



# Mary Oliver

Sept. 10, 1935 – Jan. 17, 2019

She helped us stay amazed.
(Rachel Syme, *The New Yorker)*

"And that is just the point… how the world, moist and beautiful, calls to each of us to make a new and serious response. That's the big question, the one the world throws at you every morning. *Here you are, alive. Would you like to make a comment?*"

"Instructions for living a life.
Pay attention.
Be astonished.
Tell about it."


**When I Am Among the Trees**

When I am among the trees,
especially the willows and the honey locust,
equally the beech, the oaks and the pines,
they give off such hints of gladness.
I would almost say that they save me, and daily.

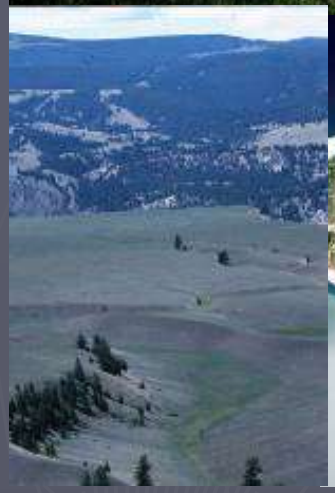
I am so distant from the hope of myself,
in which I have goodness, and discernment,
and never hurry through the world
but walk slowly, and bow often.

Around me the trees stir in their leaves
and call out, "Stay awhile."
The light flows from their branches.

And they call again, "It's simple," they say,
"and you too have come
into the world to do this, to go easy, to be filled
with light, and to shine."









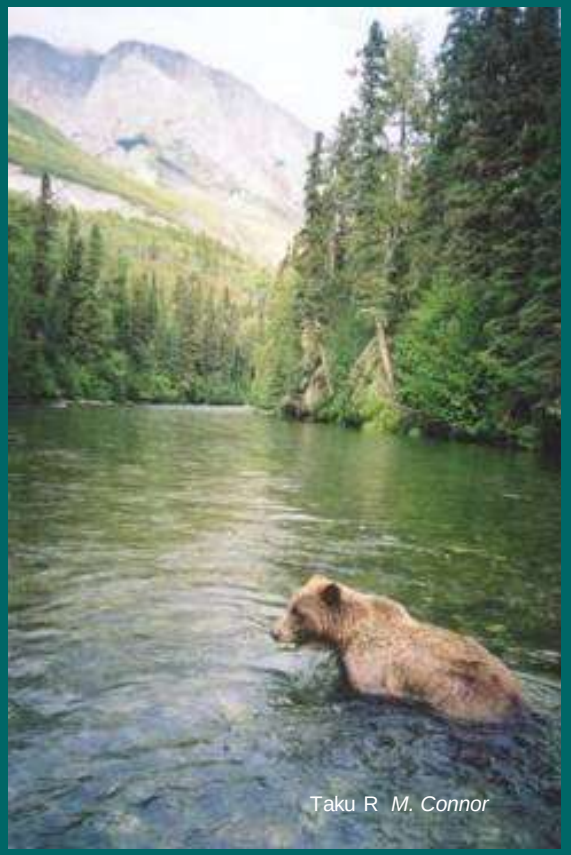

# British Columbia Is Special - Naturally




# Global Responsibilities

## Global stewardship

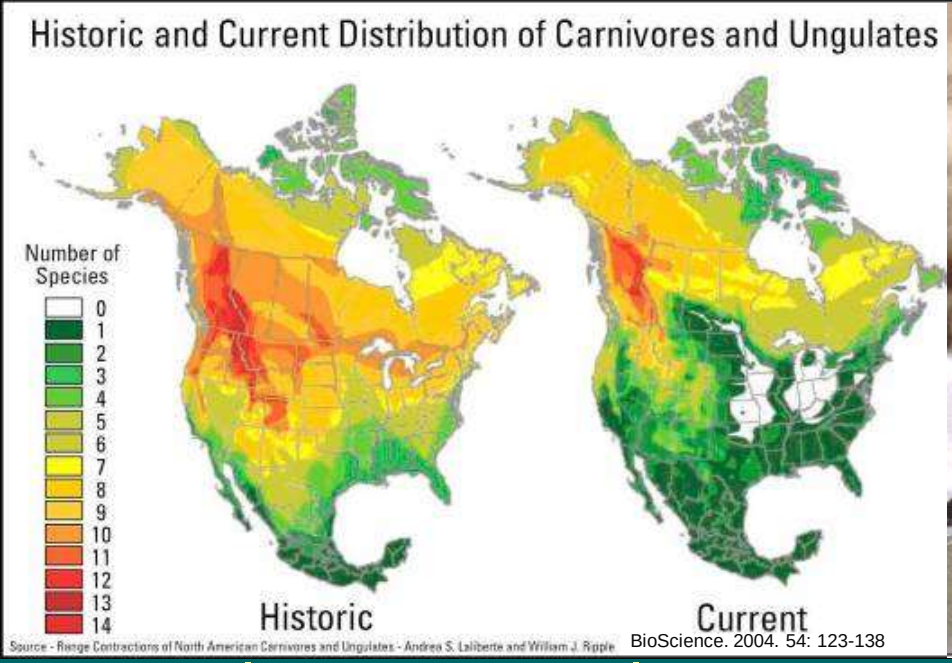
- grizzlies, goats, temperate rainforests, clean rivers & wild salmon, predator-prey systems, rich marine ecosystems, endemic species, ecosystem diversity & landscape complexity


Taku R *M. Connor*

## Don't pee in swimming pool

- Limit GHG emissions as our contribution to global reduction.
- *"BC is just 4.5 million people sharing a planet with 7 billion others. We have to be realistic about what our impacts would be."* (Premier John Horgan, 21 Aug 2018). Translation: *BC emissions don't really matter globally, so we're gonna pee (LNG) in the swimming pool. We can meet emission targets by decarbonizing other sectors.*


Burnaby Narrows *L. Horrocks*






# N Am large mammal species ranges collapse toward the northwest



# Big Enchiladas

## Landscape-level, ecological attributes of continental/global significance

- Large intact (roadless) areas; entire mountain systems & undeveloped watersheds
- Wild (unregulated) rivers
- **Temperate rainforests**, coast & interior
- Large-mammal predator-prey systems; refuge for large carnivores
- Populations of grizzly, thinhorn sheep, mtn goat, caribou, moose, wolf, cougar, lynx, wolverine, fisher
- Major North American flyways with important wetland staging & breeding areas for waterfowl
- Important populations of migratory bird species
- Connectivity from Pacific to Interior & beyond
- **Climate change sanctuaries & migration spaces**

VJ Krajina Eco-Reserve
Port Chanal, Haida Gwaii
*W. MacKenzie*

Despite significant degradation of Nature over past century, BC still has VH conservation values.

oldgrowth redcedars, Haida Gwaii
*brian eccles*

# Landscape-level, ecological attributes of national/international significance

**Healthy aquatic systems**

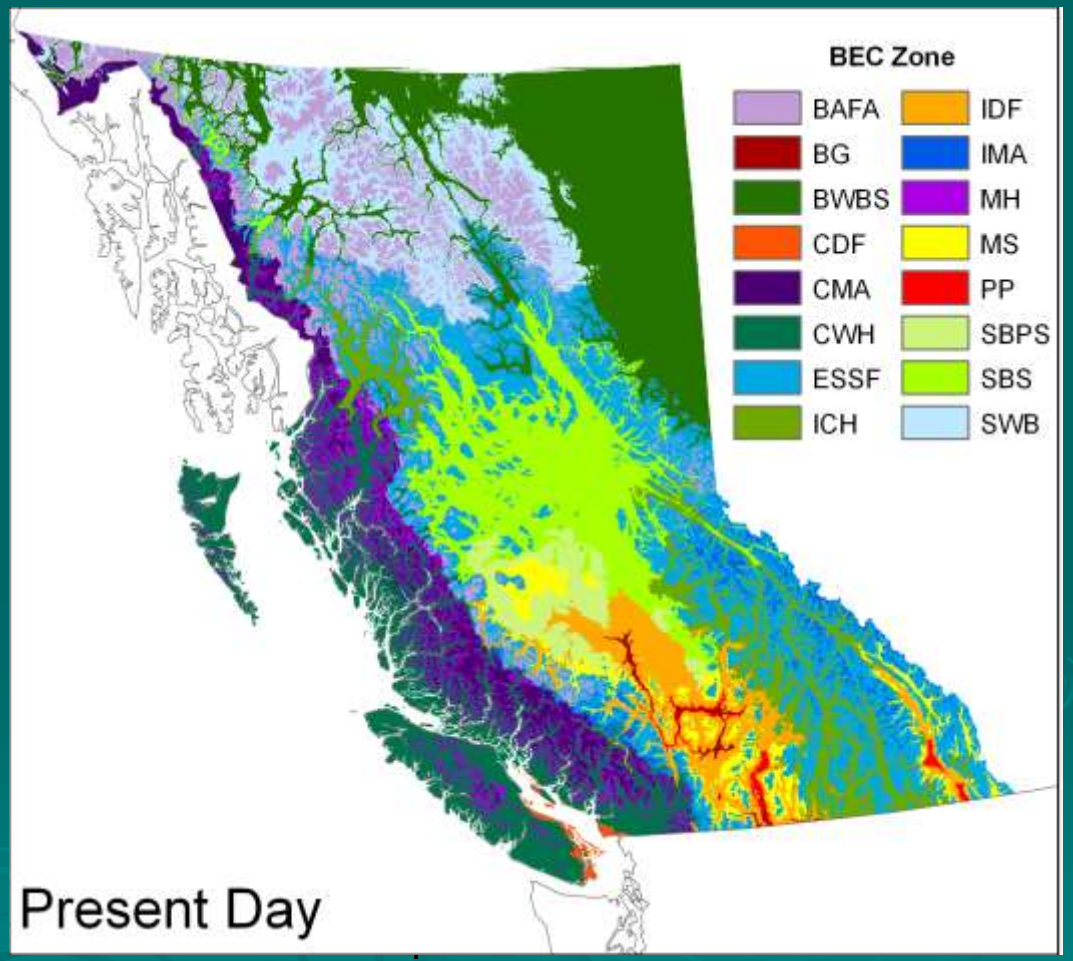
- Clean, free-flowing rivers
- Some healthy fish populations
- Clean lakes, all sizes
- Large intact watersheds (hydrologic connectivity)

Upper Skeena *J. Mikes*

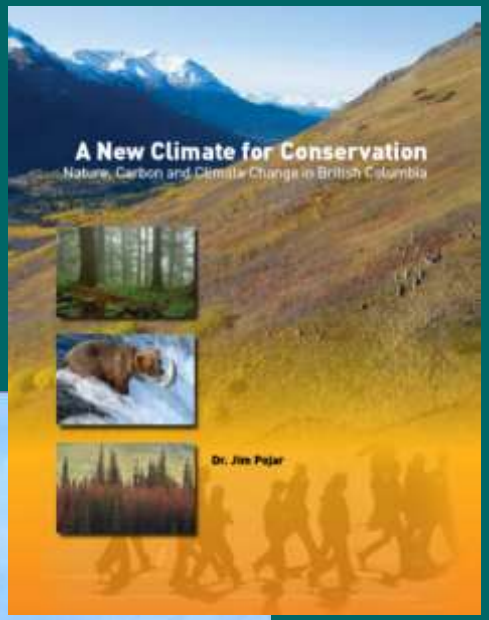
# Context

## Physical and Ecological Diversity

- Canada's most diverse province, physically & biologically
  - species richness not world class but VH for n temperate regions
  - # at-risk species also H relative to comparable jurisdictions
- Globally significant ***landscape complexity & ecological diversity***
  - 16 ecological zones, each with full range of habitats



# Integrate Nature Conservation & Climate Action




**Comprehensive B.C. Strategy**

- combine goals of biodiversity conservation & climate change action
- recognize fundamental role of ecosystem conservation in both adaptation & mitigation

Sifton Ranges from Finlay R.
*J. Mikes*

# Genetic Implications

Warming big trouble for genetically specialised, locally adapted NW conifers because:

- conditions change throughout range, not just at margins; will often exceed limits of temperature or moisture tolerances
- mortality induced by extreme events >> losses of genetic diversity
- Δ rate too fast for adaptive tracking response by long-lived tree species

Could lead to significant genetic erosion & forest decline for several forest generations.


lodgepole pine provenance trial *L. MacLauchlan*

# BC NEEDS TO GET ITS ENDANGERED SPECIES ACT TOGETHER

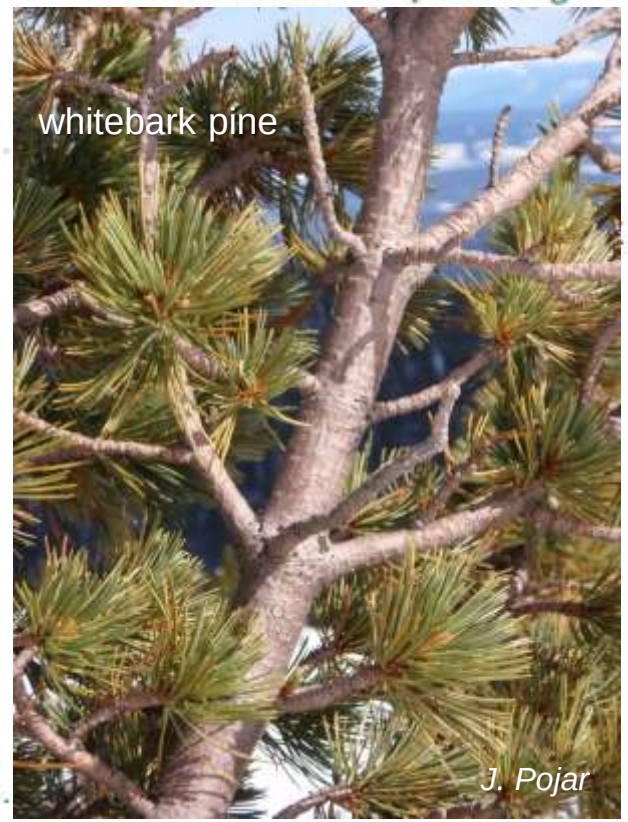
For the full report and list of supporters, visit
www.scientists-4-species.org

British Columbia has the *most biodiversity* of any province or territory in Canada and also *the most species at risk of extinction.*

It is one of only a few provinces with *no endangered species legislation*

**1807**
Species in decline

**278**
Species at risk of extinction




Westwood, A.R., Otto, S.P., Mooers, A., Darimont, C., Hodges, K.E., Johnson, C., Starzomski, B.M., Burton, C., Chan, K., Festa-Bianchet, M., Fluker, S., Gulati, S., Jacob, A.L., Kraus, D., Martin, T., Palen, W.J., Reynolds, J.D., Whitton, J. **2018. Protecting biodiversity in British Columbia: Recommendations for an endangered species law in B.C. from a species at risk expert panel.** Report prepared for BC Ministry of Environment & Climate Change Strategy. Available at www.scientists-4-species.org

# Landscape-level Implications

in S, grasslands & dry forests expand

near Penticton *J. Pojar*


*A. Nicholson*

Lac du Bois area near Kamloops *J. Pojar*

Downie Slide upstream of Revelstoke *J. Pojar*

in N, shift to warmer moister forests; boreal grasslands decrease?

# Implications

- ↑ Warmer water in rivers, lakes & ocean
- Cold-water fish decline
- Less snow, more rain (shoulder seasons) >>changes streamflow -- volume & timing
- Glacial systems differ … for a while

Taku River *M. Geertsema*

*D. Mackinnon*

# Natural Disturbances

- Increased frequency, intensity, impact
- More frequent extreme events
- Disturbance interactions & uncertainty

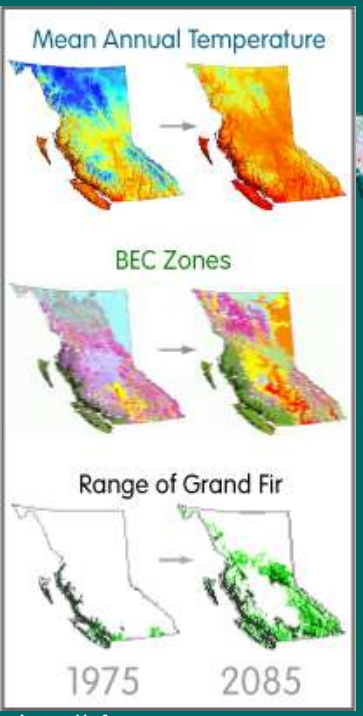
- As agents of change, shifting disturbance regimes & patterns as important as Δs in Temp & Precip.
- Landscape-scale disturbances & extreme weather events could shape transient & ultimate new ecosystems.

Swiss Fire 1983 *BCFS*

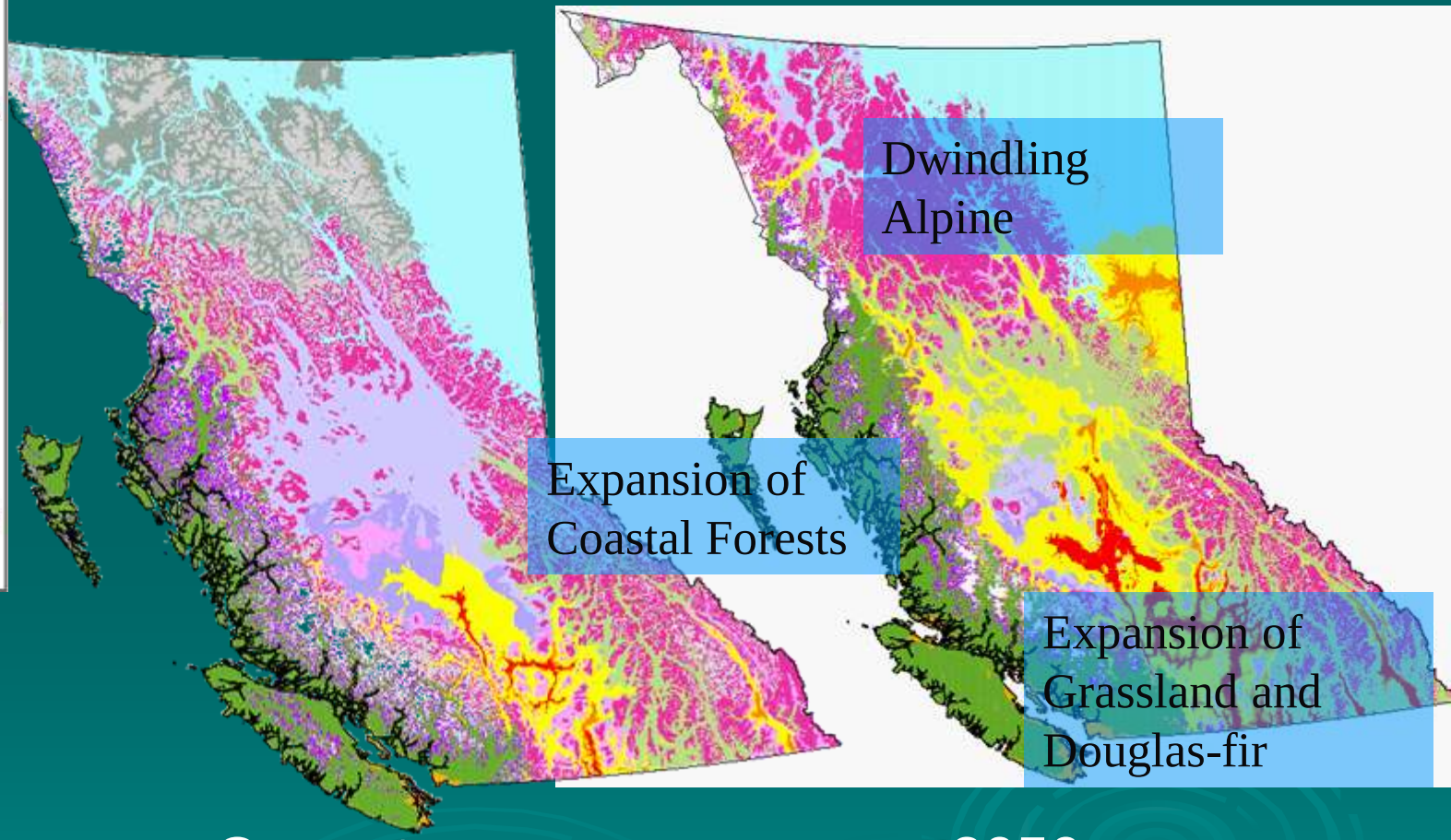
Hanceville-Riske Ck fire 2017 *BCFS*

Lodgepole pine landscape transformed by MPB, central B.C. *L. MacLauchlan*

# Modelling climate & bioclimatic envelopes




http://cfcg-forestry.sites.olt.ubc.ca/files/2013/01/Projects_bioclimatic_envelope.png




Hamman, A. and T. Wang. 2006. Potential effects of climate change on ecosystem and tree species distribution in British Columbia. *Ecology* 87: 2773-2786.


SBSmc


ICHmc
J. Pojar


IDF


ICH

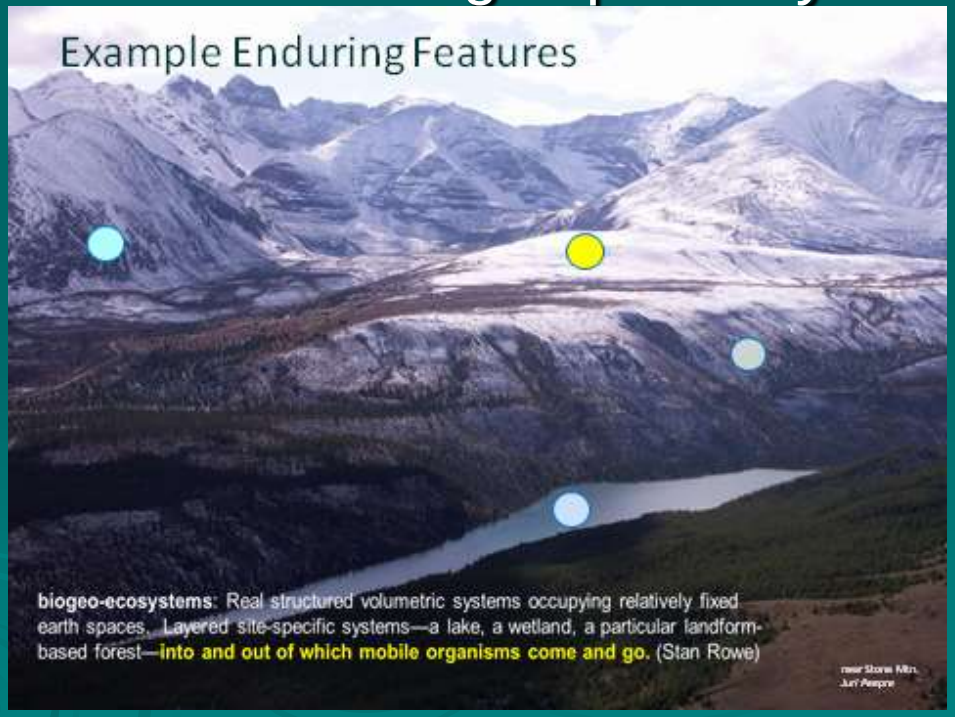
# Ecological Upheaval

- Ecosystems don't migrate, species do—largely independently.
- Species confronting rapid environmental change will either a) be extirpated or b) survive—by acclimatizing, evolving, or migrating to suitable habitats elsewhere.
- Species moving (if they can), doing own thing; will reassemble in suitable habitats elsewhere, likely in different combinations, some novel.
- Most species cannot move fast enough to keep up with projected changes.

# Invest In Connectivity

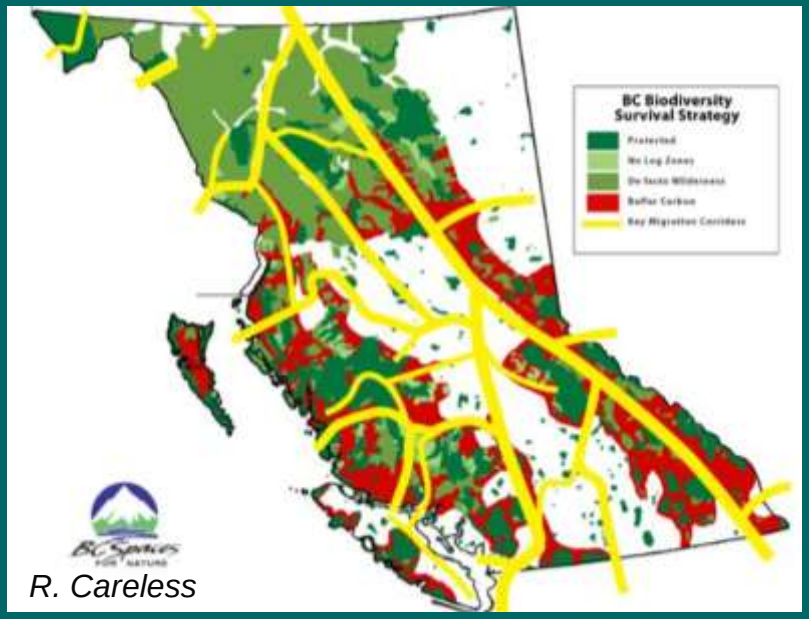
## Broaden core protected areas into a climate conservation network.

- Connections to facilitate gene flow & adaptation to cc.
- Complement existing PAs of 15% (gov't claims area conserved 30%) with additional areas managed primarily for biodiversity & carbon.
- Include large biophysical stage, on which ecological drama can play out (>> 'enduring features').
- Connectivity supplemental to core protected areas; it's not a substitute.

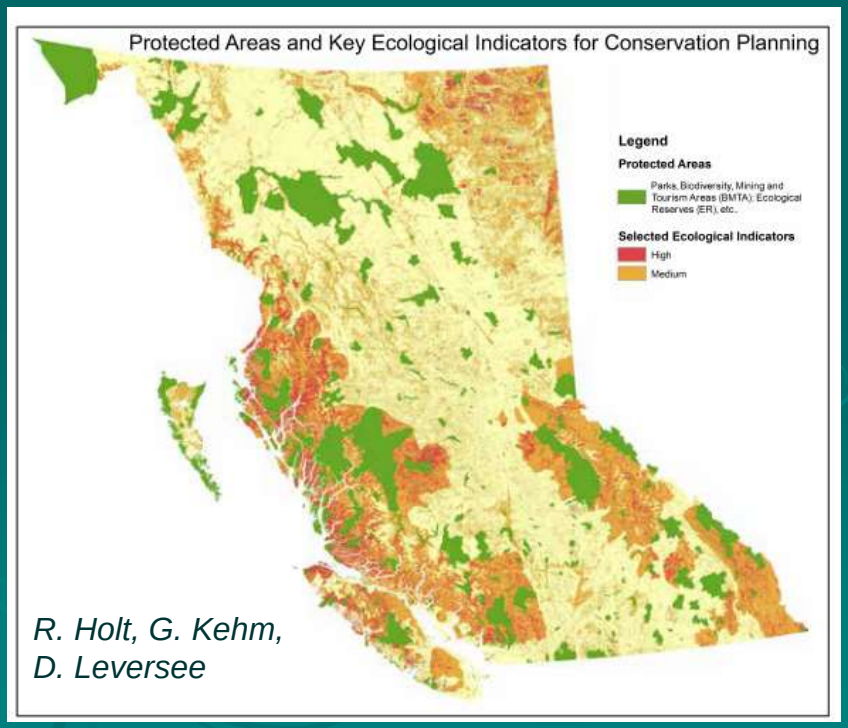


# Connectivity & Trans-regional Linkages

- Latitudinal, longitudinal, **elevational**
- Primary river corridors and major watersheds
- Hydrologic connectivity among rivers, streams, lakes, and wetlands.
- Linkages to existing PAs or unprotected wildlands & vital habitats, beyond province




*R. Careless*



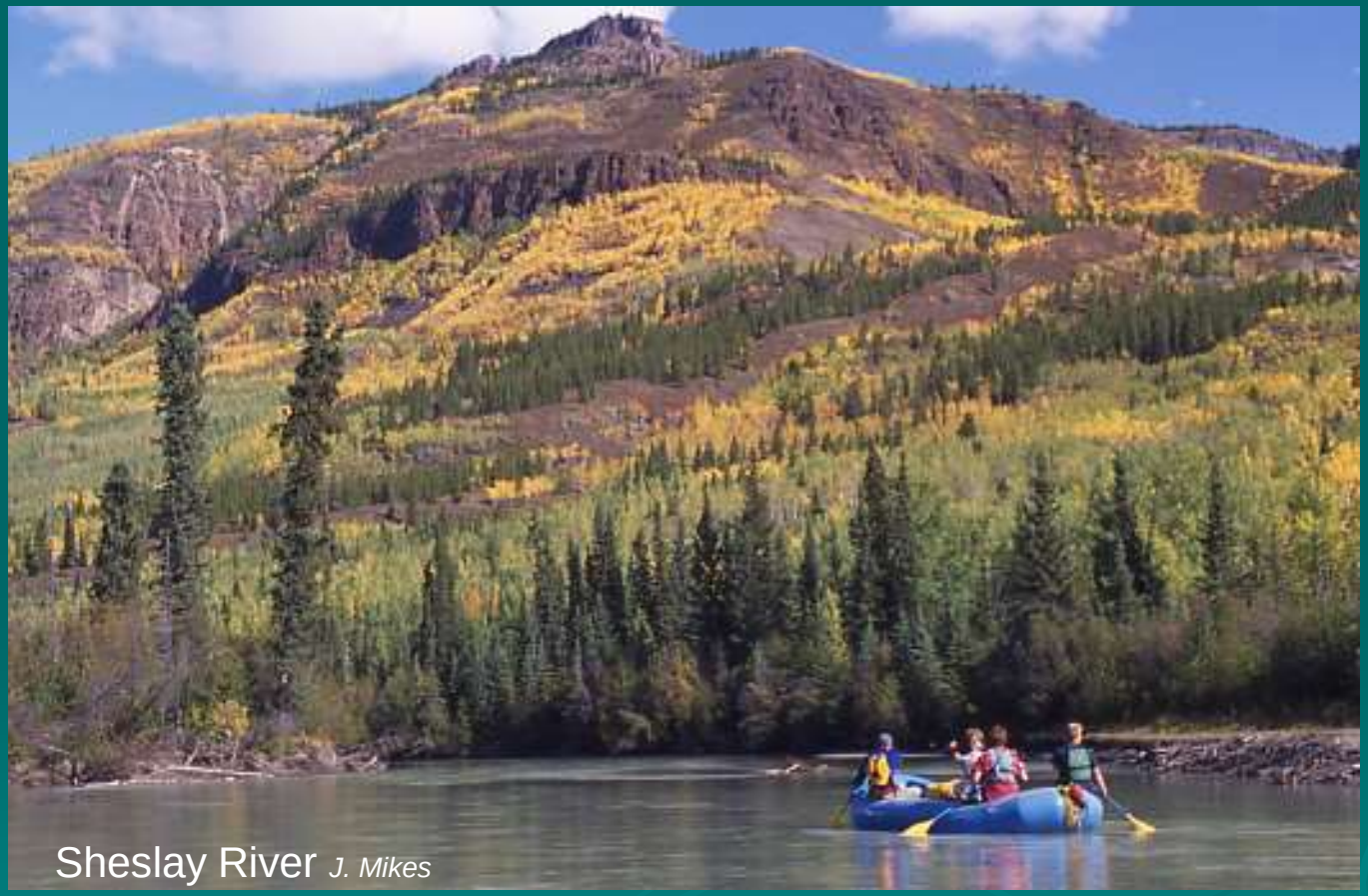

*R. Holt, G. Kehm, D. Leversee*

Sierra Club BC. 2015.
*THE FUTURE IS HERE*

# “Climb the mountains and get their good tidings.”

*John Muir*

## elevational connectivity - valley floor to ridgetop

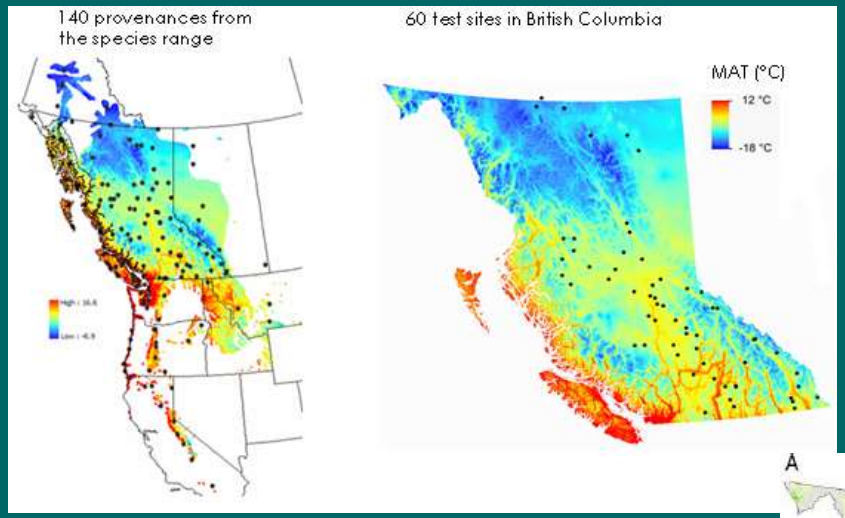


Sheslay River *J. Mikes*

"The elevational compression of biomes causes mountains to become hot spots of biological diversity. ... on a 100 km grid scale, no landscape can beat the biological richness of mountains. Nowhere else is it possible to protect and conserve so much biological diversity within a relatively restricted region, than in mountains...."[1]

[1] Korner, C. & E.M. Spehn. 2002. *Mountain Biodiversity: A Global Assessment*. The Parthenon Publishing Group, New York

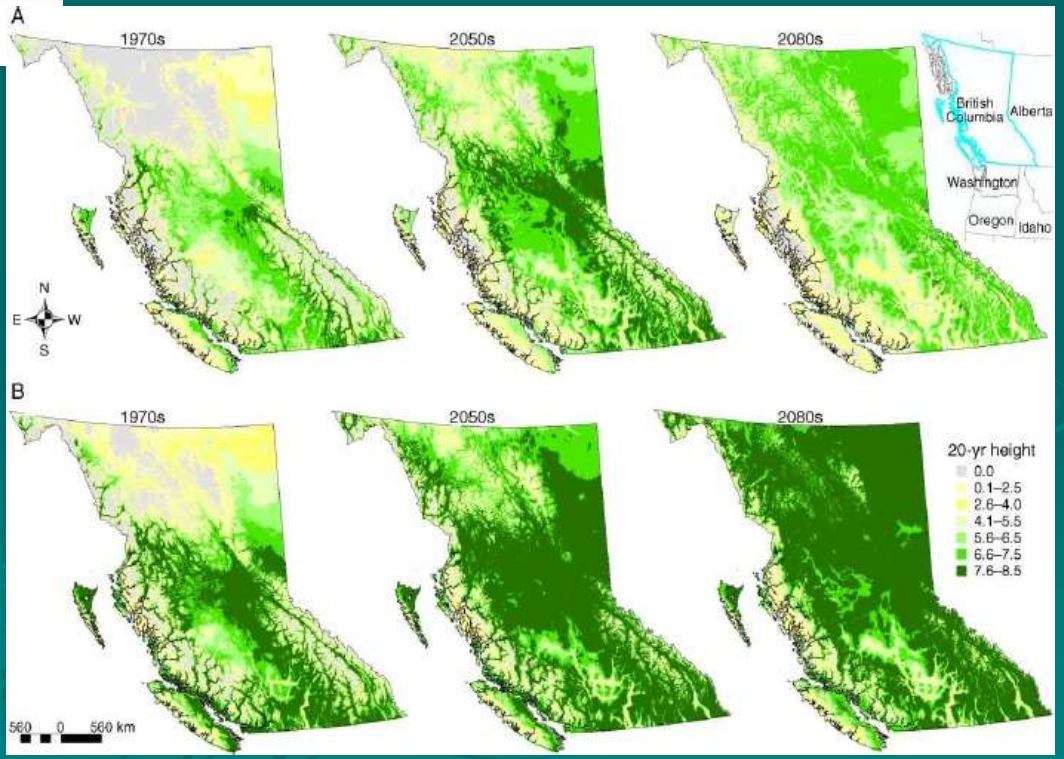
# Lodgepole Pine growth response to climate



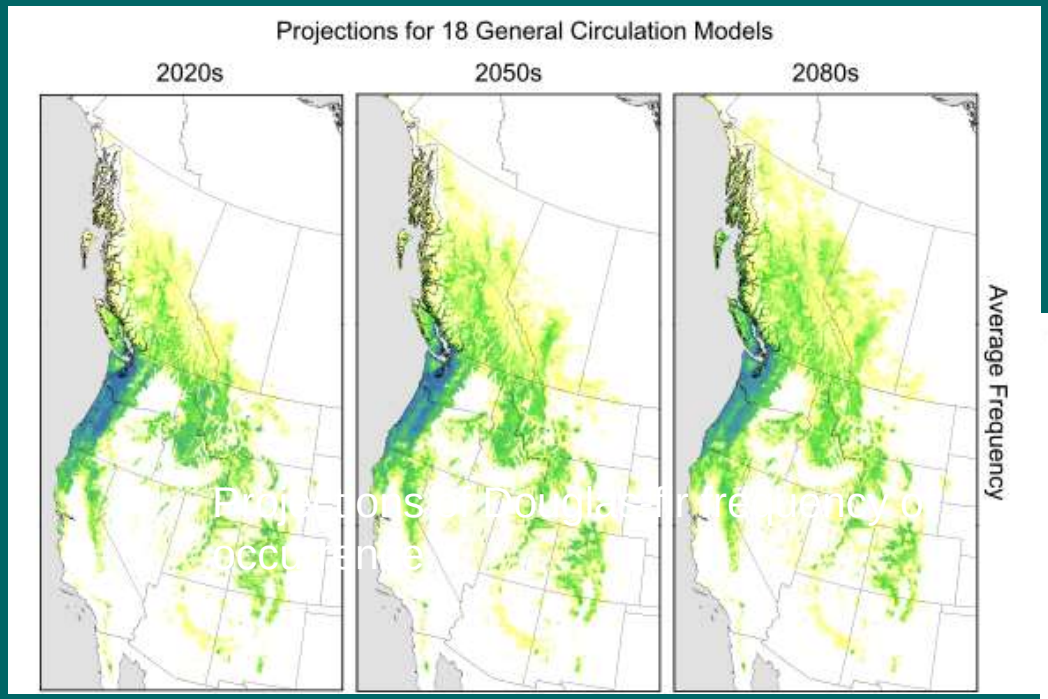

Wang, T., O'Neill, G., Aitken, S.N., 2010. Integrating environmental and genetic effects to predict responses of tree populations to climate. *Ecological Applications* 20: 153-163.

using local seed

using optimal seed

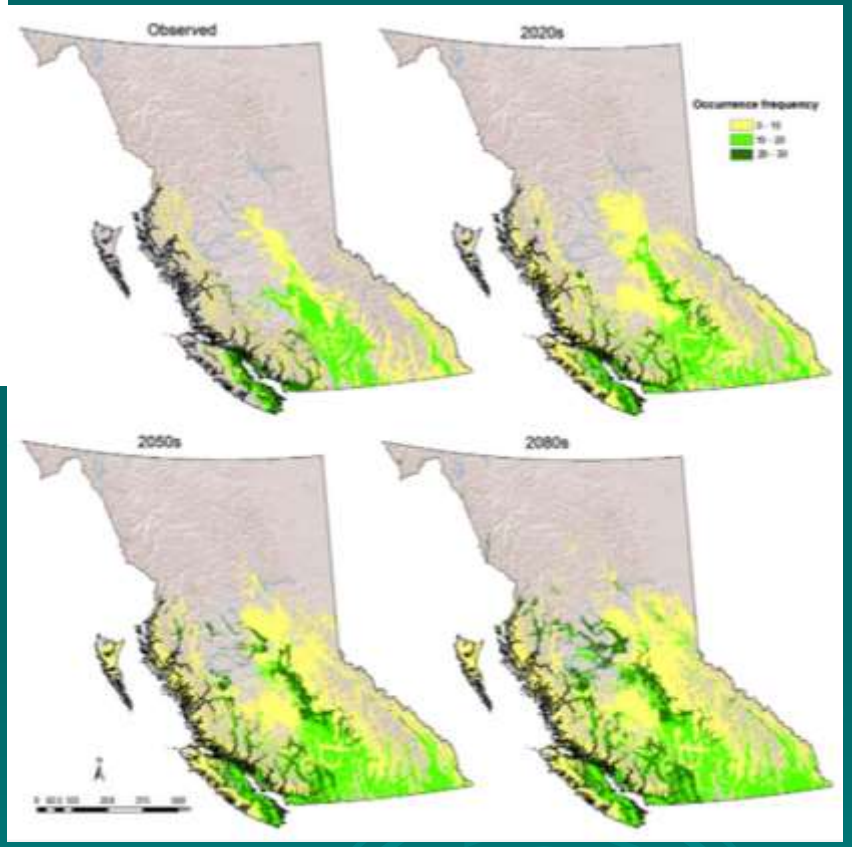


# Scenarios & Back-casting




Projected Douglas-fir ‘habitat’ & frequency under future climate scenarios.

Gray, L.K., A. Hamann. 2013. Tracking suitable habitat for tree populations under climate change in western North America. *Climatic Change* 117:289–303.




Projections of Douglas-fir frequency of occurrence.

T Wang, EM Campbell, GA O’Neill SN Aitken. 2012. Projecting future distributions of ecosystem climate niches: Uncertainties & management applications. *Forest Ecology and Management* 279: 128–140.

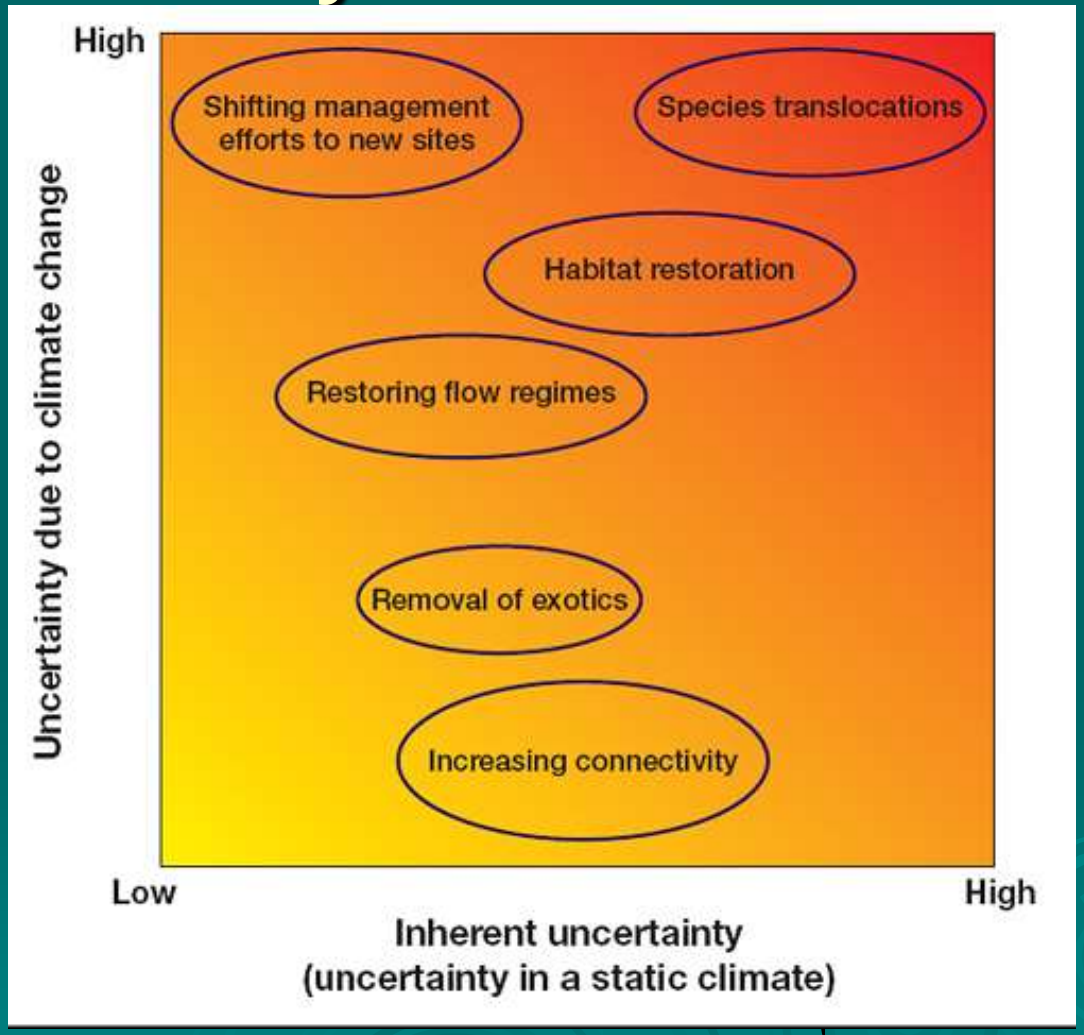
# Adaptational Lag >> Assisted Migration?

## Uncertainty requires short-term adaptation strategies

- uncertainty in projections dramatically increases towards 2080s
- seedling stage most vulnerable to climatic factors; can't plant now, genotypes optimal for 2080s climate
- long-distance transfers (2080s projections) are gambles (unforeseen issues; e.g., required mycorrhizae, changes to day length regimes that control species' phenology)
- best chance seed transfers 1997–2006 & 2020s projections; tree populations will continue to lag behind their optimal climate, targeting current & 2020s climate conditions still a low-risk improvement over status-quo mgmt that targets climate conditions of past century
- test different species or different genotypes that could be better adapted to new climatic realities (species & provenance trials)

Gray & Hamann. 2013.

# Management Strategies and Uncertainty of Their Outcomes

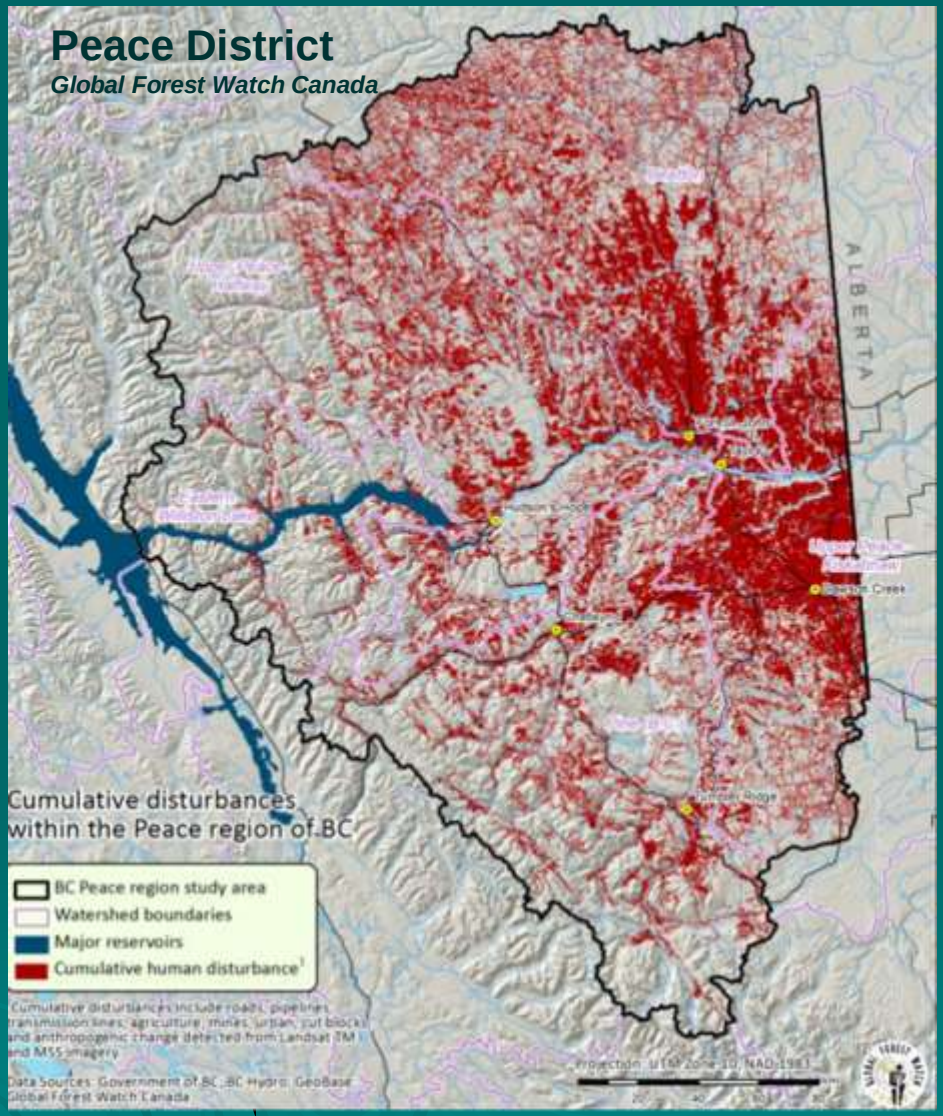



Lawler, J.J. et al. 2010. Resource management in an uncertain climate. *Frontiers in Ecology and Environment* 8: 34-43.

# Not Just Climate Change

- destruction & modification of natural habitats by land-use change a chief immediate threat to biodiversity
- past 25 years: 85%+ scientific "biodiversity scenarios" relied on simulations that project only changes in climate
- emphasis must move beyond focus on climate-change impacts

Titeux, N. *et al.* 2016. Climate change distracts us from other threats to biodiversity. *Frontiers Ecol. Evol.* 14: 291.



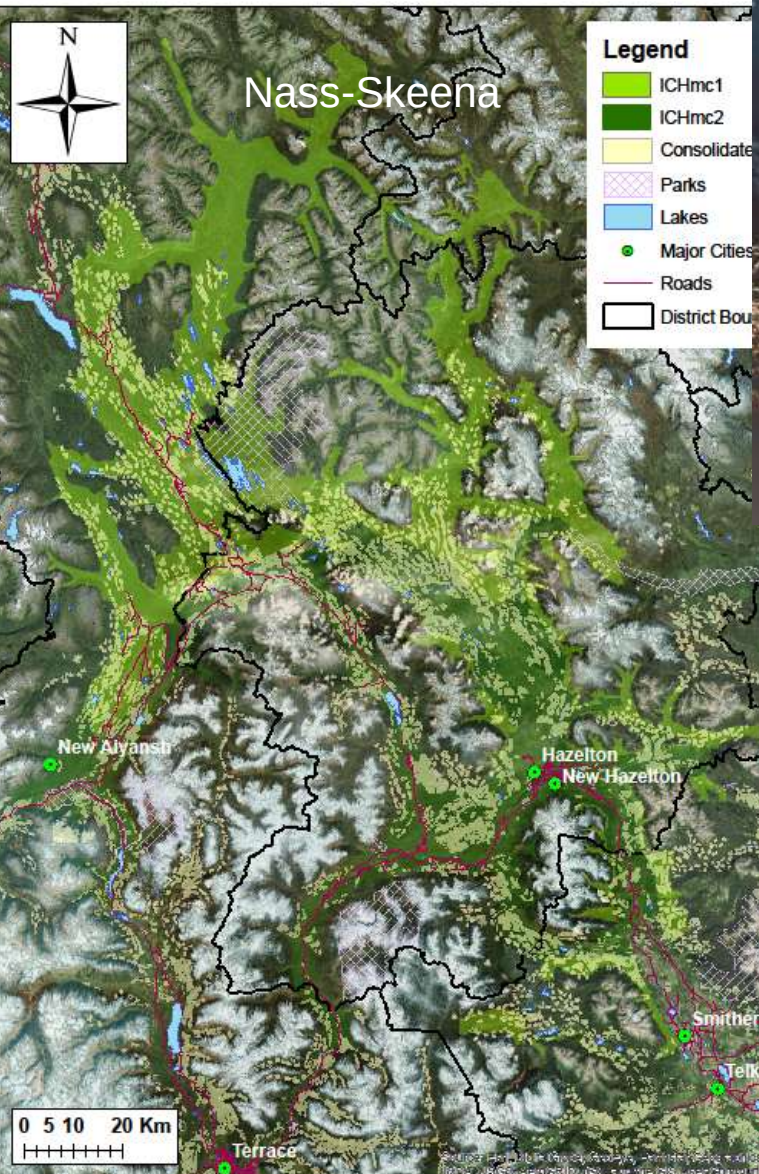

Big threat not climate change acting in isolation; combination with other human footprints.



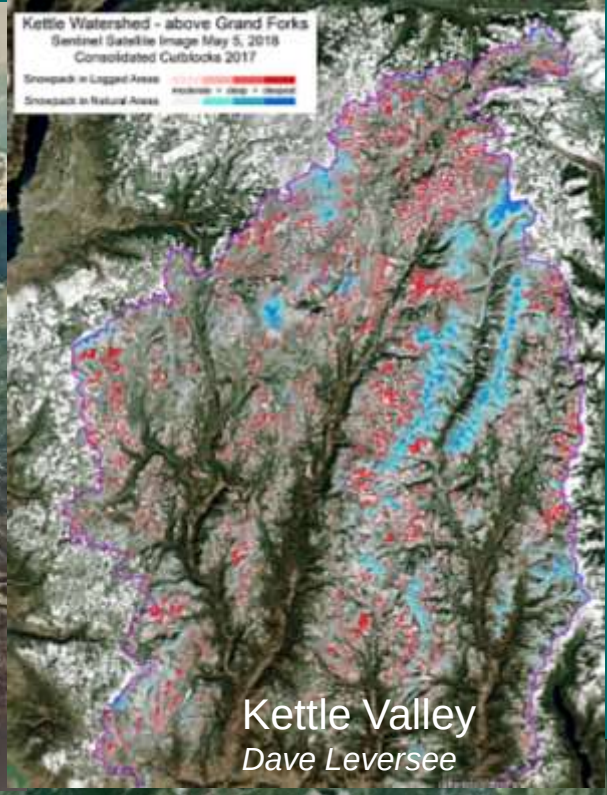
Ecosystem responses complex & difficult to predict.

Reflect ∑ effects of Δs climate, natural disturbances, land & resource uses, and invasive species.

# Clearcuts, roads, stream crossings everywhere








# Old-Growth Forests

- Highly valued by public.
- High biodiversity values.
- Effectively non-renewable
- Store billions of  tonnes of carbon, many X more than province's annual GHGs.
- Also sequester carbon.
- Logging  >> severe losses to C stocks; also lower rates of uptake for decades.
- Some OG should be removed from Timber Harvesting Land Base.

Tow Hill Ecological Reserve, Haida Gwaii *H. Roemer*

# Strategic Conservation

- Model-based change scenarios give insights, but inherently uncertain.
- Difficult to project Δs at regional & finer scales; unwise to rely heavily on such scenarios.
- Evaluate what we know about:
  - species (including invasives), ecosystems, & ecological zones of greatest concern
  - sensitivity of target organisms & ecosystems
  - key ecosystem features & processes
  - synergies with other threats
  - what realistically can be done to maintain viability of species & integrity/resilience of ecosystems in light of multiple threats.



OG redcedar n Van. Is


*Bromus tectorum* cheat grass

# Revamped Nature Conservation

- Eco-portfolio diversification —risk mgmt
- Maintain ecological & evolutionary processes; enable ecosystems to self-adapt & reorganise.
- Reorient from historical or *status quo* distributions & abundances toward:
  - a) maintaining well-functioning, resilient ecosystems of sometimes novel composition that continue to deliver ecosystem services
  - b) focus on selected biodiversity elements of concern (not just species at risk)
  - c) retaining a diversity of (native?) species & ecosystems
  - d) triage (priorized treatment)


Collared Pika
*J. Peepre*


*J. Pojar*


Selkirk Mtn Caribou
*Bart George*
*Kalispel Tribe*

# Dual Strategy for Conservation & Climate Change Adaptation

1) Near-term (ensuing decades): focal and at-risk species; maintenance of habitat connectivity based on focal species biology + contemporary land cover & patterns of productivity.

2) Long-term (centuries) conservation planning: focus on **enduring features,** in addition to scenarios of individual species and their habitat.

Conserve the **stage** and (some of) the **actors**.

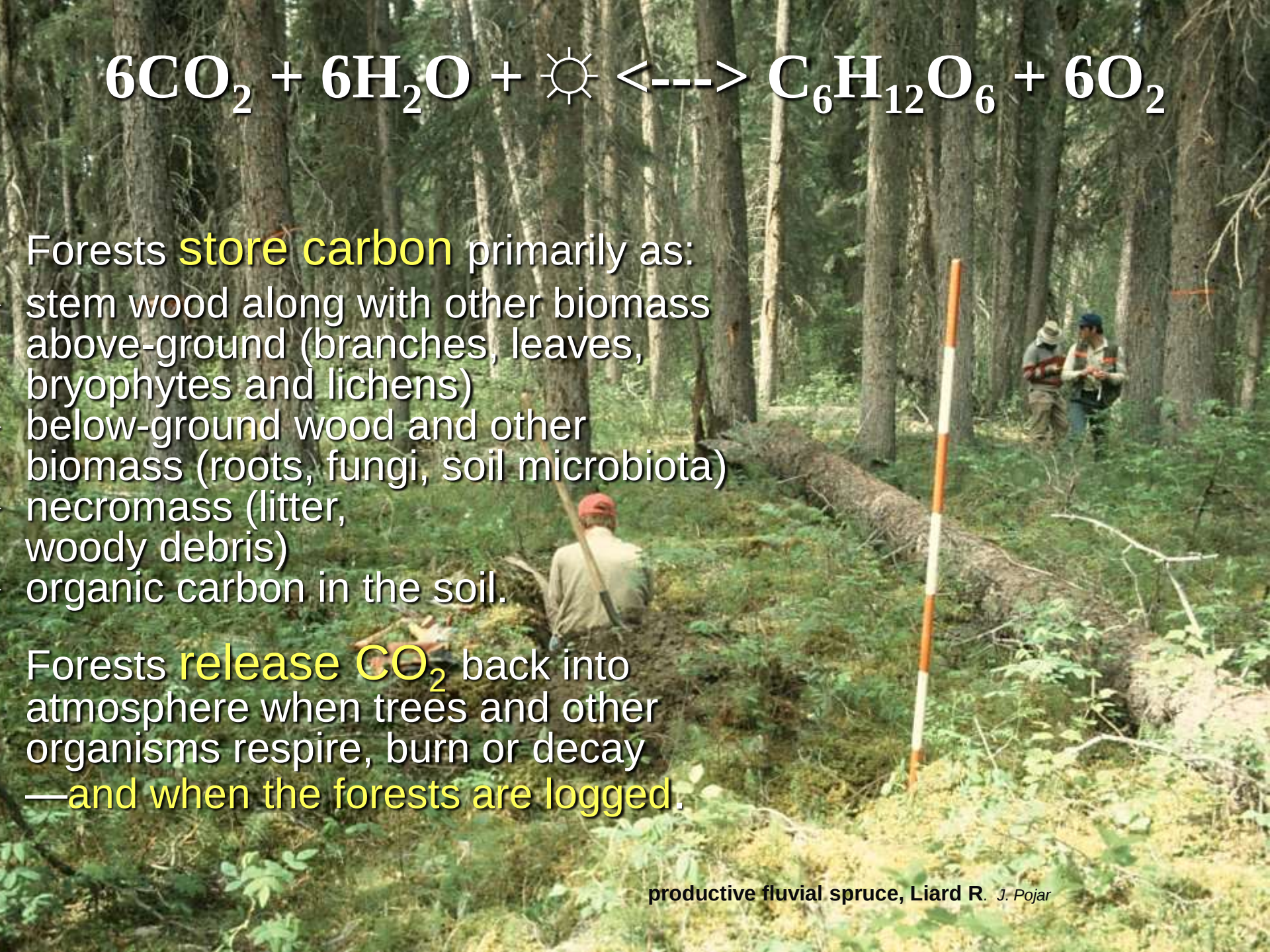
Need a variety of approaches and tactics, to get as much biodiversity as possible through "big squeeze" of climate change to end of this century.

Finlay River *J. Mikes*

# Climate Change: It's Now or Never

- **Only 10 years** to **mitigate some of the worst effects** of climate change (IPCC).
- 20-30 years to avoid 1.5$^{o}$ C threshold and forestall runaway climate warming.
- Must achieve **net zero emissions** by 2040 or 2050.
- **Imperative to reduce/avoid carbon emissions now**, not hope for increased rates of carbon uptake & recovery of storage 30-80+ years from now.


*News Agency/Hanna Franzen via Reuters*



$$6CO_2 + 6H_2O + \text{☼} \text{ <---> } C_6H_{12}O_6 + 6O_2$$

Forests store carbon primarily as:

stem wood along with other biomass
above-ground (branches, leaves, bryophytes and lichens)
below-ground wood and other biomass (roots, fungi, soil microbiota)
necromass (litter, woody debris)
organic carbon in the soil.

Forests release $CO_2$ back into atmosphere when trees and other organisms respire, burn or decay —and when the forests are logged.

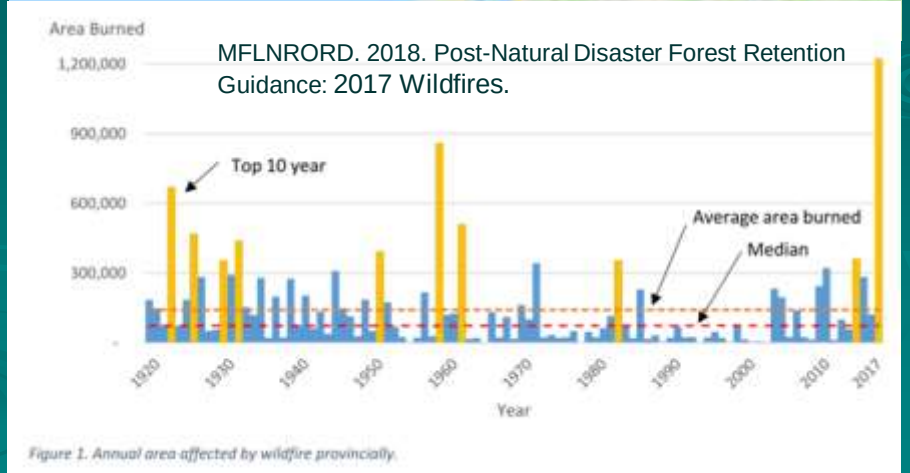
**productive fluvial spruce, Liard R.** *J. Pojar*

# Forest/Carbon Dynamics

- In terms of cc mitigation, benefits of carbon storage by intact natural forests immediate & greater than future storage in wood products. Currently stored C has much greater **time value**. Replacing persistent, old, carbon-rich forests with juvenile plantations makes no sense in present dire circumstances.
- When forests logged & soils disturbed, they release C to the atmosphere immediately; net release continues for decades and sometimes for over a century.
- Logging results not only in losses to existing carbon stocks, but also in lower rates of uptake for one to several decades, until net C uptake in secondary forest returns to pre-harvest rates.
- Industrial strength forests store less C than natural forests. Managed forests may never attain original C storage levels>>permanent carbon debt.
- Whether BC forests are a net source or a sink, they continue to store megatonnes of carbon as long as they still have trees on site—even if the trees are dead.

# Repurposed Mantra

"Our forests will all soon burn up, fall to beetles, or blow down anyway. So we should quickly log much more, store the carbon in long-lasting wood products and landfills, use the logging debris for biofuel, and promptly reforest cutover areas to take up more carbon."

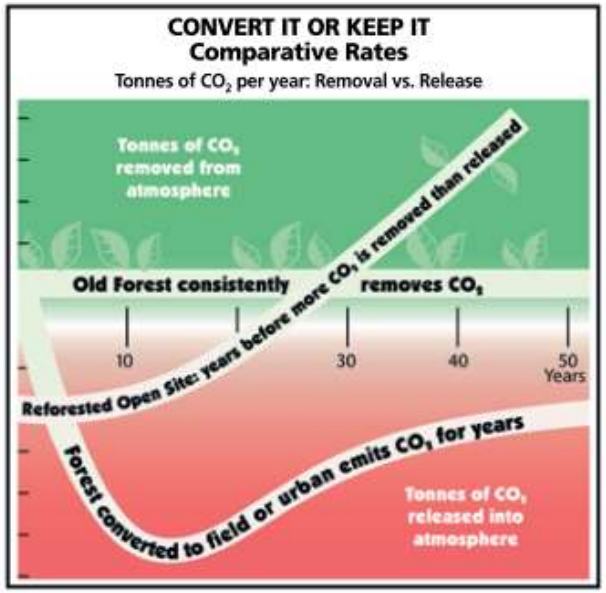




MFLNRORD. 2018. Post-Natural Disaster Forest Retention Guidance: 2017 Wildfires.

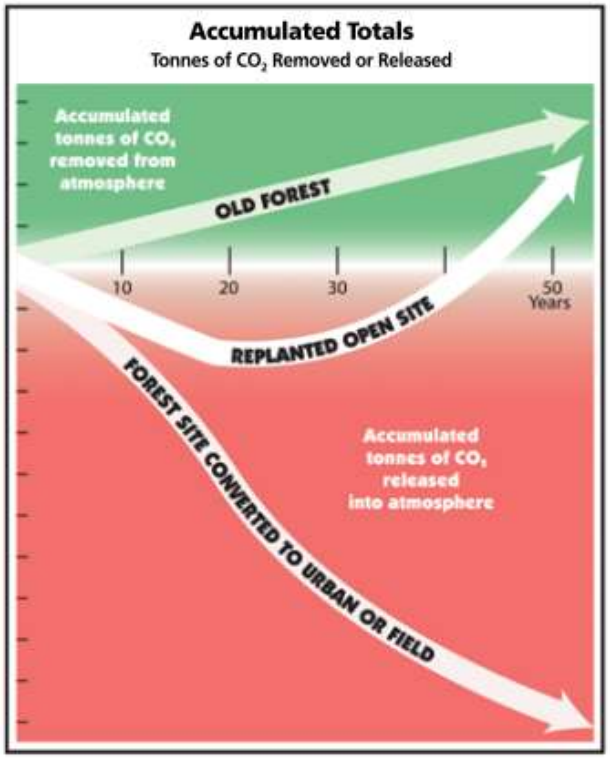
*Figure 1. Annual area affected by wildfire provincially.*

# Forest Carbon Stewardship

Uptake & Emission




Storage




source: Concept Richard Hebda, graphic Patricia Walker

Wilson, S.J. and R.J. Hebda. 2008. Mitigating and Adapting to Climate Change through the Conservation of Nature. The Land Trust Alliance of British Columbia, Saltspring Island, B.C. 58 p.

- more conservation (especially old carbon-rich forests)
- less conversion
- less logging
- more extended rotations
- more partial cutting & less clearcutting
- more reforestation, rehabilitation/ restoration

# Poison Pill: Overcutting + Chronic Highgrading

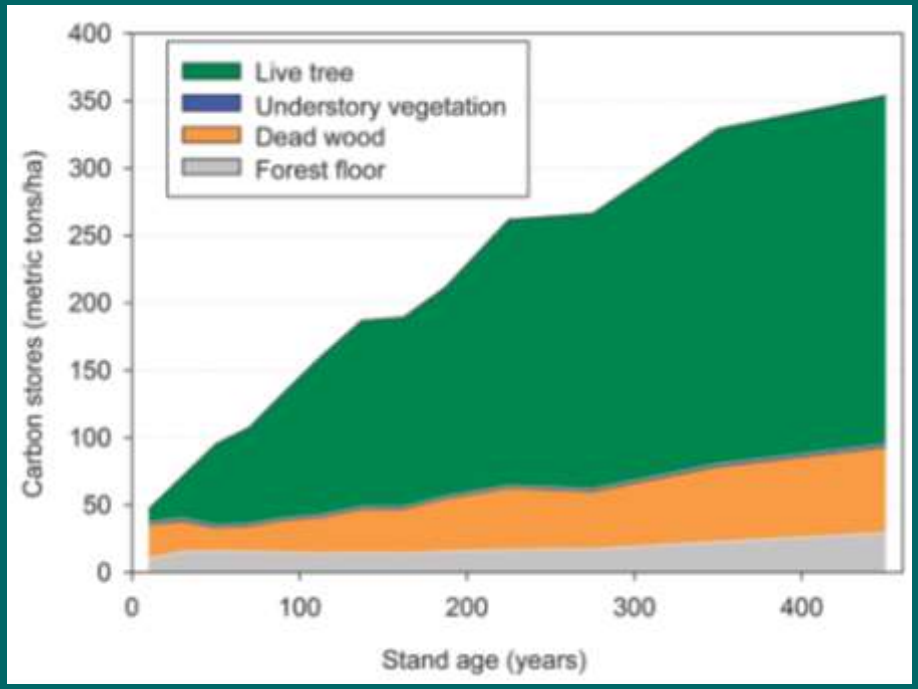
"Historically, harvesting concentrated on low elevation, younger timber types … lower cost stands of the highest sawlog component. Even when pulp markets were strong, harvesting concentrated on highest quality stands … sustain local sawmills. Currently … licensees unable to economically harvest stands of a high pulp component … are focused on stands of high sawlog content."

**Fred Philpot. 2005.** Landscape Unit Plan (LUP) for all Gitanyow Traditional Territories within Kispiox & Cranberry Timber Supply Areas

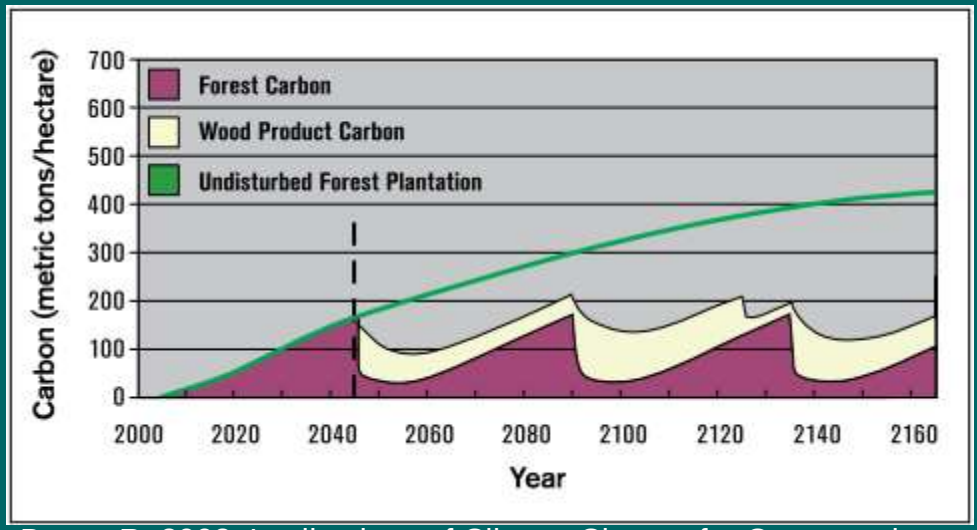
## Consequences:

- Skewed harvest of timber profile
- Mill closures
- Sympathetic administration
- Whole log exports
- Kispiox wood to Terrace, Burns Lk
- ↑↑Waste (logging residues)
- 'Clearcut selection' logging
- Biomass blunder
- Pressure on timber in sensitive areas and in distant or marginal stands

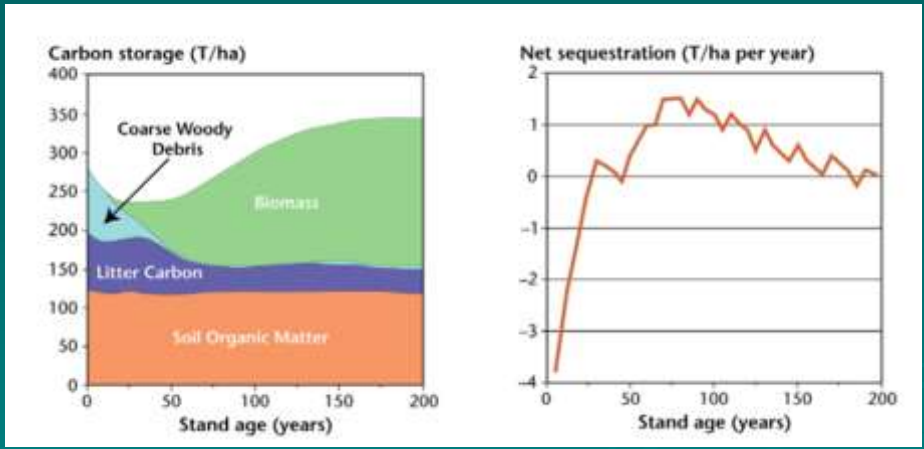

**Burn piles, Kispiox Valley near McCully Creek**



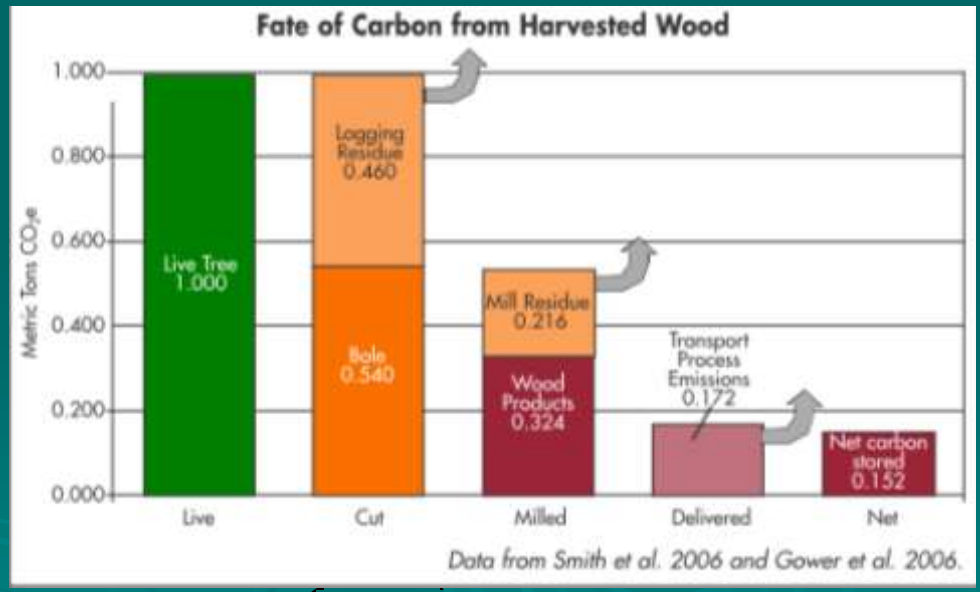

Gray A, Whittier T. 2017. There's carbon in them thar hills: But how much? Could Pacific Northwest forests store more? Science Findings 195. USDA For. Service, PNW Res. Stn., Portland, OR.




Brown R. 2008. Implications of Climate Change for Conservation, Restoration, and Management of National Forest Lands. Rep. for Nat'l Forest Restoration Collaborative, Portland, OR. 32 p.




Greig M, Bull G. 2008. Carbon management in British Columbia's forests: Opportunities and challenges. Forrex Series 24, Kamloops, BC.

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# What About Bioenergy From Wood?

## Do wood pellets fight climate change?

http://www.pinnaclepellet.com

- Makes economic sense as secondary industry utilizing mill debris.
- Large-scale production of bioenergy from forests is not carbon neutral, sustainable, or environmentally friendly.
- Wood is renewable but trees grow slowly. Burning pellets releases $CO_2$ almost instantly; regrowth of wood takes >75 years in BC.
- Wood also has low energy density. For equal heat, you must burn more woody fuel than fossil fuels, giving off more $CO_2$.
- Burning wood pellets will not help reduce GHG emissions by 2050.
- Pellets *could* help reduce air pollution from slashburning & fire hazard from logging debris left in the bush. Domestic use of pellets for heating would reduce air pollution in rural communities if pellet stoves replaced inefficient, traditional wood stoves & fireplaces.

# Solutions?

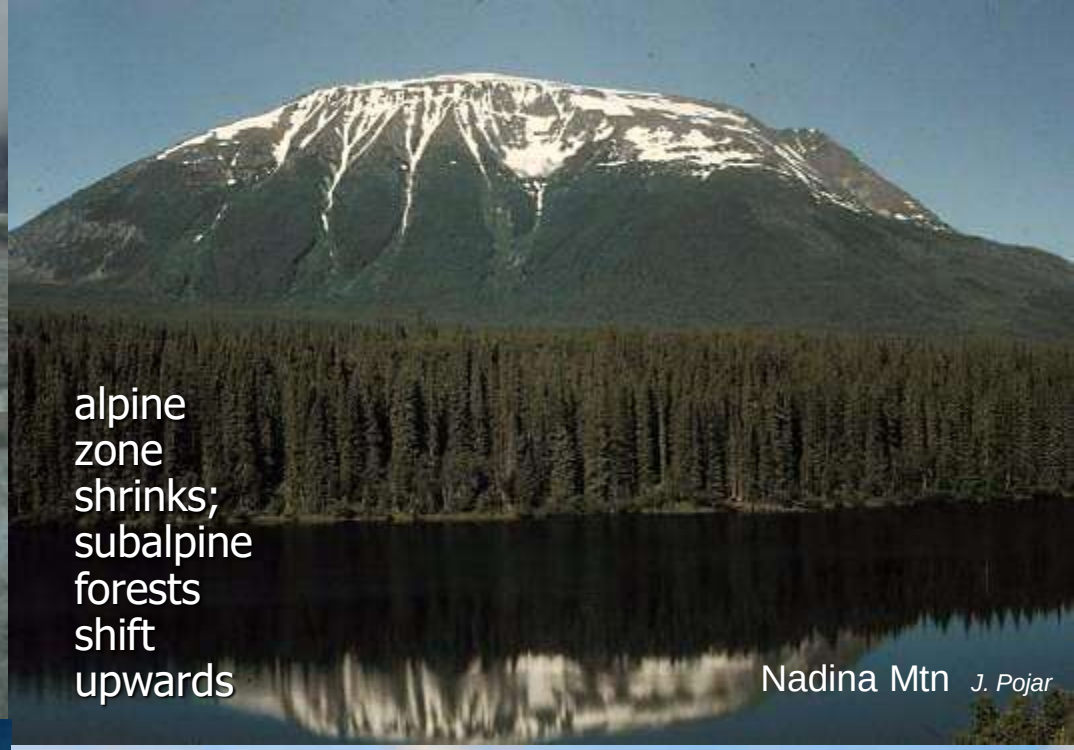
- Protect more old, carbon-rich forests with good chance of being with us for a long time.
- Prevent catastrophic wildfire—if we can.
- Reduce AACs to sustainable levels.
- Reduce drastically slash burning.
- More commercial  forests on extended rotations.
- Continue planting trees to remove $CO_2$ from atmosphere in the future.


- Do more partial cutting and less clearcutting, especially in primary, mature & old forests.

# What's Really At Risk?

- Revamp conventional approaches to at-risk species & ecosystems.
- Apply concept of stewardship responsibility to BC's biota generally.
- Also focus on selected species more important ecologically than most others, regardless of commonness or rarity (keystone, focal, foundation, etc.).
- Most BC tree species are of conservation concern, for reasons relating to ecosystem role (structure and function), ecosystem services, carbon dynamics, genetics & life history characteristics, and economic significance.


Tulsequah Glacier
M. Geertsema


alpine
zone
shrinks;
subalpine
forests
shift
upwards
Nadina Mtn
J. Pojar


permanent ice & snow dwindle
N. Coast Mtns
J. Peepre


melting permafrost
Horseranch altiplano
thermokarst pond
J. Pojar