Chilling Hours vs Dormancy

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Introduction

- The importance of diurnal and annual changes in seedling physiology in response to environmental cues cannot be understated.
- Three physiological processes are important to stress resistance during lifting, handling, planting and to root and shoot growth after outplanting:
  1. Dormancy
  2. Cold Hardiness
  3. Accumulation of carbohydrate reserves

Cold hardiness and dormancy

- Difficult to separate under field conditions because both respond to similar environmental cues.
- They are, however, separated both spatially and in terms of organs tissues and temporally.
- Physiological process of dormancy and cold hardiness are complex and not well understood especially in southern pines.

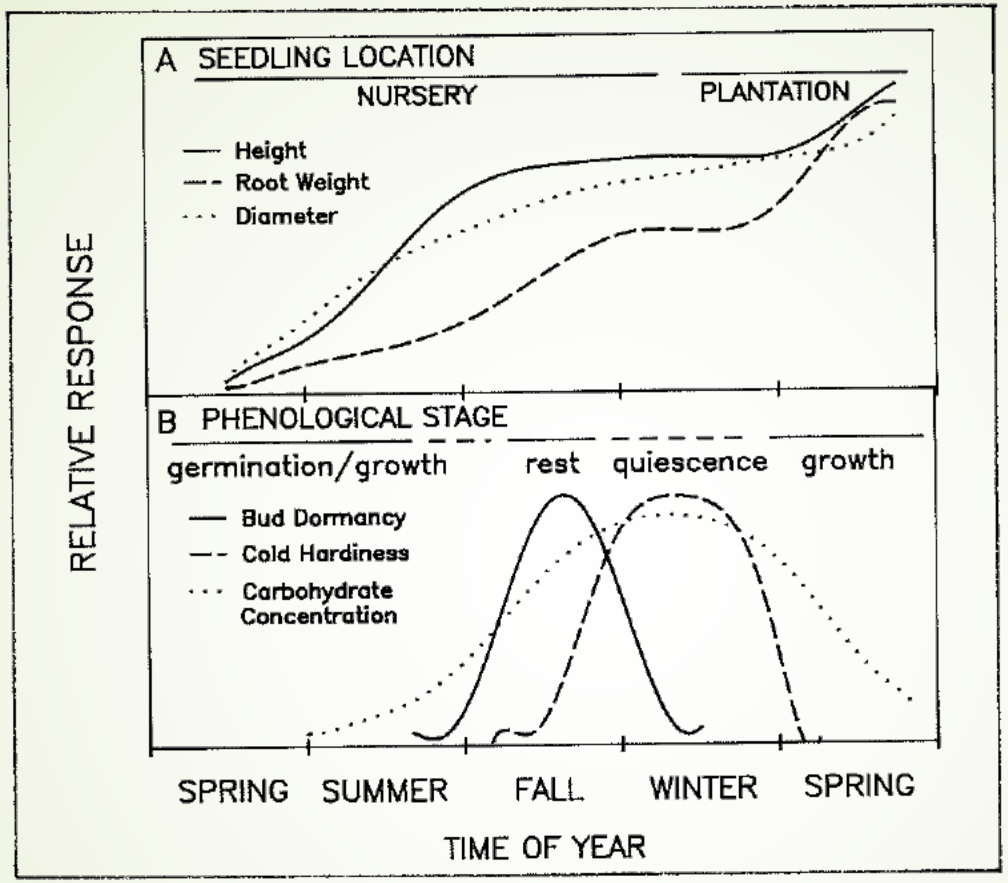


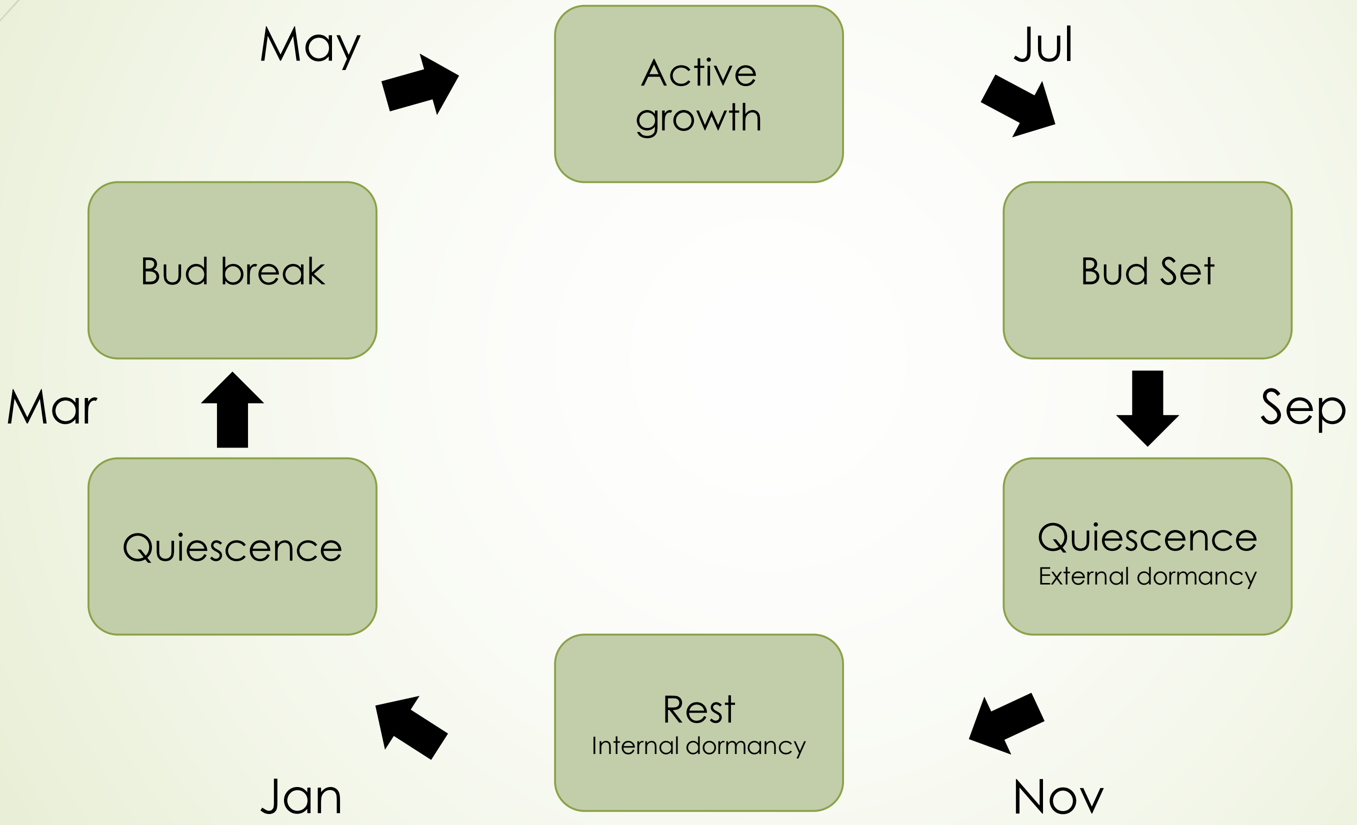
Figure 8.1. Idealized changes in seedling morphology (A) and physiology (B) over time.

Johnson and Cline (1991). *In* Duryea and Dougherty (editors) Forest regeneration manual

Cold hardiness and dormancy

- The two processes normally occur sequentially beginning mid fall with the onset of dormancy and followed late fall and early winter by the development of cold hardiness.

Typical phenological cycle



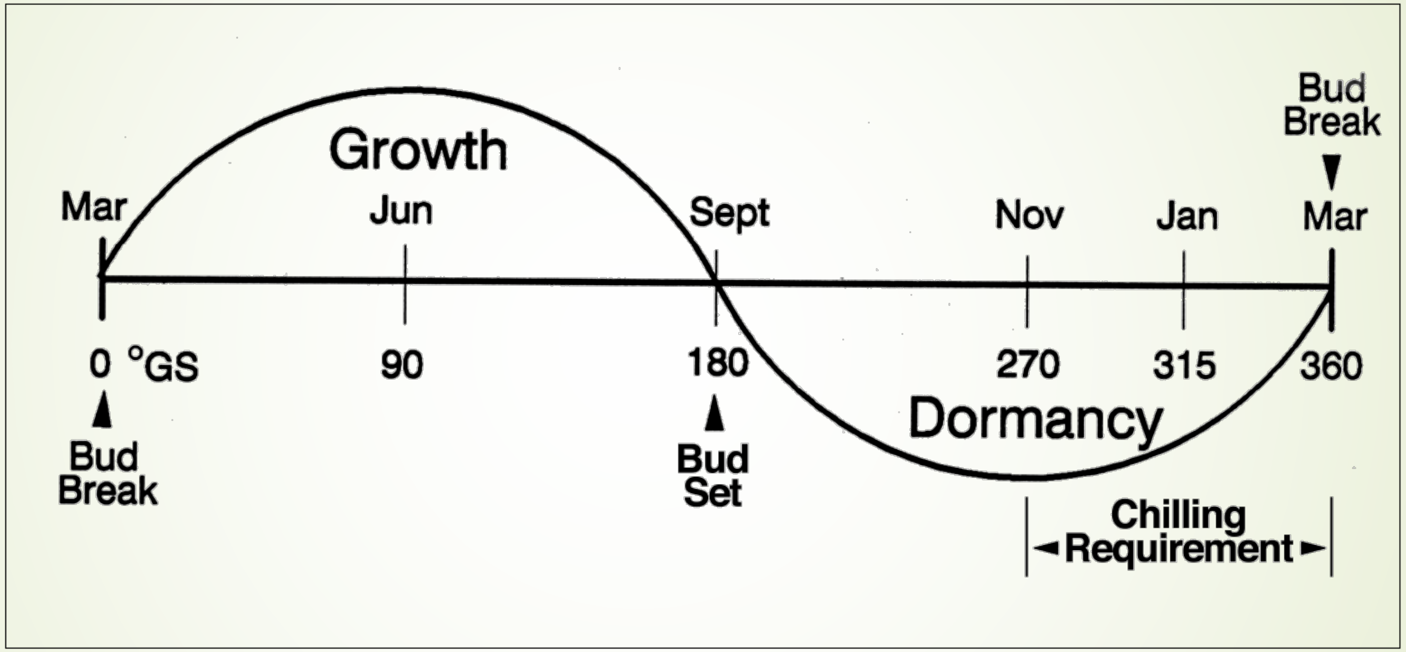


Figure 1. The shoots of all perennial plants, including forest and conservation nursery stock, undergo a seasonal cycle of shoot growth and dormancy. Note that peak dormancy occurs in late fall instead of mid-winter as is popularly believed. Bud dormancy is released by cumulative exposure to cold temperatures - the chilling requirement (modified from 2).

Ritchie and Landis -Forest Nursery Notes 2004

Dormancy - quiescence

- Dormancy is a physiological state attained by one tissue type specifically the shoot meristematic region (i.e. buds).
- Quiescence can occur anytime during active growth in response to stressful conditions such as drought, high and low temperatures or nutrition limitations
- Reversible by amelioration of limiting environmental factor resulting in the meristem to become active again.

Dormancy - quiescence

- Slowing of shoot growth coincides with a shift from active growth phase during late spring and summer to the quiescence phase, typically characterized by the formation of buds.
- Quiescence is initiated primarily by decreasing temperatures in early Sep – Oct. though shortening of photo period may be important in some northern provenances.
- Under favorable conditions (warm temperatures and adequate soil moisture) quiescence is reversible.

Dormancy - rest

- Next phase is rest or true dormancy.
- Begins Oct or Nov and continues into Dec. It is characterized by the seedlings inability to rapidly grow under warm temperatures without first experiencing some period of low temperatures (i.e. meeting chilling requirements).
- During rest, chilling requirements are met and seedling re-enters quiescence.
- During this time only low temperatures are inhibiting the resumption of shoot growth.

Dormancy - rest

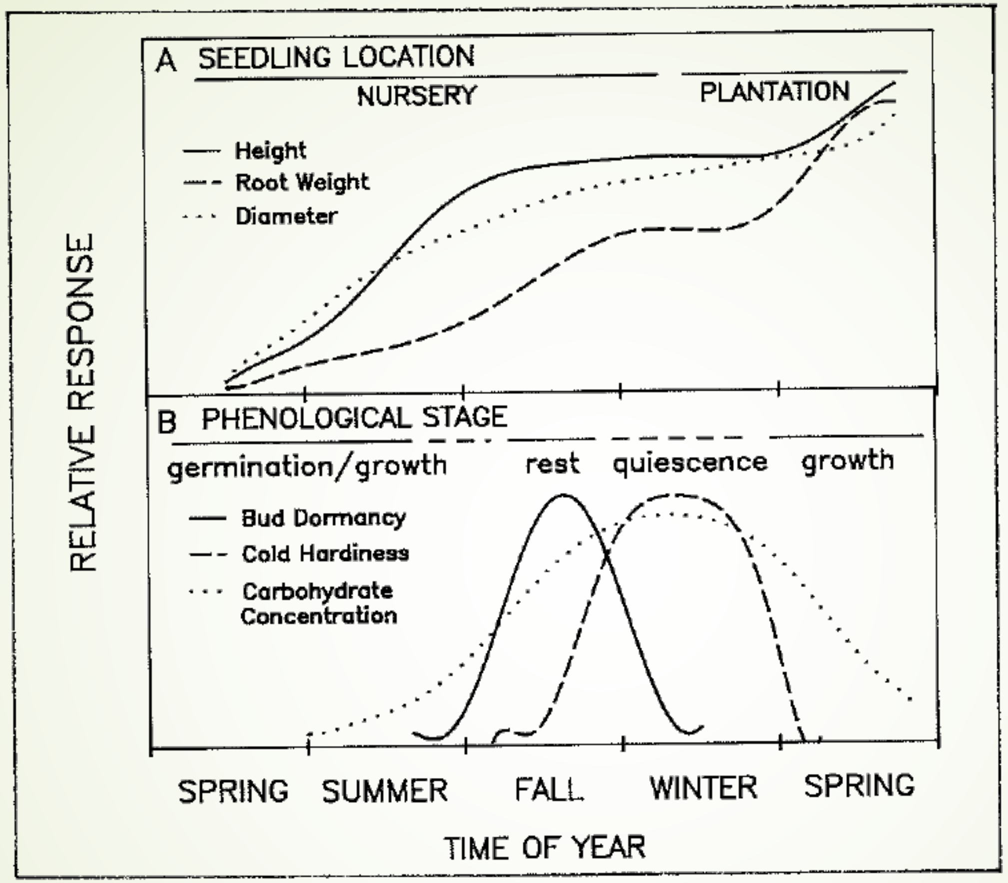
- Northern Species dormant in winter must fulfill a chilling requirement before buds can elongate.
- For southern pines the role of bud dormancy is unclear with regards to the presence of rest.
- Little is known about the acquisition of bud dormancy in southern pines other than it appears to be related to changing photoperiod and temperature although nutrition and water availability can influence the timing of bud development

Dormancy – southern pines

- Southern pines appears to respond to chilling quantitatively, the more chilling received the faster the rate of bud break up to a maximum.
- The cumulative number of hours of exposure to temps between 32 – 45 °F (arbitrarily chosen) is referred to as chilling hours.
- Loblolly pine requires between 200 – 400 chilling hours to overcome dormancy, depending on geographic origin of the trees.
- Chilling hours are typically met early to mid-Dec for southern pines.

Dormancy – southern pines

- Increased photo period was found to partially substitute for chilling temps
- Exposure to low (above freezing) temperatures once the chilling requirements have been fulfilled enhanced height growth in subsequent growing seasons
- Cold storage can also affect seedling physiology by partially satisfying the chilling requirements to break dormancy



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Cold hardiness – freeze tolerance

- The physiological changes throughout the tissues of a seedling after rapid cell expansion has ceased.
- Cold hardening or acclimation begins in southern pines when air temperatures decrease and lags behind bud dormancy.
- Tissues of southern pines acclimate to different degrees.
- For forest tree seedlings, accumulating chill hours equates to an increase in freeze tolerance.
- Seedlings lose cold hardiness in response to increasing temperatures.

Cold hardiness – freeze tolerance

- Seedlings deacclimate to some degree with as little as 3 to 7 warm nights that might encourage bud break and shoot elongation.
- Once seedlings have received sufficient amount of chilling hours one can't assume seedlings will tolerate a hard freeze.

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Reasons given for tracking chill hours

- To evaluate storability of seedlings
  - Assumption here is that as chilling hours increase, so does storability of seedlings
  - **MYTH** – as successful storage of seedlings is not directly related to the number of chilling hours (South 2013 – Chilling Hours: Myths and Facts)
- To evaluate acclimation of seedlings
  - Seedlings exposed to natural colder temperatures usually become acclimatized in the fall as a response to chilling whereby increasing their freeze tolerance with increasing chilling hours
  - **FACT** - Many studies have shown freeze tolerance increases as chilling hours accumulate through the fall and winter as air temperature decrease
  - The level of freeze tolerance for a species is genotype specific
  - Inadequate chilling has occasionally been used to explain low outplanting survival that follows a hard freeze

Chilling hours and seedling storage

- The topic of chilling hours and freeze tolerance should not be mistaken with the impact on seedling storage
- Successful long term storage of seedlings requires seedling being able to tolerate extended periods in dark storage while maintaining seedling quality and physiological integrity (Grossnickle and South 2014)
- Short term cold storage is often used once seedlings have been lifted and until planting occurs

Chilling hours and seedling storage

- Often a two week supply of seedlings are kept in cooler, however, chilling hours are not necessary for short-term cooler storage
- Bareroot seedlings exposed to 113 chilling hours were capable of tolerating 4 weeks of storage
- Bareroot seedlings exposed to 223 chilling hours were successfully stored for 11 weeks

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