# CP vs FP Paper outline

## 3 main messages

1. The effect of forest on landslides might be underestimated
2. climate change isn’t the only factor that leads to landslides
3. The need to apply probabilistic approach in forest management and landslide studies (knowledge gap)

# Outline

1. Introduction
   1. Increased global landslide frequency
      1. Number of debris flow and slides in recent years and the cost for damage
      2. Although recent landslide fatalities show a decreasing trend, the economic and social damages cannot be unseen
         1. Socioeconomic loss due to landslide accounts for up to 20 billion US dollar annually worldwide (Sim et al., 2022). According to Government of Canada, “terrestrial landslides … [account] for an estimated $200 to $400 million in direct and indirect costs annually” (Landslides, 2013)
      3. Slow moving, historical landslides putting more stress on the current landslide situation in BC
         1. City of Quesnel undergone 810 mm of movement since the late 1998 (Monitoring Program 2020, 2021).
         2. Regionally, hundreds of landslides occurred in 2020 and 2021, leading to numerous road recovery projects
         3. Landslides along the Canadian Railway
            1. “Although movement was slow in the late 20th Century, cumulatively it was sufficient to open numerous tension cracks in the main body of the landslide and cause a visible shift in the fence line of the CPR track by the early 2000s (Bunce and Chadwick, 2012).” (Huntley and Bobrowsky, 2014, p. 6)
      4. (Sobie, 2020)
      5. World wide
         1. (Jemec Auflič et al., 2023)
      6. Economic loss and public safety concerns
   2. Past studies on triggers of landslides
      1. Climate change
      2. Land use change
   3. Knowledge gap
      1. Regional scale landslide phenomenon
         1. “While most research tends to centre on basin scale landsliding, focusing on modelling and understanding the mechanisms and precursors that lead to landslide initiation, understanding the relationship between landsliding and climate change is a regional-scale problem which needs to be assessed at this level through regional-scale studies.” (Wood et al., 2015)
      2. Landslides aren’t single factor events
         1. “Exceedance of a climatic threshold is thus a necessary, but not a sufficient, condition for debris flow occurrence.” (Jakob et al., 2005, p. 756)
2. Role of Forest in slope stability
   1. Direct effect (deterministically)
      1. Decreased root cohesion
      2. Increased pore pressure
   2. Indirect effect (probabilistic)
      1. The frequency of saturated soil
         1. Snowmelt
            1. Loss of canopy cover leads to faster and more rapid snow melt

Overwhelming soil capacity easily

* + - 1. Rainfall
      2. Energy balance
    1. soil fatigue/ threshold behavior
  1. cumulative effect

1. Past studies on forest harvesting and landslide frequencies
   1. Determinism
      1. Many studies investigating harvesting effect on landslides lack temporal analysis. The frequency density of landslides is often used in comparing pre- and post-treatment period. Frequency density is defined as the number of landslides happened in the basin divided by the area of the basin, which does not represent how landslide occurrence changes in relation to time.
      2. doesn’t tease out how landslide frequencies change with time but only compare the “frequency of landslides” in different categories
      3. example from Jakob 2000:

A table with numbers and text

AI-generated content may be incorrect.

* 1. event-base analysis
     1. use rainfall events as the only predictor of landslide occurrence
        1. Johnson et al. use 48-hr rainfall to determine the relationship between harvested and forested sites (2007), Johnson & Edwards pointed out other rainfall factors could also trigger landslides, demonstrating the stochastic nature of landslide activity (2008).
        2. In modeling exercises, rainfall is also often the input used to calculate for landslide events.

1. Attribution science in landslide related studies
   1. causal framework
      1. The frequency of landslides
         1. Repetitive movements at the same location
         2. Similar events happening in the same region
   2. Climate change isn’t the only factor causing the increased in landslide frequency. As there are many factors that could trigger landslides, and often the combination of different factor can lead to triggering effect. The same probem
      1. “Exceedence of a climatic threshold is thus a necessary, but not a sufficient, condition for debris flow occurrence.” (Jakob et al., 2005, p. 756)
      2. “(it is possible that not the largest but a smaller event following a period with large antecedent rainfall amount may have triggered the landslide)” (Lehmann et al., 2019, p. 9966)
   3. the need to develop regional analysis
      1. When the whole system is non-stationary, only regional analysis can shed light on the change in landslide behaviors. This view is supported by the abundance of attributional science approach in dealing with stochasticity of landslide events under climate change
      2. Climate change landslide studies
         1. landslide pdf methods (still learning)
            1. [Landslide inventories and their statistical properties](zotero://note/u/UJ8MMI6R/) (Malamud et al., 2004)

# Questions

* Should we zoom in to snow hydrology? Because I do think regional phenomenon applies to all climatic regimes but is even more relevant in snow dominated regions.

# To research

* Attribution science
* Modern causal inference
* Soil fatigue/ threshold behavior

Bibliography

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