

Monitoring forests to anticipate and respond to climate change in BC.

- John Innes, Margie Eddington, Laurie Kremsater
 - Project in 4 phases



Outline for today

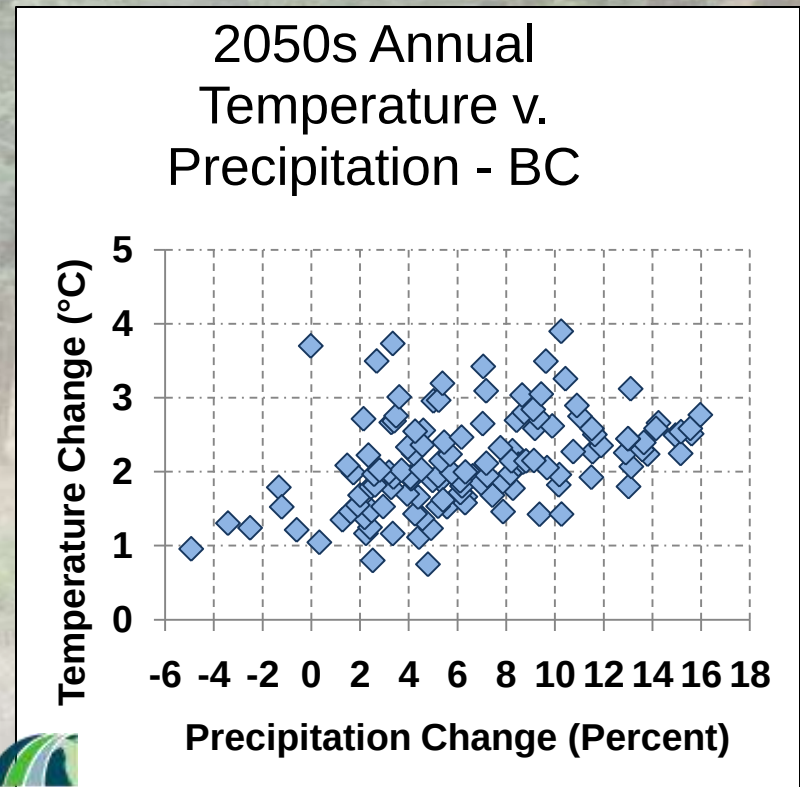
1. Intent of project
2. Review project steps
 - Surveys (two steps)
 - Resulting indicators
 - Refining survey
3. State of information to measure indicators



4. Summary

Rationale/Intent of Project

- **Climate change brings many uncertainties in abiotic changes**
 - Magnitude of temperature increases
 - Direction and magnitude of precipitation
 - Impacts on extreme events like frost, wind, drought
 - Impacts on streams, wetlands, groundwater
 - Magnitude of changes in fire and other disturbances



And even greater uncertainty in ecological responses: trees, insects, diseases (and other organisms)

Rationale for Project con't

- While predictions can help guide management, monitoring -- tracking over time -- is a necessity to be able to react to actual changes.



Tracking changes over time

- What would monitoring for climate change in forest look like?
- What are the most important biophysical attributes to monitor in light of climate change?
- Using current data collections is a logical step
- Currently we have SFM in BC, and monitoring for SFM, but that does not generally include tracking changes due to climate.

Project components

- 1) Consultations with experts
- 2) Workshop to gather indicators
- 3) Surveys to refine and prioritize indicators
- 4) Assess information available for each indicator
- 5) Pilot indicators in South Selkirks

Project steps:

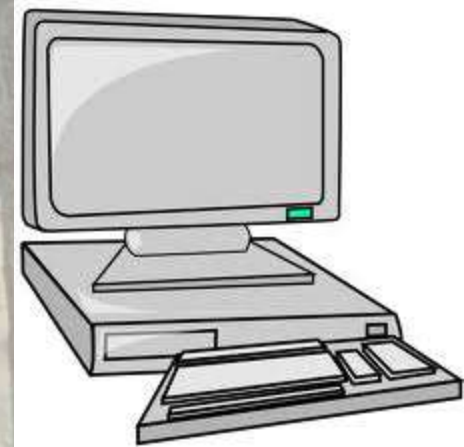
1) Consultation and workshop

- Focused discussion with experts to compile a 'straw list' of indicators
- Workshops to consider, add, and develop those indicators (about 58 people). *Part of development was noting information likely available to track the indicators*
- Further review and refinement of indicators



2) Further survey to refine indicators

- June 2010; internet survey; >500 forest and range managers (60% MoF; 17% MoE)
- To better determine the key climate change monitoring and reporting information needs
- Led to several important refinements to the indicator set



Importance of indicators

Ecosystem productivity	3.05	Pathogen incursions	2.64
Ecosystem distribution	2.96	Fire season severity	2.62
Ecosystem composition	2.93	Species phenology	2.58
Precipitation timing	2.93	Water quality	2.55
Precipitation rate	2.85	Ecosystem connectivity	2.54
Species' ranges	2.84	Species population levels	2.53
Snowpack extent, depth	2.79	Mass movement/erosion	2.52
Insect incursions	2.77	Genetic diversity	2.52
Precipitation form	2.76	Water temperature	2.49
Streamflow rate	2.65	Unexpected weather	2.46
Streamflow timing	2.65	Fire season length	2.37
		Wind throw damage	2.18
		Extent of glaciers	2.15

State of Information for the Indicators

- **Abiotic**
 - Temperature; precipitation
 - Snowpack; glaciers
 - Streamflow
 - Water temperature and quality
 - Extreme weather
- **Disturbances**
 - Fire, insects, pathogens, wind, mass wasting
- **Biotic**
 - Ecosystem composition, distribution
 - Ecosystem productivity
 - Species ranges
 - Genetic changes

Temperature and Precipitation

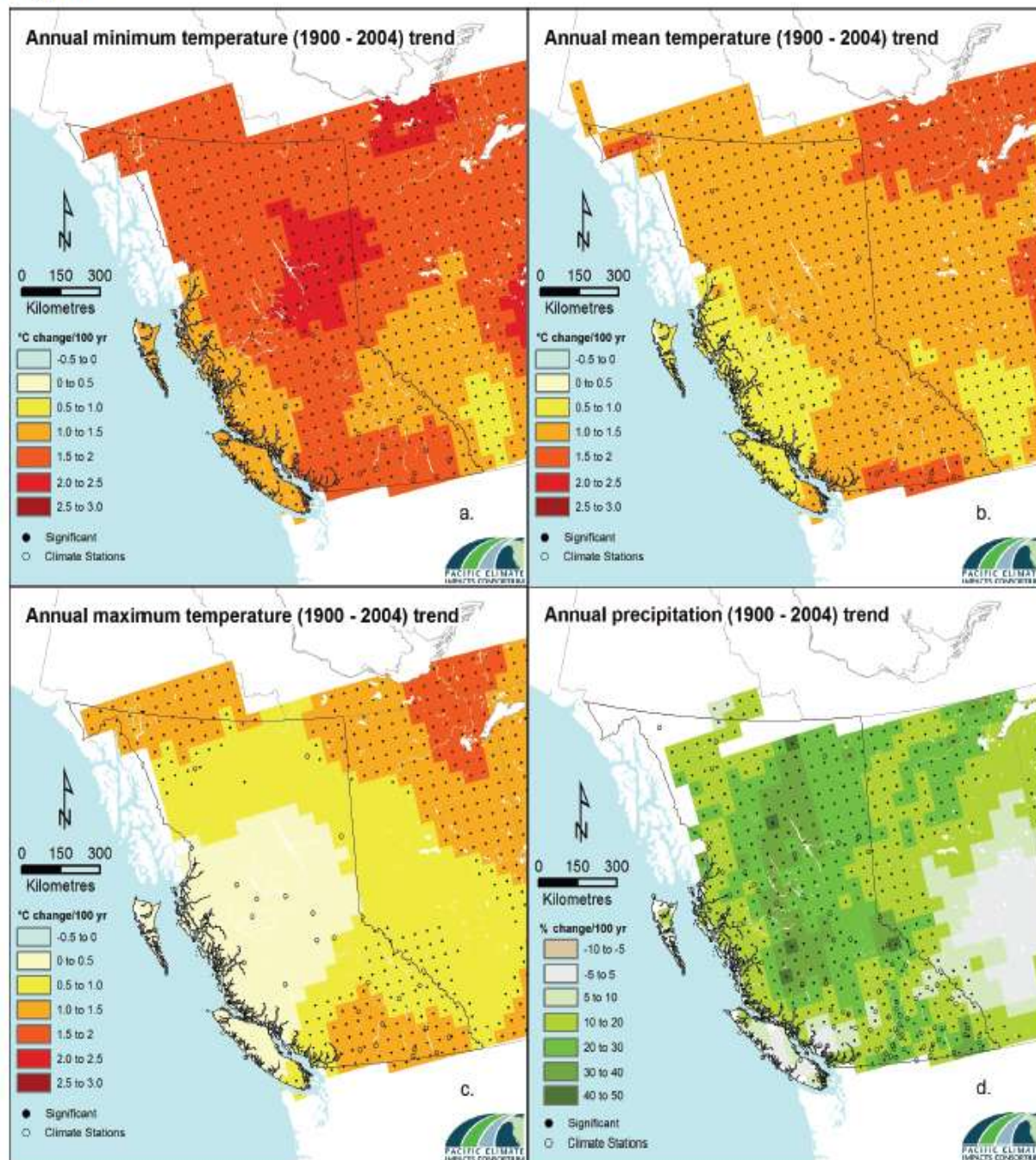
- **Who has data?**
 - Environment Canada
 - Province of BC
 - BC Hydro
- **PCIC has summaries**



Temperature and Precipitation

- Temperatures are expected to warm, with BC becoming less cool (minimum temperatures are expected to rise more than maximums)
- Precipitation is predicted to shift to warmer, wetter years, more frequent wet years, greater year-to-year variability, and more extreme precipitation events. Summer drier than winter.
- Do historical data support predictions?

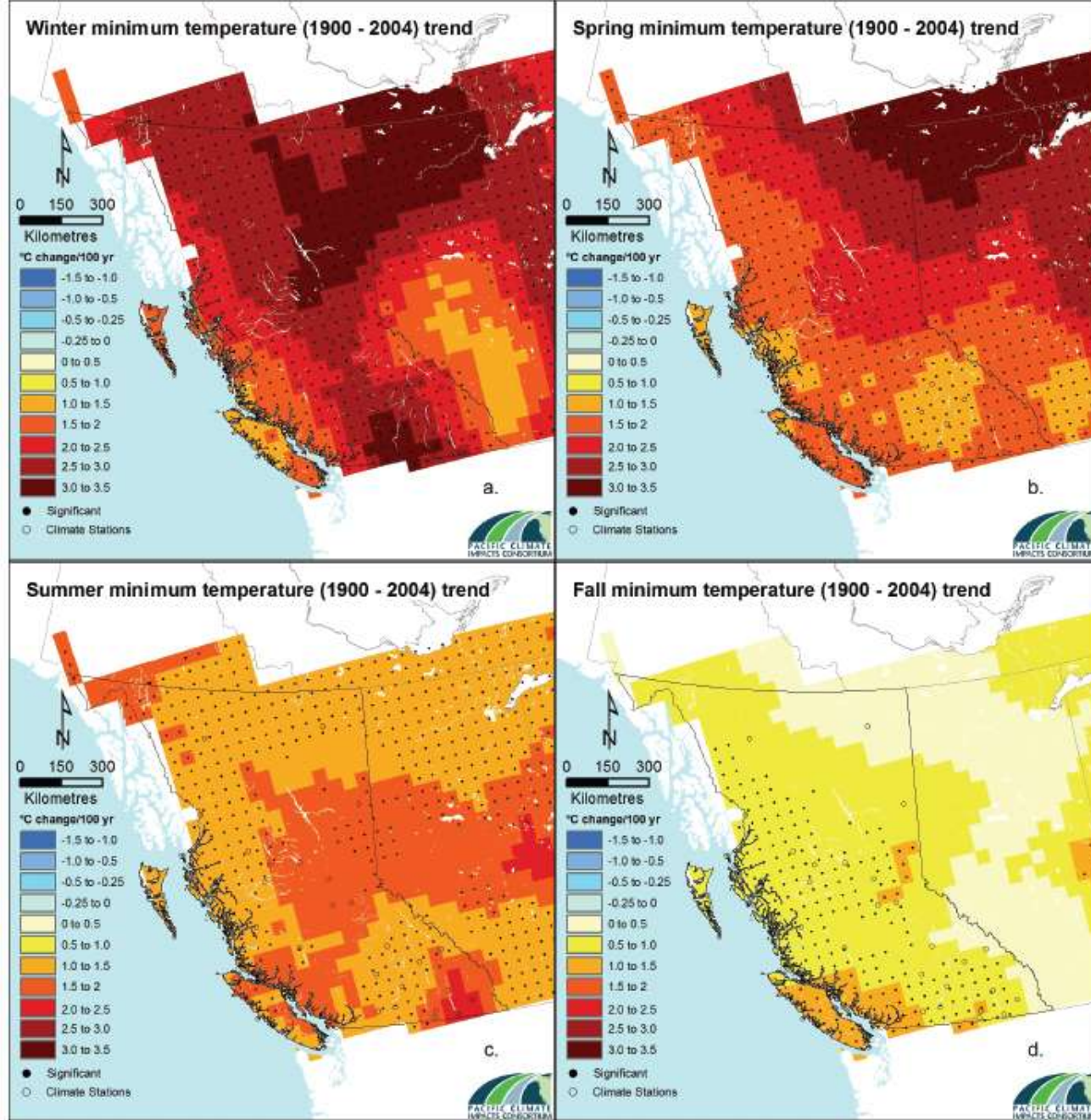
Figures



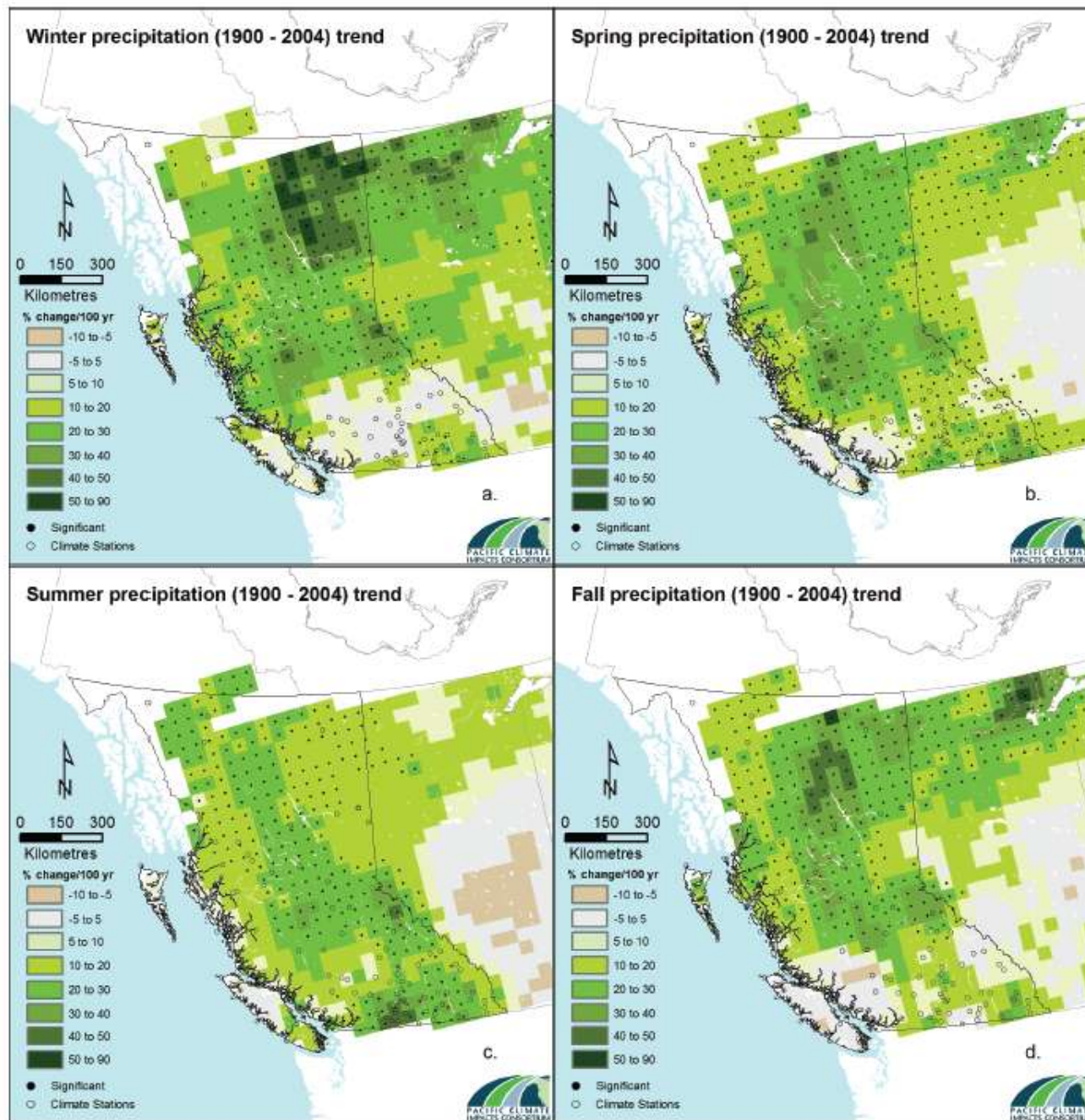
Annual
Temperature
trends

Annual
Precipitation
trends

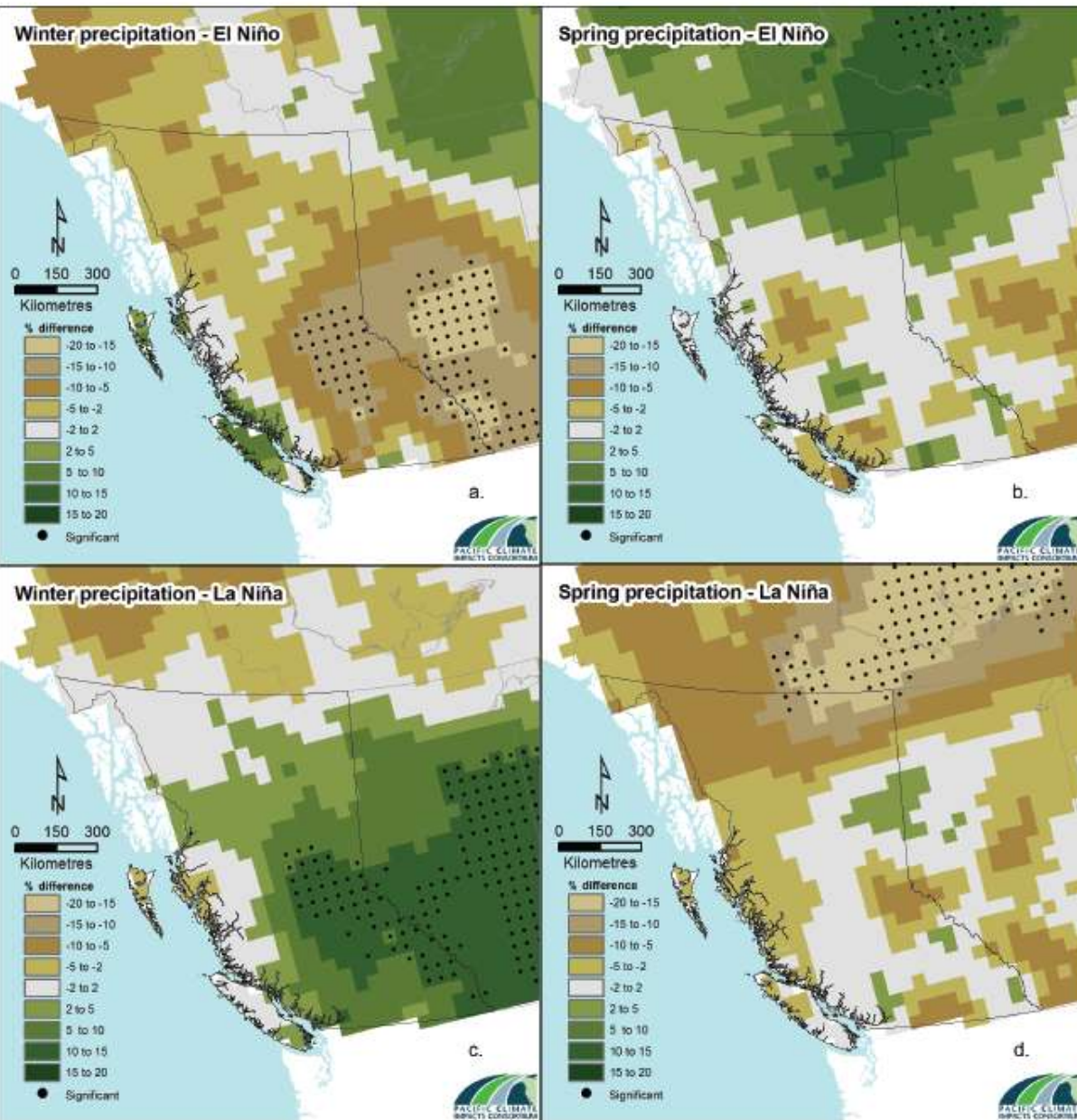
Seasonal temperature trends



Seasonal precipitation trends



Precipitation trends vary with ENSO and PDO cycles



Snowpack

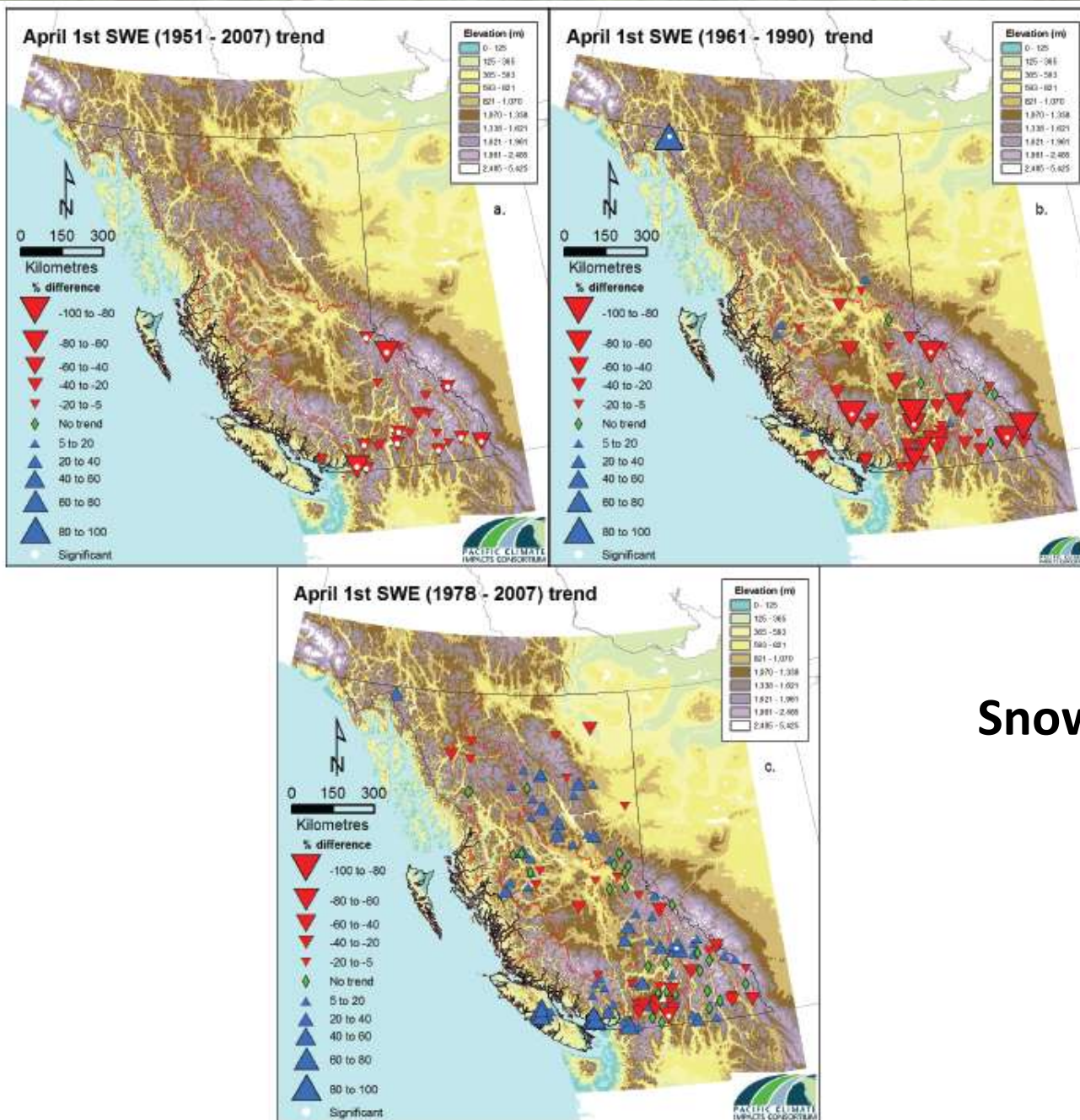
Who has data?

- MoE River Forecast Centre
- BC Hydro
- **PCIC has summaries**



Snowpack

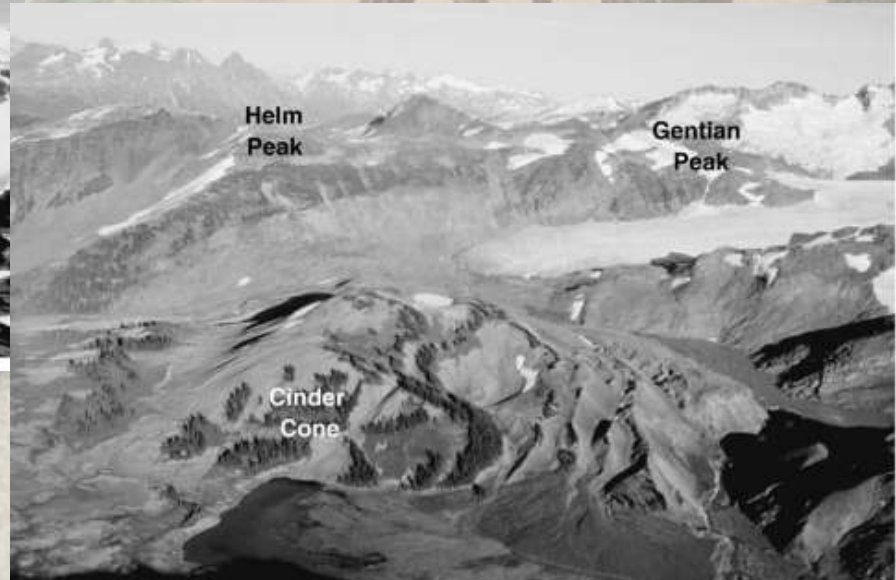
- Losses of April 1st snowpack of -25% on average at BC sites over the past 50 years
- As much as -50% at a few sites.
- For shorter record lengths, however, the variability is large and not homogeneous across the Province.
- ENSO influenced snowpack by -12% to +21%.



Snowpack trends

Glaciers

- Studies detecting changes in volume and area
- Studies doing more detailed mass balance calculations.

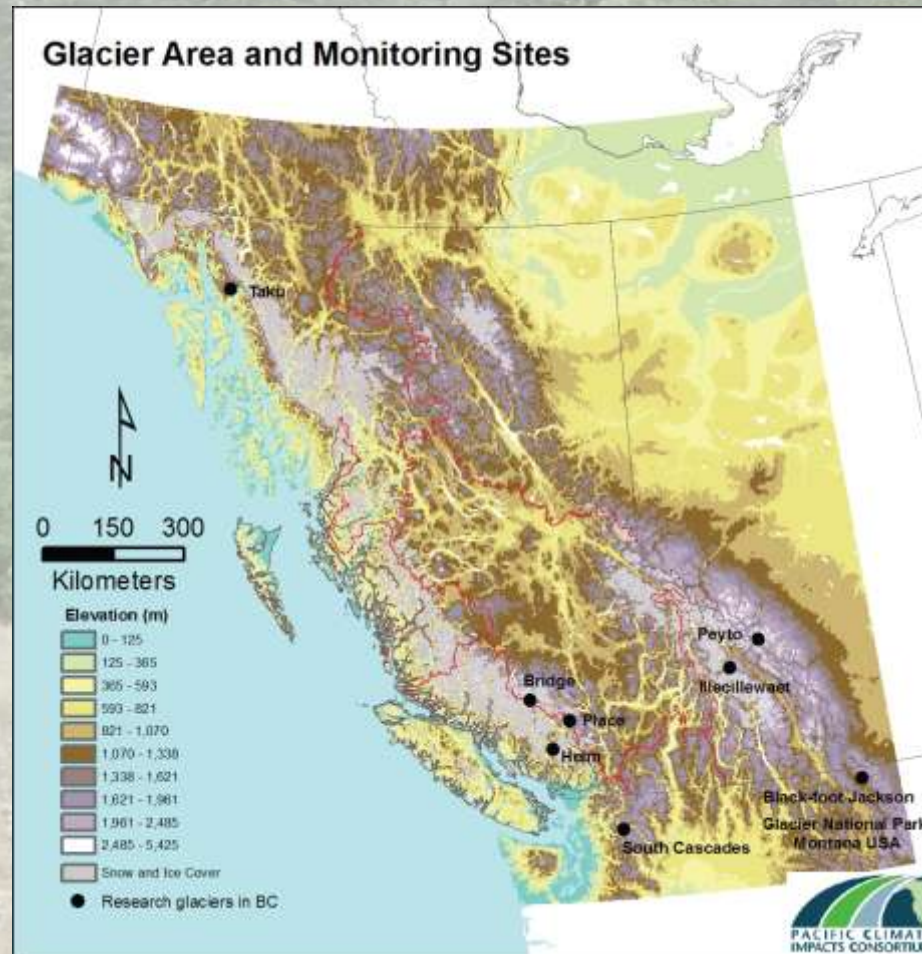


Glaciers

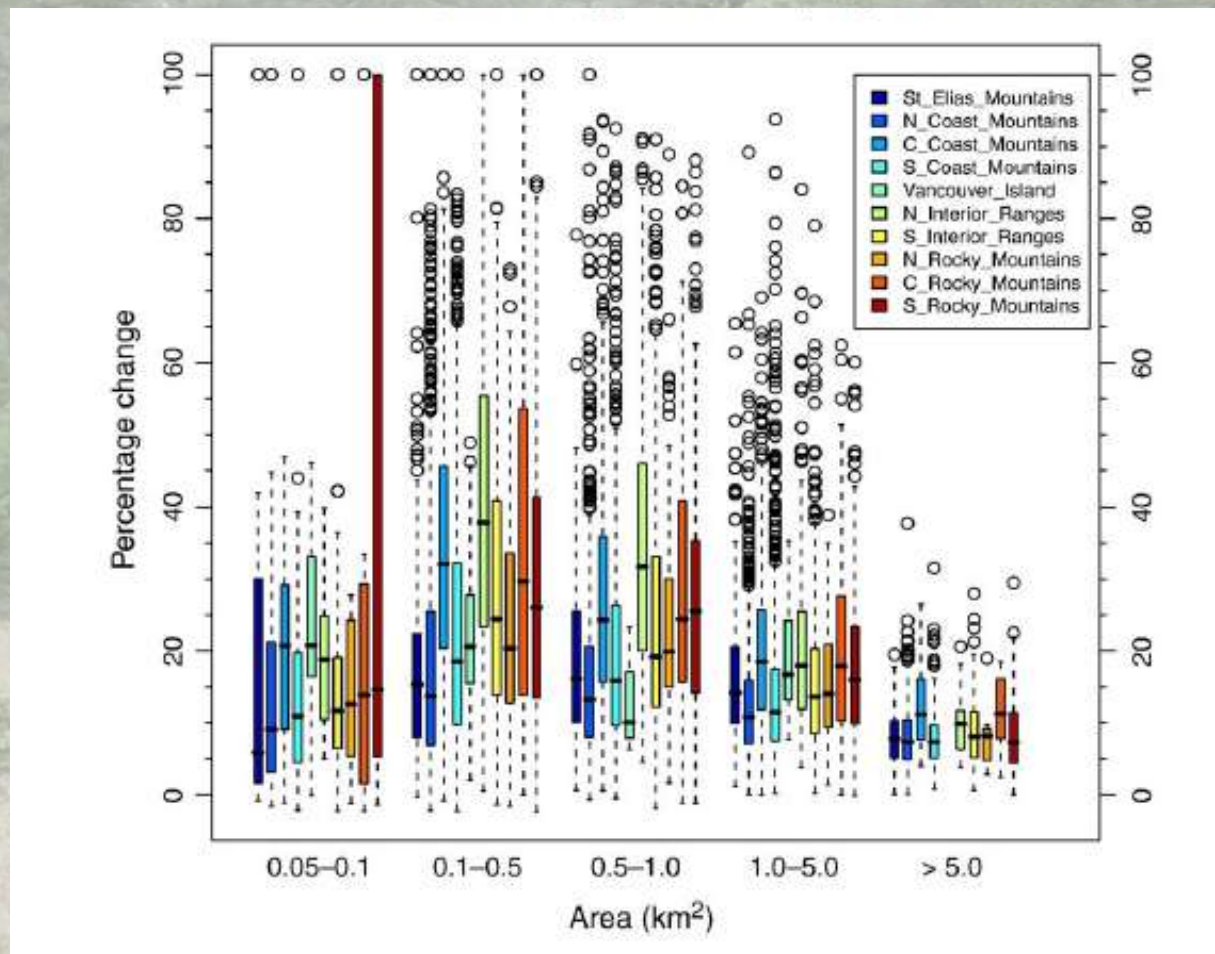
- **Who has data?**
 - Canadian Cryospheric Information Network
 - Canadian Glacier Information Centre
 - Many researchers
- **PCIC has literature summaries**



Glaciers: Detailed monitoring sites in BC



Glacier – volume/area changes



Streamflow

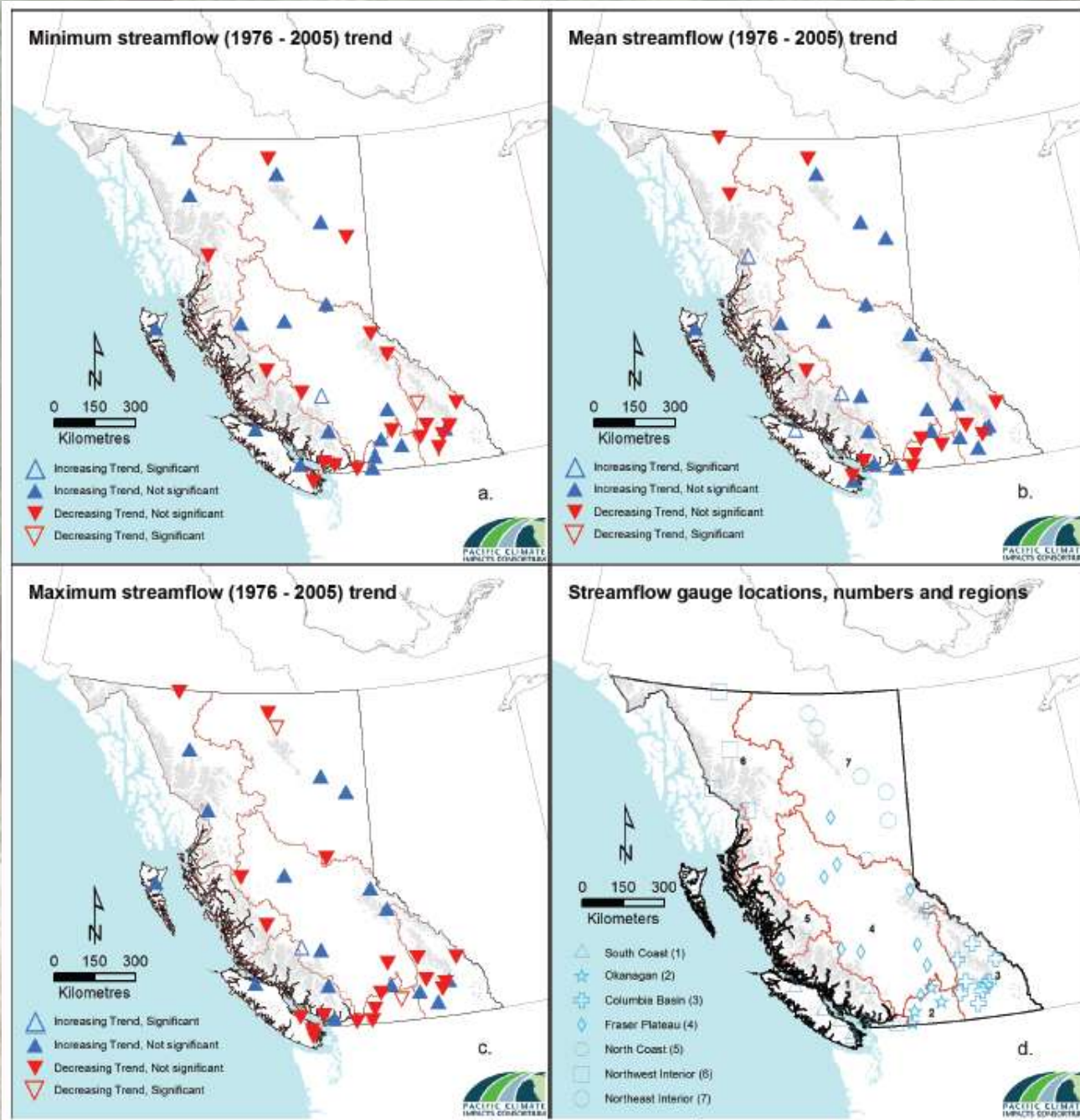
- **Who has data?**
 - Environment Canada Water Survey
 - BC Hydro
 - BC MOE streamflow inventory
 - USGS
- **PCIC has summaries**



Streamflow

- In general, annual mean streamflow decreased in the southern parts of the Province, increased in the central and Fraser Plateau regions, and decreased in northwestern areas. Trends in the South Selkirks were generally not significant





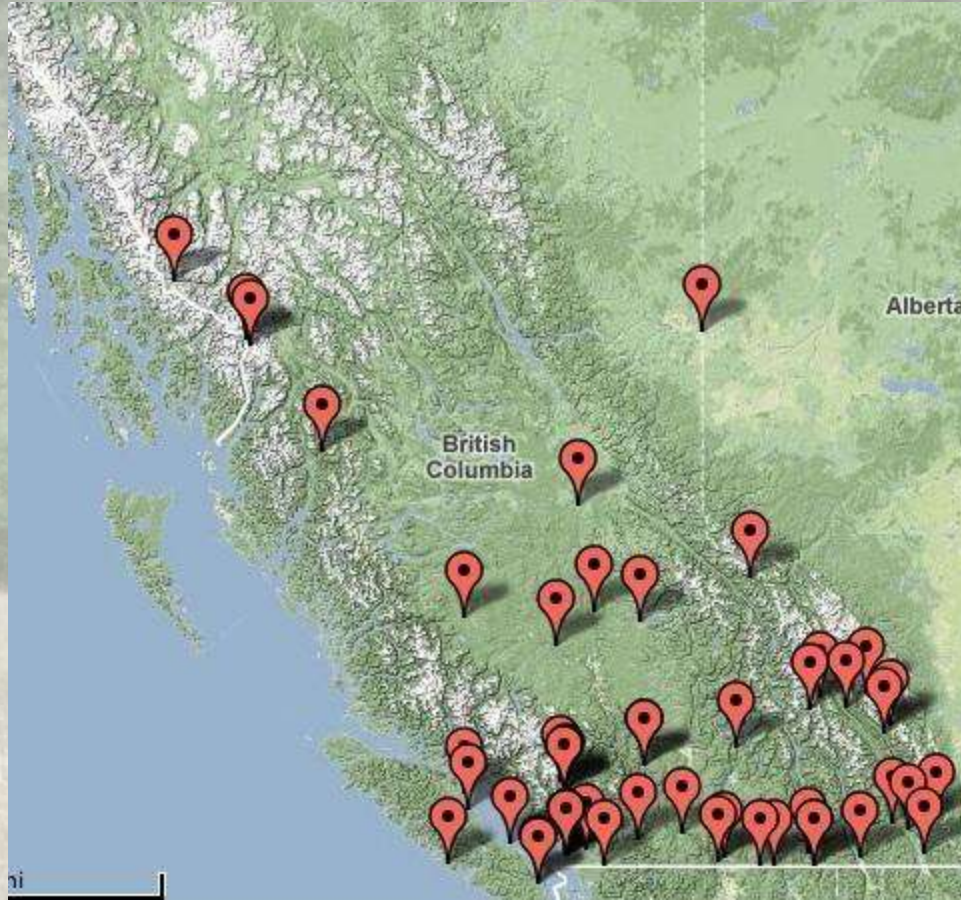
**Streamflow -
trends are
variable**

Water temperature and quality

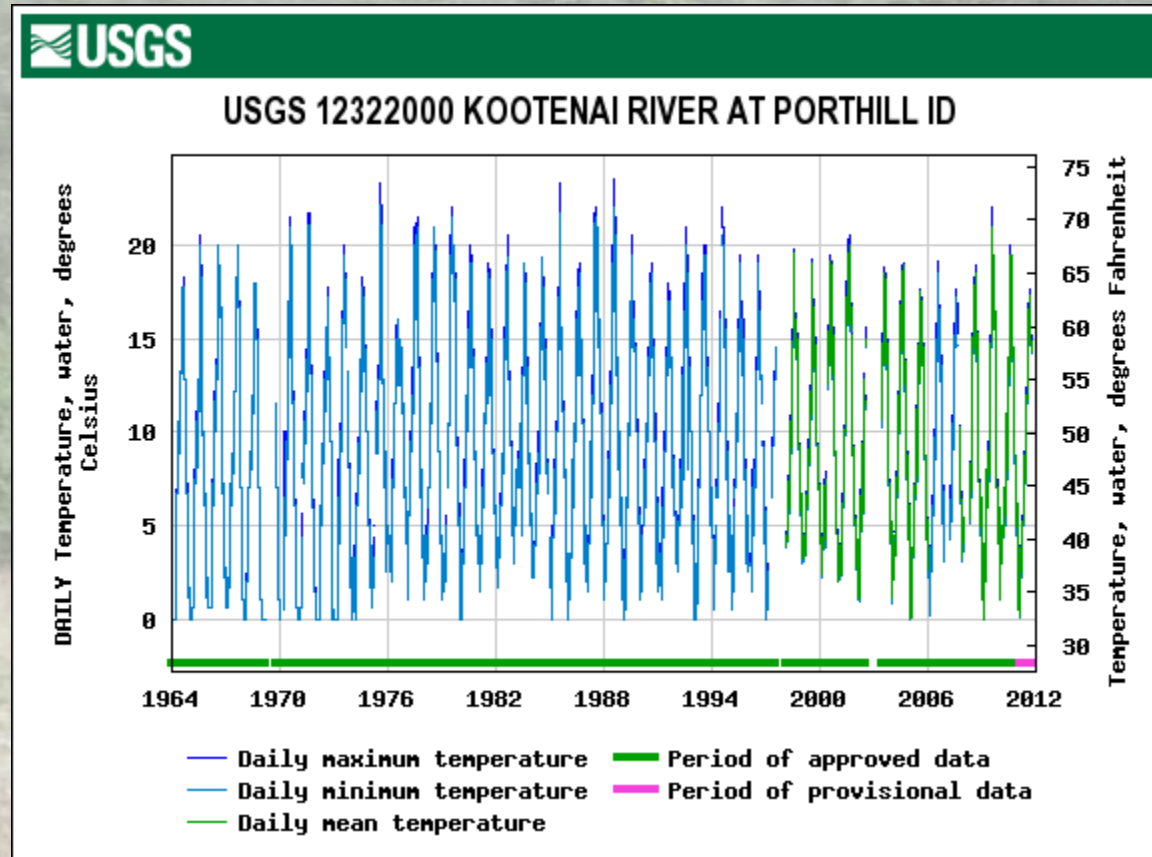
- **Who has data?**
 - Environment Canada's Water Survey of Canada.
 - B.C. Ministry of Environment (*MOE Water Stewardship Division*)
 - The B.C. and Yukon Water Quality Monitoring Network
 - Specific projects/consultants
 - FREP (stand level)



En. Can. Water quality sites in BC

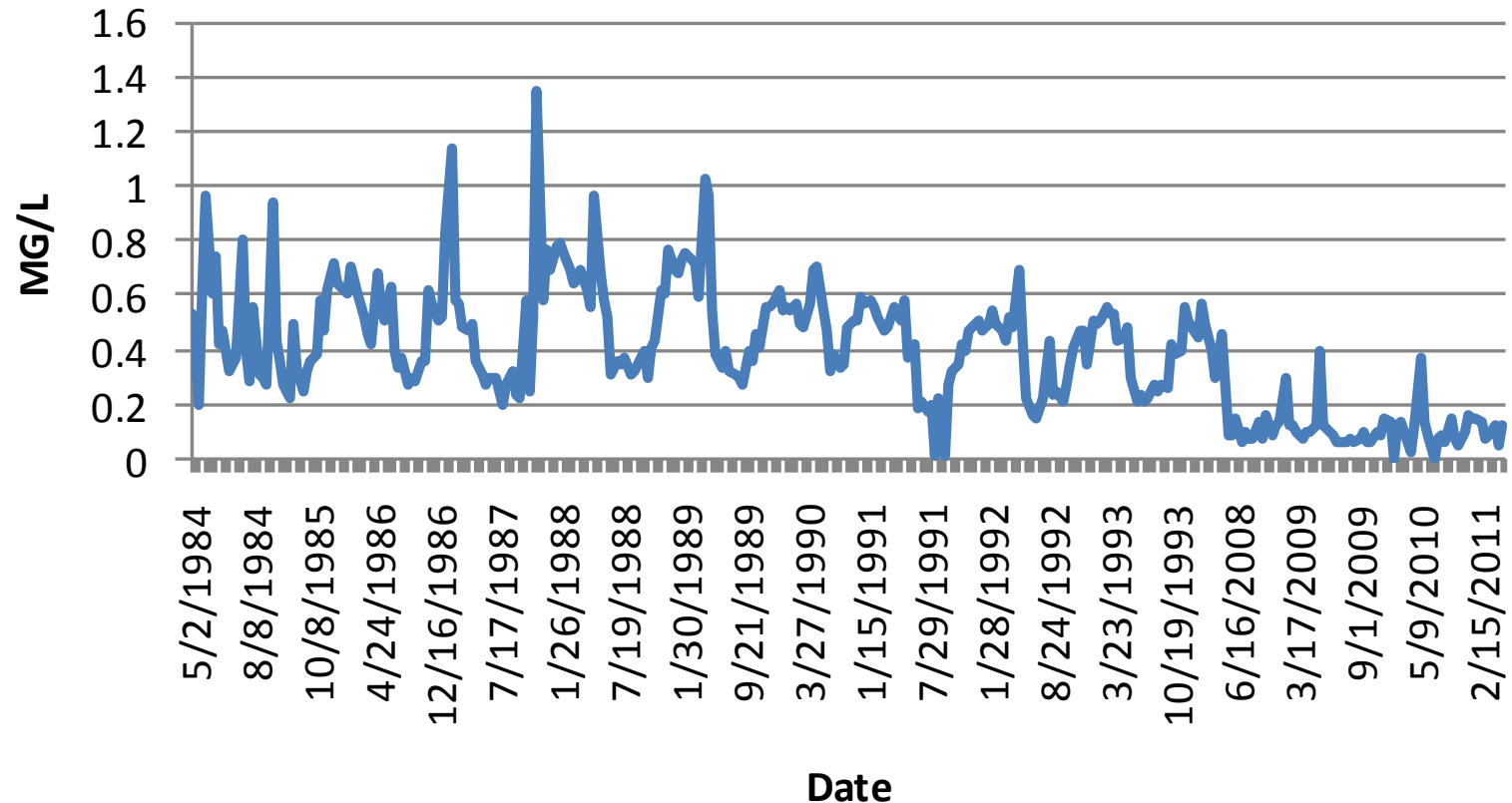


Example water temperature information



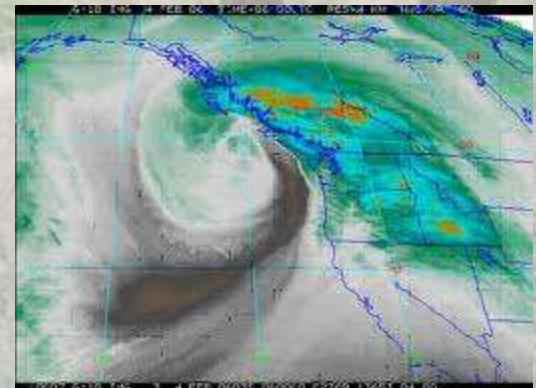
Example water quality information

Dissolved NO₃ and NO₂

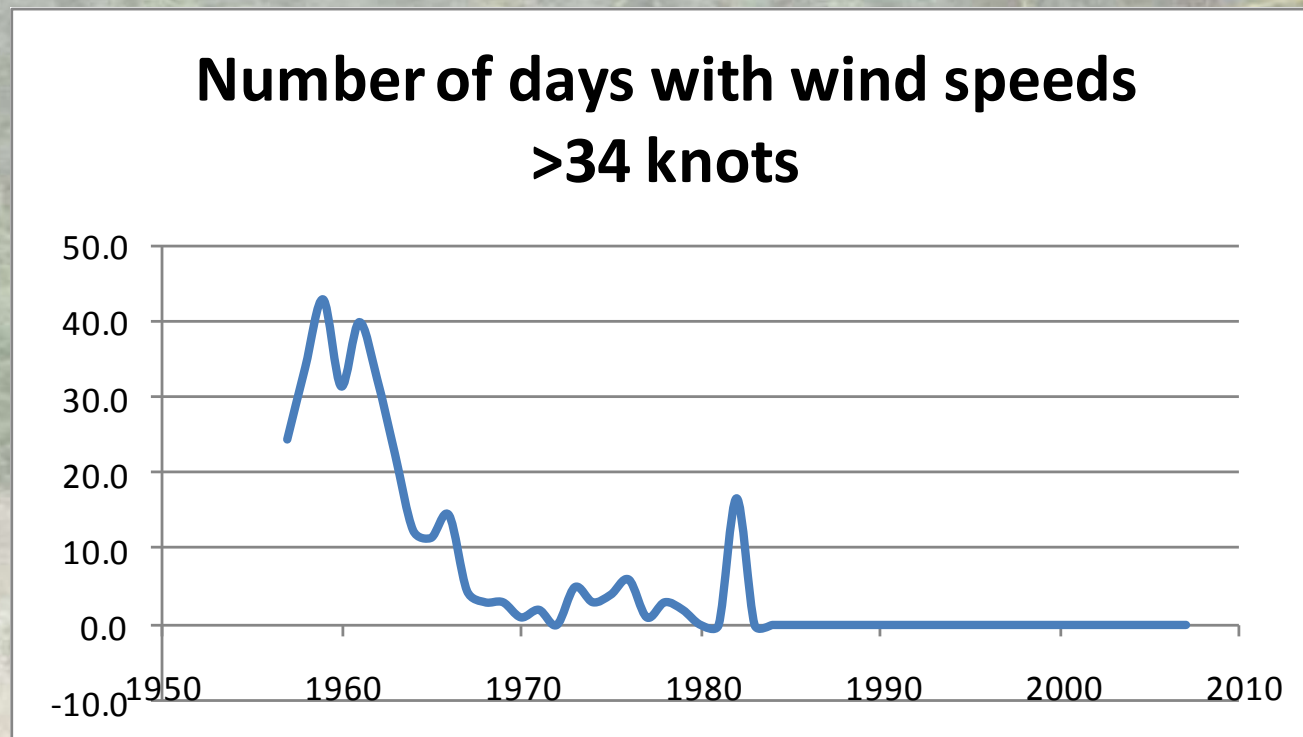


Extreme weather

- **Who has data?**
 - Environment Canada's Meteorological Service of Canada (500 sites BC and Yukon)
 - hurricanes, tornadoes, severe thunderstorms, storm surges, strong winds, high heat or humidity, heavy rain or snow, blizzards, freezing rain and extreme cold
 - Very little information *reported* on extreme weather events

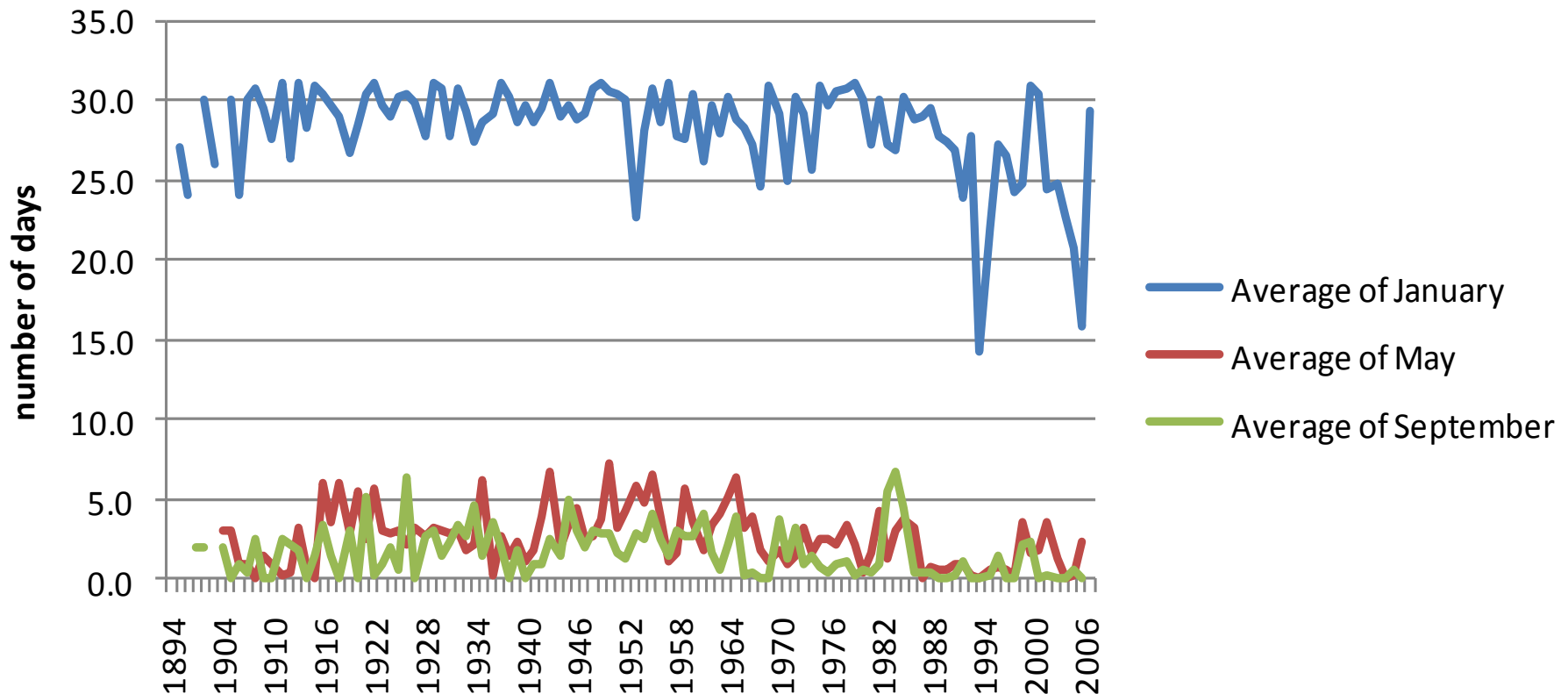


Examples of extreme weather information

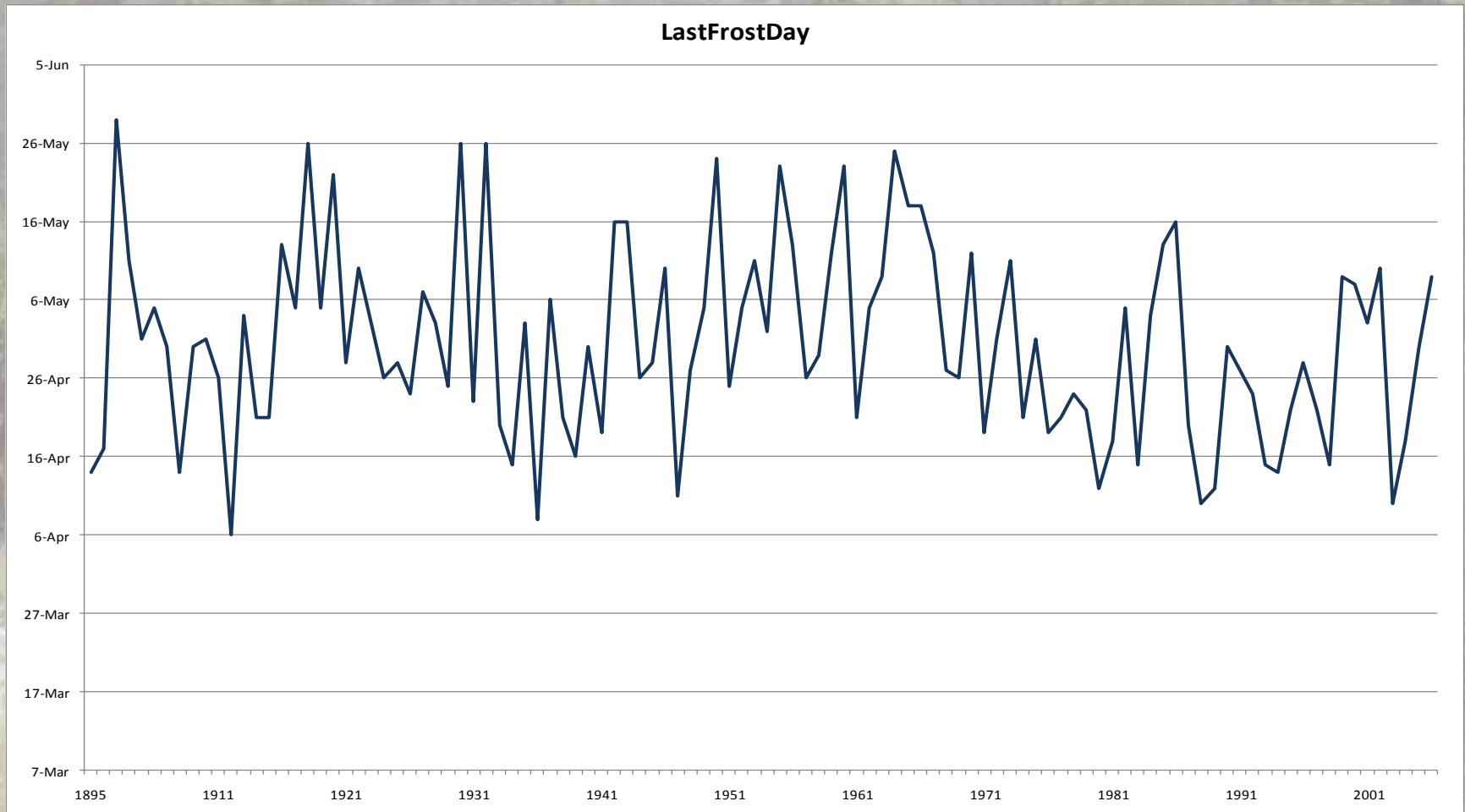


Examples of extreme weather information

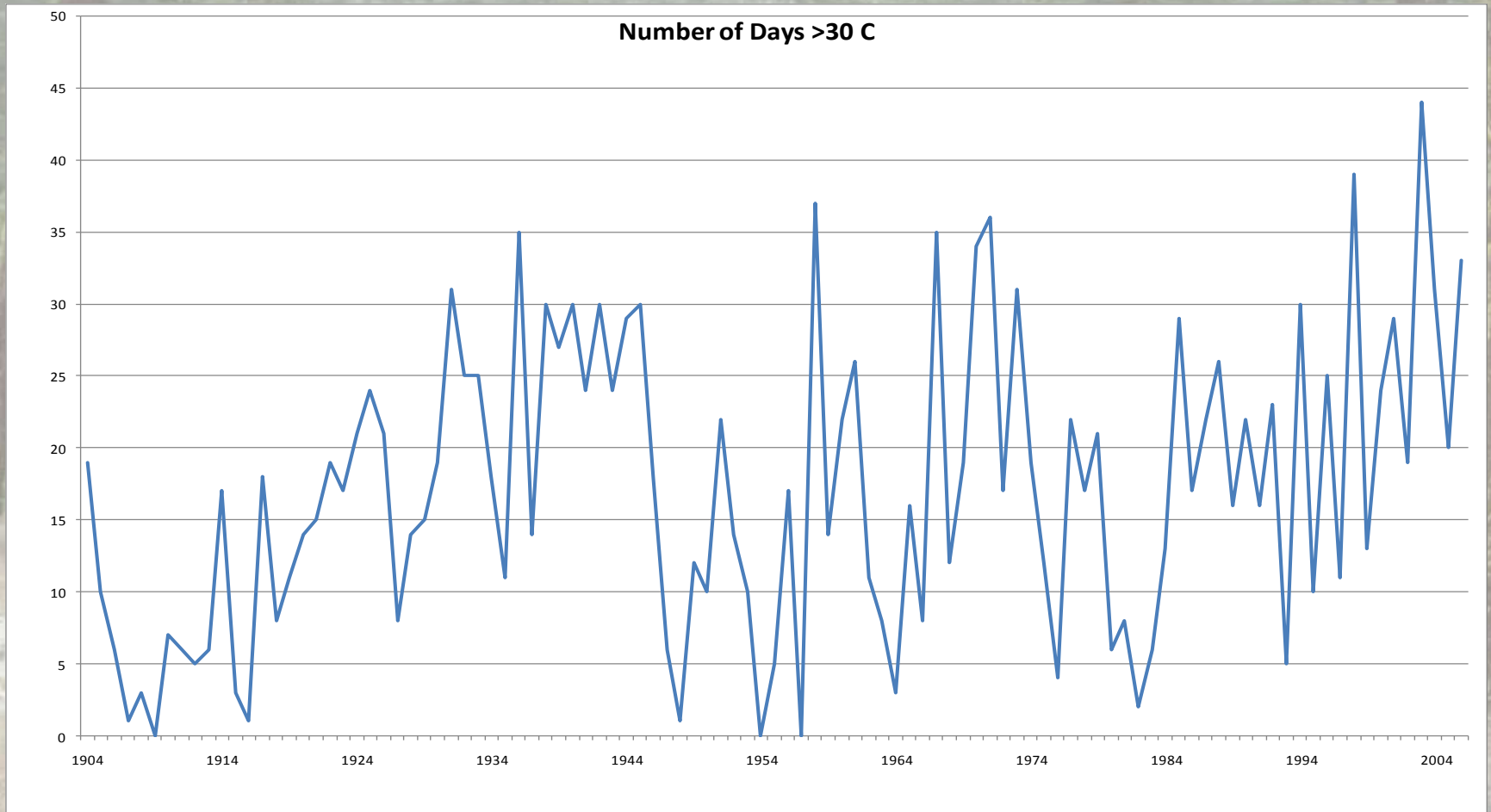
Number of days per month of frost



Examples of extreme weather information



Examples of extreme weather information



State of Information for the Indicators

- Abiotic
 - Temperature; precipitation
 - Snowpack; glaciers
 - Streamflow
 - Water temperature and quality
 - Extreme weather
- ***Disturbances***
 - ***Fire, insects, pathogens, wind, mass wasting***
- Biotic
 - Ecosystem composition, productivity
 - Ecosystem productivity
 - Species ranges
 - Genetic changes

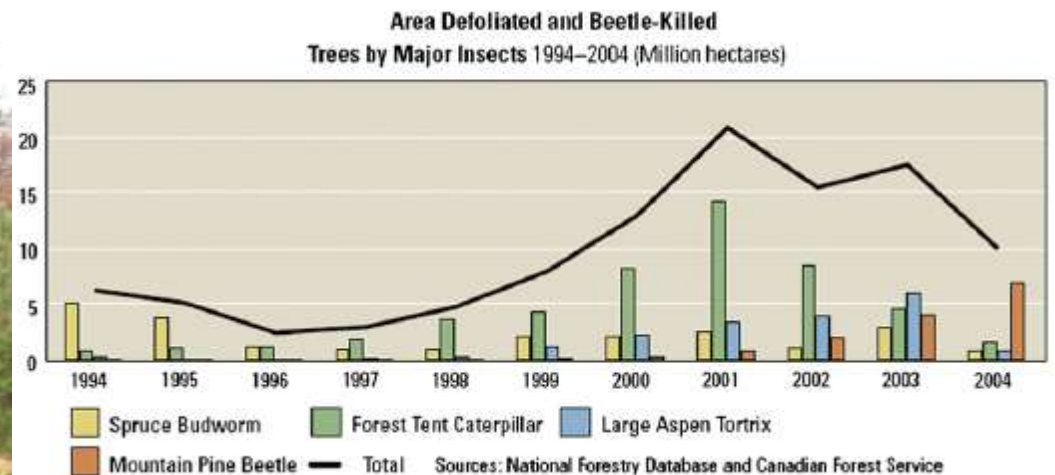
Fire

- **Who has data?**
 - MFLNRO Wildfire Management Branch which operates approximately 260 hourly weather stations province wide; fire size, severity



Insects and Disease

- **Who has data?**
 - Province-wide aerial surveys conducted by the MFLNRO
 - Variety of other surveys for specific areas



Mass movement

- In the survey mass movement was seen as highly important for monitoring in light of climate change but many confounding factors
- **Who has data?**
 - Many studies: Geertsema, Millard, Jordan, Coupe, etc.
 - Provincial forest health surveys
 - FREP stand level



Windthrow

- **Who has data?**
 - Many studies at the stand level: Beese, Rollerson, Jull, Quesnel, Delong, FREP....
 - Very few studies at the landscape level: Pearson
- Many confounding factors



State of Information for the Indicators

- Abiotic
 - Temperature; precipitation
 - Snowpack, glaciers
 - Streamflow
 - Water temp and quality
 - Extreme weather
- Disturbances
 - Fire, insects, pathogens, wind, mass wasting
- ***Biotic***
 - ***Ecosystem composition, productivity***
 - ***Ecosystem productivity***
 - ***Species ranges***
 - ***Genetic changes***

Composition of ecosystems

- Tracking changes in distribution and composition ecosystems is considered to be core to preparing for effects of climate change
- To date there have been few systematic attempts in the province to monitor changes occurring in composition and distribution of ecosystems



Ecosystem Composition

- **Who has data?**
 - We have BEC, VRI, TEM, but not repeated samples over time to track changes
 - NFI plots will have repeated measures but a number of the BEC zones are not covered by the NFI ground plots. Of particular note are the BEC zones: Boreal Altai Fescue Alpine, Coastal Mountain-heather Alpine, and Interior Mountain-heather Alpine

Forest Productivity

- Forest productivity was rated as the single most important topic
- **Who has data?**
 - Vegetation Resources Monitoring Program (VRMP)
has been developed to assess broad scale changes in forest volume over time.
 - Growth and Yield Permanent Sample Plots in BC



Species ranges/distribution

- ***Originally*** ... trends in population, range and phenology for species from a range of taxa
- ***But*** ... data not good enough for most taxa: Conservation Data Centre, Ecocat, BC Species and Ecosystems Explorer and the Fisheries Data Warehouse; BC Breeding Bird Atlas, Nature Counts, Frog Watch, Worm Watch, Plant Watch and the Canadian Community Monitoring Network

Species ranges/distribution

- Exception is birds – good data
- No data exists even to allow examination of changes in tree species distribution or treeline shifts in all but a few areas.
- BEC, VRI, and TEM not repeated
- NFI has potential



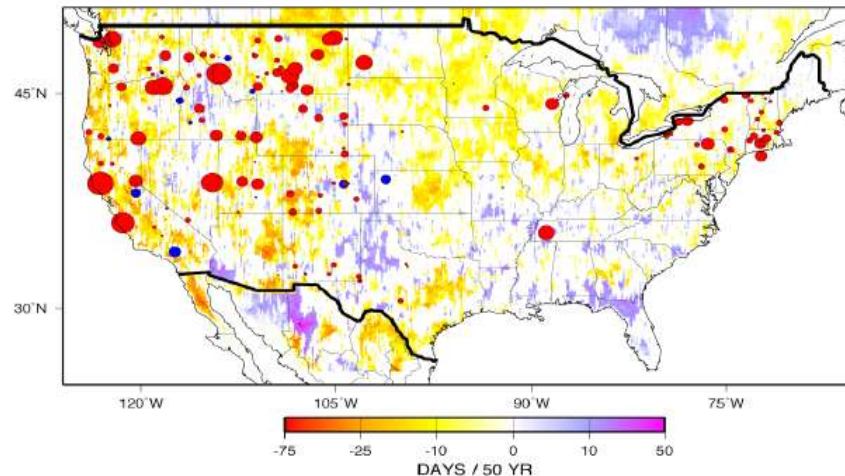
Summary

1. Some basic trends in data already are tracked and reported well, particularly for abiotic indicators:

- Temperature
- Precipitation
- Snowmelt
- Streamflow
- Glaciers
- Ice on lakes

Figure 6. Trends in Frost-Free Growing Season Length and Phenological Observation of Bud Burst

SHADES: TRENDS OF BEGIN DATE OF GROWING SEASON, 1950-99, FROM TEMPERATURES
DOTS: TRENDS IN LILAC FIRST-BLOOM DATES (Sites with 20+ yrs of record)



- **BUT** some derived indicators lacking: growing season, drought

Summary con't

2. Some abiotic indicators not tracked as well

- Extreme weather (frost, drought) – *and this is what forests respond to quickest and most strongly!*
- Water temperature
- Water quality



Summary con't

3. **Natural disturbances: fire and insects/disease tracked better than mass wasting or windthrow**
- **Fire** (confounded with suppression so note suppression levels and which ones suppressed)
 - **Insects and disease** (FIDS, then MOF overview flights help on this, they also track windthrow and mass wasting if seen)
 - **Mass wasting** – mostly site level but for Geertsema
 - **Windthrow** – also mostly site level so confounded (but Pearson on Coast looked at landscape level)

Summary con't

4. Tracking biotic responses weakest!

- **Ecosystem distribution and composition** – *we have benchmarks but no plans to measure again for trend (BEC, VRI, TEM)*
 - *There are change measurements plots that are happening through NFI*
- **Ecosystem productivity** (*PSPs, other?*)
- **Species distributions** changes – *few data even for trees*
- **Genetic diversity** – *few data, did not discuss today*
- **Ecosystem connectivity** (*did not discuss today*)

Next steps

The summary suggests some key holes to fill:

- Organize water temperature and quality information
- Measure and report extreme weather – frost, duration of drought, growing season length, etc
- Continue insect and disease surveys and perhaps add wind and mass wasting reporting
- Establish repeated measures for ecosystem composition and distribution (use BEC plots as PSPs?)
- Track tree productivity
- Track ranges of sensitive species
- Measure our adaptations



Measuring adaptation...

- Success (or not) of assisted migration trials
- Benefits (or not) of various harvesting methods



- Will be important to use and track usefulness of a diversity of practices

A photograph of a forest with tall, thin trees and a grassy clearing. The text "Thank You!" is overlaid in the center.

Thank You!

Conveying Information

Topic Area	Mean	Standard Deviation
Internet	3.46	0.61
Technical articles	3.38	0.56
Government reports and briefings	3.36	0.57
Journal articles and other academic literature	3.14	0.75
Face-to-face extension	2.95	0.77
Cooperate Databases	2.90	1.02
Professional association(s)	2.75	0.82
Seminars	2.62	0.68
Webinars/e-lectures	2.55	0.81
Consultants	2.53	0.92
Newspapers/Magazines	2.53	0.80