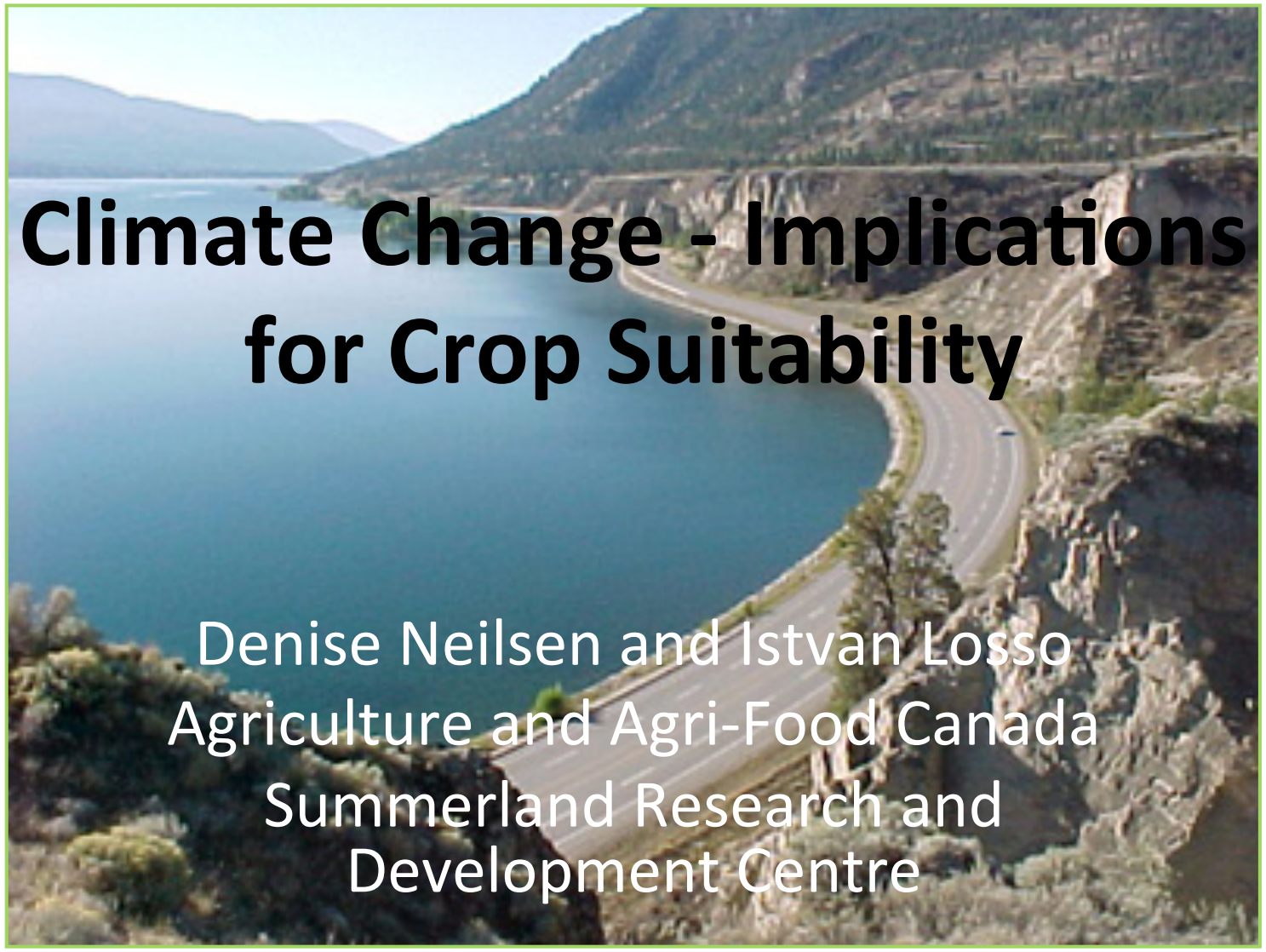

# Climate Change - Implications for Crop Suitability

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# Rationale

- Climatic boundaries of many temperate deciduous fruit crops have changed creating potential for new growing regions
- British Columbia is at the N. limit for many temperate fruit crops
- Complex terrain in British Columbia also imposes altitudinal climatic limits
- Crop suitability models developed in BC can be extended to other regions

# Land use change is already happening

- **Expanding areas wine grape/cherry**

- **Sweet cherry is a useful model crop for risk assessment – early bloom, moderately hardy, short growing season**

# Approaches

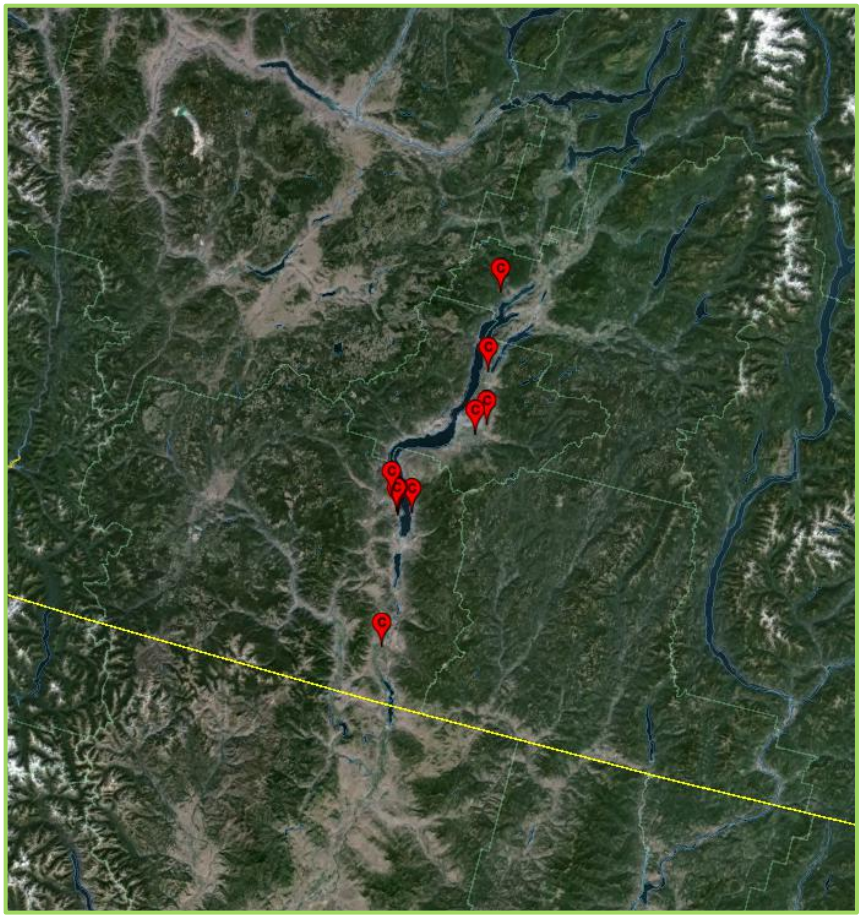
- Phenology/hardiness modelling
  - Dormancy, Spring floral development, Fruit growth, Cold hardiness
- Climate modelling
  - High resolution gridded datasets
- Soil and landscape suitability
- Risk assessment
  - Risk criteria developed and combined risks mapped in GIS

# Phenological modelling

- Year round plant growth and development models
- Tested against threshold damaging temperatures at all stages
- Empirical models developed from regional survey data and controlled laboratory studies

# Study location and sample sites

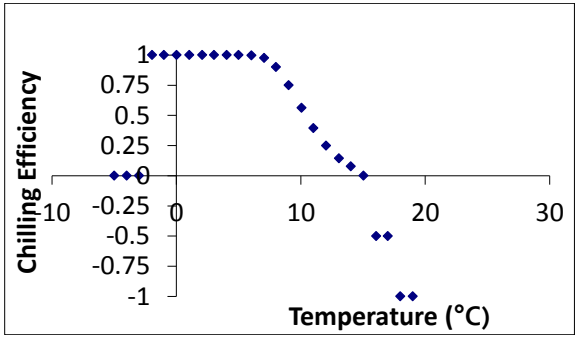
- Survey sites chosen to represent a wide range of micro climates
- Four years of data
- Hourly temperature measurements

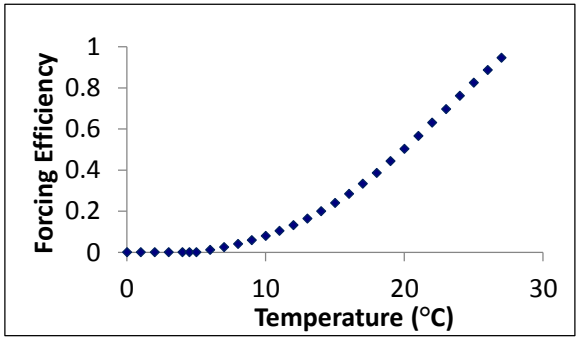


# Breaking dormancy – controlled studies

Two stages

- Internal bud requirements (endo-dormancy)
  - met by ‘chilling’: exposure to temperatures between -2°C to 8°C
  - Fall and Winter
- External bus requirements (eco-dormancy)
  - Met by ‘forcing’: exposure to temperatures between 5°C to 30°C
  - Late Winter and Early Spring

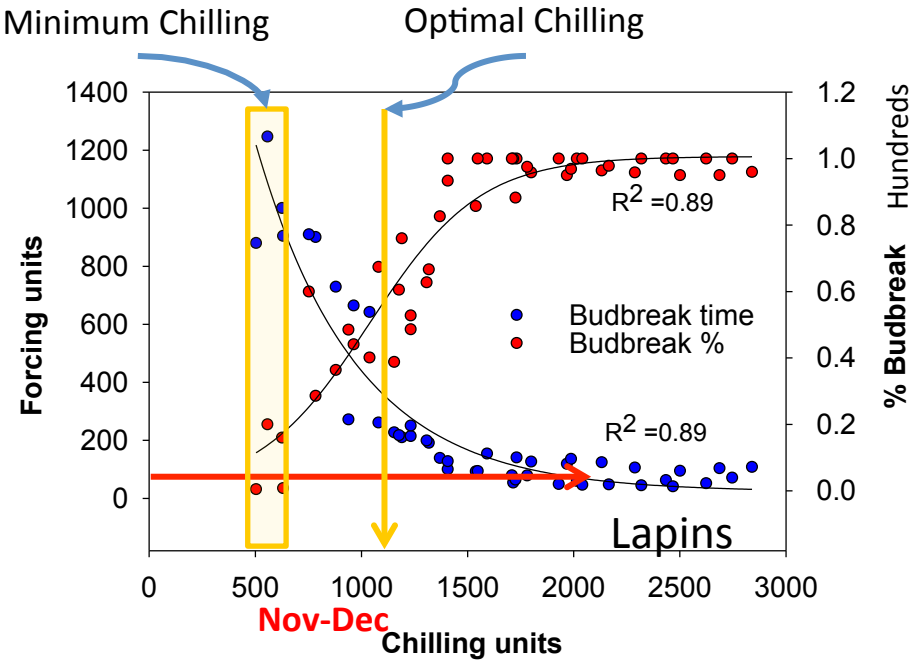


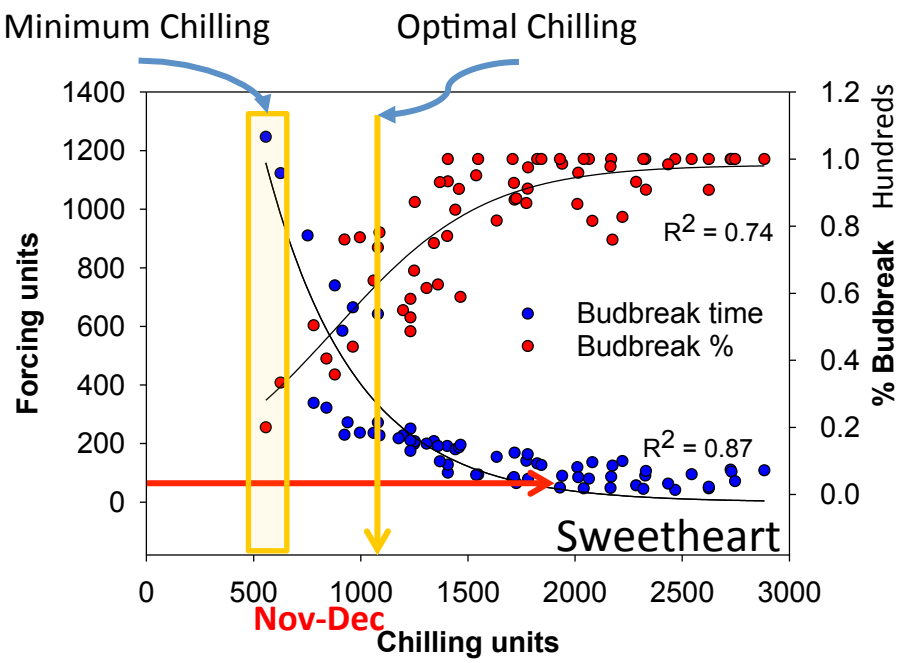



# Verification of chill and forcing requirements

- Field samples collected early fall to spring
- Forced at 18-23C
- Bud quality and days to bud break assessed
- Chill units determined hourly at date of sampling
- Forcing units determined hourly from greenhouse temperatures + outdoor temperatures occurring after the date of the first sample to break bud in each year (critical bud break).

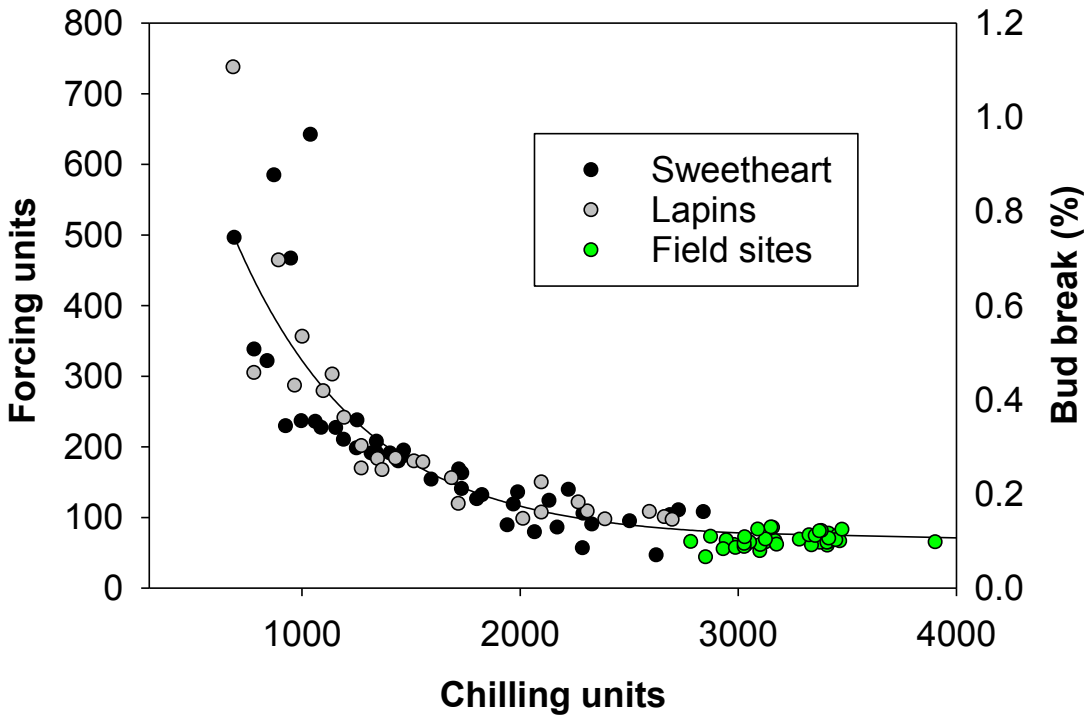
# How much chilling and forcing is required to break bud in ‘Lapins’ and ‘Sweetheart’ cherry



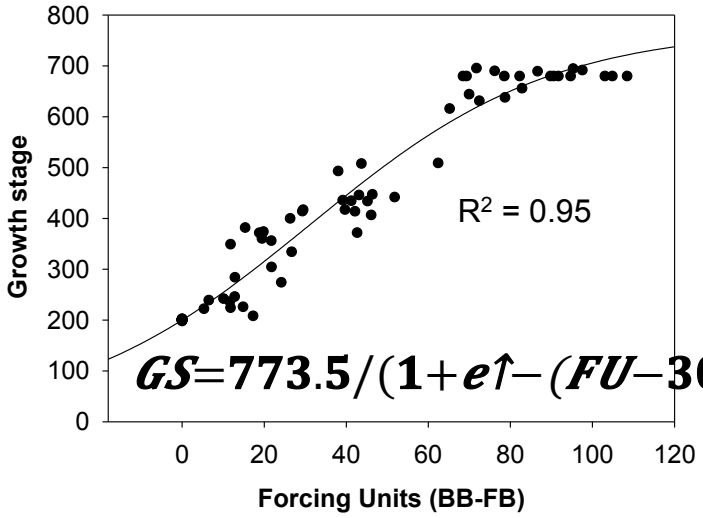

- **Minimum chill requirements** to break endo dormancy (550-650 CU)
- Chilling beyond (550-650 CU) reduced the amount of heating required to break bud (DTBB) and bud viability (% BB)
- **Optimal chill ~ 1120CU** (~60% BB)
- After optimal chill reached **forcing required to break ecodormancy ~ 70FU**

# Field validation of the model

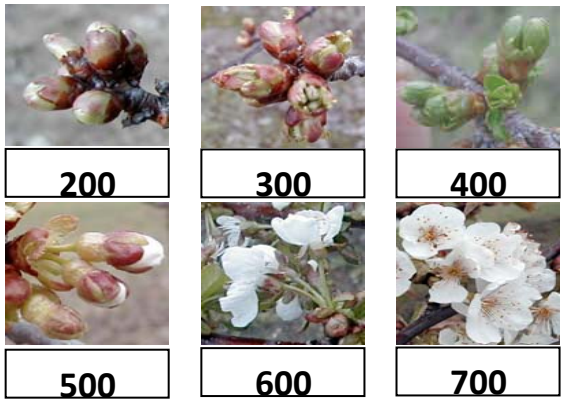


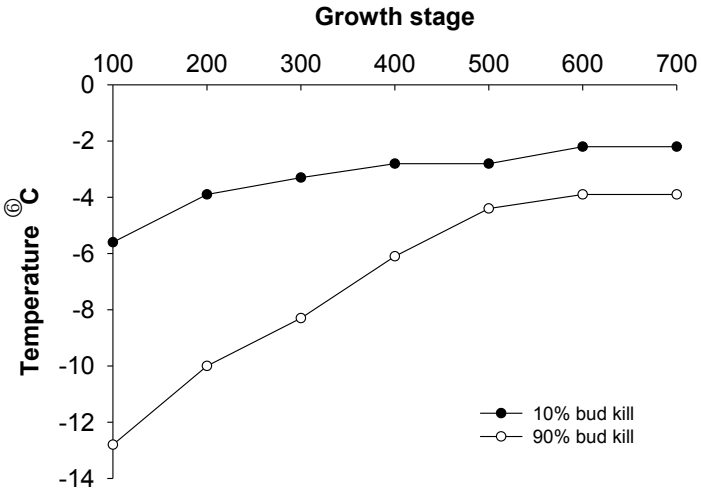

- Optimum chilling ~ 1120 CU
- Optimum forcing from time of optimum chilling ~70 FU
- Regions which do not receive optimum chilling will require more FU
- **Best RMSE field validation set = 3.3d**

# Sweet Cherry spring phenological stage modeling from field site data




$$GS = 773.5/(1+e^{-(FU-30.99)/29.41})$$




Multistage model: **RMSE = 3.5d**

Model methodology:

***Neilsen et al. 2015 Acta Hort. 1063***

Spring frost risk:

***MSU Extension website 2008***

# Sweetheart cherry growth curve

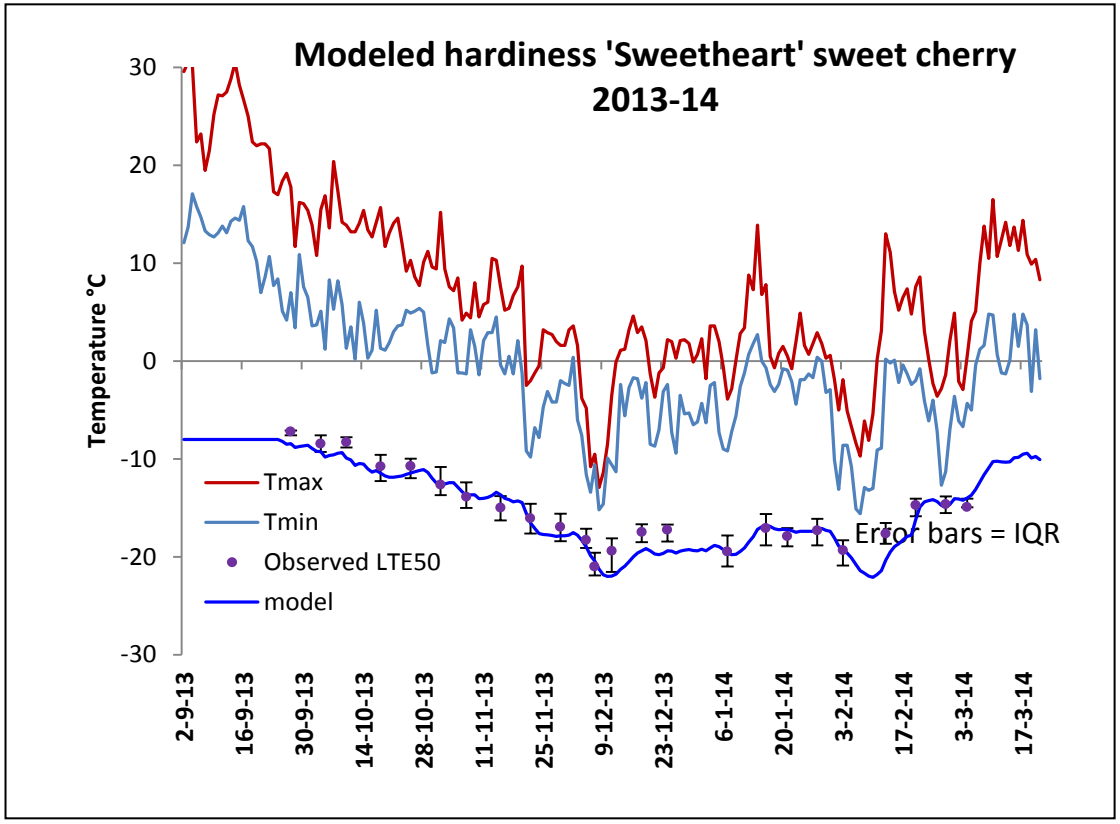



$$y = 0.123 + (2.12/1 + ((GDD5/173)\uparrow -4.6)) + (8.13/1 + ((GDD5/647)\uparrow -5.7))$$

- Fruit diameters measured through growing season (3sites)
- Average heat requirements from bloom (10 sites) GDD5 ~1100
- Annual heat requirements (10sites) GDD5 ~1220

# Cold temperature risks - modelling

- Absolute minimum risk = -30C
- Model modified from Ferguson et al., 2011. Ann. Bot. 107
  - Acclimation f(daily min T)
  - De-acclimation f(daily max T)
  - Boundary between predominantly acclimation and predominantly de-acclimation phases set at FU=10 i.e. during lead-up to BB
- Model parameterization: 2011/12; 12/13; 13/14
- Model validation: 2008/09; 09/10; 14/15.
- **RMSE parameterization data set = 1.29C**
- **RMSE validation data set = 1.73C**



# Climate models

- 500m downscaling/upsampling was applied to the 300 arc second (~10 km) Anusplin dataset 1951-2010 and select GCM and  Earth Systems Models (ESM) for British Columbia to produce daily climate surfaces for modelling

Models include:

- CGCM3.1_a2.BCSA;
- CANESM2; CSIRO Mk3-6-0; ACCESS1-0; CNRM-CM5; INMCM4 all with RCP= 4.5, 8.5.

http://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios

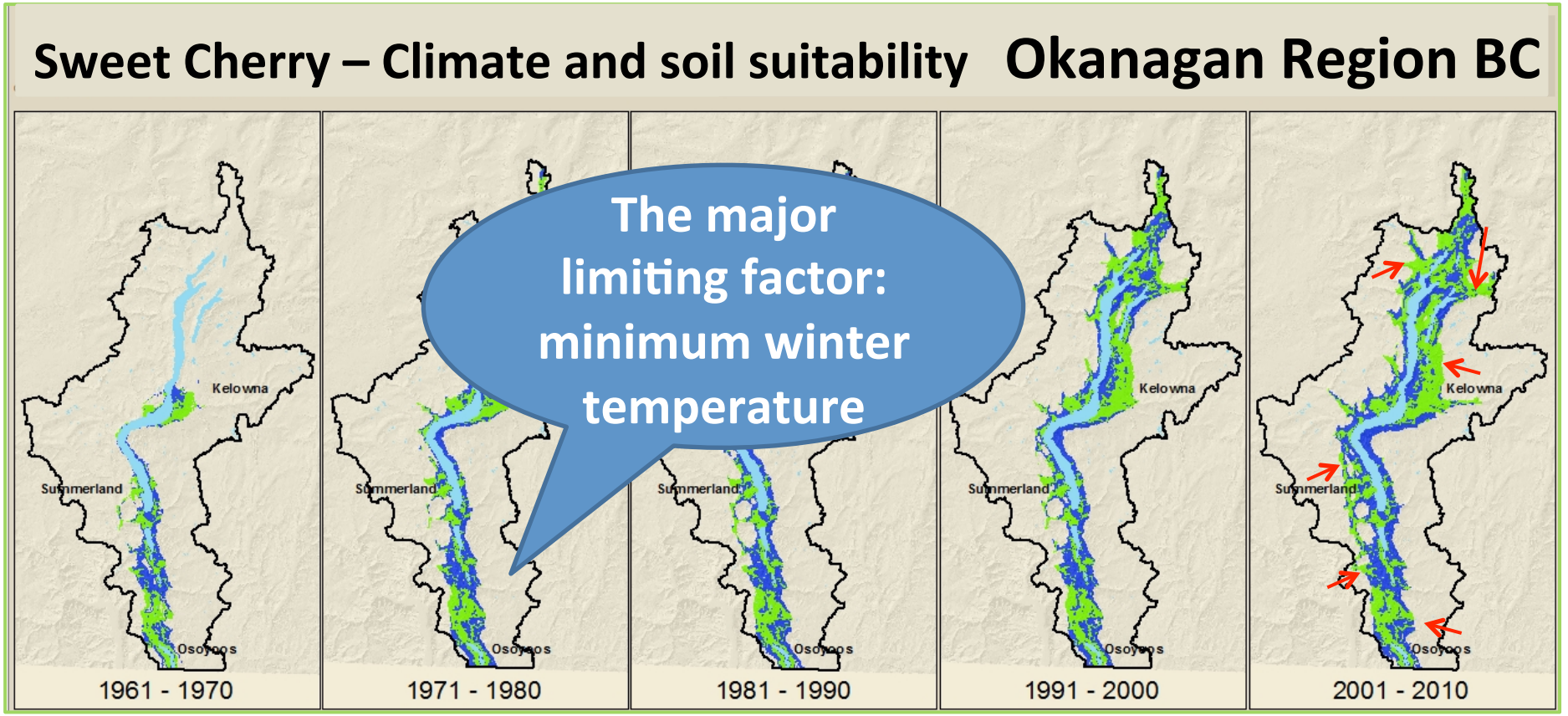
# Soil and landscape suitability

- Slope <30%
- Soil (not rock)
- Drainage
- Stoniness
- Soil texture

# Risk assessment

| Name | Description | Risk threshold |
|---|---|---|
| **GDD5** | Number of growing degree days with base 5 C for fruit maturation: minimum 1100 GDD5 | > 3/10 years |
| **Absolute minimum temperature** | -30 C in wintertime; no tolerance. | > 0/10 years |
| **Dormancy complete** | Number of chilling units required to complete dormancy: 1120 units | > 3/10 years |
| **Spring frost risk, dormancy complete** | Spring temperatures above cold hardiness level | > 4/10 years |
| **Spring frost risk, 10% kill** | Temperature threshold for 10% damage | > 5/10 years |
| **Spring frost risk, 90% kill** | Temperature threshold for 90% damage | > 2/10 years |
| **High temperature** | Three days within fruit development period with temperatures > 37 C | > 5/10 years |
| **Cold hardiness** | Temperatures remain above cold hardiness levels | > 4/10 years |

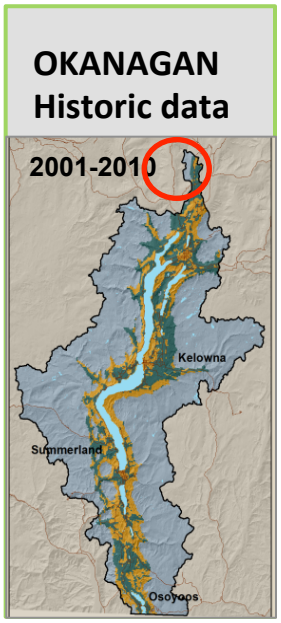
# Changing distribution of cherry production

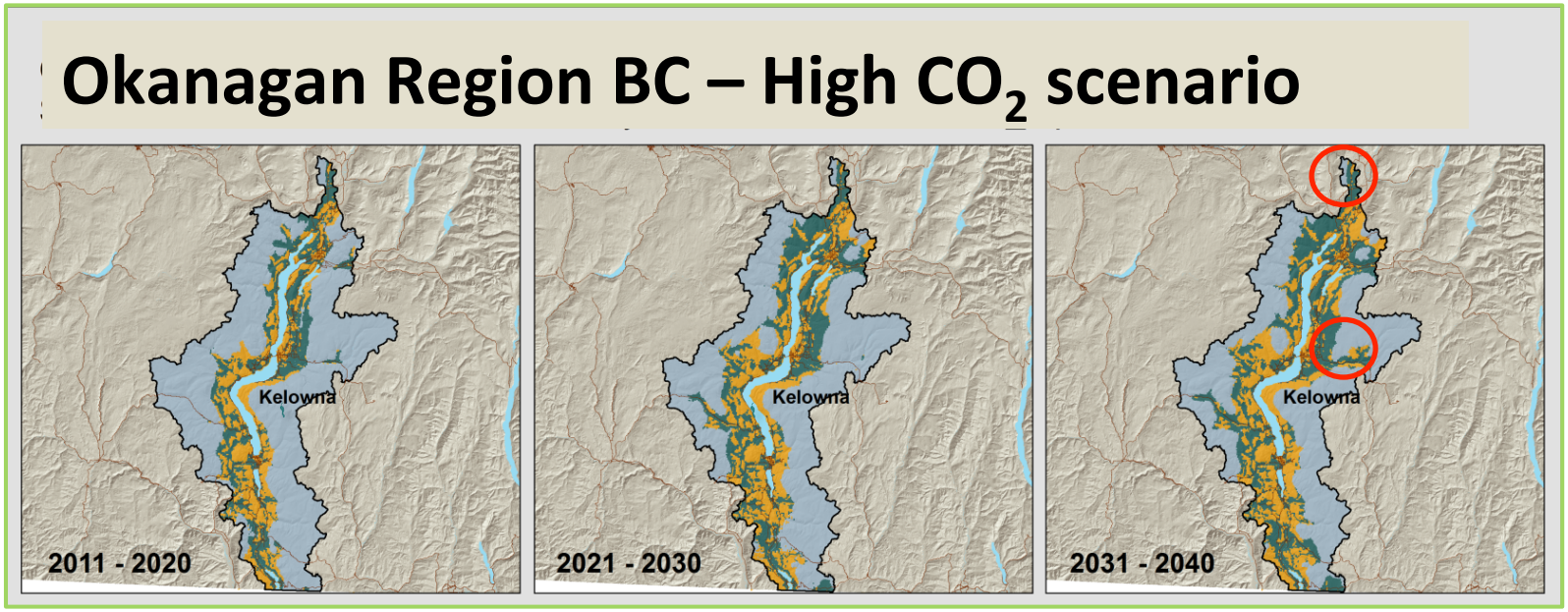



**Models**

- **dormancy**
- **cold hardiness**
- **phenology**
- **in- season fruit growth**

# Changes in suitability due to climate for sweet cherry in the Okanagan region



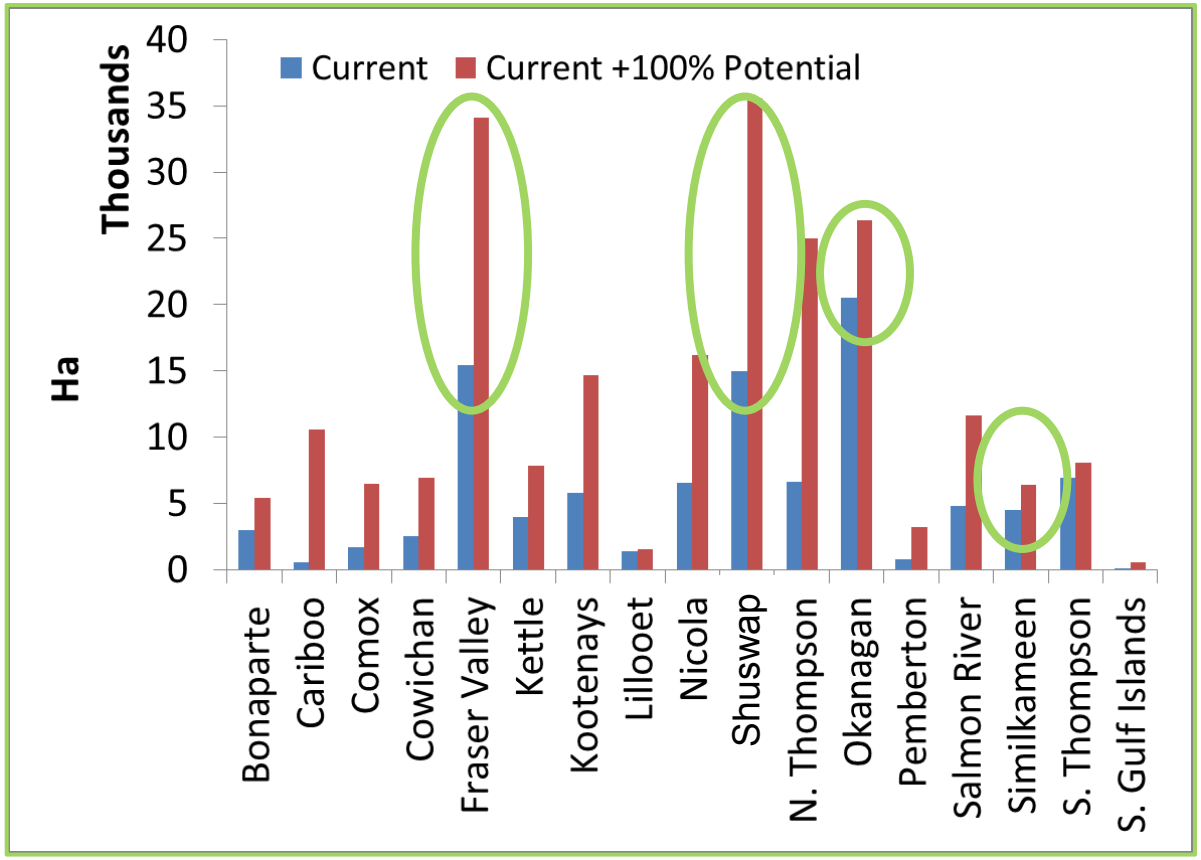

- Climate and soil/landscape suitable
- Climate suitable and soil/landscape unsuitable
- Unsuitable

- Small potential increases in area

# Potential land available for crop production in ALR

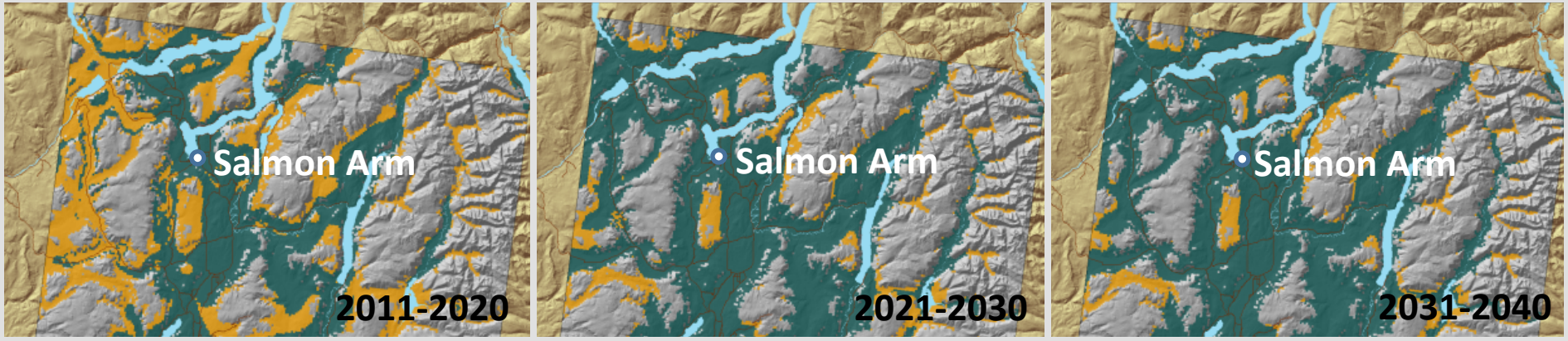
## Criteria for all regions

- **within 1,000 m of water supply (lake, water course, wetland, high productivity aquifer, water purveyor)**
- **must be within the ALR**
- **with Ag Capability class 1-4 (only where information is available)**



# Changes in climate suitability for sweet cherries the N. Okanagan/ Shuswap

**Shuswap Region BC – High $CO_2$ scenario**




- Climate and soil/landscape suitable
- Climate unsuitable
- Soil and landscape unsuitable

- Large potential increases in area suitable for high value crop production

# Thank you

# Climate and crop production

- **In general, climate determines location suitability for crops**
  - Is there enough heat to mature a crop?
  - Is the growing season long enough?

- **For perennial crops such as grapes and tree fruit there are other considerations**
  - Can the plant acclimate to winter minimum temperatures?
  - How frequently does winter damage occur?

- **There are climate thresholds that affect quality and production and these are often crop specific**
  - Frost risk in spring and fall
  - High summer temperatures that can reduce fruit growth or cause sunburn
  - Hail and rainfall that can damage fruit and foliage