

# Living Lab Program for Climate Change and Conservation - Final Report



## Characterizing changing winter snow conditions at high-use BC Recreational Provincial Parks

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### Research findings

- The SNOWARP algorithm is able to detect changes in daily fractional snow cover at a fine spatial resolution
- We demonstrated large variation in snow cover by area at eight provincial parks from 2000-2020
- In the poorest snow year, we found that the park with the most reduction in snow cover was Mount Seymour with a 24.2% decrease in 2014, compared to an average snow year (Table 1)
- In the best snow year, we found that the park with the greatest increase in snow was Mount Seymour with a 33.7% increase in 2006, compared to an average snow year (Table 1)
- Mount Seymour therefore has the greatest susceptibility to snow cover change based on seasonal conditions
- Cypress Mountain showed high variation in fractional snow cover with a 13.7% increase in snow cover for a good snow year, compared to an average snow year, and a 20.1% decrease in snow cover for a poor snow year, compared to an average snow year (Table 1)
- The BC parks in the Pacific Mountain Range (Callaghan Lake Park, Callaghan Conservancy, Upper Soo Conservancy) showed the least variation in snow cover across both good and poor snow years (Table 1)
- Overall, the snow season is getting shorter
  - The last five years have seen, on average, 8 fewer days with snow compared to the first five years of the two-decade study period (Table 2)
  - The date of snow accumulation was on average, 6 days later in the most recent five years compared to 2000-2004 (Table 2)
  - The date of snow melt was, on average, 8 days earlier in the most recent five years compared to 2000-2004 (Table 2)

*Table 1 Average percent change in fractional snow cover from an average snow year for BC Parks of high recreational and economic importance*

<i>BC Park</i>	<i>Good snow year, 2006: percent change from average snow year (%)</i>	<i>Poor snow year, 2014: percent change from average snow year (%)</i>
<i>Callaghan Lake Park</i>	0.856	-0.431
<i>Callaghan Conservancy</i>	0.710	-0.898
<i>Cypress Mountain</i>	13.7	-20.1
<i>Garibaldi Park</i>	13.3	5.89
<i>E.C. Manning Park</i>	3.07	-7.92
<i>Pinecone Burke Park</i>	25.2	-8.21
<i>Mount Seymour</i>	33.7	-24.2
<i>Upper Soo Conservancy</i>	1.11	-1.53

*Table 2 Comparison of key annual statistics for first five years of two-decade period to last five years averaged across all eight parks*

	<b>2000 - 2005</b>	<b>2015-2020</b>
<i>Average number of days with snow</i>	210	202
<i>Average date of snow accumulation</i>	October 7	October 13
<i>Average date of snow melt</i>	June 11	June 3

## Methods summary

- Using the SNOWARP algorithm, we fused Landsat data and MODIS data to produce daily fractional snow cover data from 2000-2019
- We investigated the fractional snow cover of eight parks:
  - Callaghan Lake Park
  - Callaghan Conservancy
  - Cypress Mountain
  - E.C. Manning Park
  - Garibaldi Park
  - Mount Seymour Park
  - Pinecone Burke Park
  - Upper Soo Conservancy
- Key results were daily fractional snow-covered area at a 30m x 30m spatial resolution for all eight parks
- In addition, the following key annual statistics were determined:
  - Date of snow accumulation
  - Date of snow melt
  - Number of days with snow cover in year
- Using open-source manual snow depth data from DataBC, average, good, and poor snow depth years were determined, and additional investigation of snow cover dynamics were evaluated for these years

## Key outcomes for BC Parks

- Understanding of snow dynamics over the last two decades (2000-2020) and how these trends may impact recreational use, hydrology, and biodiversity of eight key parks
- Overall decrease in snow cover and duration of the snow season indicates vulnerability of certain parks to be impacted by a warming climate
- Peer reviewed paper is being prepared

## Relevance to BC Parks management

- Of the eight parks processed, Mount Seymour, Cypress Mountain, and Pinecone Burke Park had the most variation over the years of poor snow conditions with 24.2, 20.1, and 8.21 percent decrease of fractional snow respectively compared to an average snow year
- Mount Seymour, Pinecone Burke Park, and Cypress Mountain, had the most variation over the years of good snow conditions with 33.7, 25.2, and 13.7 percent increase respectively compared to an average year
- We are seeing gradual decrease in snow across all parks
- Maps showing regions where there was found to be a high number of days with 100% fractional snow cover over the last two decades are available and may indicate potential for expansion of recreational activities

## Project's challenges/opportunities

- No computational challenges associated with SNOWARP processing
- These daily, fractional snow cover datasets are large spatially and temporally so effective use and integration into future planning may be challenging
- Climate change continues to modify snow dynamics and past data may not be sufficient to accurately predict the rate of future snow melt and the trajectory of future snow trends

## Conclusions/next steps

- These maps of annual fractional snow cover provide indication of, even under warming conditions, which regions will remain fully covered in snow
- This provides insights to new management strategies around ensuring successful recreation
- Preparation for peer reviewed paper is underway to be submitted by April 2022

## References and links

- SNOWARP methodology is provided here:
  - Berman, E. E., Bolton, D. K., Coops, N. C., Mityok, Z. K., Stenhouse, G. B., & Moore, R. D. (Dan). (2018). Daily estimates of Landsat fractional snow cover driven by MODIS and dynamic time-warping. *Remote Sensing of Environment*, 216, 635–646. <https://doi.org/10.1016/j.rse.2018.07.029>