Aspiration of inter-tracheid pit and cavitated lumen of tracheids cause inhibition of transport induced by frost drought in young stem of *Abies veitchii*

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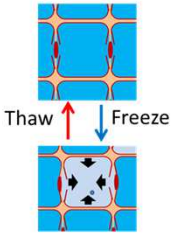
What Does Pit Aspiration in Sap Freezing Cause Branch Hydraulics?

- Hammel (1967) predicted the aspiration of pit of conifer tracheid due to a flow generated by expansion of sap volume while xylem sap frozen.
- Few studies have demonstrated the pit aspiration and its effect on stem water transport.



Hammel 1967

Conclusions

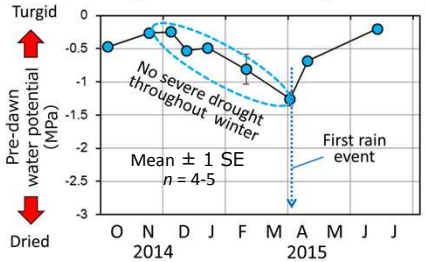
1. Much Snowfall & Early First Rain (Mild drought stress)
   - Pit aspiration caused slight inhibition and rapid recovery of stem water transport.
2. Little Snowfall & Late First Rain (Severe drought stress)
   - Pit aspiration & xylem cavitation caused severe inhibition and slow recovery of stem water transport.

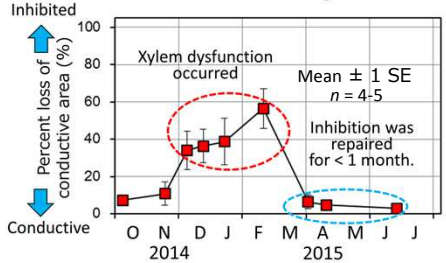
- **Plant materials** : Sun-exposed one-year-old branches of *Abies veitchii* occurring at Mt. Shimagare (36°5'N, 138°2'E, 2304 m a.s.l.)

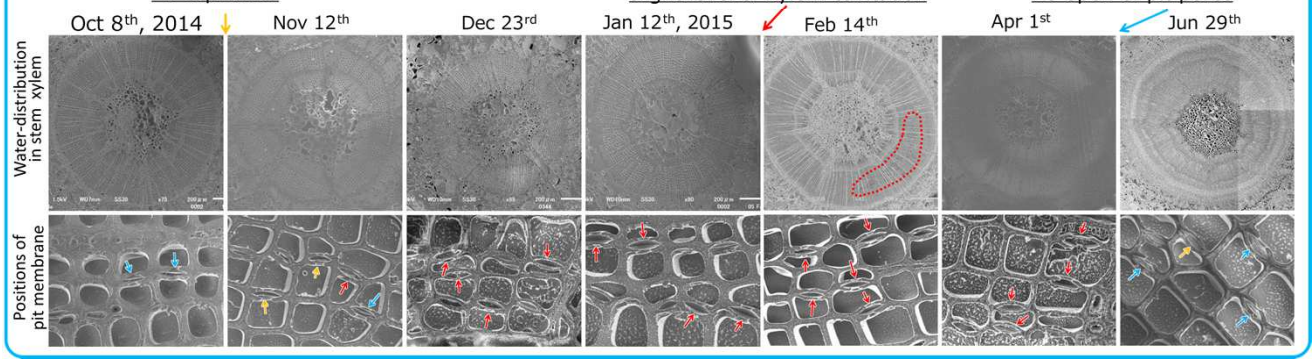
- **Methods**
  1) Water potential <- pressure bomb
  2) Percent loss of conductivity
     <- dye injection (2014-2015, Hietz et al. 2008)
     <- Sperry's method (2017, Sperry et al. 1988)
  3) Observation on xylem <- Cryo-SEM method

2014-2015 Mild Frost Drought Caused Xylem Dysfunction Due to Pit Aspiration

Much snow fall covered branches throughout the mid-winter.

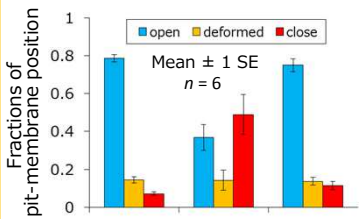




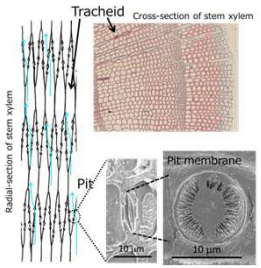


Pit aspiration was made without xylem cavitation in sap freezing, and maintained after thawing.

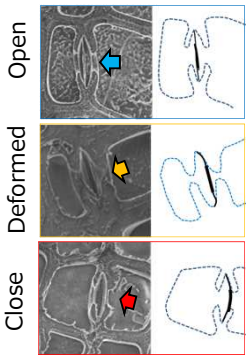
1) Aspirated-pit fraction increased after 11 freeze-thaw cycles



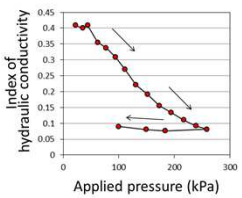
- **Anatomical feature of conifer stem xylem**

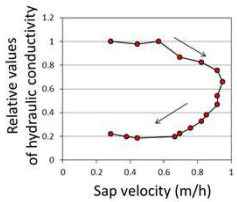


- **Pit-membrane positions**

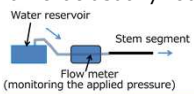


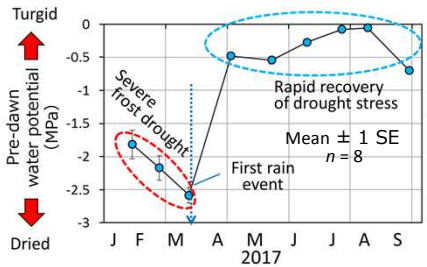
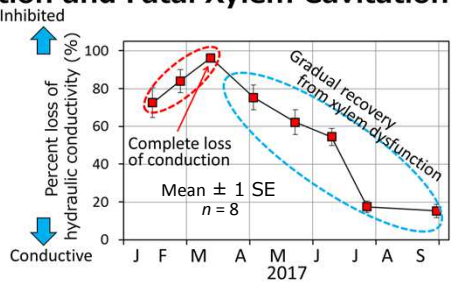
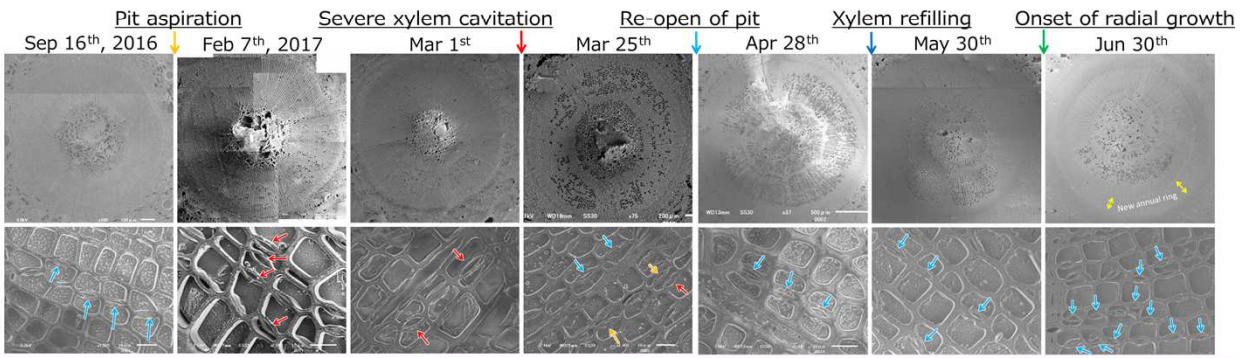
2) High sap velocity caused decrease in stem conductivity because of pit aspiration.





Sap velocity decreasing conductivity was 0.4-0.6 m/h, which was higher than that usually found (< 0.3 m/h).



2016-2017 Severe Frost Drought induced Pit Aspiration and Fatal Xylem Cavitation

There was small snowfall this winter, resulting in braches exposed to strong wind for longer period.