University of Idaho

THE IMPORTANCE OF SEEDLING QUALITY FOR SUCCESSFUL REFORESTATION IN THE INLAND NORTHWEST

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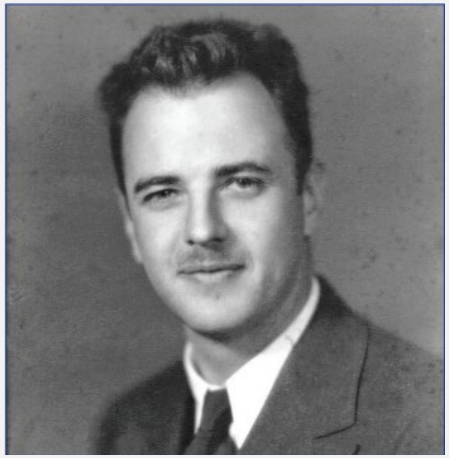
SEEDLING QUALITY

- In simple terms, performance of nursery-grown seedlings in the field
  - Fundamental aspect of the Target Seedling Concept

Landis, Dumroese, and Haase. 2010. The Container Tree Nursery Manual. Vol. 7, Chp. 1. USDA Agric. Handbk. 674

SEEDLING QUALITY

- Philip Wakeley (1948) introduced the concept of physiological seedling quality
  - Morphological grades often poorly predicted field performance
- What high quality seedlings looked like and their physiology were difficult to determine
- Rapid development of seedling quality tests from the 1970s through today



Philip Wakeley. Barnett. 2013. Tree Planters' Notes 56:54-59

Wakeley. 1948. Proc. Soc. Amer. For. Ann. Conv. P. 311322

SEEDLING QUALITY

- **Morphological Attributes:** easy to see and measure
  - Seedling height, stem diameter, root:shoot ratio
- **Physiological Attributes:** Need to be measured with instruments
  - Cold hardiness, bud dormancy
- **Performance Attributes:** Subjecting seedlings to testing protocols and observing responses
  - Root growth potential

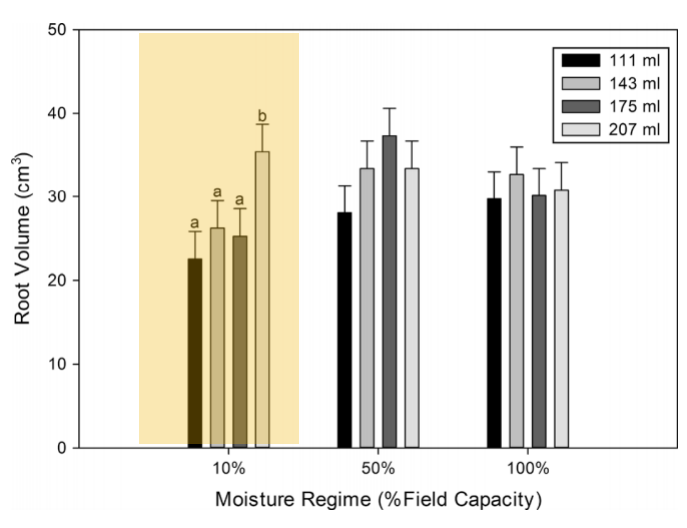
Landis, Dumroese, and Haase. 2010. The Container Tree Nursery Manual. Vol. 7, Chp. 2. USDA Agric. Handbk. 674

MORPHOLOGICAL ATTRIBUTES

- **Container Volume:** Determines how many roots a seedling can produce, how big a shoot the plant can produce, and moisture and nutrient reserves in plug when planted

Seedling morphology after nursery phase

	Height (cm)	RCD (mm)	RV (cm^3)	RDM (g)	SDM (g)
Container volume					
111	25.05 (0.91) a	4.99 (0.14) a	5.8 (0.38) a	1.35 (0.09) a	2.48 (0.17) a
143	26.46 (0.91) a	5.33 (0.14) ab	6.35 (0.39) a	1.53 (0.09) a	2.81 (0.17) ab
175	25.52 (0.91) a	5.29 (0.14) ab	6.65 (0.38) a	1.58 (0.09) ab	2.84 (0.17) ab
207	26.59 (0.91) a	5.49 (0.14) b	6.77 (0.38) a	1.79 (0.09) b	3.11 (0.17) b

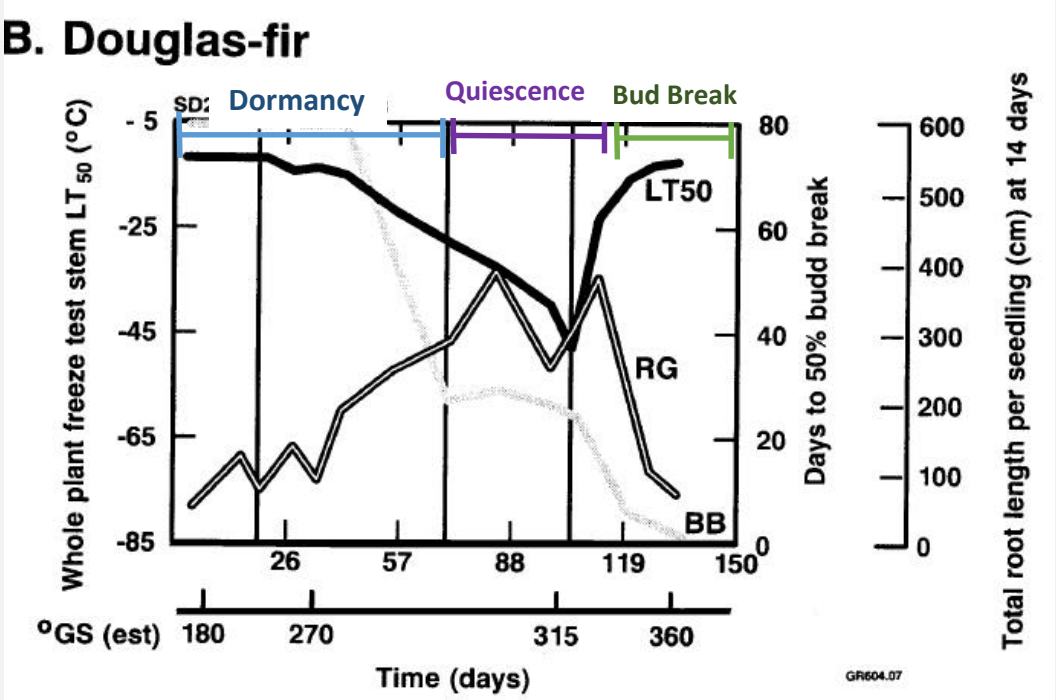


Seedling performance after simulated outplanting under different moisture regimes

Aghai, Pinto, and Davis. 2014. New Forests. 45: 199-213

PHYSIOLOGICAL ATTRIBUTES

- Physiology changes even when seedlings are not actively growing
- Cold hardiness increases through the fall
- RGP increases as seedlings become more cold hardy and crashes immediately before bud break



Ritchie and Tanaka. 1990. Target Seedling Symposium. GTR RM-200: 37-51
Adapted from: Burr et al. 1989. Tree Physiology 5: 291-306

SEEDLING QUALITY TESTS

- Cold hardiness
  - Whole plant
  - Freeze-induced electrolyte leakage
- Root growth potential
  - Ability of seedlings to produce roots under a favorable environment
- Root electrolyte leakage
  - Assesses root damage
- Bud dormancy
- Water potential
  - Moisture stress, seedling ability to transport water
- Chlorophyll fluorescence

Haase. 2008. Tree Planters' Notes. 52(2): 24-30.

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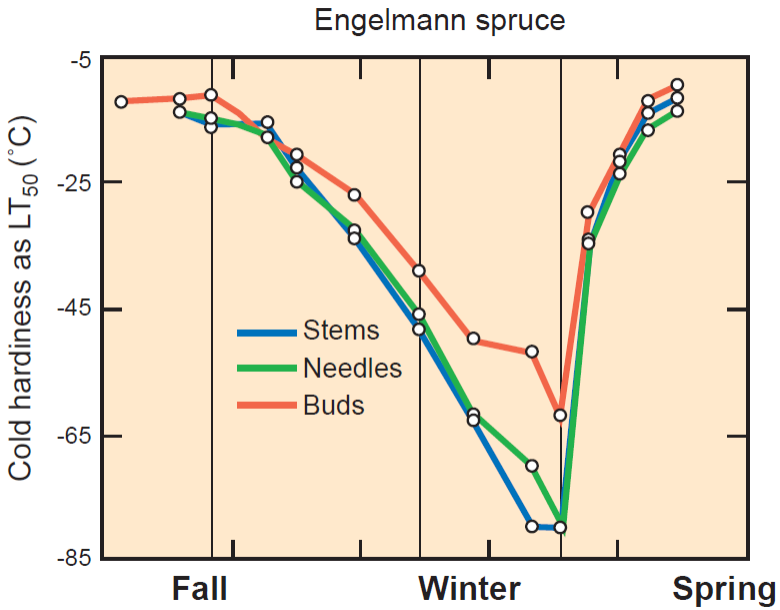
COLD HARDINESS

- As winter approaches, plants develop tolerance to cold and general stress resistance
- Solutes within plant cells resist water freezing, thus allowing them to super-cool and not burst
- Proper hardening ensures they can be freezer stored for extended periods and maintain high seedling quality with substantial carbohydrate reserves

Cold hardiness across seasons. LT_{50} is the lethal temperature where 50% of the seedlings are damaged



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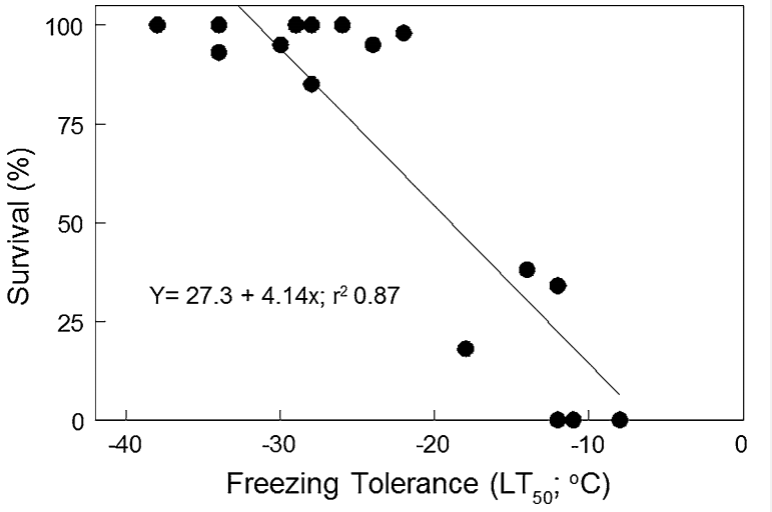
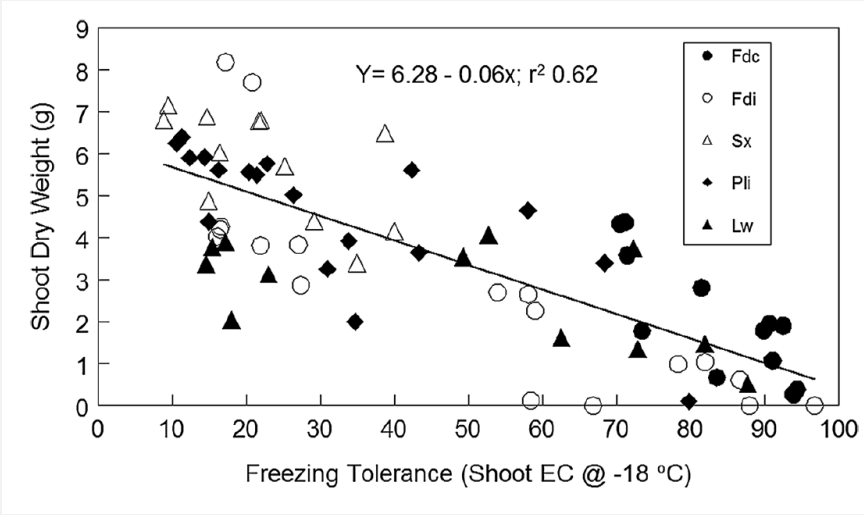
COLD HARDINESS AND FIELD PERFORMANCE

Lodgepole pine first year survival in relation to cold hardiness



Grossnickle. 2012. New Forests 43: 711-738
Adapted from: Simpson. 1990. Can J. For. Res. 20: 566-572

First year shoot growth of multiple western conifers in relation to cold hardiness

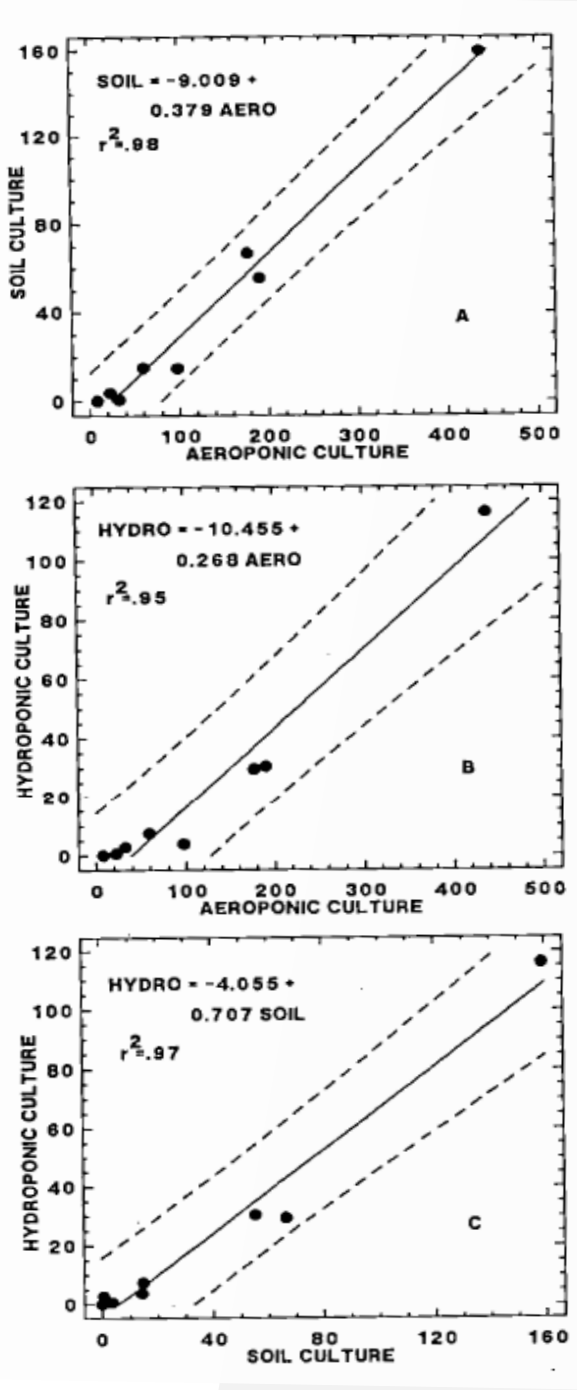


Grossnickle. 2018. New Forests 49: 1-34
Adapted from: L'Hirondelle. 2006. New Forest. 32: 307-321

ROOT GROWTH POTENTIAL

- "…defined as a seedling's ability to grow roots when placed into an environment which is highly favorable for root growth (i.e., warm, moist, well lighted) (Ritchie and Tanaka 1990)

- Developed in seedlings while in the nursery
  - Photoperiod
  - Root culturing
  - Fertilization
  - Irrigation
  - Etc.



COMPARISON OF RGP METHODS

- Potted, hydroponic, and aeroponic
- Different methods produce different RGP values
- But results from different tests are often highly correlated within a seedlot

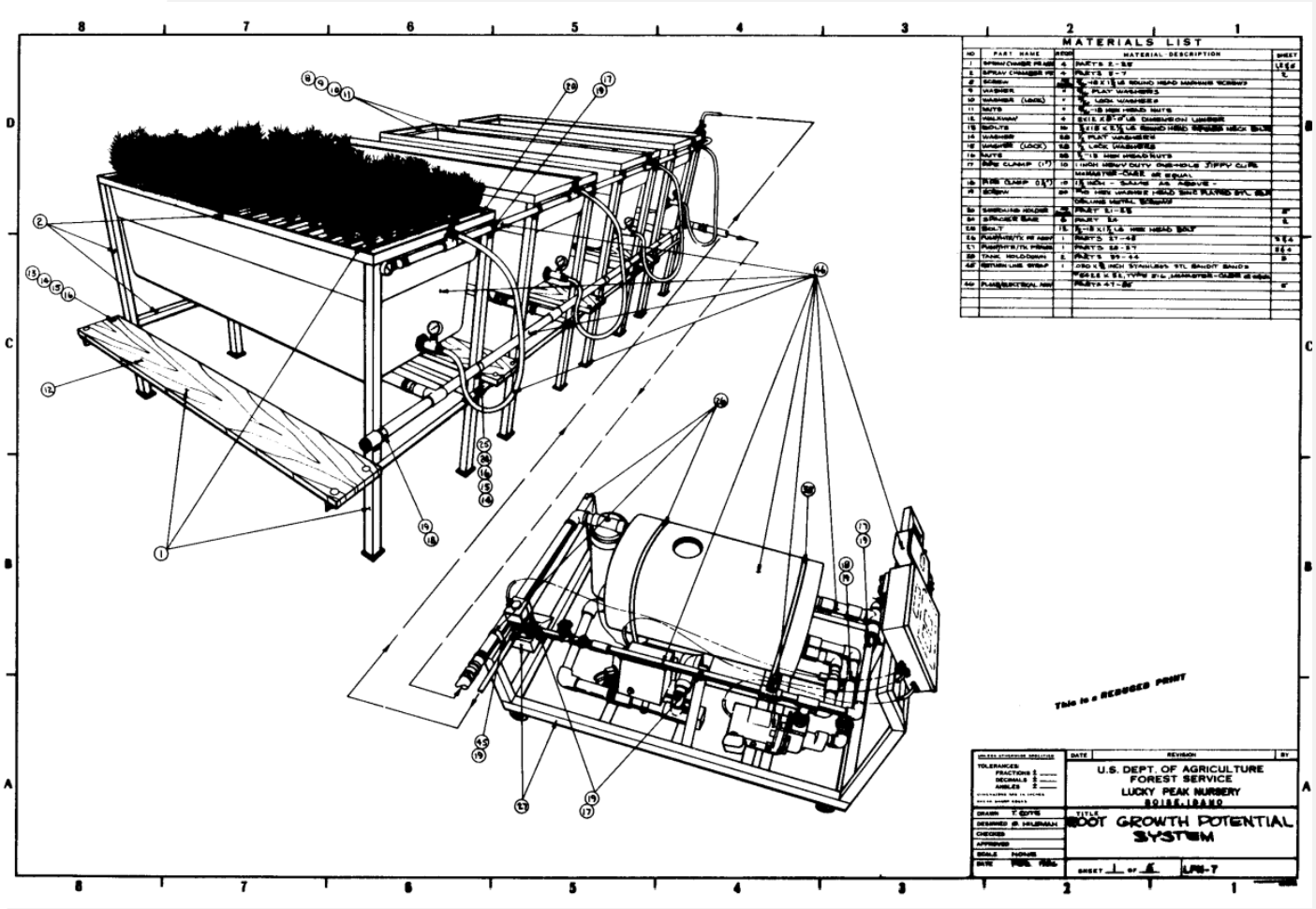
Rietveld, W.J. 1989. New Forests 3(2): 181-189

IMPETUS FOR RAPID AEROPONIC SYSTEM

- Drawback of RGP test has been the long time length: typically 30 days
  - Can be too long when you need to make important management decisions
- Potted tests can often take a substantial amount of space in the lab or greenhouse
- Independent, third-party testing facility

AEROPONIC SYSTEM

BASED ON A MIST CHAMBER SYSTEM DEVELOPED AT USDA LUCKY PEAK NURSERY



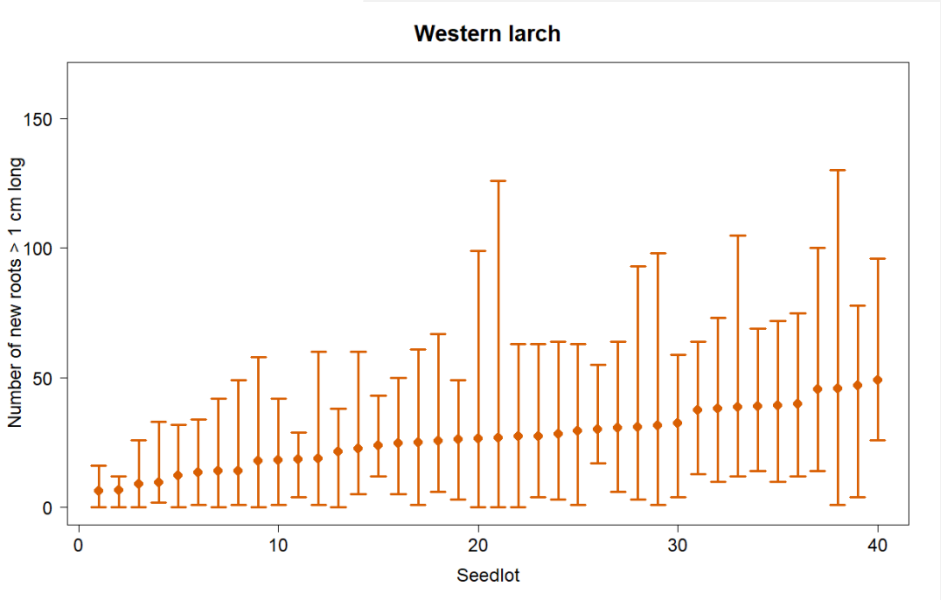
Hileman. 1986. *In:* Proceedings Combined Western Forest Nursery Council and Intermountain Nursery Association Meeting.

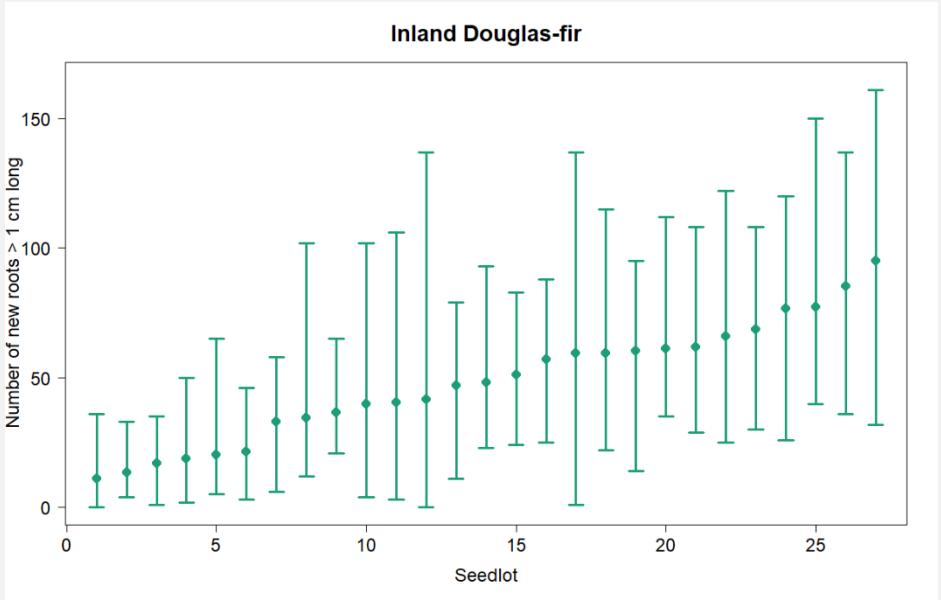
TESTING PROCEDURES

- 15 seedlings per seedlot
- 16 day testing period (20 days for western larch)
- Air temperature constant at 21 °C (70 °F)
- 12 hours of supplemental LED light (~120 µmol m^{-2} s^{-1} PAR)
- Chest freezers
  - Internal: 137 cm (54 in) x 51 cm (20 in) x 71 cm (28 in)
- Recycling water mist system
  - Diaphragm pump
  - 3 misting nozzles (Fogg-it superfine: ½ gallon per minute)
- Mist for 5 seconds followed by 4 minutes, 55 seconds no misting (24/7)
- Aquarium heater set at 21 °C
- Air stone to add oxygen to water
- Blackout curtains

PICTURES BEFORE & AFTER TESTING

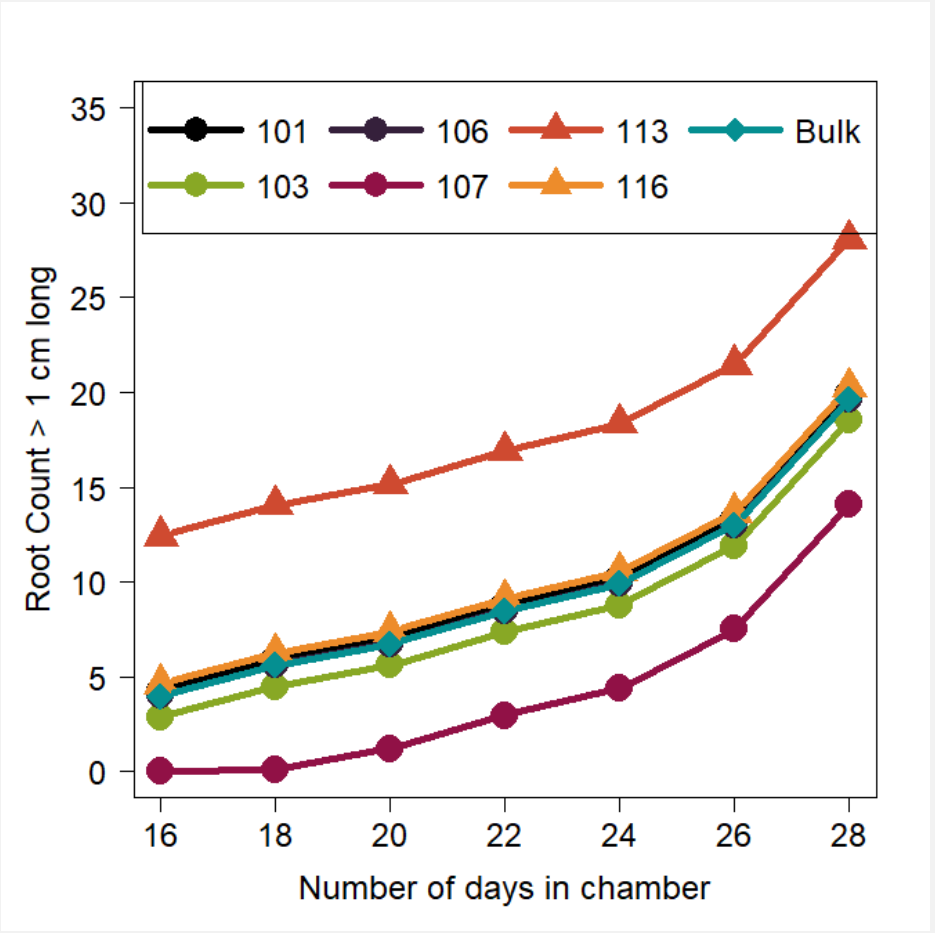
VARIABILITY BETWEEN AND WITHIN SEEDLOTS



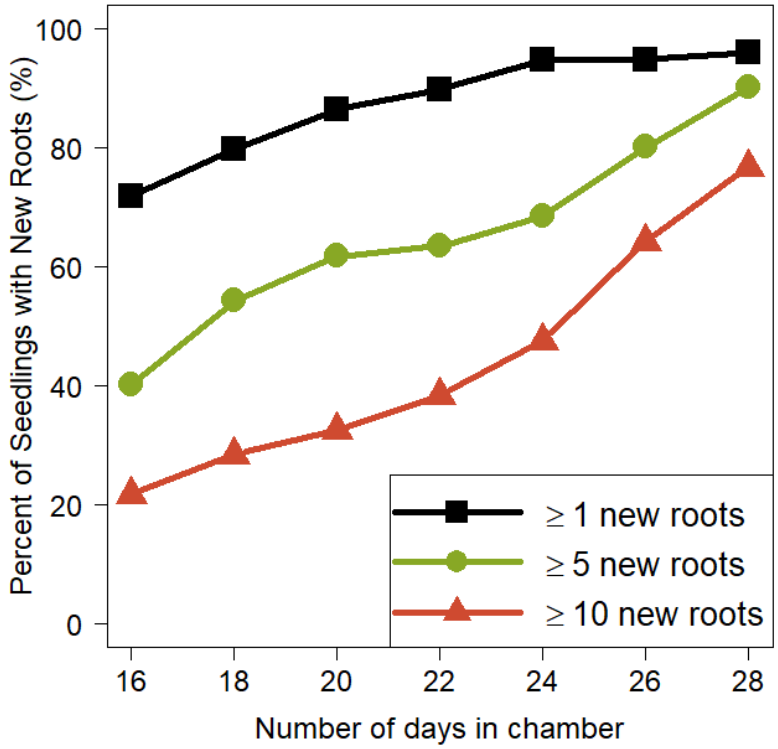


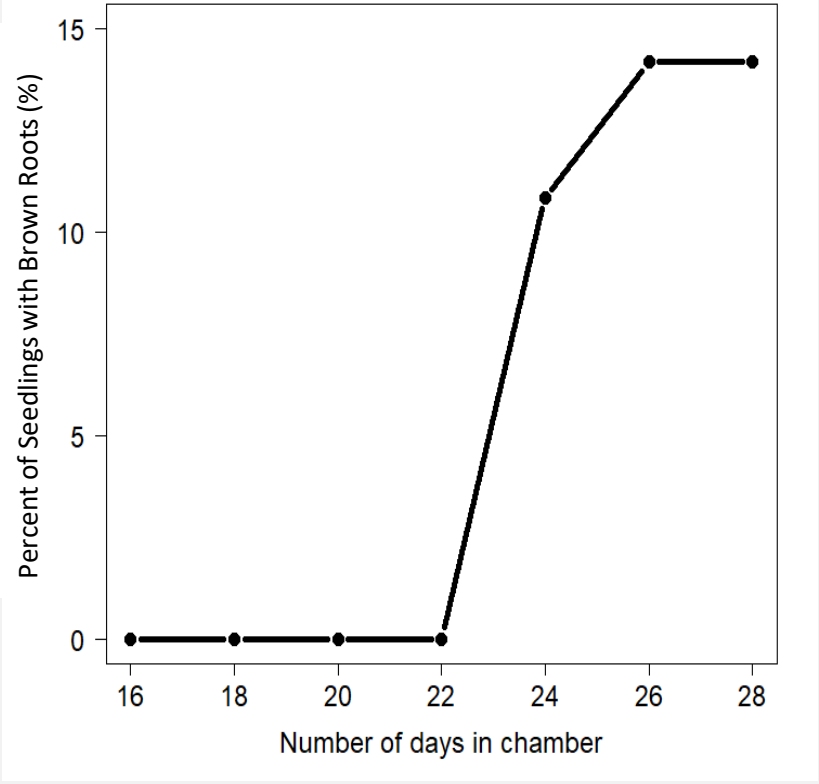
HALF-SIB WESTERN LARCH RGP

How long should western larch (a deciduous conifer) be tested in RGP mist chambers assuming that photosynthesis in conifers is required for new root growth?



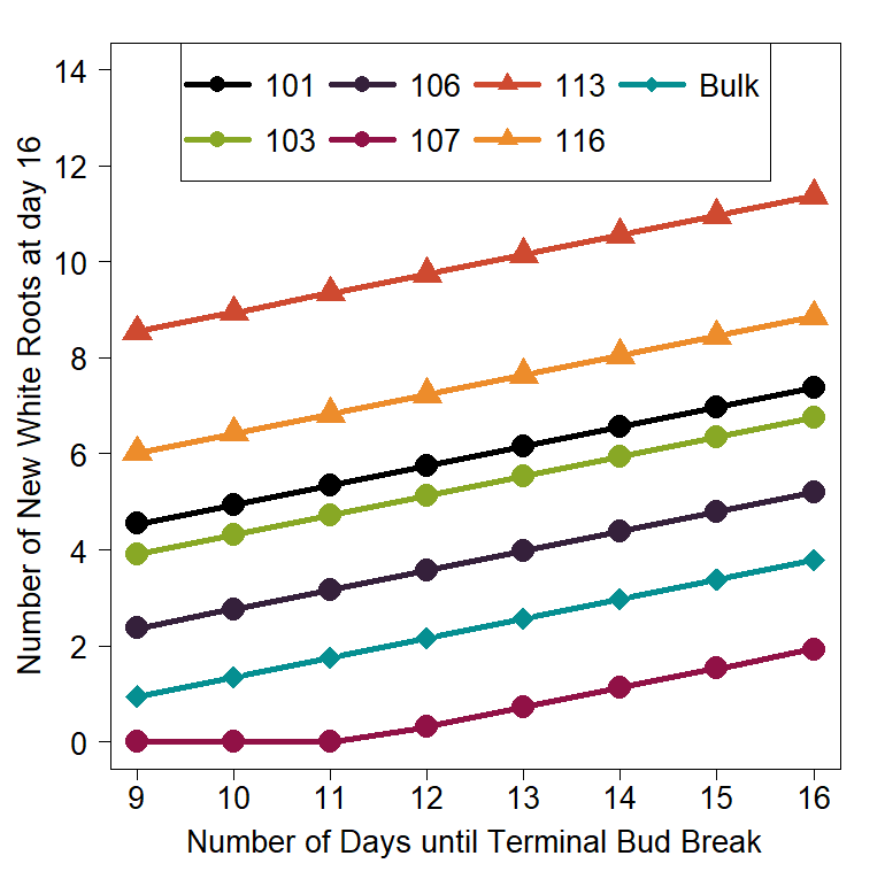
WESTERN LARCH ROOT PHENOLOGY IN CHAMBERS





WESTERN LARCH RGP AND SHOOT DEVELOPMENT

- Seedlings that took longer for the terminal to produce more foliage had more new roots at day 16
- Root growth was possibly a greater sink than shoot growth
- New foliage production may not be necessary for new root growth in larch

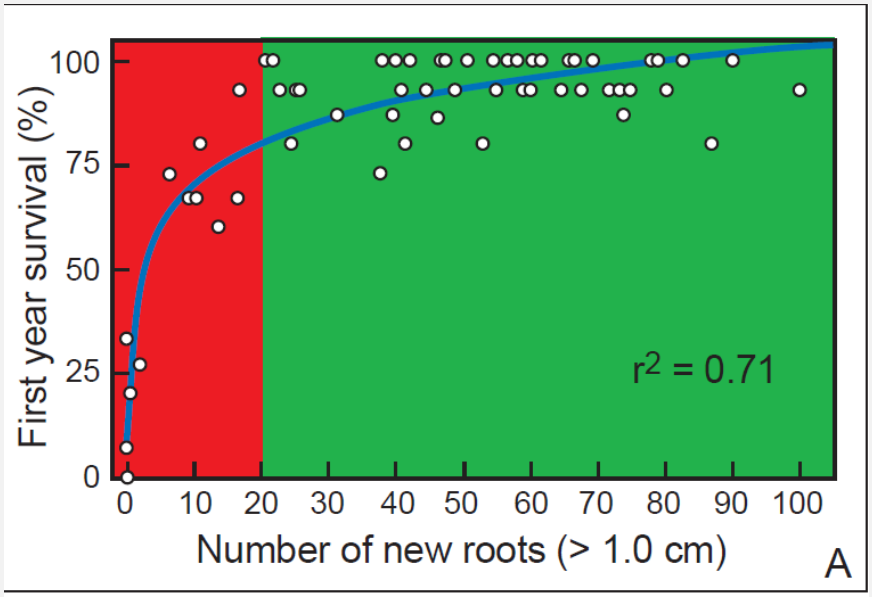


CAN RGP PREDICT FIELD PERFORMANCE?

AN ONGOING DEBATE

- Relationships between RGP and field performance have been documented for many species

- RGP values below expected values for good seedlots may indicate poor seedlings from the nursery and poor outplanting performance



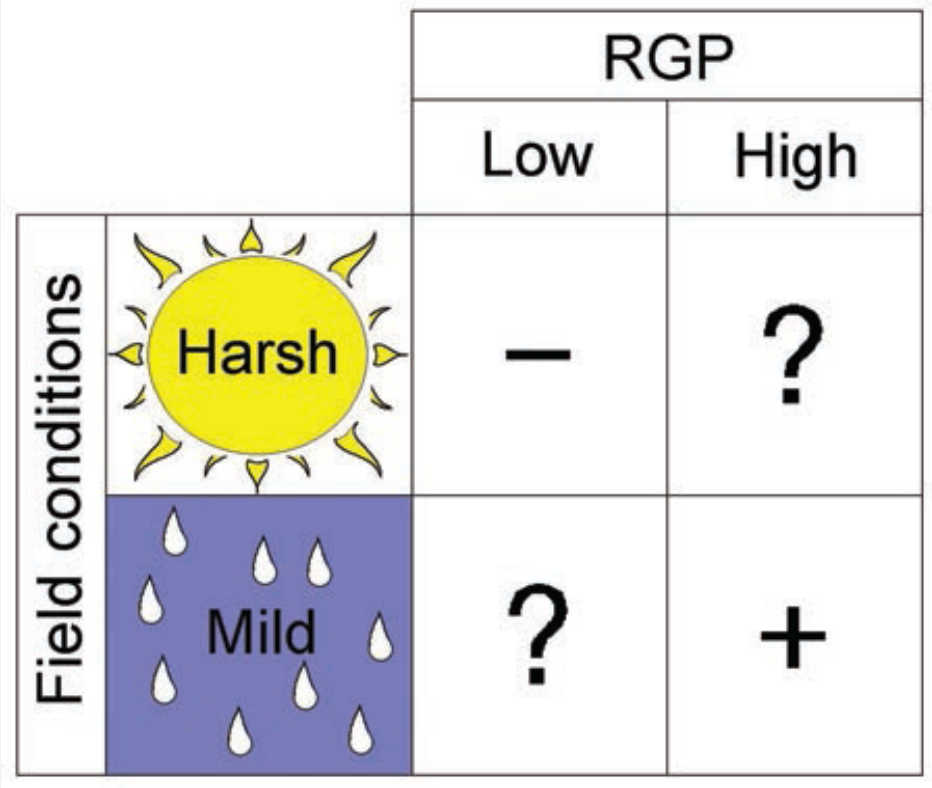
Ritchie et al. 2010. The Container Tree Nursery Manual. Vol. 7, Chp. 2. *Modified from:* Grossnickle. 2000. Ecophysiology of northern spruce species. NRC Research Press

Simpson and Ritchie. 1996. New Forests. 13:249-273

CAN RGP PREDICT FIELD PERFORMANCE?

AN ONGOING DEBATE

- Other factors influence outplanting success:
  - Site conditions
  - Seedling morphology
  - Stress resistance (stress associated with lifting, storage, handling, and planting)
  - Seedling vitality (freedom from disease, injury, or stress-inducted disorders)



Simpson and Ritchie. 1996. New Forests. 13:249-273

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INLAND NORTHWEST RGP OUTPLANTING

- 81 seedlots planted at 3 sites
  - 24 DF from 10 nurseries
  - 44 WL from 9 nurseries
- 15 seedlings planted per seedlot within a row
- Rows randomized across the sites
- Planted April 2018
- Measured after planting and fall 2018

SITE CHARACTERISTICS

Idaho – Clearwater

- 3,442 ft elevation
- Parent material ash over basalt
- Avg. max temp 55.2 °F
- Annual precip 44.9 inches

Idaho – St. Joe

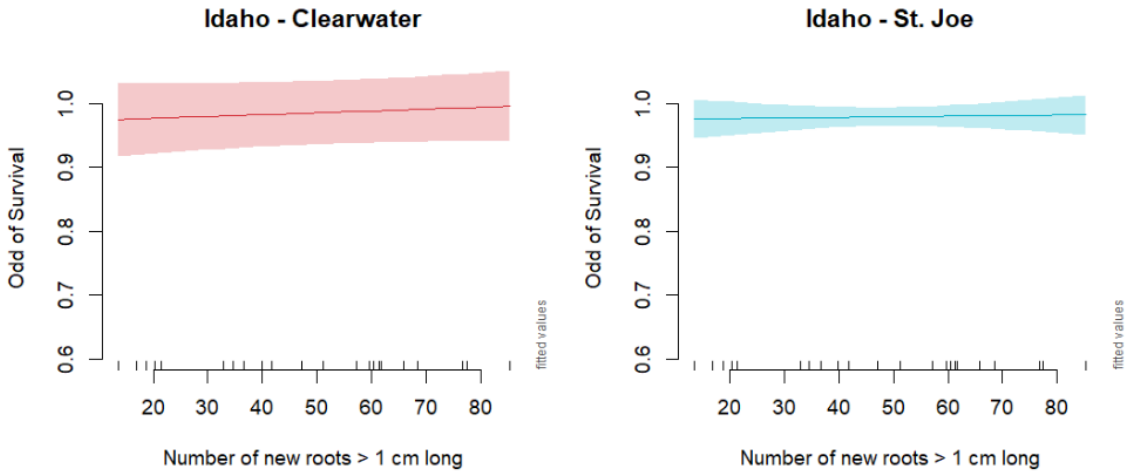
- 3,258 ft
- Parent material ash over loess
- Avg. max temp 57.1 °F
- Annual precip 31.1 inches

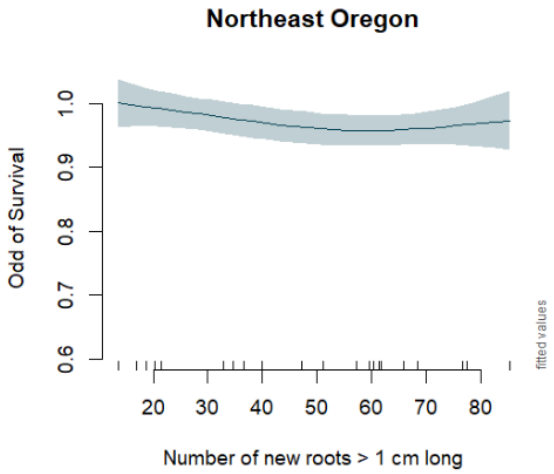
Blue Mountains

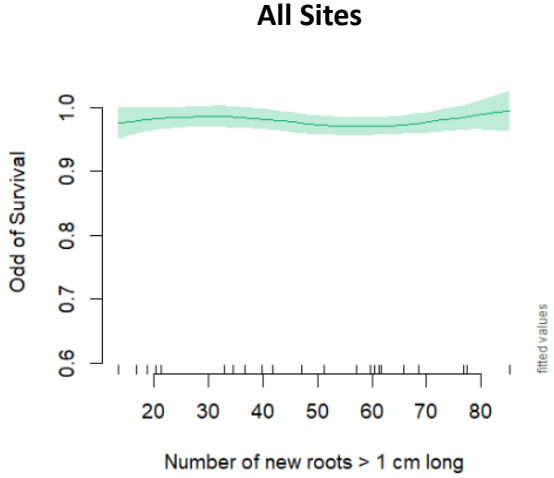
- 4,392 ft elevation
- Parent material ash over loess and basalt
- Avg. max temp 56.6 °F
- Annual precip 38.0 inches

www.climatetoolbox.org
Web soil survey

DOUGLAS-FIR SURVIVAL IN RELATION TO RGP

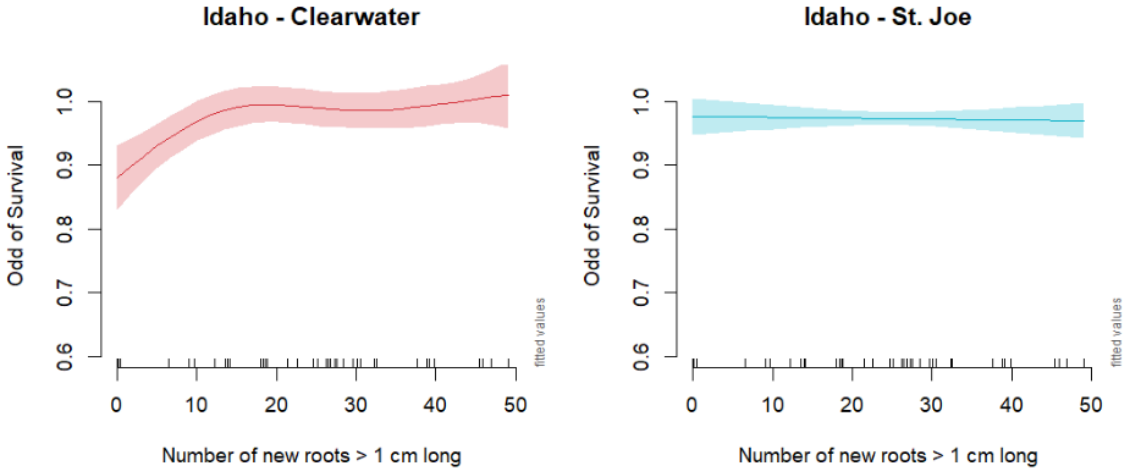


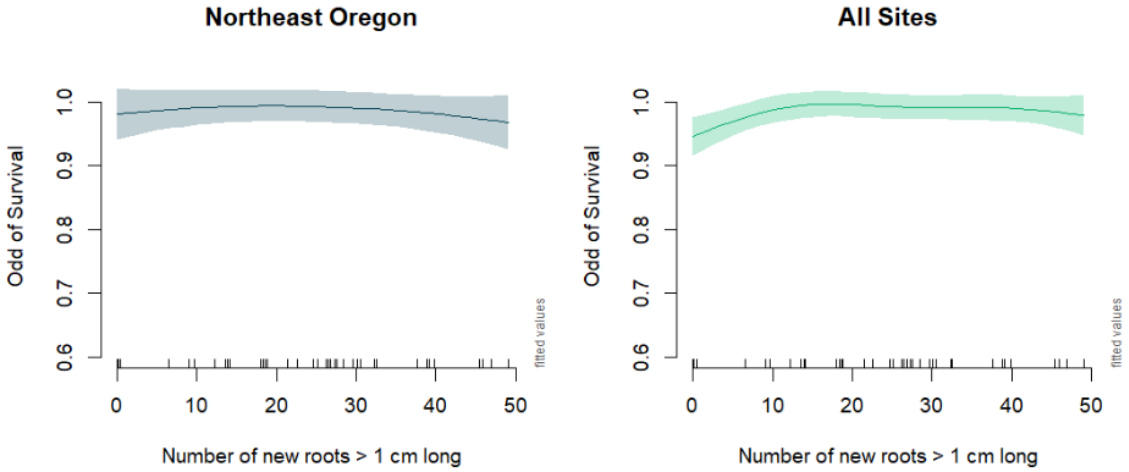




- Douglas-fir survival was generally high across all three sites
- Minimal to no effect of RGP on Douglas-fir survival in the first year

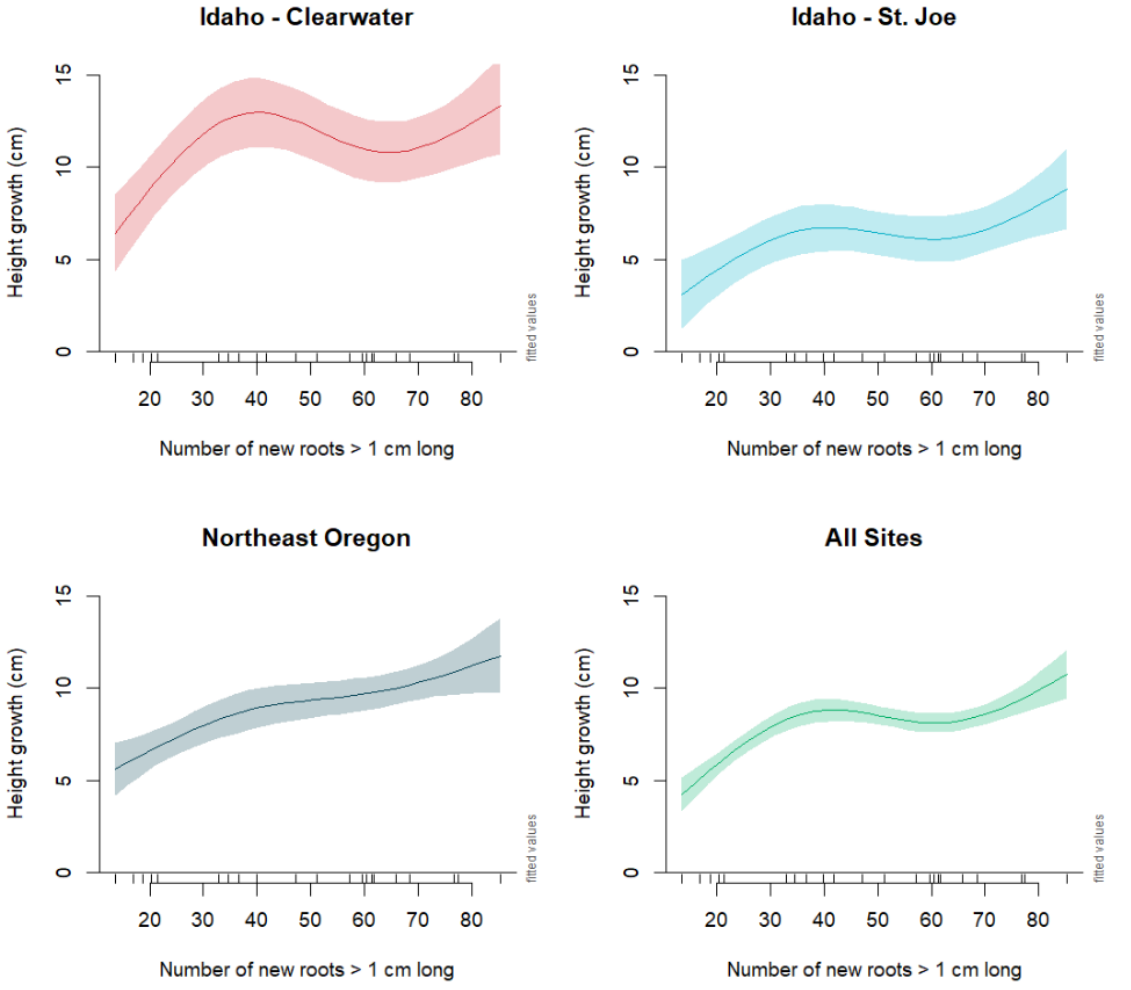
WESTERN LARCH SURVIVAL IN RELATION TO RGP





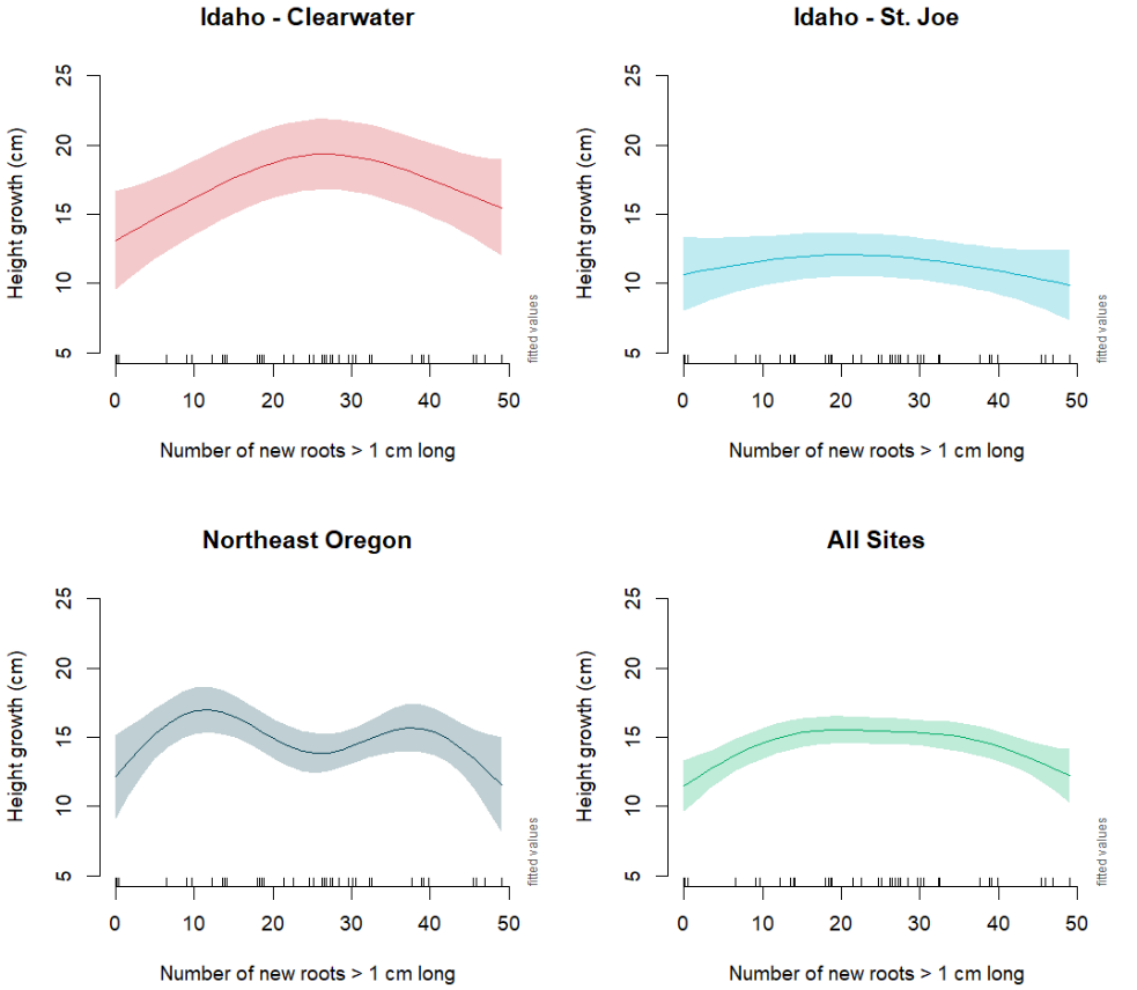
- Western larch survival was 90% or greater at all 3 sites
- The Clearwater site was the only site to show a trend of increasing survival with a slight increase of RGP at low RGP values

DOUGLAS-FIR HEIGHT GROWTH IN RELATION TO RGP



- Douglas-fir height growth differed considerably between the 3 sites
- The general pattern was an increase in height growth with greater RGP

WESTERN LARCH HEIGHT GROWTH IN RELATION TO RGP

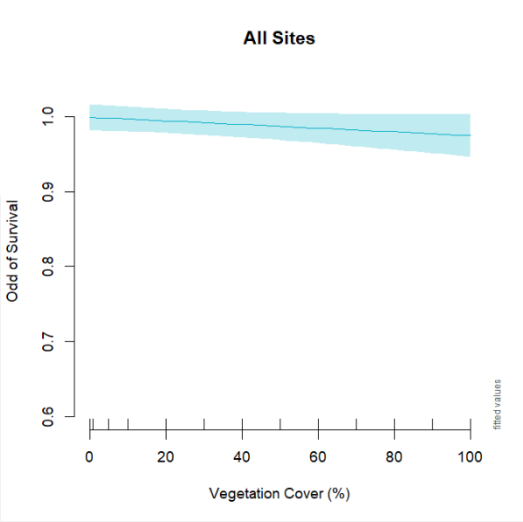


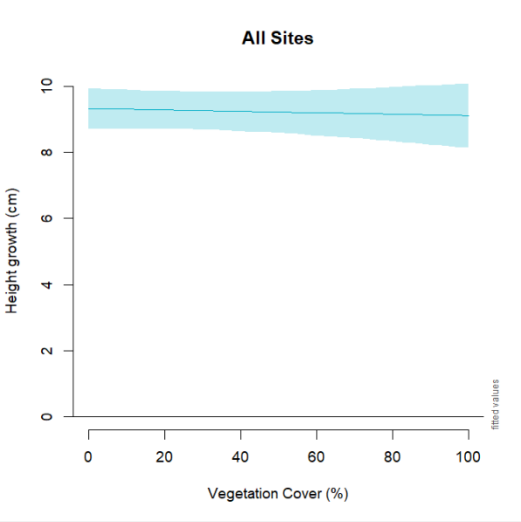
- The relationship between RGP and height growth was less consistent for western larch
  - Possibly because of indeterminant growth habit

MODEL OF RGP ALSO INCLUDE COMPETING VEGETATION COVER

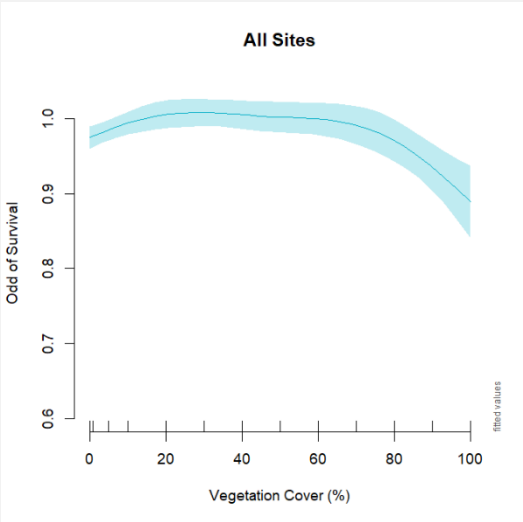
Survival

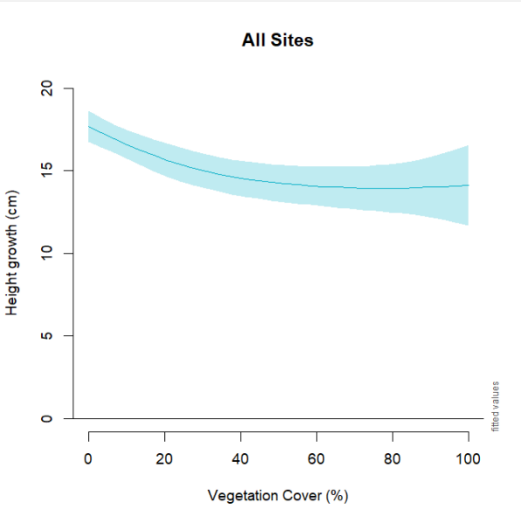
Height Growth





Douglas-fir: mostly insensitive to first year competition





Western larch: More sensitive to competition

SUMMARY

- Interest for rapid RGP testing in the Inland Northwest as part of seedling quality assessment programs
- RGP testing can help identify seedling vitality issues, but there is still debate on whether RGP is an adequate predictor of field performance
- The results from the outplanting experiment show that site factors can influence the relationship between RGP and field performance during the first year
- Data is being combined with other data to model the relative contribution of seedling quality, competition, soil characteristics, and climate on seedling survival and growth