

 Agriculture and Agri-Food Canada    Agriculture et Agroalimentaire Canada



**Climate driven adaptive traits in phenology and ecophysiology of *Populus balsamifera* L.**

Raju Y. Soolanayakanahally  
Science and Technology Branch  
Agriculture and Agri-Food Canada  
Canada



**Canada**

Tree species that occupy large ranges at high-latitude must adapt to widely variable growing periods associated with geography and climate.



Fort Nelson, BC



Kuujuuaq, Quebec

This variation may represent adaptation to environmental heterogeneity that exists both locally and globally with latitude.

During 20<sup>th</sup> century, longer growing season was the most widely observed biological change in response to climate warming; i.e. advanced spring and delayed autumn arrival.



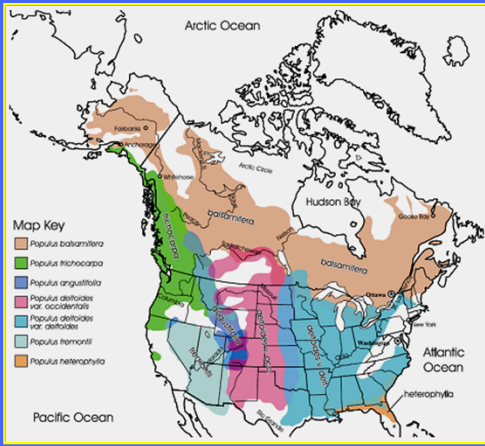
However, these phenological events (flowering, leafing out, leaf senescence, bird migration, fish spawning) are very sensitive to interacting environmental cues like:

- **Temperature** (unpredictable)
- **Photoperiod** (predictable)

### Tree responses to photoperiod in changing climates?

Phenophases are regulated by photoperiod and/or other signals, in addition to temperature

Distributional range of native riparian cottonwoods in North America



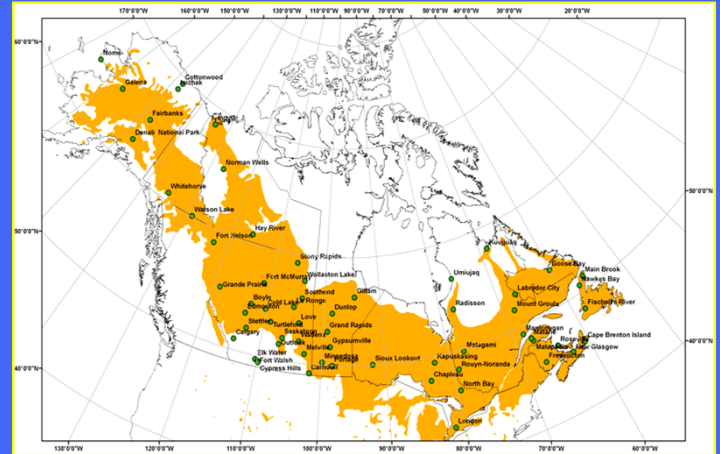
Cottonwoods in North America

Study objective

Canada will need to meet the long term challenges of climate change. As a result, there is considerable interest in *Populus balsamifera* at AAFC breeding program. There is a strong need to understand the functional variation in ecophysiological and other adaptive traits of this species over a wide range of environmental conditions and latitudes.

Agriculture Canada Balsam Poplar collection (AgCanBaP)

AgCanBaP collection: 65 populations



Populus balsamifera native range (shaded area)



Wild stock of balsam poplar



Don collecting dormant whips



60 day old stecklings under extended photoperiod



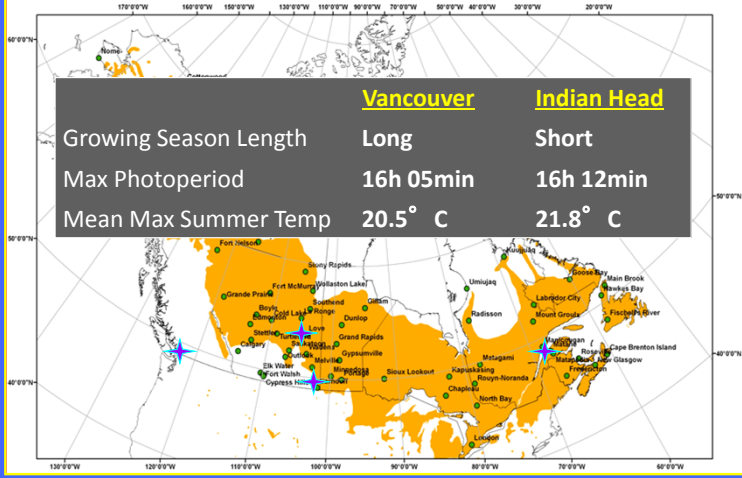
Field preparation for planting stecklings at Vancouver, British Columbia



Active growth during summer at Indian Head, Saskatchewan

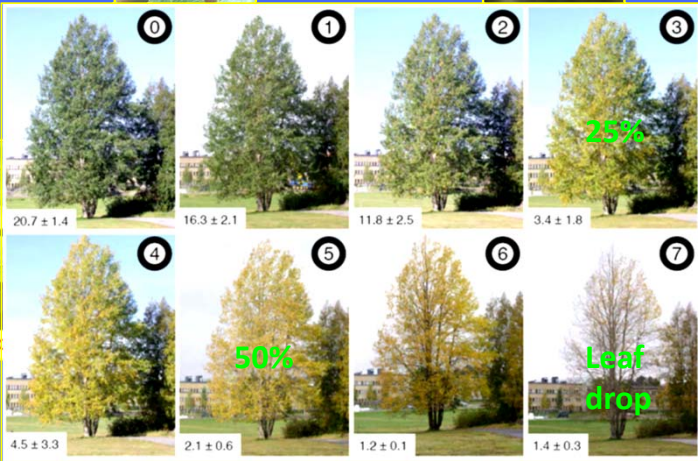
### AgCanBaP collection

	Vancouver	Indian Head
Growing Season Length	Long	Short
Max Photoperiod	16h 05min	16h 12min
Mean Max Summer Temp	20.5° C	21.8° C



Populus balsamifera native range (shaded area)

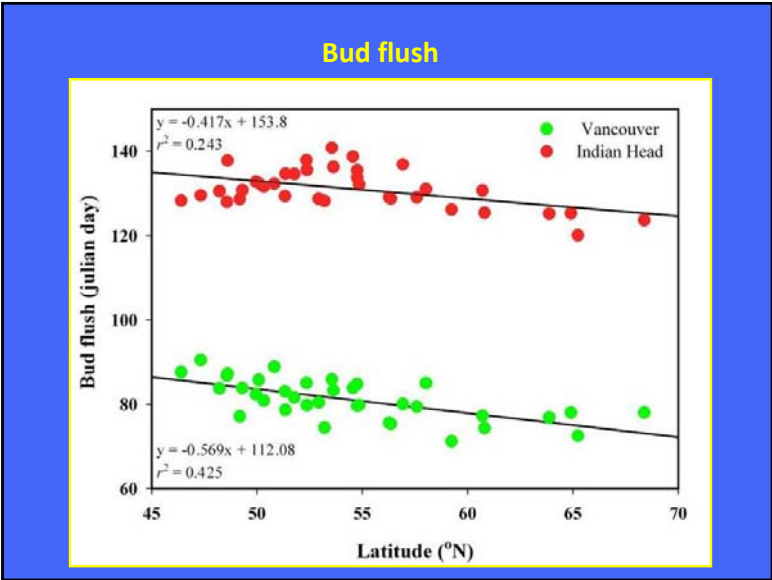
### Phenological events

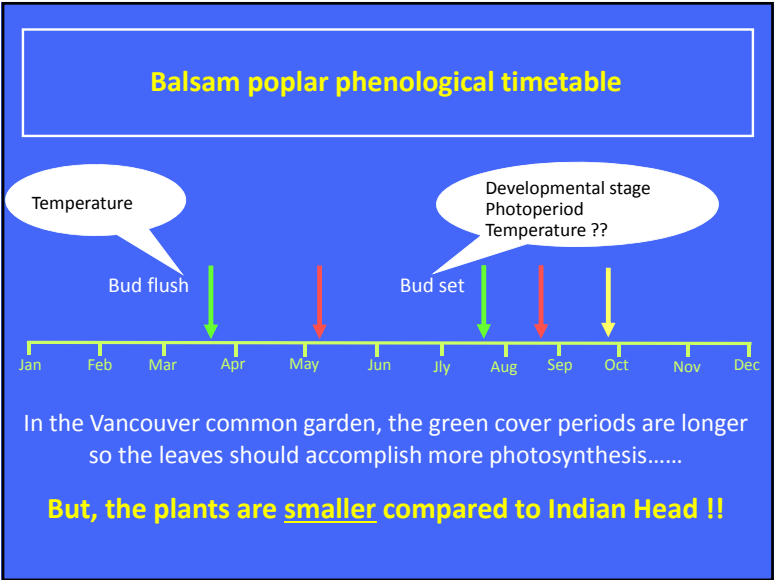
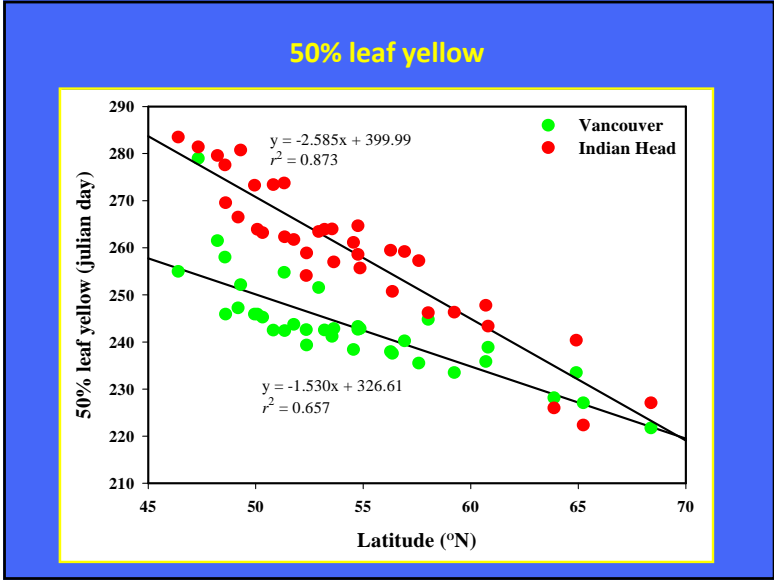
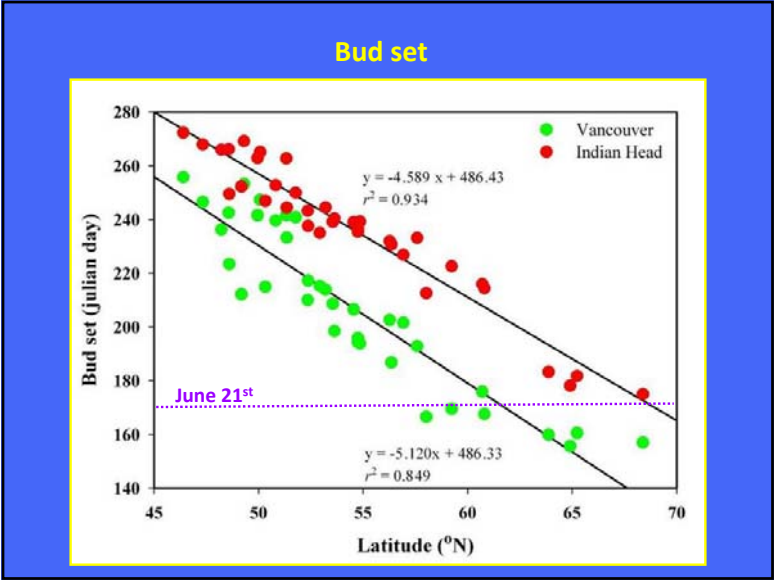


20.7 ± 1.4    16.3 ± 2.1    11.8 ± 2.5    3.4 ± 1.8    25%

4.5 ± 3.3    2.1 ± 0.6    1.2 ± 0.1    1.4 ± 0.3    50%    Leaf drop

Active growth    senescence score card    Leafy stage

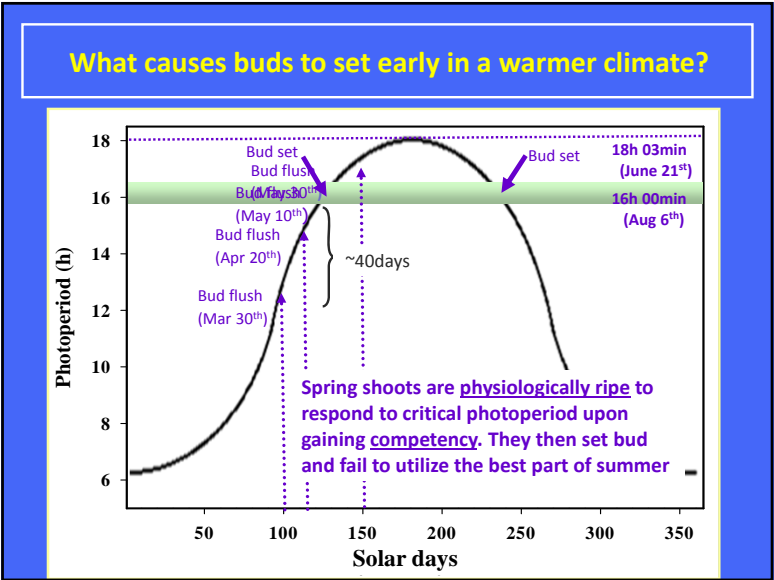
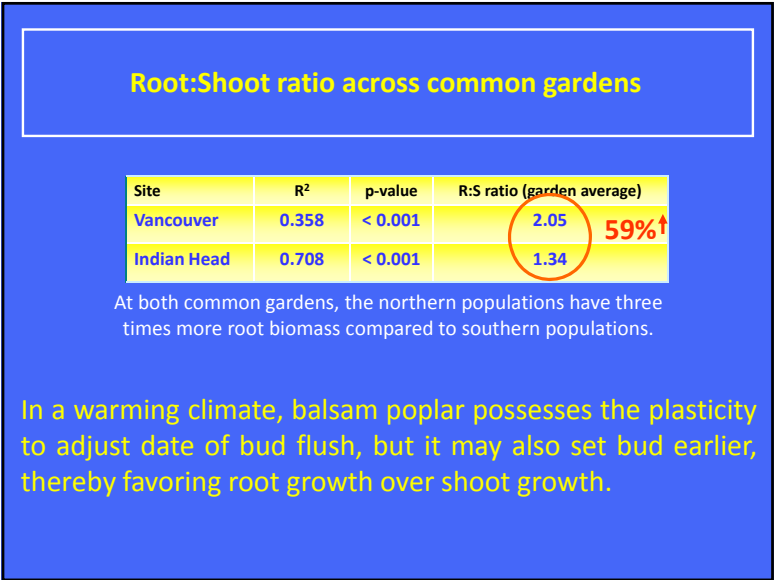
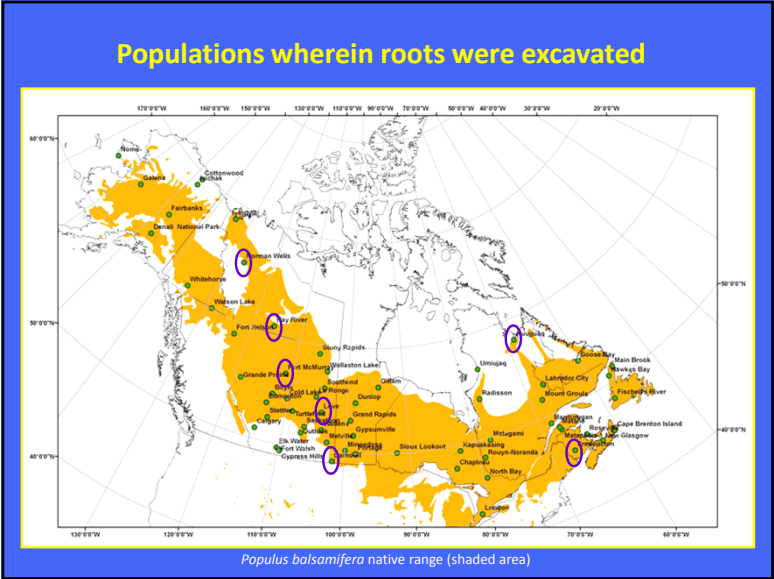




**Where is all the fixed carbon going?**

Is it being invested into roots as a consequence of early bud set across all populations?





Common gardens exposed

Problems of early spring arrival for native balsam trees....

- Trees reach photoperiodic competency too early
  - respond to spring photoperiod
  - stop height growth and set bud early
  - fail to utilize the summers for shoot elongation
- Increase in root:shoot ratio with the lengthening of green-cover period
  - drought tolerance ??
  - respiratory costs ??
  - ecosystem carbon cycling ??

Latitudinal gradients in height in common garden



Strong photoperiodic control of bud set leads to differences in shoot growth among populations at the Indian Head common garden after four years.

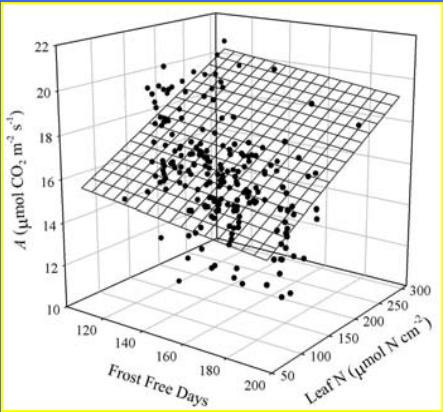


Populations grown in greenhouse under 21 hours light period

Plant height during peak growth across high latitude and low latitude populations



Assimilation rate ( $A$ ) as a function of Leaf N and frost-free days across all genotypes of balsam poplar



### **Latitudinal gradients in height in greenhouse**



A clear demonstration of the overwhelming importance of bud set in determining annual growth rate in trees adapted to different growing season lengths is obtained from their response to unconstrained photoperiod.

### **Greenhouse study exposed:**

- Photosynthetic rates and water-use efficiency were enhanced in genotypes from shorter growing season.
- In balsam poplar much of the increase in Leaf N is attributed to leaf mass area.
- High latitude genotypes of balsam poplar are capable of greater growth when photoperiodic restrictions are removed.

### **Applications**

- Identifying inherently fast growing genotypes of balsam poplar for biomass plantations across Canada for carbon capture.
- Further genetic improvement of poplars as a Canadian bioenergy feedstock will speed up the establishment of a short-rotation, fast growing trees .
- Our breeding program will provide Canadian land owners with adapted poplar trees for agroforestry systems particularly riparian buffers for water protection and carbon sequestration.

**Thank you all..**