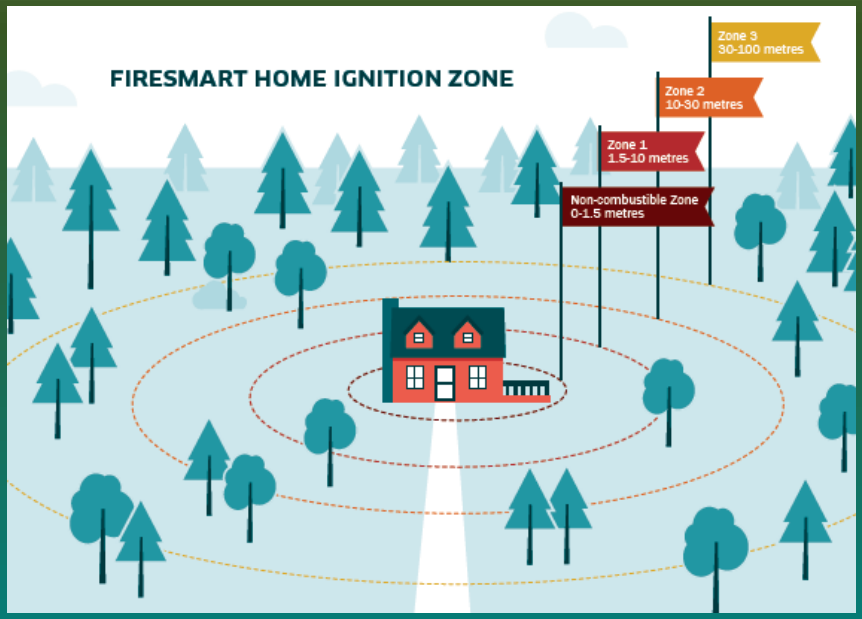
Similarly, forests in Colorado attacked by the spruce beetle burned about 30% ***less*** often than forests not attacked by the beetle [Bebi *et al*. (2003; Ecology 84:362)].

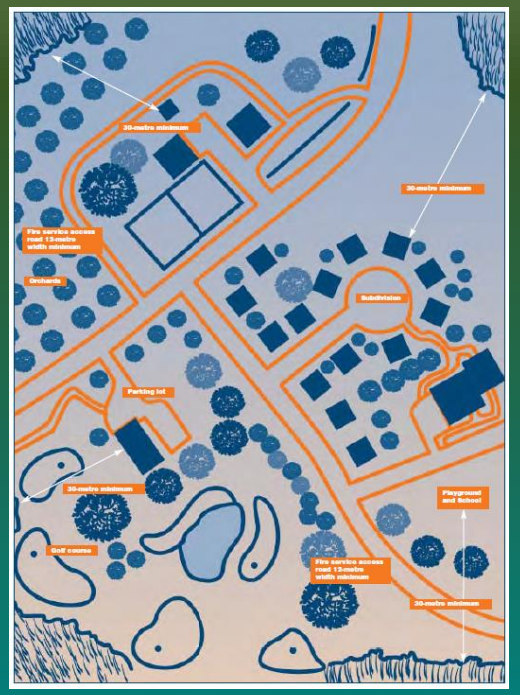
But in Wyoming, forests attacked by the mountain pine beetle were about 11% ***more*** likely to burn in the 1988 Yellowstone Fire [Lynch *et al*. (2006; Ecosystems 9:1318)].

-Simard *et al*. (2011; Ecological Monographs 81:3)

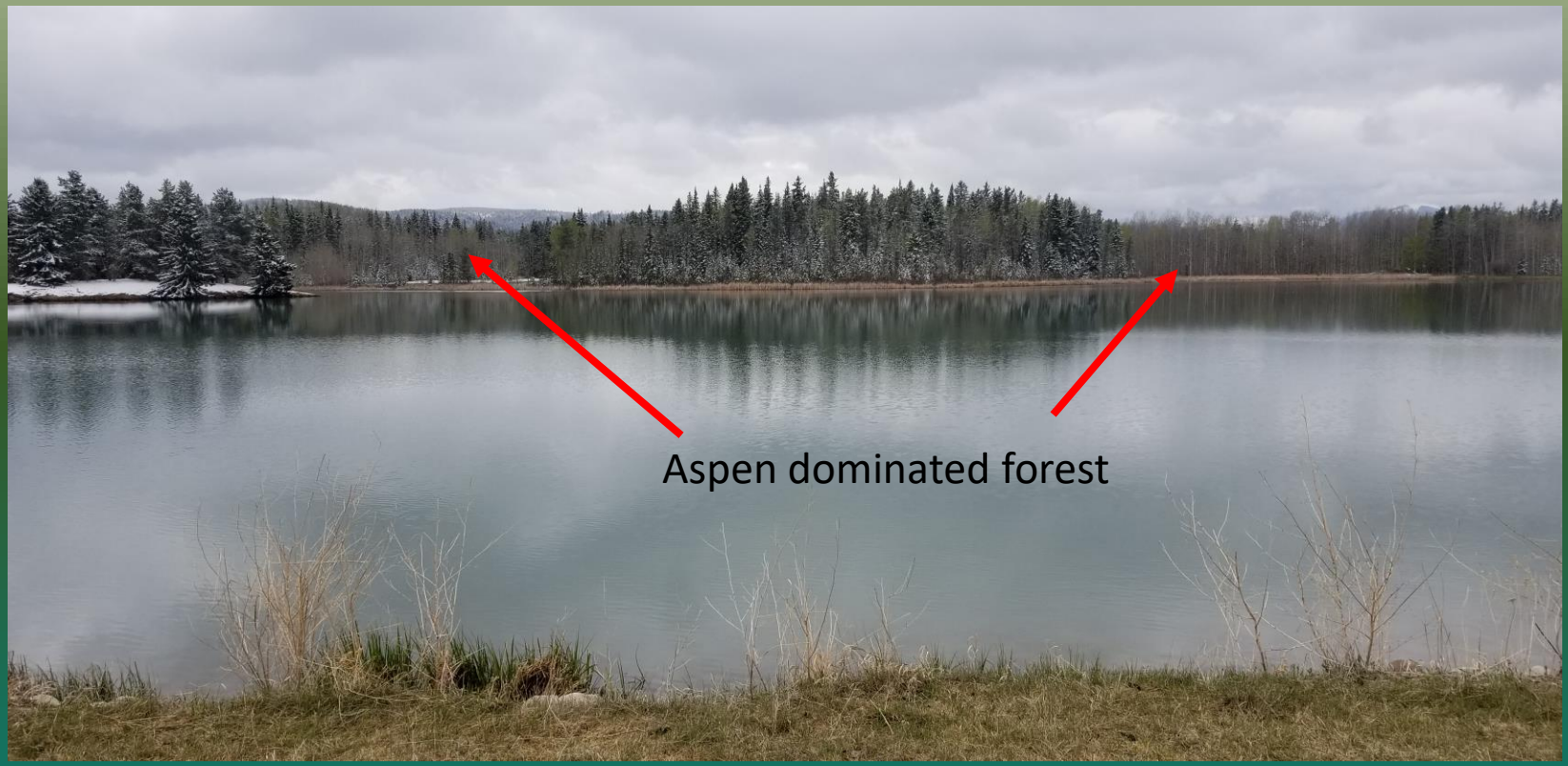
Firesmart for the inevitable.

- Firesmart: Protect private and public infrastructure.
- Parks and public lands: Let fire burn as a natural disturbance for regeneration.



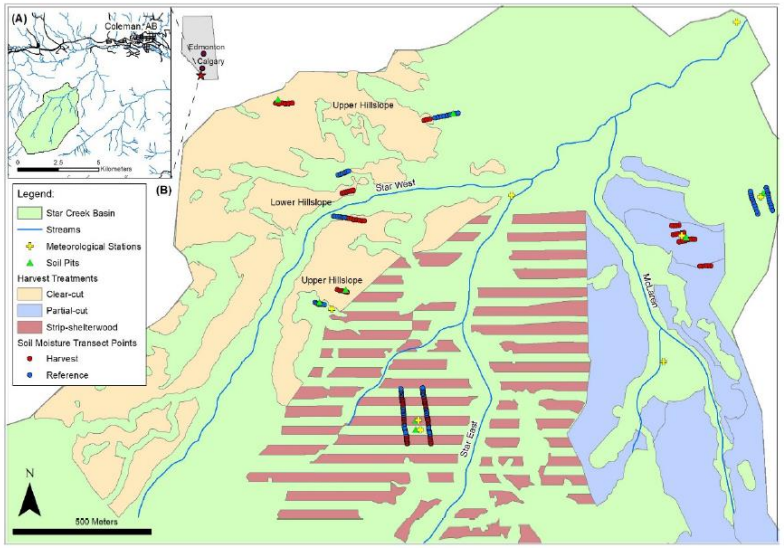


Deer lake and aspen firebreak



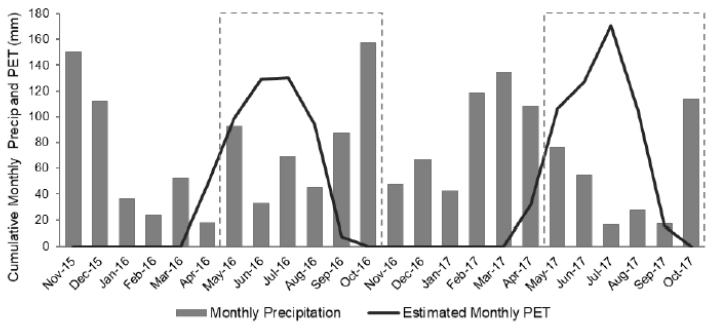
Soil Moisture Storage is better in harvested forests due to less evapotranspiration from trees. But harvest type matters: strip cut is best retention. SW Alberta

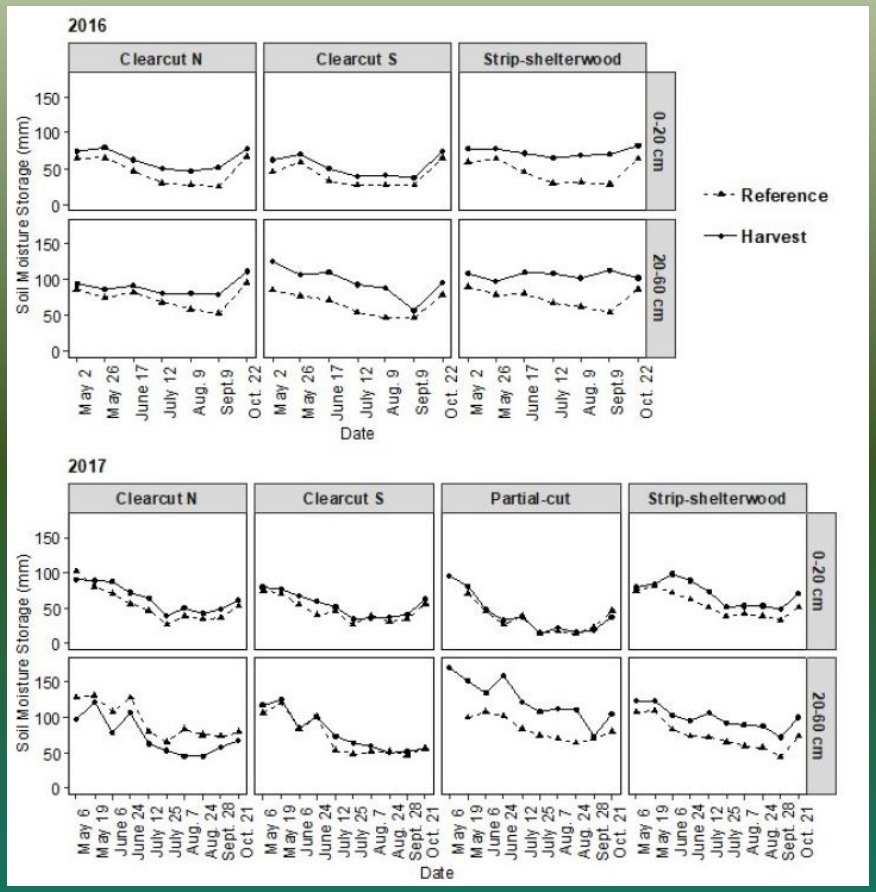
Figure 3-1: (A) Location of the study area in Star Creek watershed, in relation to the community of Coleman, Alberta. (B) Schematic map of harvesting treatments in the Star Creek watershed, as well as locations of soil moisture sampling transects, soil pits, and meteorological stations.



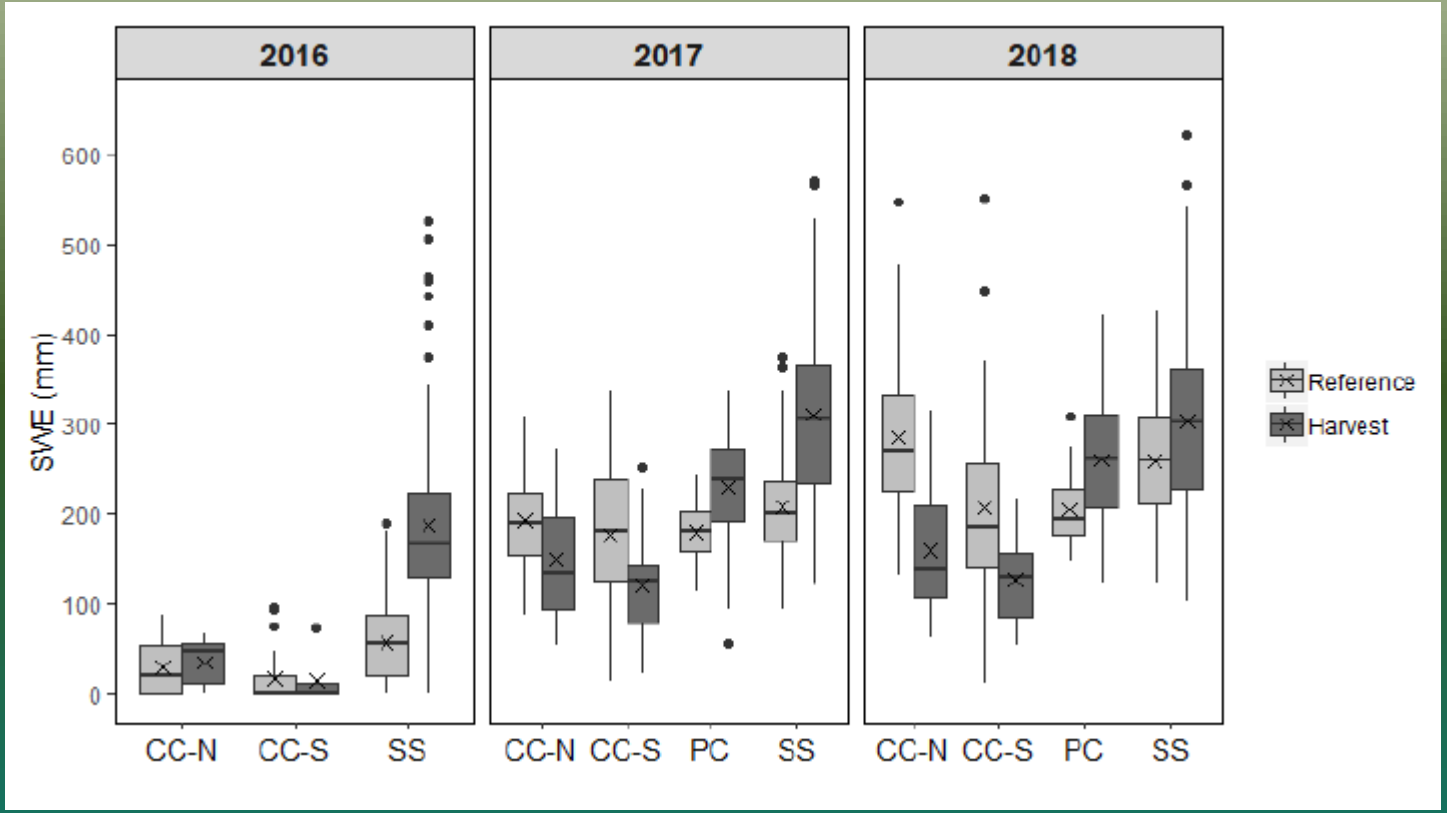
84

Figure 3-3: Temporal patterns of monthly precipitation and potential evapotranspiration in Star Creek during the study. Dashed grey rectangles denote duration of sampling within each year.





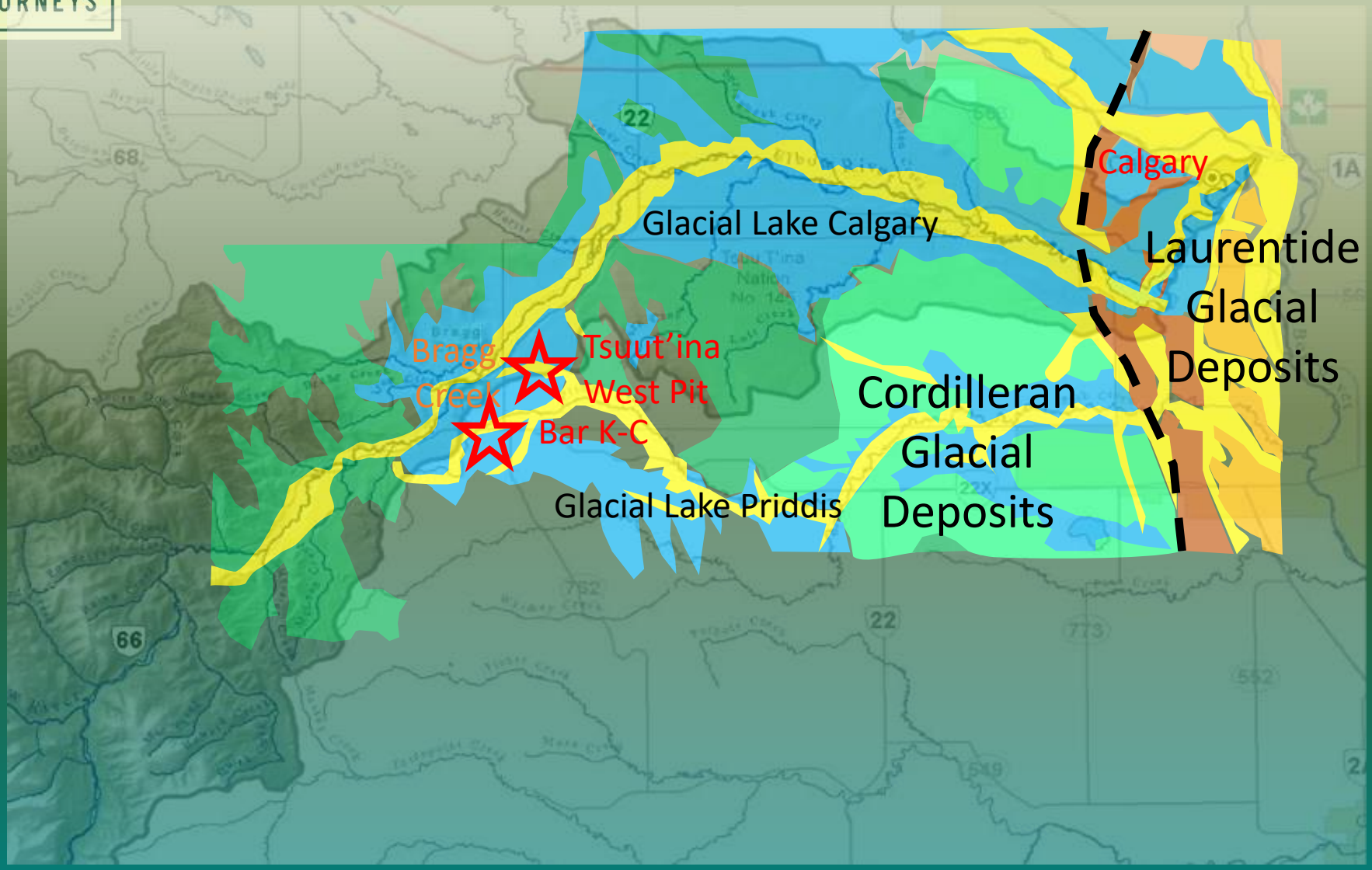
Snowpack retention in forested vs harvested areas in Snow-Water-Equivalent. From Greenacre 2019, MSc U of A



Note that snowpack retention is larger in forested areas (reference) vs clearcuts (CC) due to wind and solar ablation.

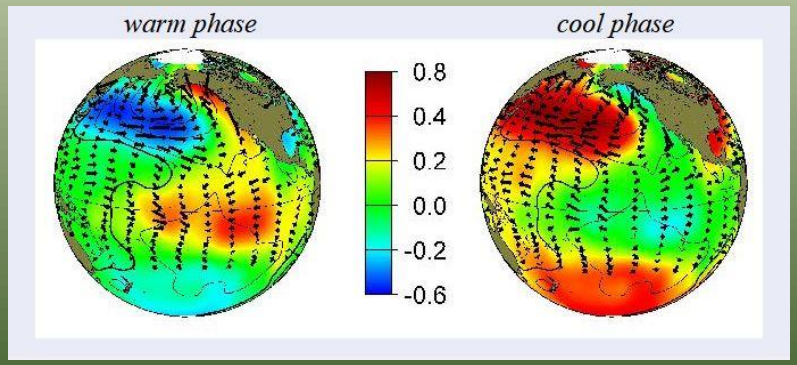
EXPERIENCE JOURNEYS

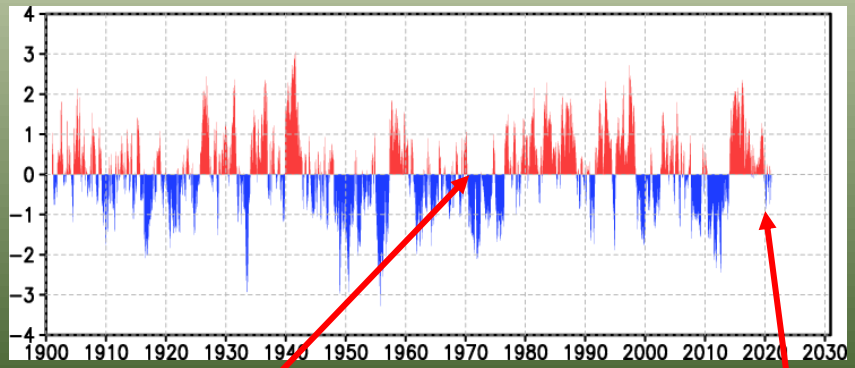
Surficial Deposits of the Elbow River Watershed



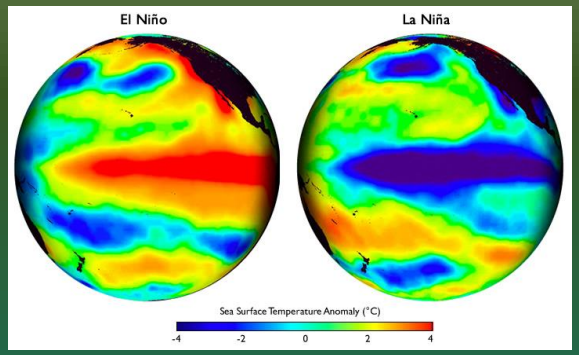
Climate Drivers for flood, fire, drought and infestations.

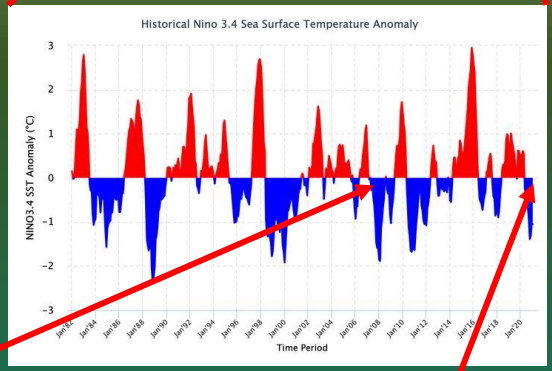
Pacific Decadal Oscillation



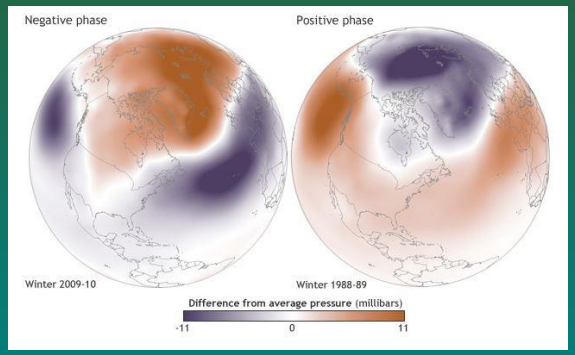


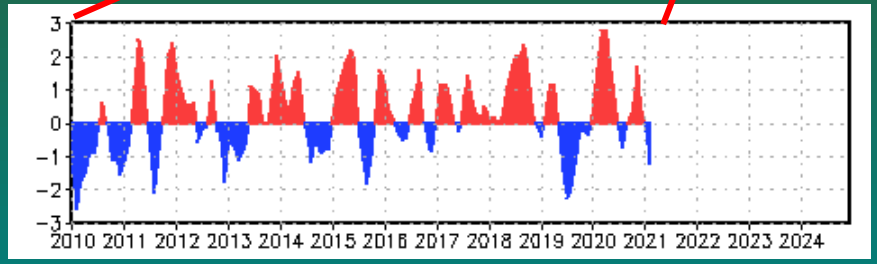
El Nino Southern Oscillation





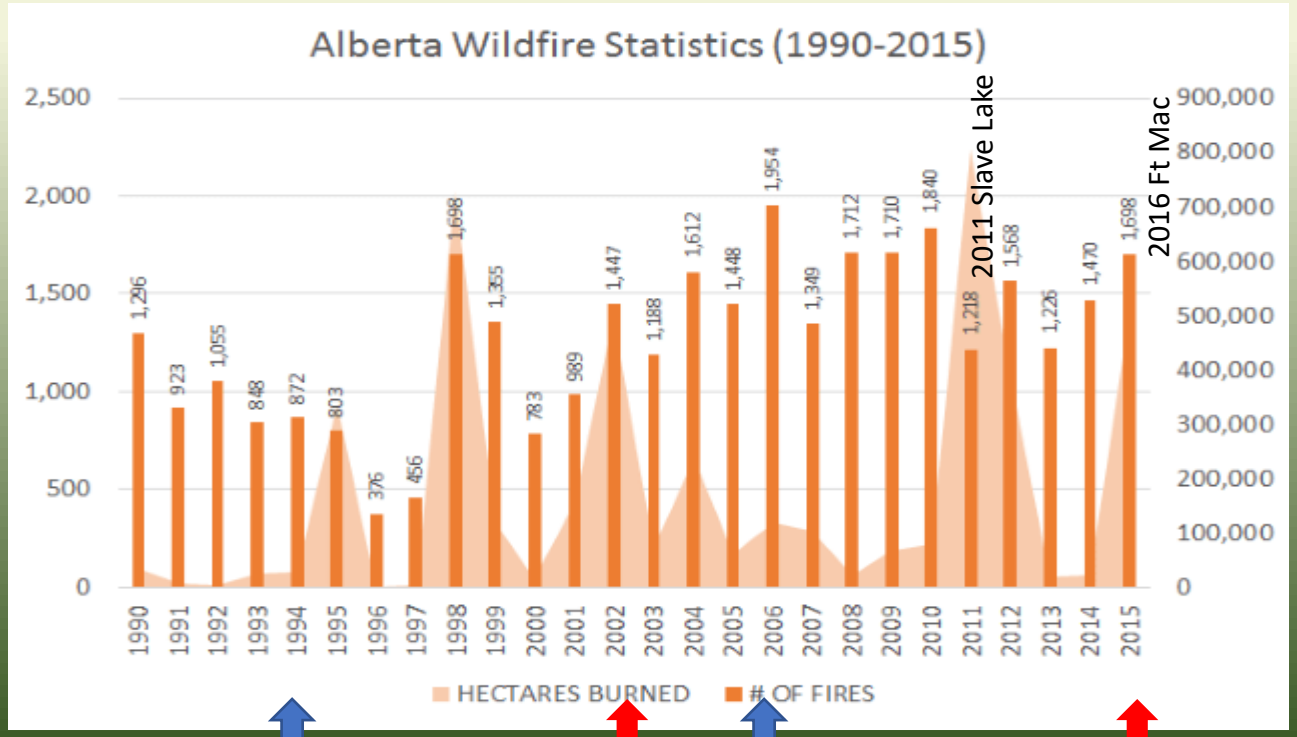
Arctic Oscillation





EXPERIENCE JOURNEYS

Correlation of climate cycles and forest fires.

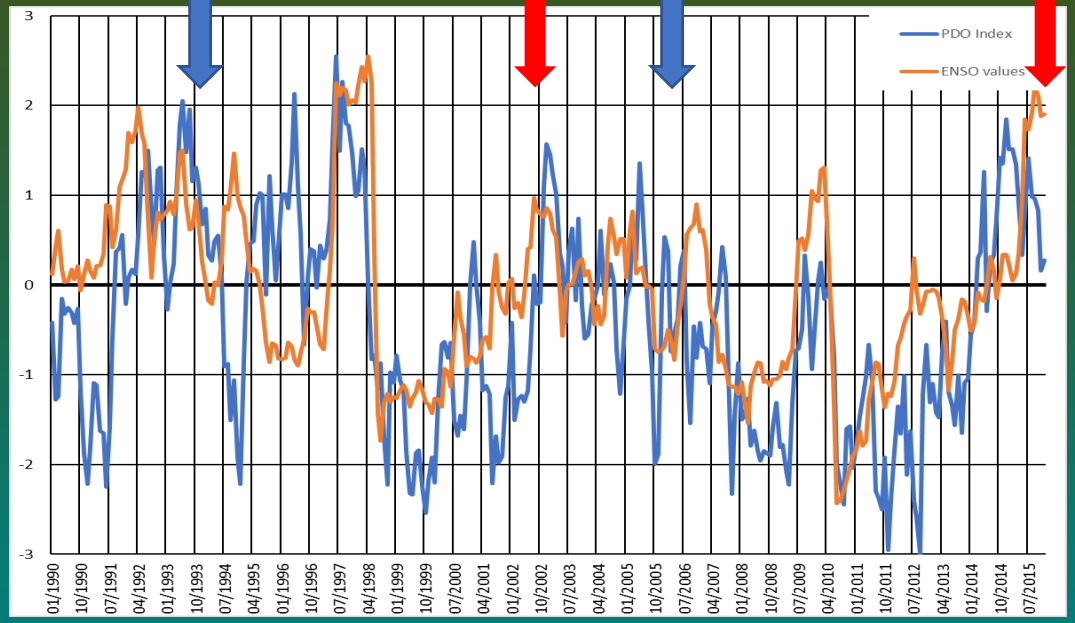


+ve PDO Dry Phase

+ve El Nino dry phase

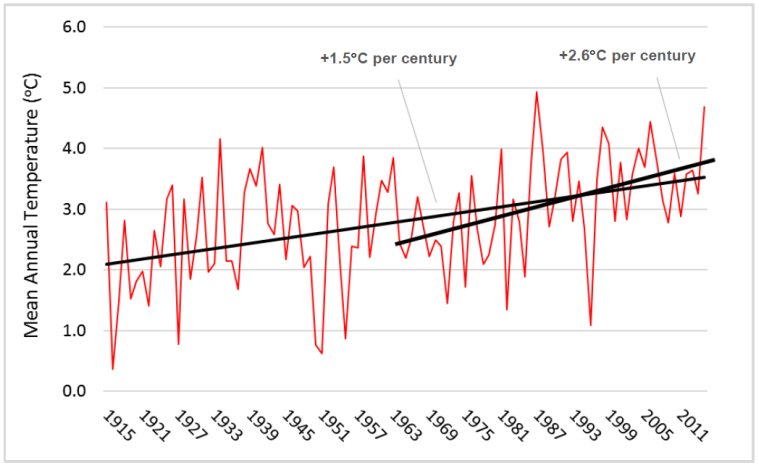
PDO and ENSO 1990-2015

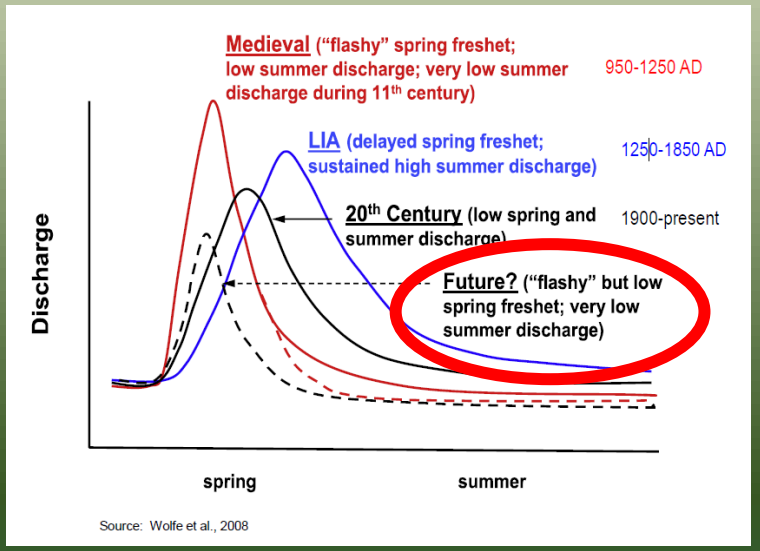
-ve La Nina wet phase

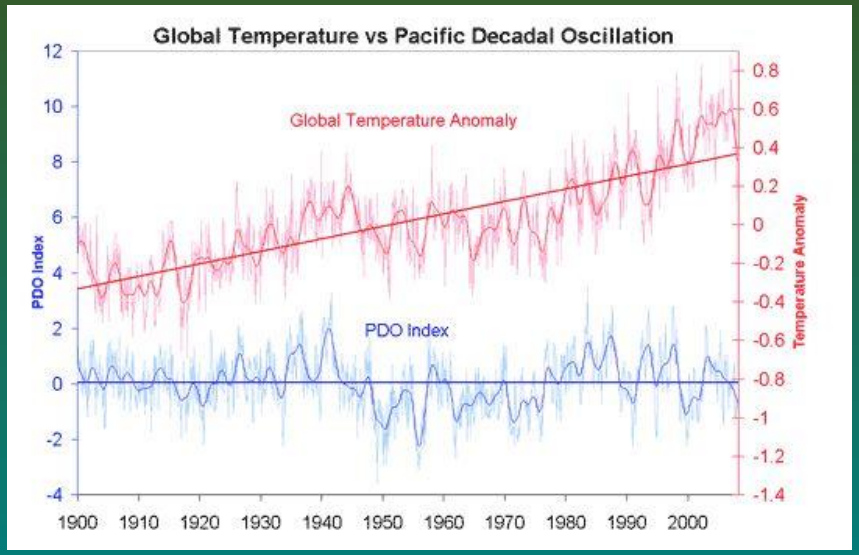


Current climate variations are the addition and subtraction of oceanic circulation cycles superposed on rising temperatures.

Figure 2: Mean Annual Temperature in the Bow Valley Corridor (1915-2015)

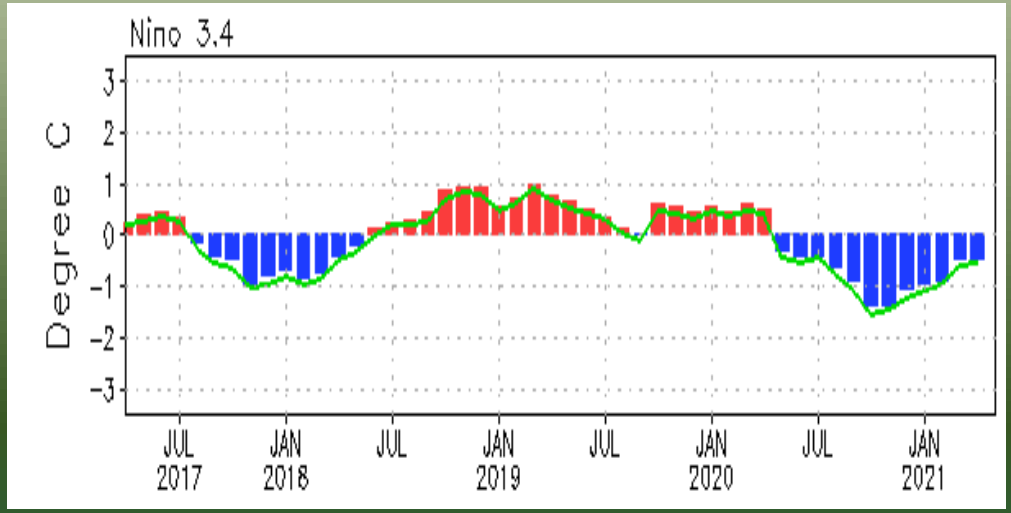


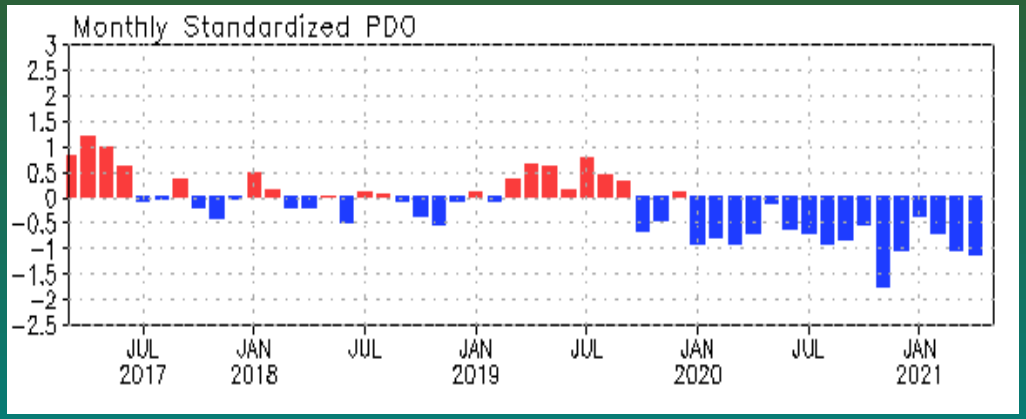




EXPERIENCE JOURNEYS

The Climate Prediction Center of the US National Oceanographic and Atmospheric Administration predicts the cool (-ve) phase of PDO will persist until the years end and turning +ve next year.





Conclusions 2

- Bar KC is fairly well situated for wildfires from SW EXCEPT for near structure firesmarting (especially white spruce).
- Large aspen and mixed aspen conifer stands limit wildfire spread.
- Pine Beetle infestation appears minor and lodgepole pines should recover with increased resistance.
- Any harvesting operations are not motivated by forest ecology but by landowner asset monetization.
- Logging operations or Btk spraying will significantly and negatively disrupt the forest ecosystem at Bar KC.
- Bar KC seems well situation for water due to glacial geology. However it Important to maintain moisture content of soils to limit increased fire and infestation hazard in the future due to climate change.