Seasonal development of cold hardiness and needle retention in Christmas tree plantations in Michigan

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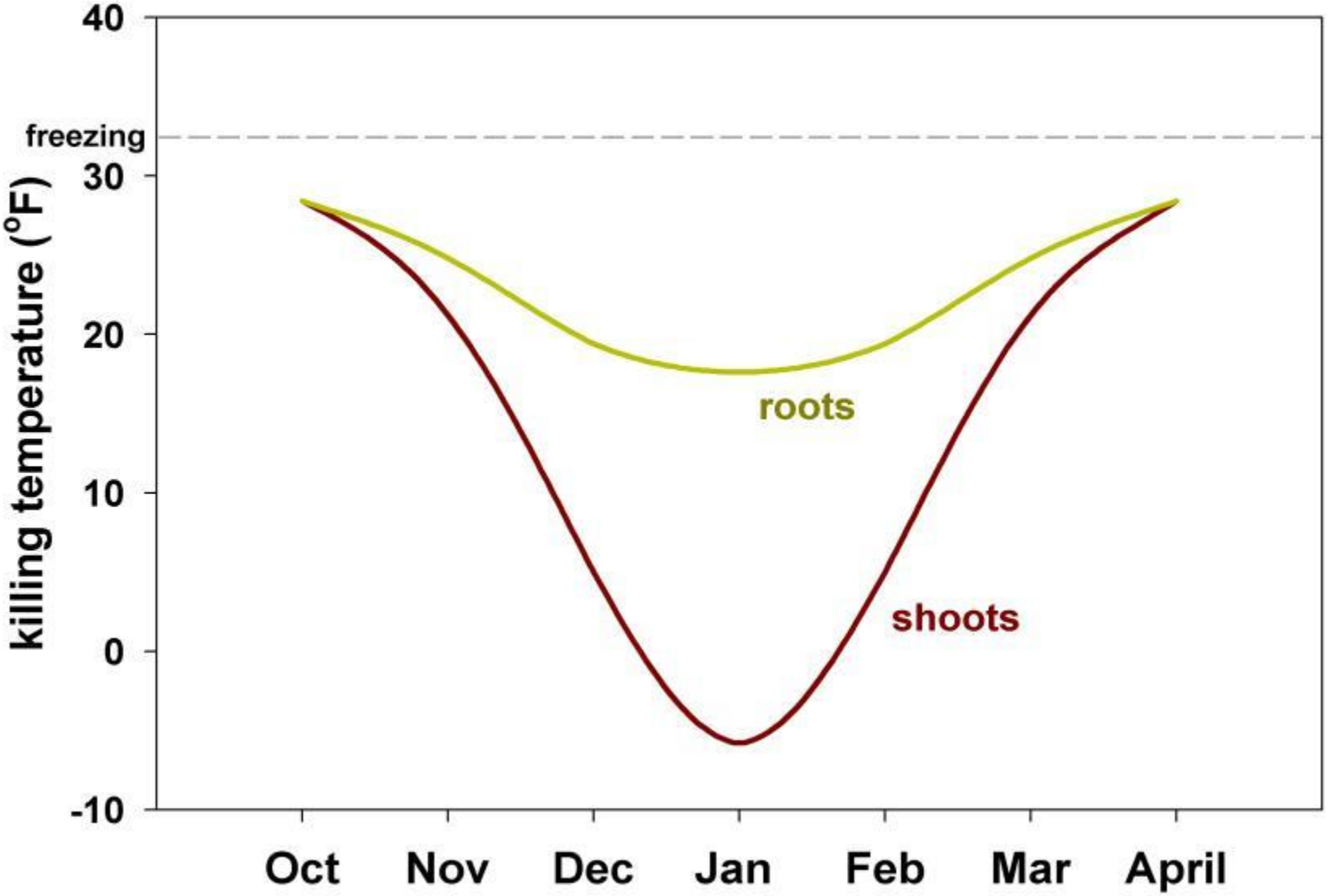
Introduction

- Cold acclimation processes trigger mechanism which are also related to needle retention (Mitcham-Butler et al. 1987, Thiagarajan et al., 2016)
- Acclimation responses are linked to reduced photoperiod and increased cold accumulation (MacDonald et al., 2017)

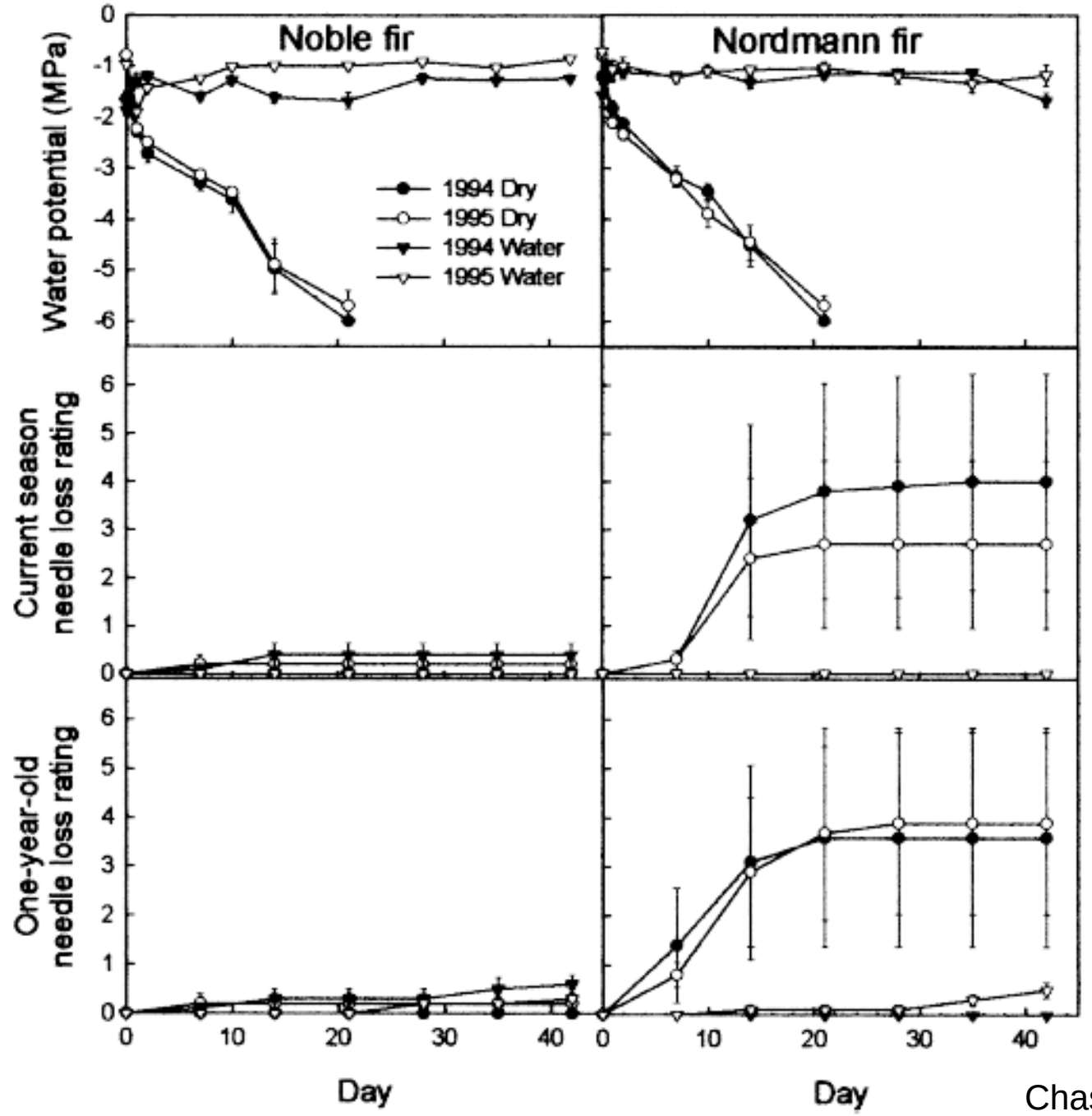
"Typical" pattern of cold hardiness for woody plants



Adapted from Ritchie 2002

Introduction

- Needle retention of conifers typically increases with later harvest dates (Mitcham-Butler et al. 1988, MacDonald et al. 2014)
- Cold acclimation processes trigger mechanism which are also related to needle retention (Mitcham-Butler et al. 1987, Thiagarajan et al., 2016)



Chastagner and Riley 2003

Needle drop in *Abies concolor*

Introduction

- Few studies have examined cold hardiness and needle retention concurrently

Objectives

- Initiate a program of monitoring to determine seasonal patterns of cold acclimation and needle retention
- Identify critical cold exposure requirements for cold acclimation and needle retention
- Provide harvesting recommendations (alerts) to growers

Methods

- Study conducted winter 2016-17
- 4 species
  - Black hills spruce *Picea glauca* var. *densata*
  - Concolor fir *Abies concolor*
  - Balsam fir *Abies balsamea*
  - Fraser fir *Abies fraseri*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Sampling

- 8 trees per species
- 4 sample dates
  - November 1, 2016
  - November 22, 2016
  - December 13, 2016
  - January 11, 2017

Sampling

- Cold hardiness
  - ~12 one-year-old shoots per tree
- Needle retention
  - 3 two-year-old shoots per tree

Cold hardiness testing

- Controlled freeze test
- Samples placed in a programmable freezer
- Cooled at -3ºC h^{-1}
- Samples pulled at 3ºC intervals to -42ºC


TRIPLE S
FF CF 0°
CF FF 75°
CF FF 75°
CF FF 75°
FF CF 75°
FF CF 75°
FF CF 75°
1 2 3 4 5 6 7 8

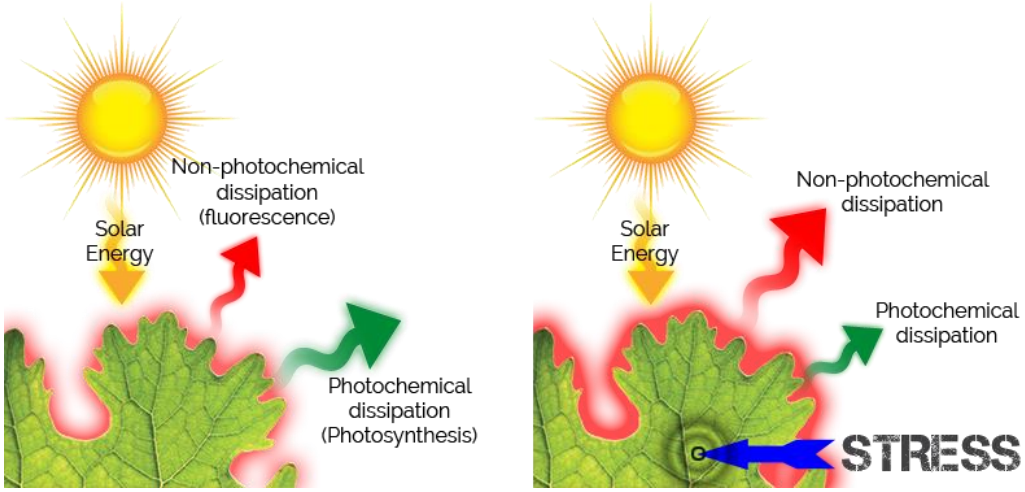

BF 8
BHS
BF 8
CF 8

Evaluation

- Samples incubated for 5-7 days @ 22ºC
- Visual needle injury (0 - 2 scale)
  - 0 = no browning
  - 1 = some browning
  - 2 = severe browning (dead)
- Bud damage (0 - 2 scale)
- Chlorophyll fluorescence

Chlorophyll fluorescence

- Measure of photosynthetic efficiency
- Theoretical optimum of Fv/Fm ≈ 0.82



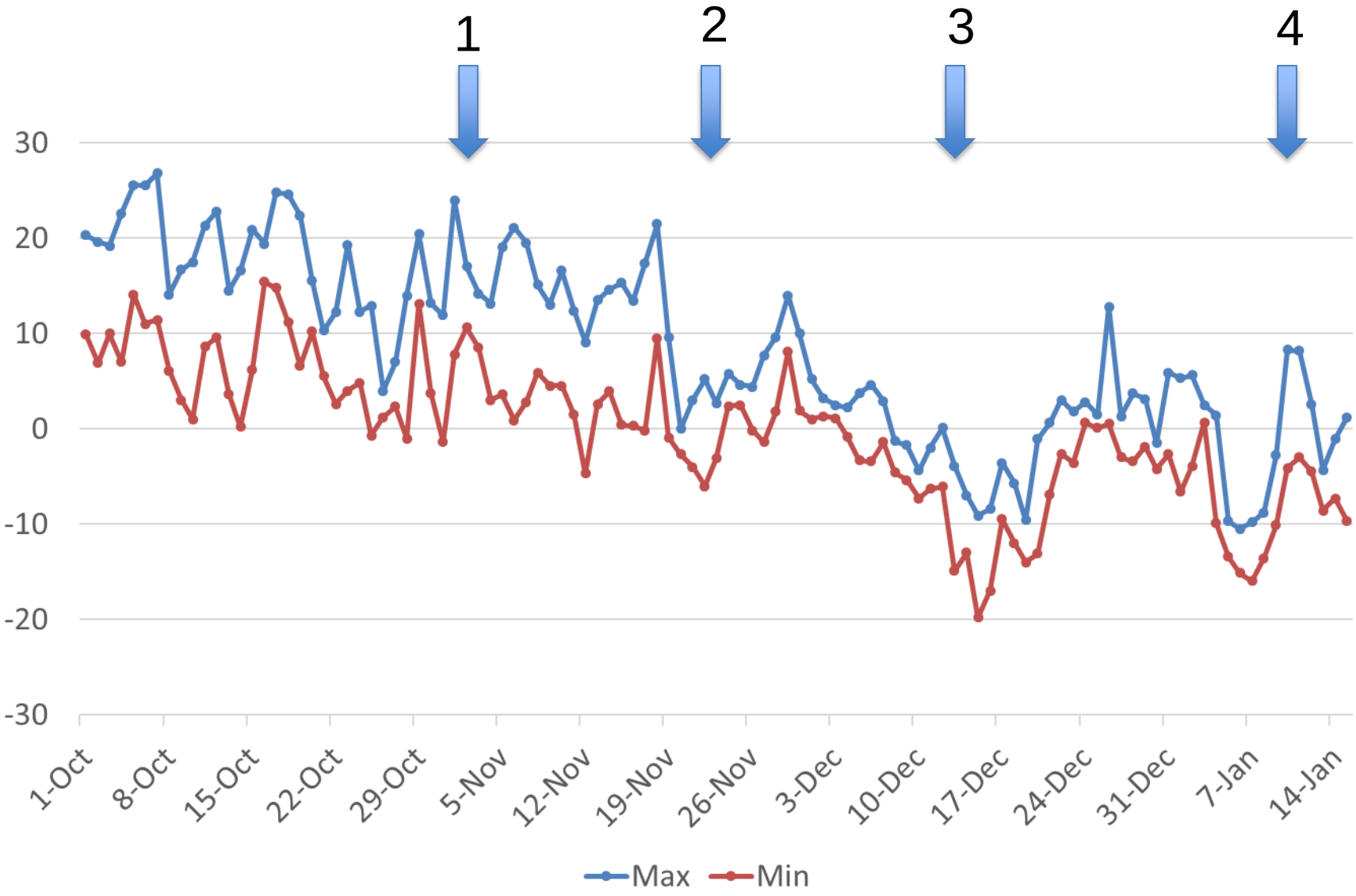
Arborcheck.com

Needle retention

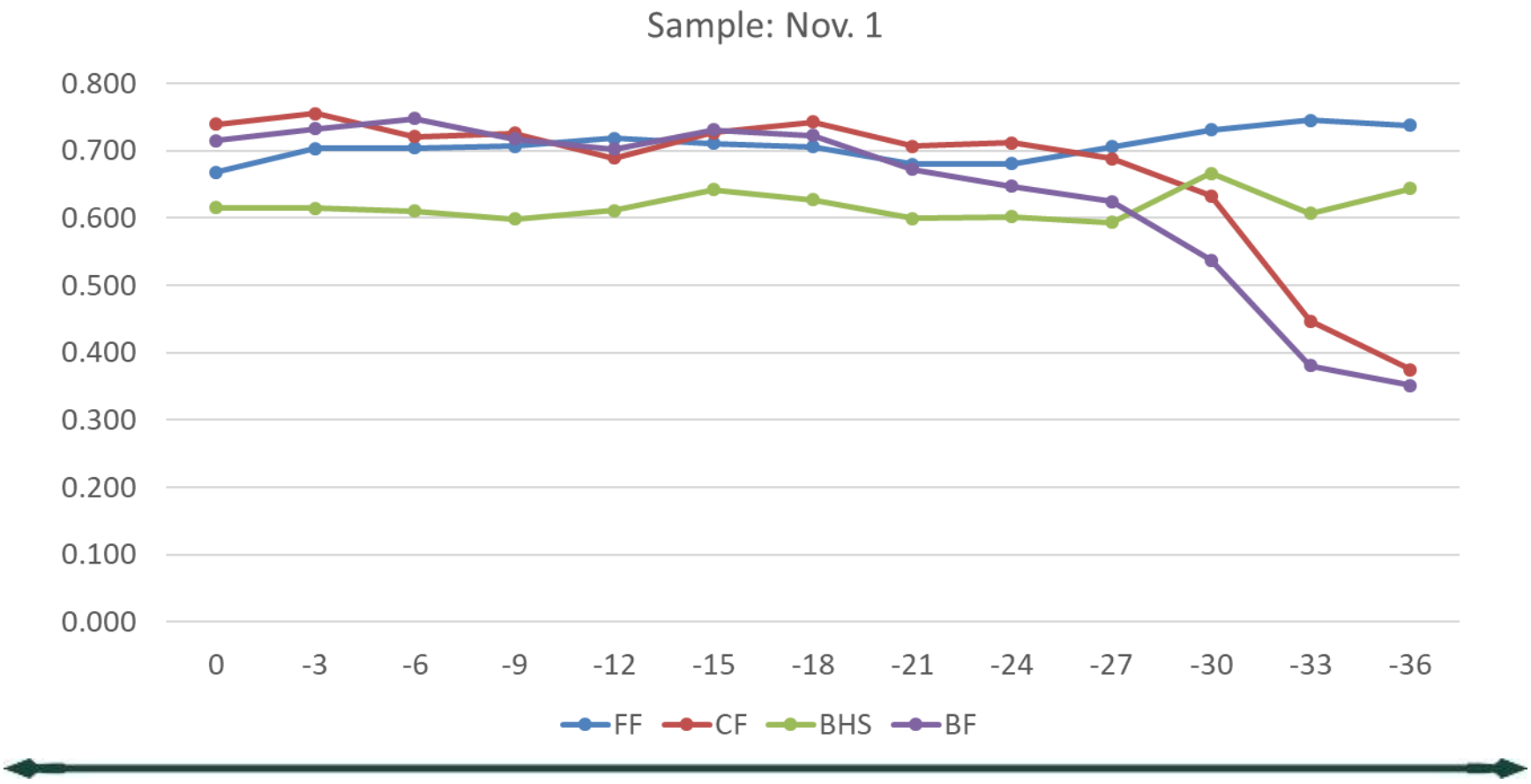
- Samples displayed dry in unheated cooler attached to MSU winery
- Evaluated weekly for 5 weeks
- Gentle pull test
- Needle loss rated 1-10


Failure to launch:
Pressure:Volume Curves

Daily maximum and minimum temperatures



Cold Hardiness: Fv/FM



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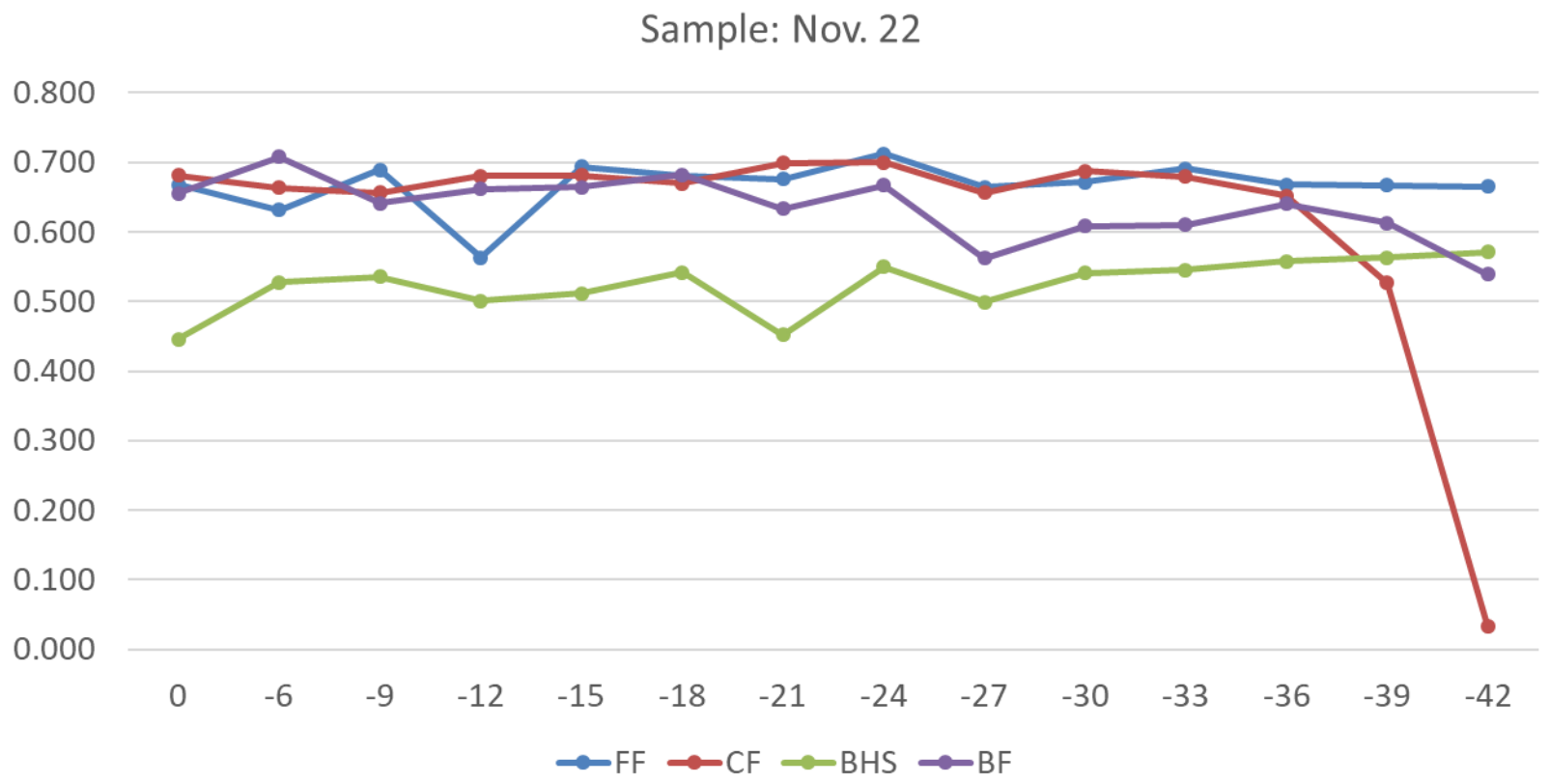

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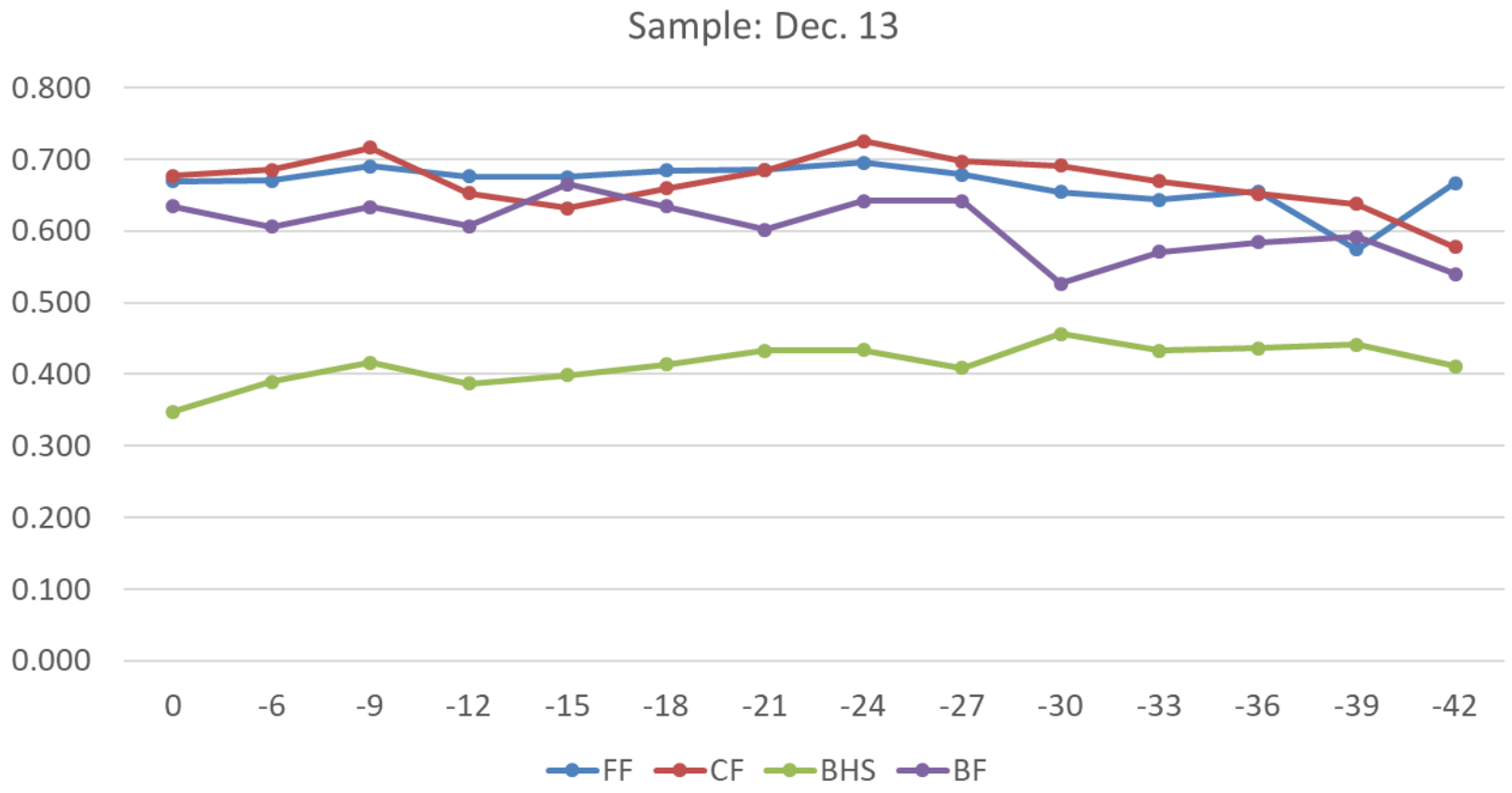
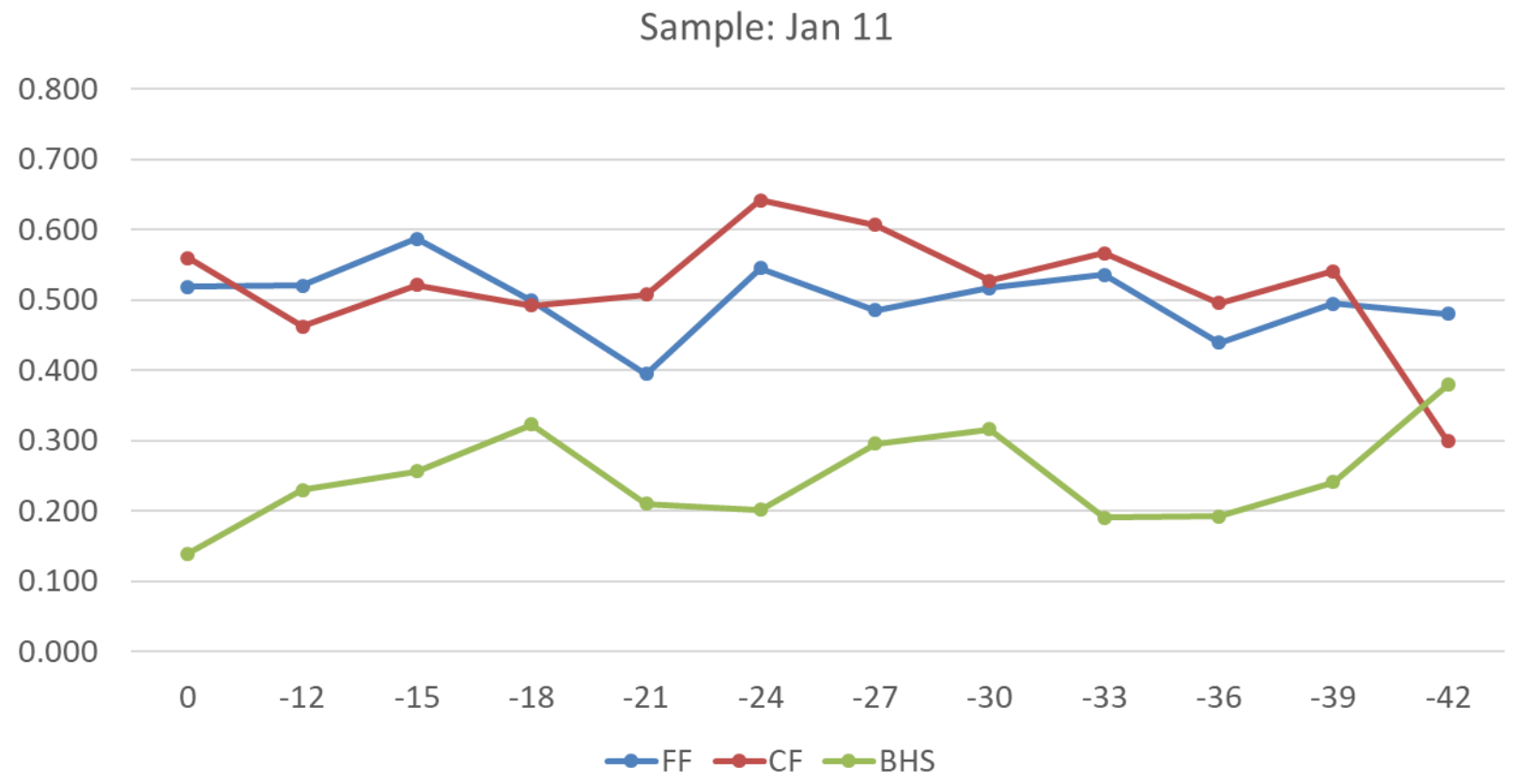
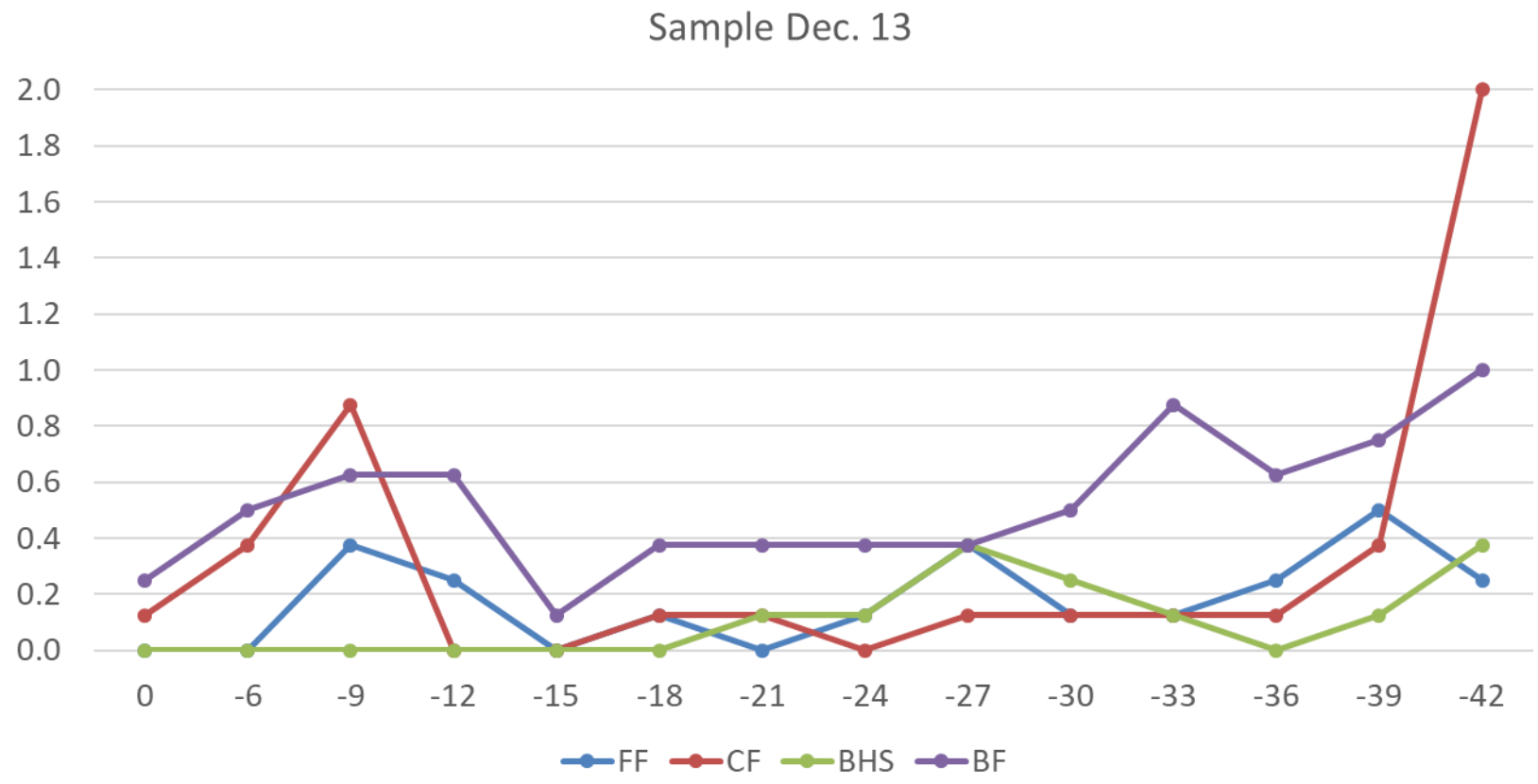


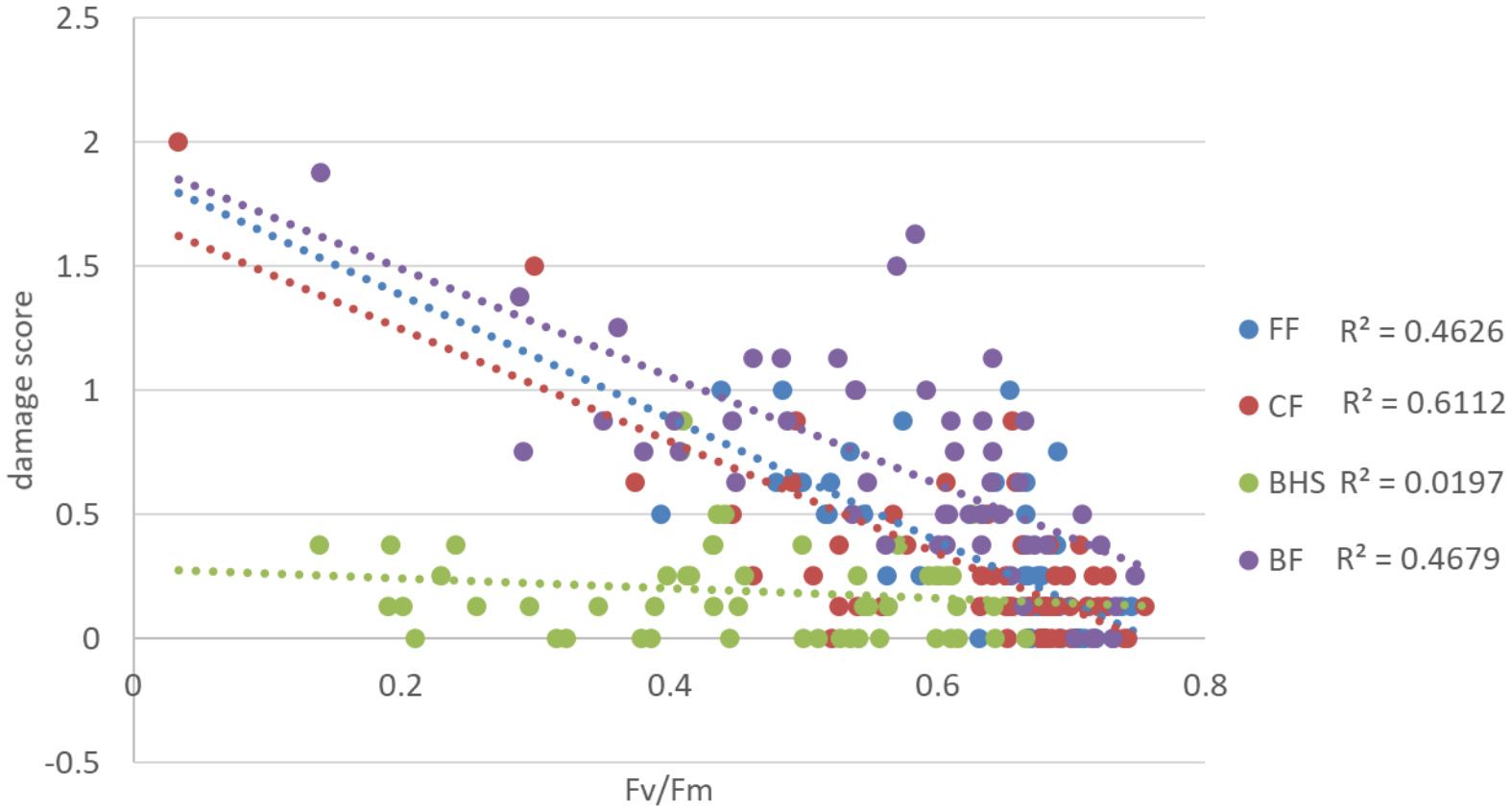
Cold Hardiness: Fv/FM



Cold Hardiness: Visual Needle Injury

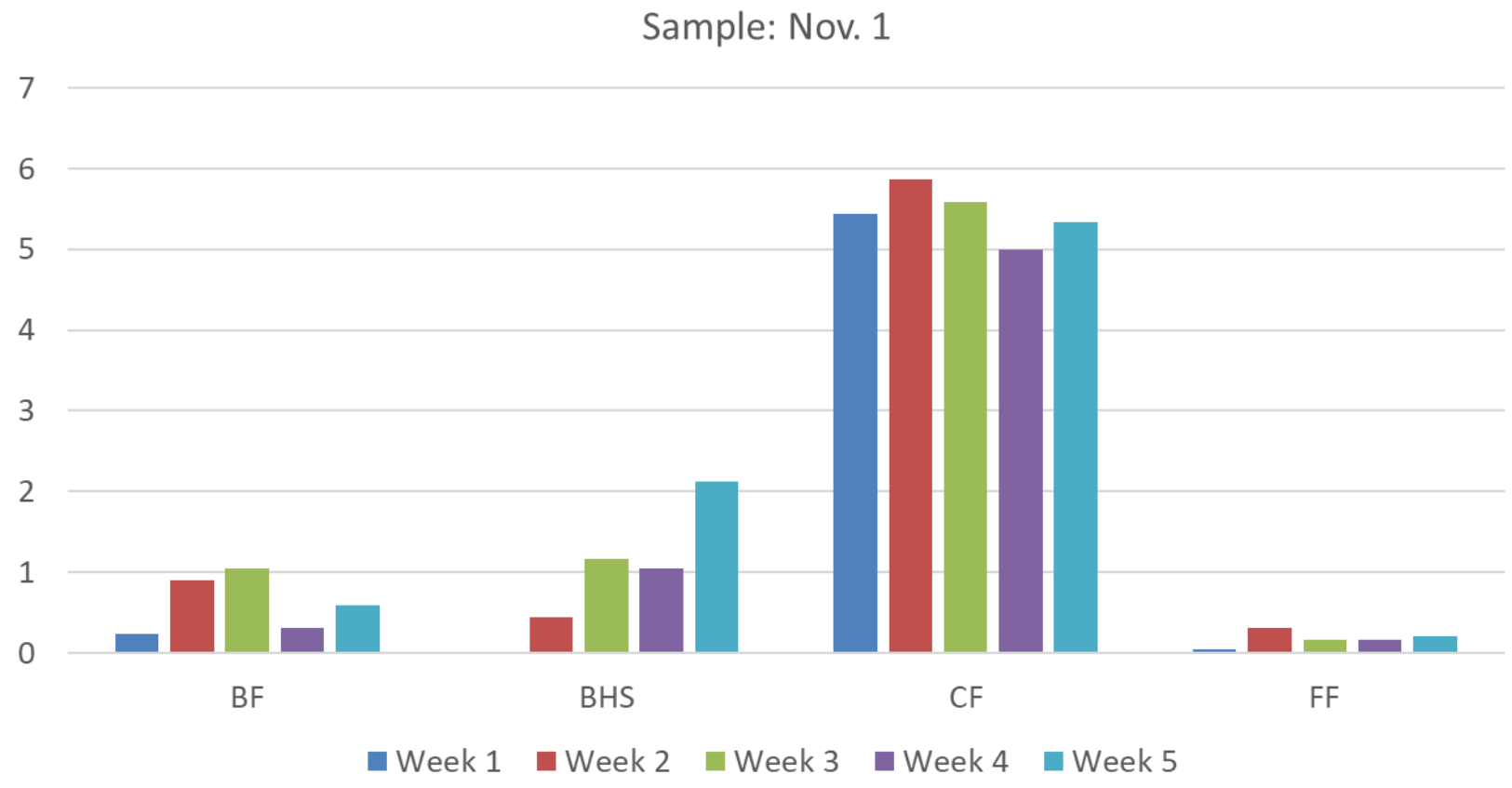


Relationship between visual assessment and Fv/Fm: Black hills spruce responded differently than firs



Needle retention

Needle retention



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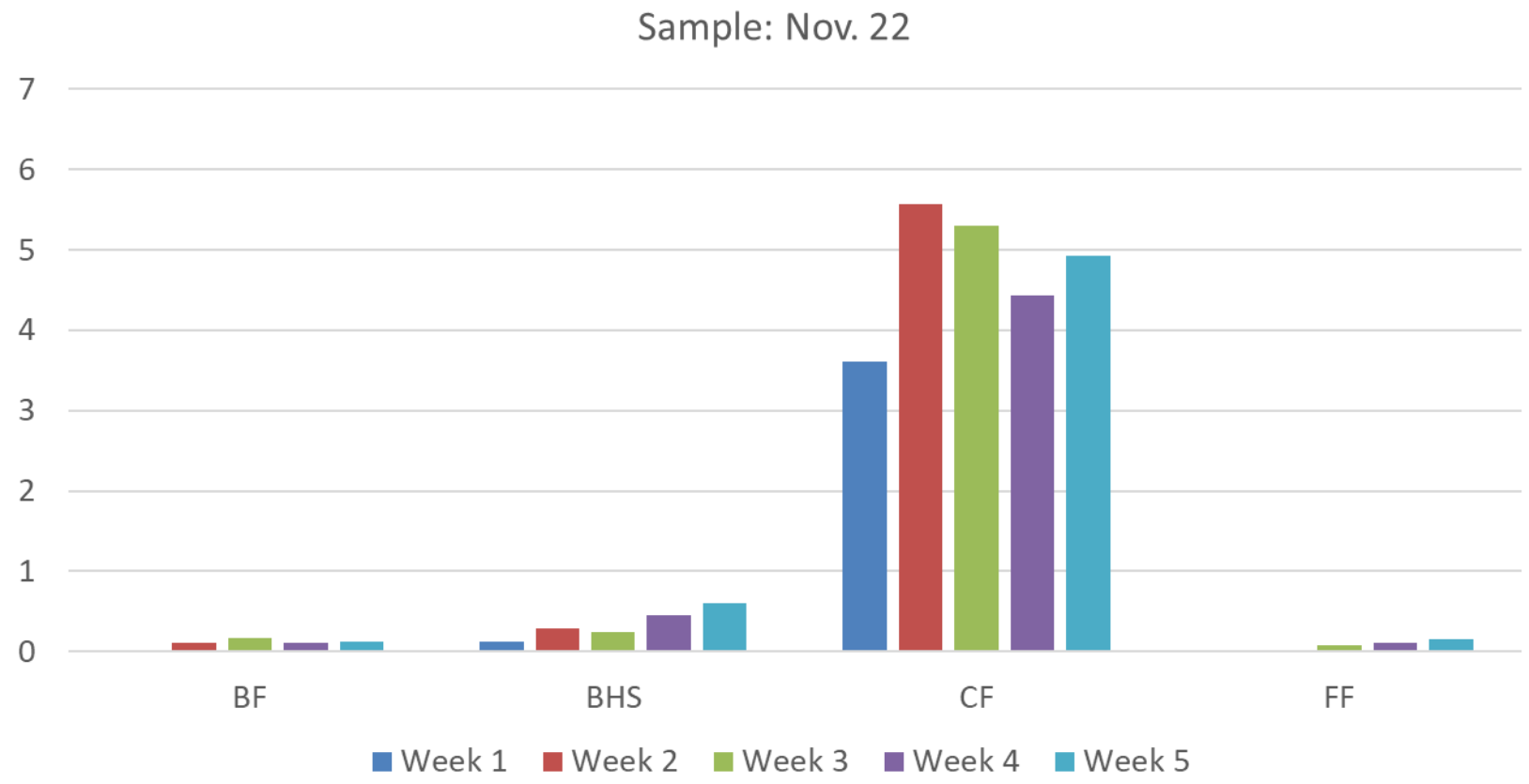

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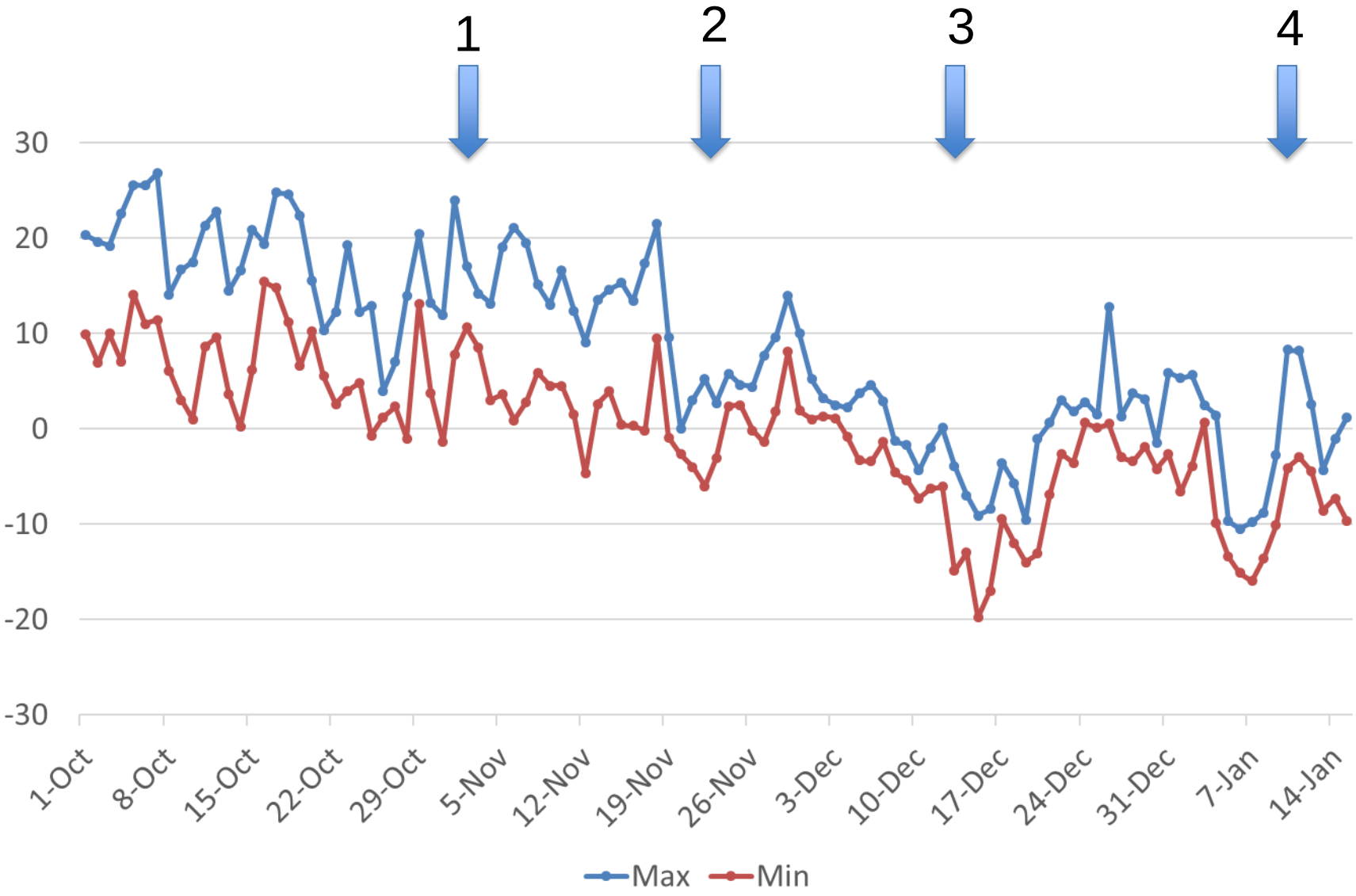

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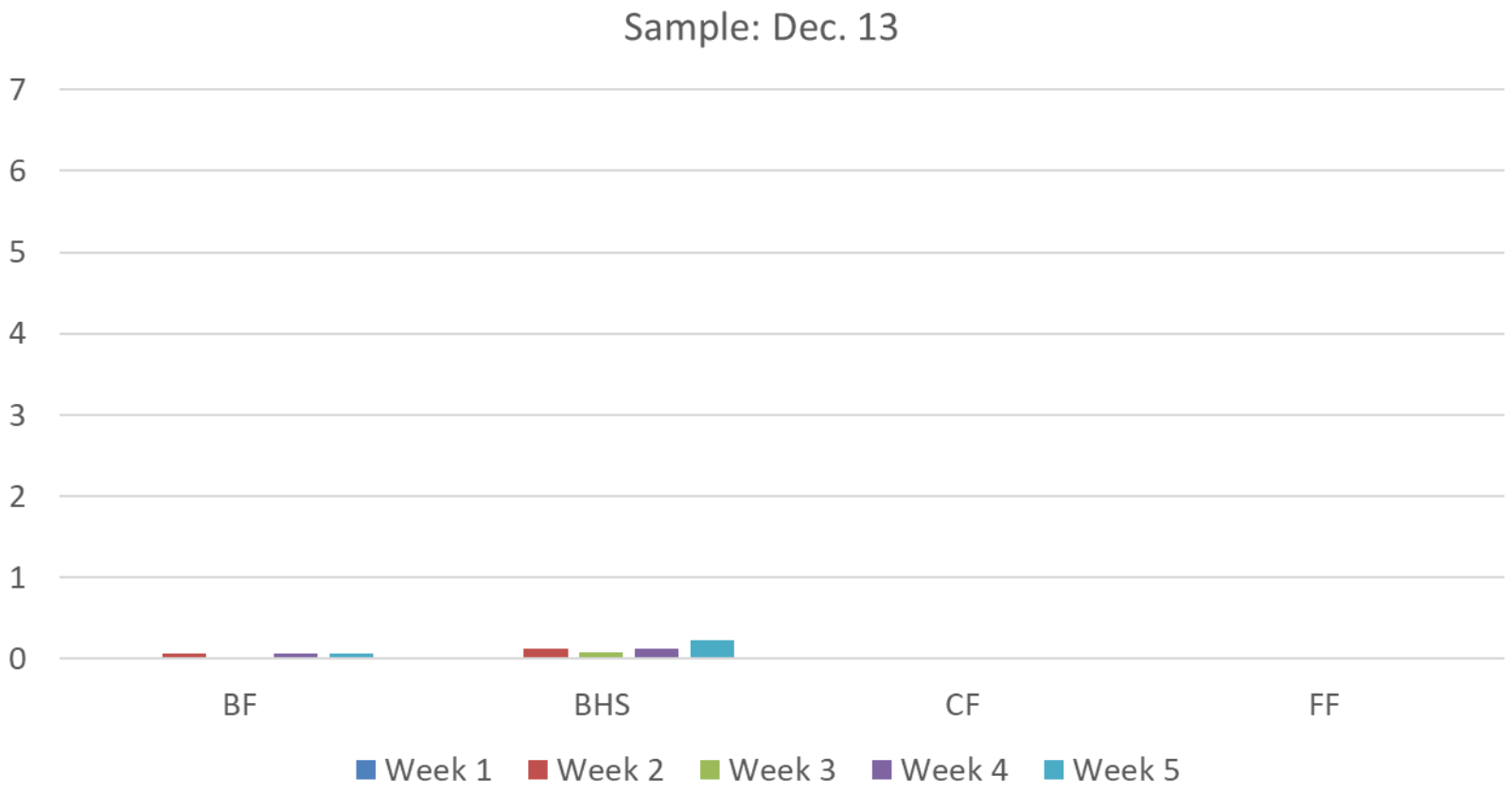

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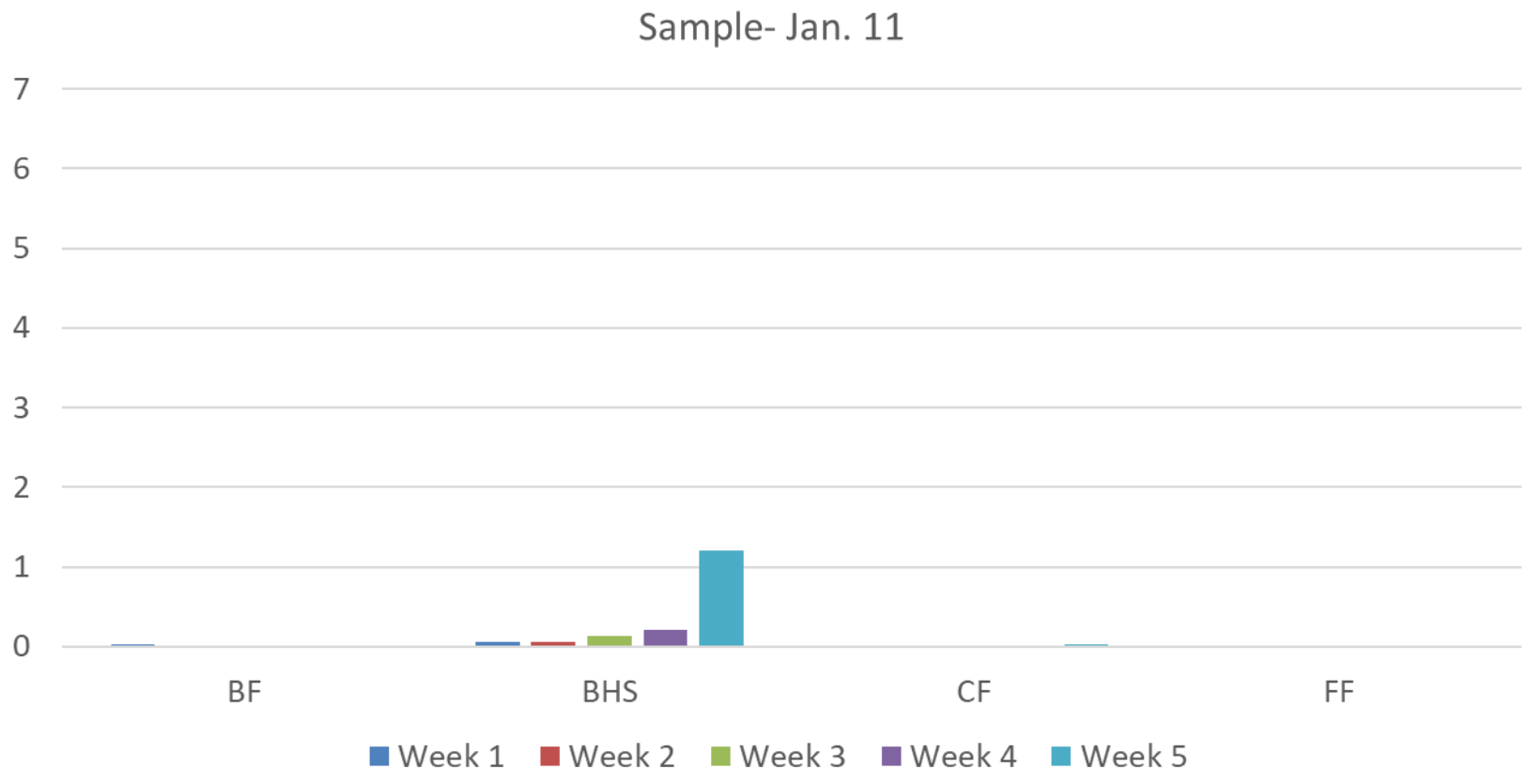

Summary

- Fraser fir had excellent needle retention and cold hardiness regardless of cold exposure
- Concolor fir was very sensitive to cold exposure – Balsam fir to a lesser extent
- Black hills spruce had good cold hardiness though Fv/Fm declined with increased cold exposure (photo-protective mechanism?)

Next steps

- Refine analysis of current data (cold sum analysis)
- Repeat sampling – Oct. 2017 – Jan. 2018
- Refine procedures
  - Cold hardiness – longer incubation period?
  - Osmotic potential
    - Pressure – volume curves
    - Osmometer

Acknowledgements

- Tannenbaum farms

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