Forests and Water
Background Slides

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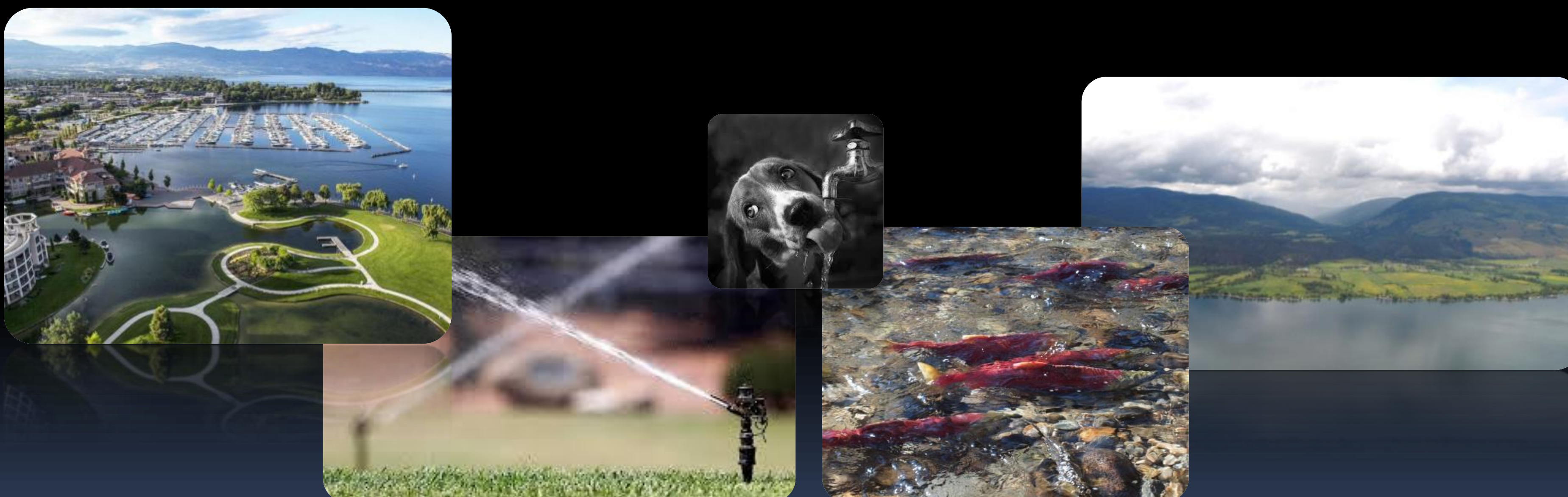
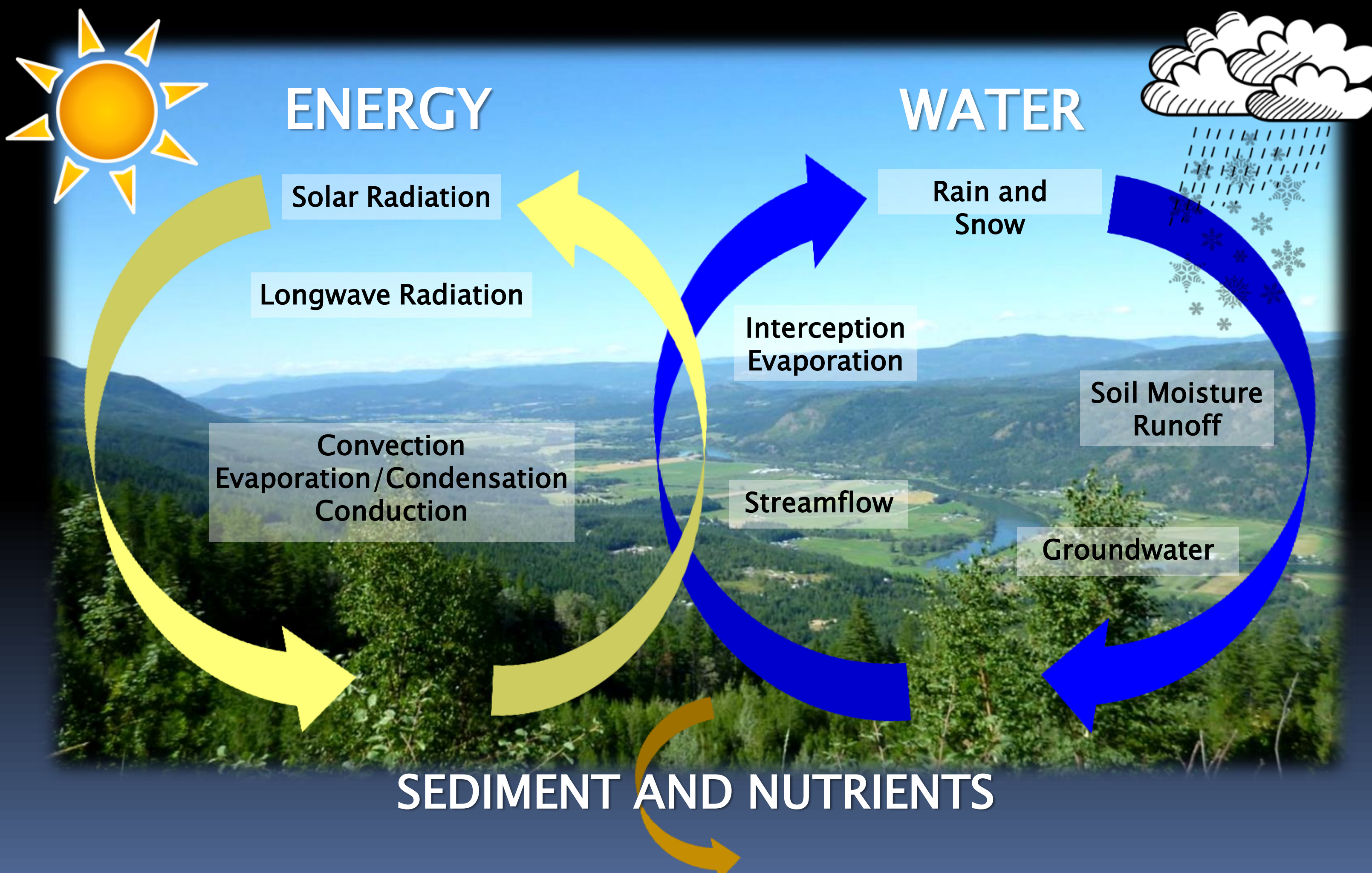
- >75% of the people in BC rely on surface sources for domestic and irrigation water, most of which originates in, or flows through, forested landscapes
- this water also sustains wildlife (including fish and other aquatic life) and provides many other environmental and social benefits
- consequently, understanding how forests affect water is key to sustainable water resource management in BC



- forests affect the distribution and flow of water through the environment, the energy available to drive the flow of water, and the flow of sediment and nutrients carried by water
- these processes are commonly 'pictured' as streams, cycles, or balances



- how forests affect water depends on variables such as:
  - hydrologic regime (rain, snow, or rain-on-snow driven)
  - geography
  - precipitation form and pattern
  - soils and geology
  - vegetation
  - disturbance

Disturbance

Natural
- Wildfire
- Insects/Disease
- Species Conversion

Anthropogenic
- Harvesting/Silviculture
- Roads
- Grazing

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Modifies

Forest Structure
Flowpaths
Soil and Soil–water Chemistry

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Hydrologic Response

Within Forests
- Interception
- Evaporation
- Surface Runoff
- Soil Moisture
- Subsurface Flow
- Groundwater

Watershed Outputs
- Water Yield
- Peak Flows
- Low Flows
- Sediment
- Water Chemistry
- Stream Health

Depending on the:
- weather
- watershed, and
- severity/extent of disturbance

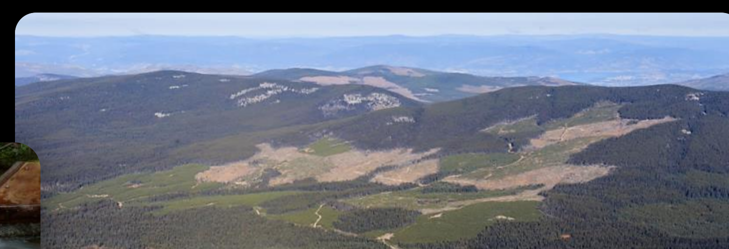
- primary forest disturbance types are:
  - harvesting
  - insects and disease
  - wildfire

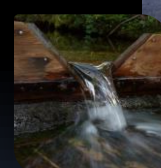


- key industrial forestry questions are:
  - how much can we log
  - should we leave dead trees standing
  - when will stands/watersheds ‘recover’

- watershed research focuses on quantifying hydrologic processes and the flow of water – in different environments, under different climatic conditions, and with disturbance
- over the past 30+ years, work in the southern interior has helped us to better understand the interrelationships between forests, forest disturbance, and water, improving our ability to guide operational best practices

BC's watershed research network – includes the long-term Upper Penticton Creek watershed experiment in the south Okanagan





BC interior forest and water flow interaction research results are summarised in the next four slides.

- interior BC watershed research has shown the following changes post-logging:

Upper Penticton Creek; 47% of the total area was clearcut by 2007 (Winkler, Spittlehouse and Boon 2017, Gronsdahl et al in press)

  - increase in April and May yield and decrease in June and July
  - peak flow increase 21%
  - advance in peak flow timing by up to 7 days
  - snowmelt from high elevation clearcut synchronised with lower elevation forest
  - significant decreases in low flows

Camp Creek; 30% salvage harvested in 1976-77 (Cheng 1989, Moore and Scott 2005, Gronsdahl et al in press)

  - annual water yield increase 21%
  - peak flow increase 21%
  - advance in peak flow timing 13 days
  - decrease in low flows

Modelled forest disturbance effects on floods (Green and Alila 2012)

  - increase in peak flows of up to 35% after 33-40% clearcutting
  - timing of peak flows advanced by up to one week, as a result of snowmelt synchronization from upper and lower elevations
  - increase in frequency of flood events of all magnitudes

Bowron and Willow watersheds; extensive salvage harvest (Zhang and Wei 2012, 2013, 2017)

  - increase in annual peak flows of ~48% following MPB salvage over 62% of watershed
  - interactions between forest disturbance and climate variability may have offsetting or additive effects, depending on the watershed

- post-fire research in BC and Alberta also shows:

  - increased annual runoff
  - increased net precipitation
  - earlier snowmelt and greater melt generated runoff
  - increased high flows of all magnitudes
  - slightly lower mid- late-summer baseflows

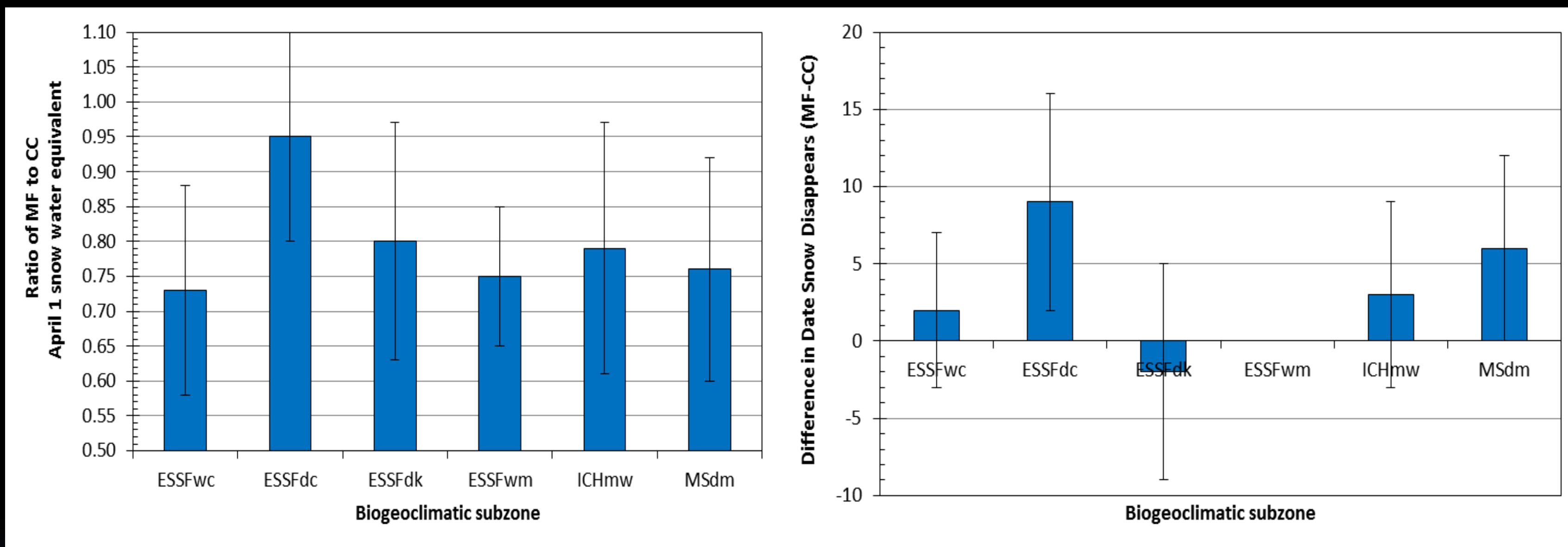
and associated changes in water quality, such as:

  - increases in sediment and phosphorus, that may be long-lasting
  - incremental effect of salvage logging on sediment and phosphorus, particularly during the snowmelt period
  - increases in stream nitrogen that generally return to baseline within 3-6 years
  - increased metals such as mercury in water and fish
  - increased DOC, temperature, algal growth, odour and taste issues
  - increased water treatment costs

Based on: SRWP: U. Silins and M. Emelko; Fishtrap Cr: P. Owens and T. Giles; UPC: G. Hope and R. Winkler; Mayson Lake: R. Winkler and S. Boon; Matt Fire: D. Toews and D. Gluns; the U.S. literature

- these post-disturbance changes in streamflow and seasonal water yield are largely related to changes in snow accumulation and melt

Snow in the forest relative to the open (Winkler et al in progress)



5 to 30% less snow water (SWE)
in mature forest than clearcut

snow disappears
a few days earlier to 9 days later

with tremendous spatial and annual variability

Snow in forests attacked by mountain pine beetle or burned

Post-MPB (Winkler et al 2014) :

- no change in snow accumulation or melt until fourth year post attack (the year of greatest needle fall)
- defoliation effects were confound by weather variability, forest litter and the compensating effects of green trees in the understory

Post-Wildfire (Winkler 2011) :

- by year 4, snow accumulation in the burn was similar to that in the clearcut but ablation rates remained slower until year 5

- **'recovery' of forest stands, currently measured as snow accumulation and melt, averages 75% when young pine trees are 50% of the original stand height** (Winkler and Boon 2015)
- **long-term data at research watersheds now enables watershed-scale 'recovery' to become a key research focus**

Summary:

- forest cover has a significant effect on snow accumulation and melt
- if 50% or more of local upland watersheds are logged, a hydrologic response should be expected – sooner or later
- hydrologic response to forest cover loss varies with disturbance severity and extent as well as with the weather, watershed, and forest attributes
- hydrologic response may lag natural disturbance
- salvage logging may increase or moderate hydrologic response to natural disturbance depending on local conditions
- disturbance related hydrologic change can affect water supplies (ex. water storage management, irrigation and aquatic habitat
    - and can also affect flows with geomorphic consequences potentially increasing downstream risk to infrastructure and public safety
- climate change may compound these effects

- managing forests and water, requires not only an understanding of how watersheds function but also the careful consideration of a broad range of values from economic, to environmental, to social

Cartoons (minus hearts) from: Toews and Brownlee 1981

Hydrology
Water quality
Stream health

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Downstream basin scale effects

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Implications for communities (drinking water)

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Economic implications (ecosystem goods & services)

(U. Silins, 2017)

- water scarcity in other areas has shifted people's thinking about water management, for example in:

California/Colorado

- burning, thinning and patch cutting is used to increase snow catch, reduce evaporative losses, extend melt season, increase reservoir inflow and provide additional water for remaining trees
- "forests to faucets" initiative to get water utilities and hydropower producers to pay for thinning to sustain water supplies

New Mexico

- "water for forests" –thinning, mulching and irrigation to reduce forest vulnerability to increasing water stress

Brazil

- water availability zoning, water efficient species selection, 'mosaic' plantation management strategies, use of the 'catchment' as the planning unit for water conservation in forest management plans

Europe

- "hydrology-oriented silviculture", thinning to reduce influence of climate change on tree growth, to enhance infiltration to groundwater and sustain reservoir inflows

- considerations for the future
  - the demand for space, resources, and water is increasing
  - forest disturbance can have a significant effect on water
  - disturbance increases watershed sensitivity to the weather
  - variability in the weather is increasing due to climate change
  - hydrologic responses to the weather and disturbance may also become more extreme, depending on the watershed
  - this future highlights the need for increasing our focus on water, watershed management, water use and water knowledge



Free on-line, reading:

The Compendium of Forest Hydrology and Geomorphology in BC
(including Chpts 6 and 7: Forests, forest disturbance and hydrology)