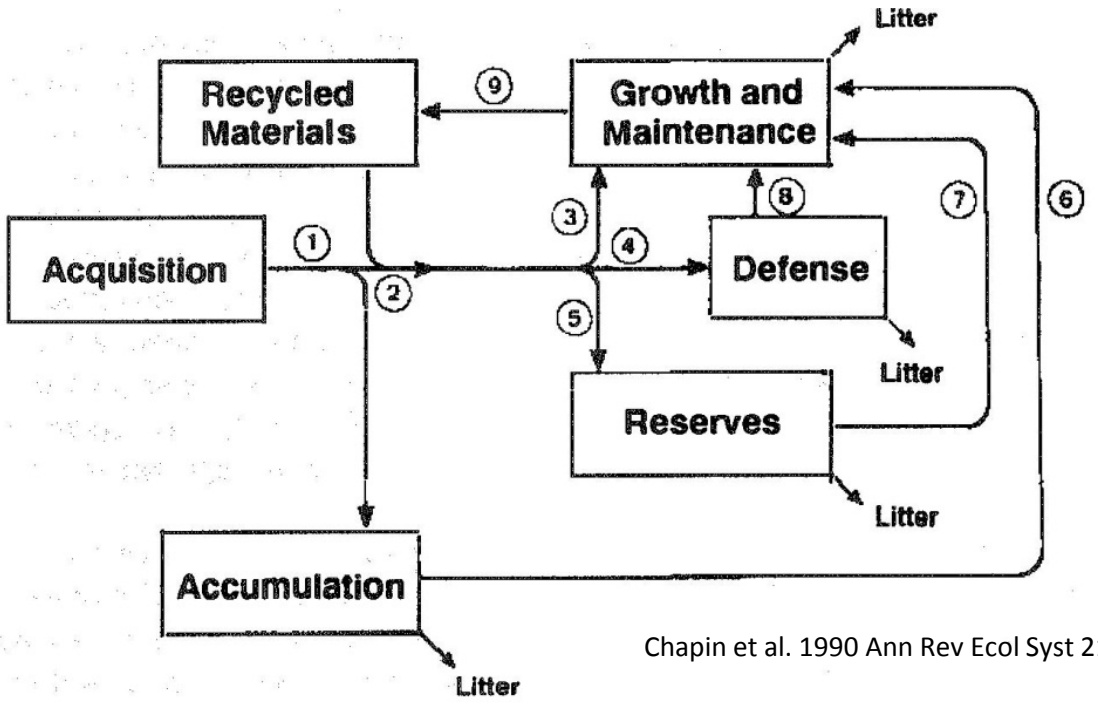
The role of non-structural carbon reserves in nutrition and stress tolerance of aspen seedlings

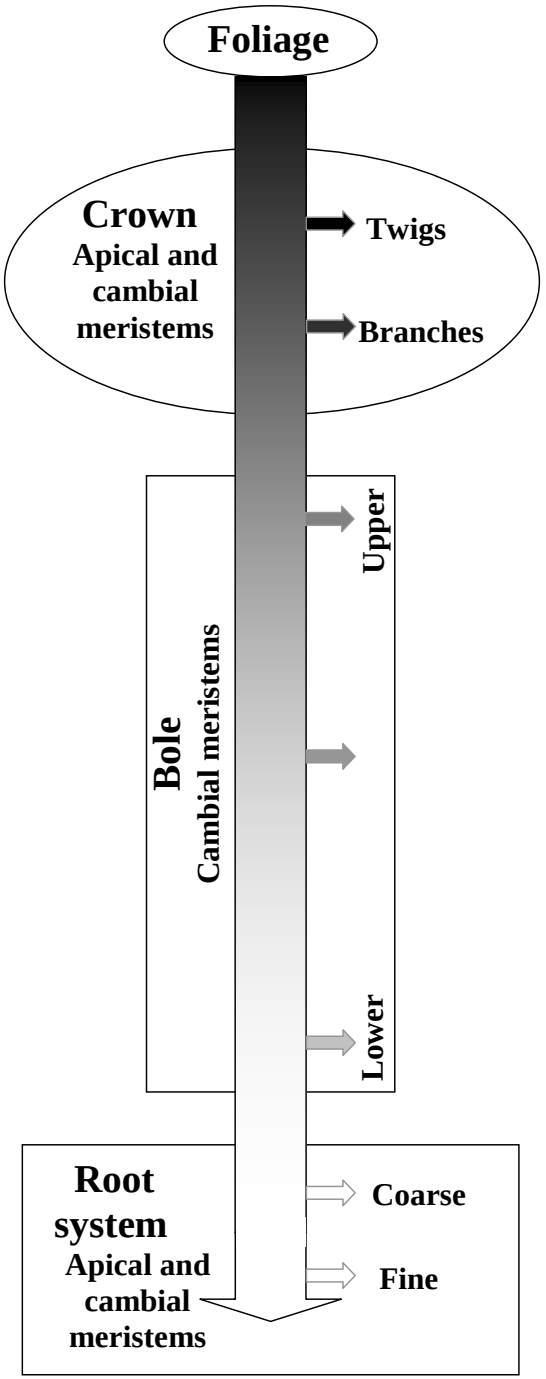
Simon Landhäusser, Brad Pinno, and Kaitlin Schott

Reserve types and pools

- Soluble sugars and starch
- Storage proteins (nutrient storage), glycerol forms, free fatty or amino acids



Chapin et al. 1990 Ann Rev Ecol Syst 21: 423-447



A conceptual model of reserve allocation

State of tree in spring and early summer

- **Satisfy sinks top down, starting in crown tissues**
- **Stem as a sink**
- **Reduced amount of reserves reach the root system**

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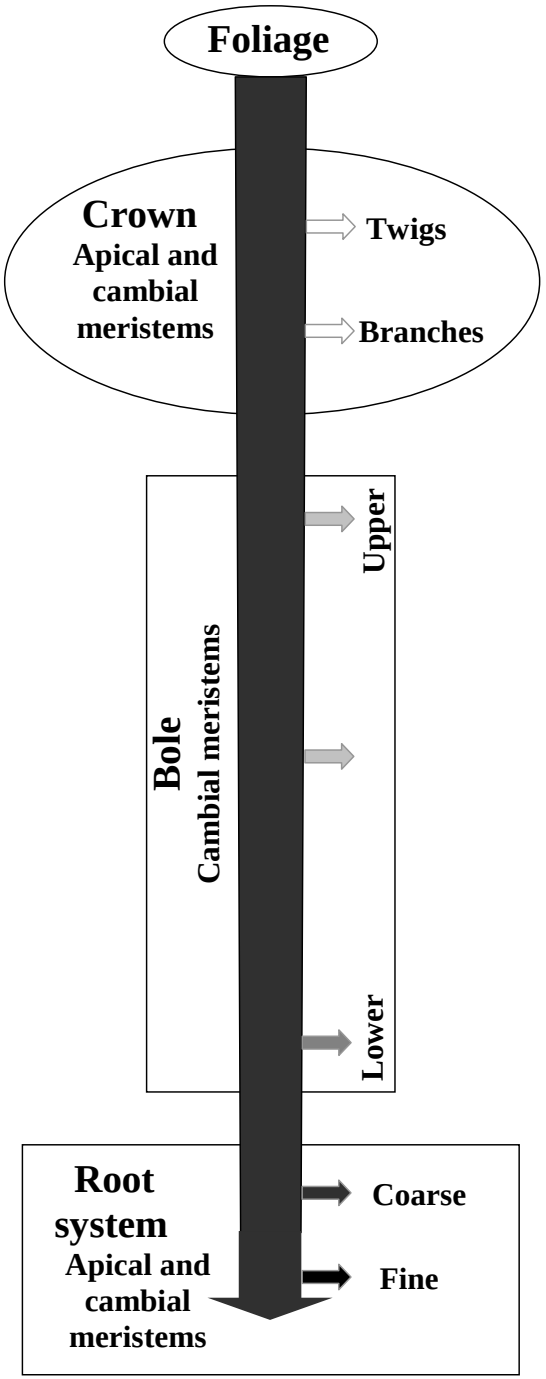

State of tree in late summer

- **Crown tissues sated, shoot growth ceased**
- **Bole growth reduced (latewood production)**
- **Refilling of root system and root growth**

However during

Carbon limitations (e.g. defoliation)

- **Spring and early summer state could be prolonged**

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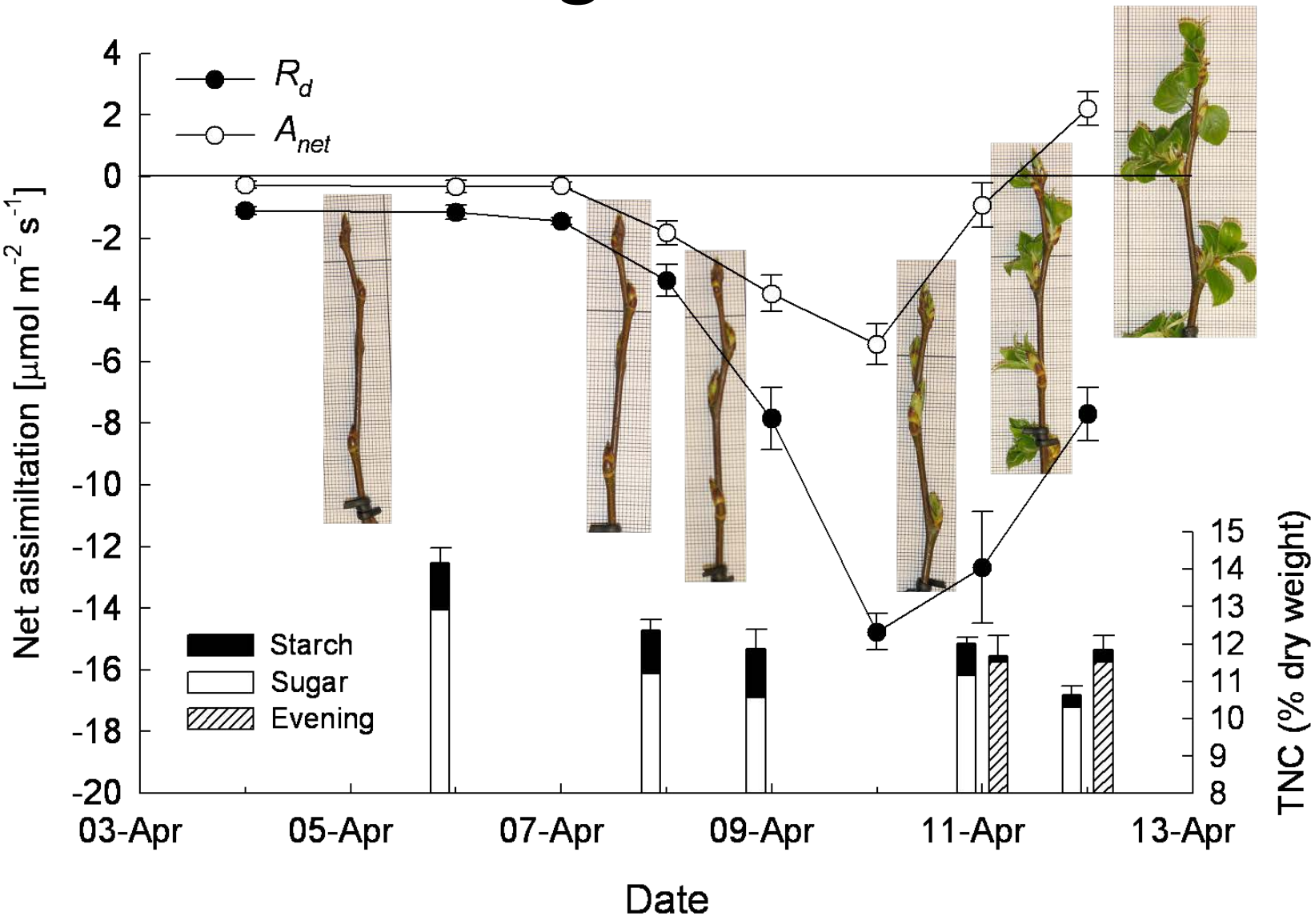
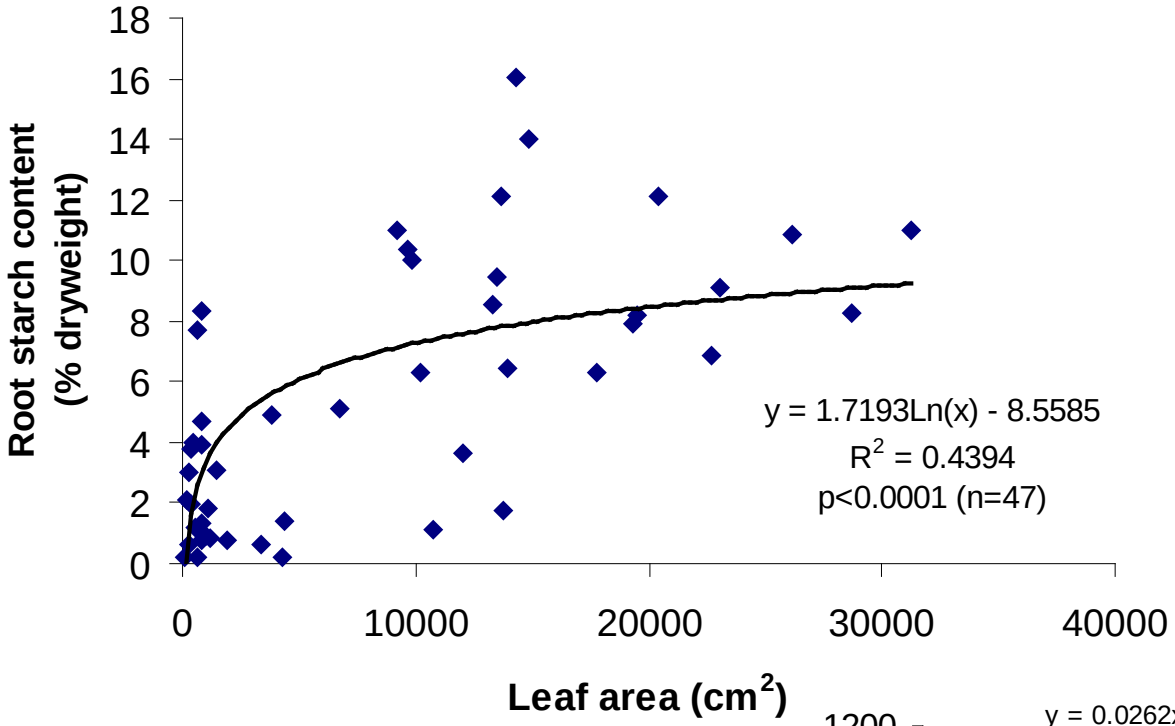
Storage in stems

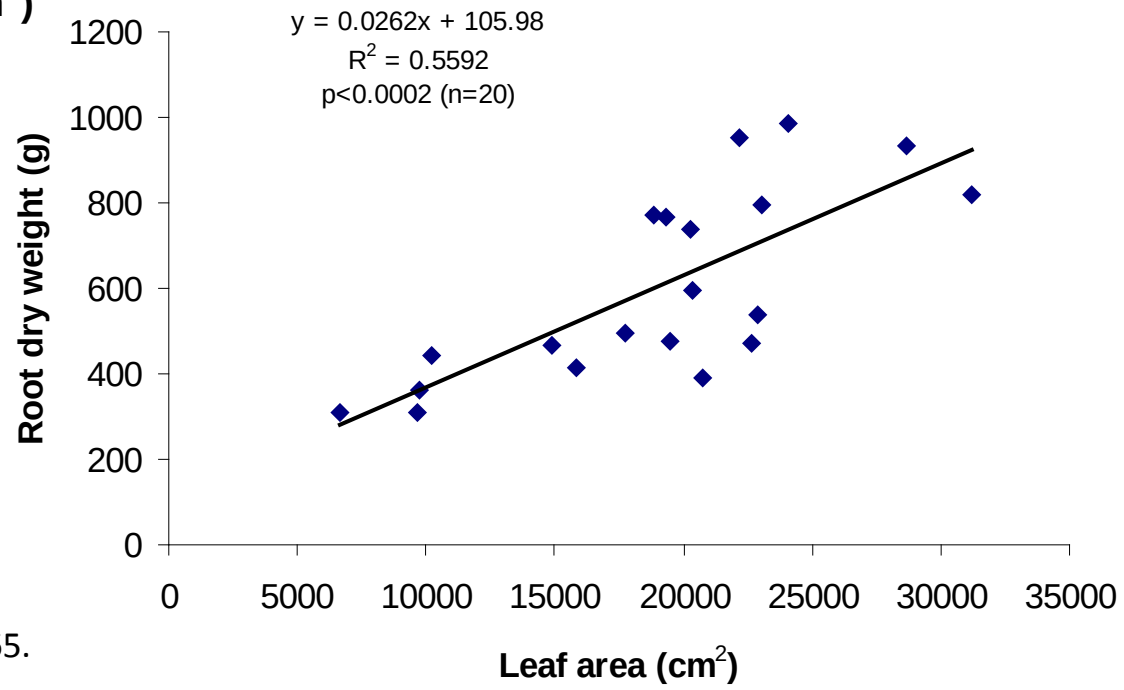


Landhäusser SM 2011. Trees 25:531–536

What limits reserves?

- Driven by biotic and abiotic variables that incite stress in plants, reducing carbon and nutrient acquisition and/or change the allocation patterns

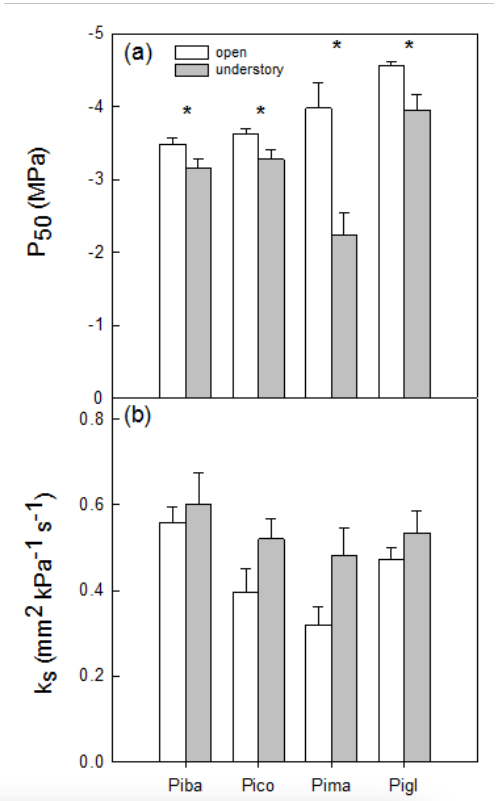


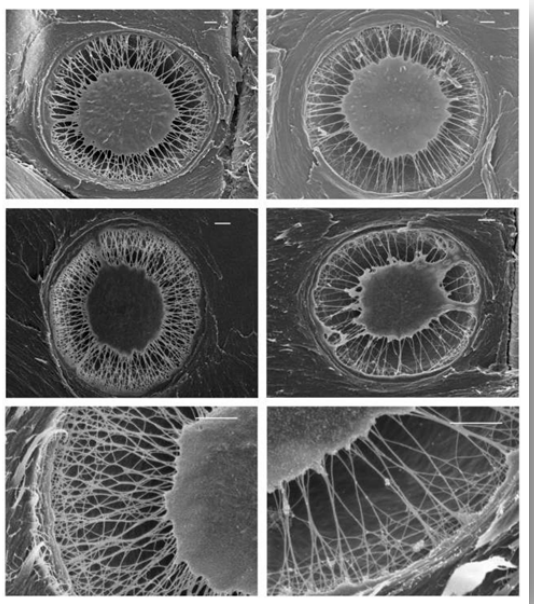


Landhäusser and Lieffers 2002 J. Ecol. 90: 658-665.

Impact on stem function

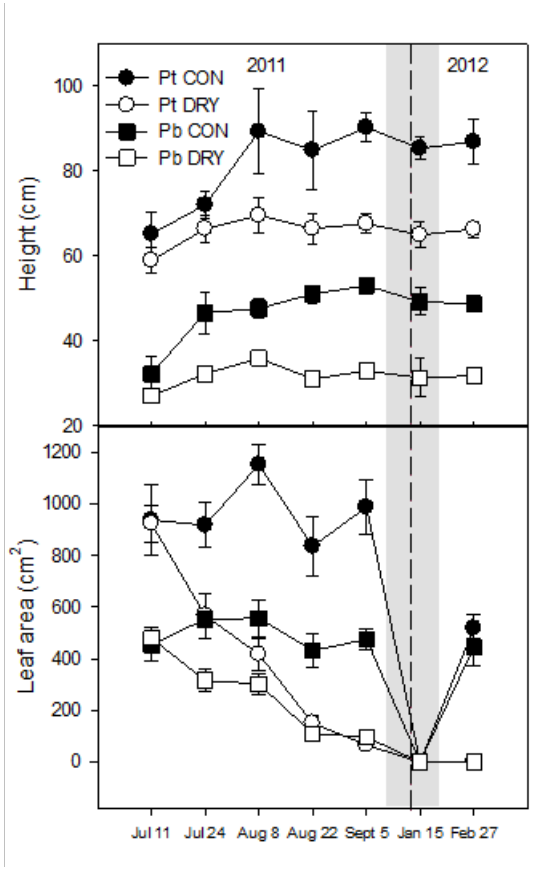
- Shaded conifers had an increased vulnerability to cavitation (P_{50}), but no difference overall xylem conductivity (k_s)
  - although shaded trees had much smaller tracheid diameters
- Shaded conifers had shoddy constructed pit membranes (thinner margo strands, greater torus extensions)
  - seal is poor (increase risk of cavitation)
  - allow more water to move through.

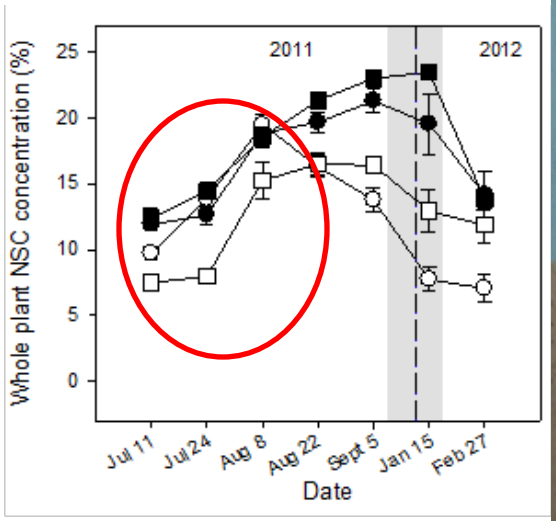




Schoonmaker et al. 2010 Pl Cell Envir 33: 382-393

Drought



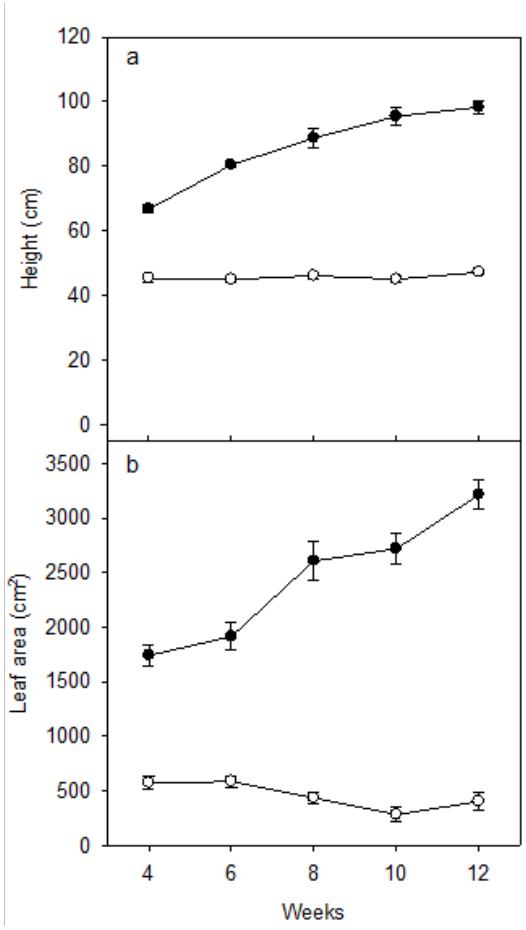


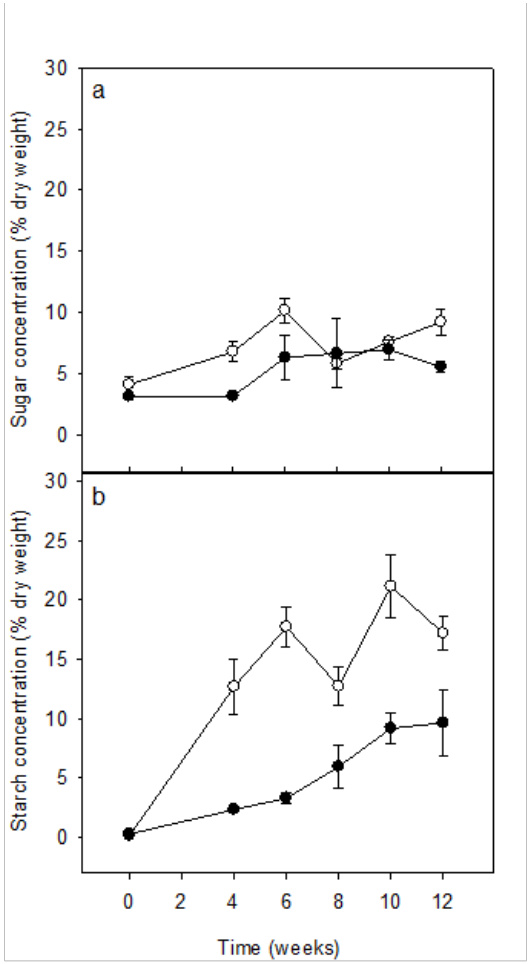
Galvez et al. New Phyt. In pressw

Seedling quality

- Root growth
- Leaf area development
- Shoot dieback and tree form
- Poor outplanting performance and stress tolerance

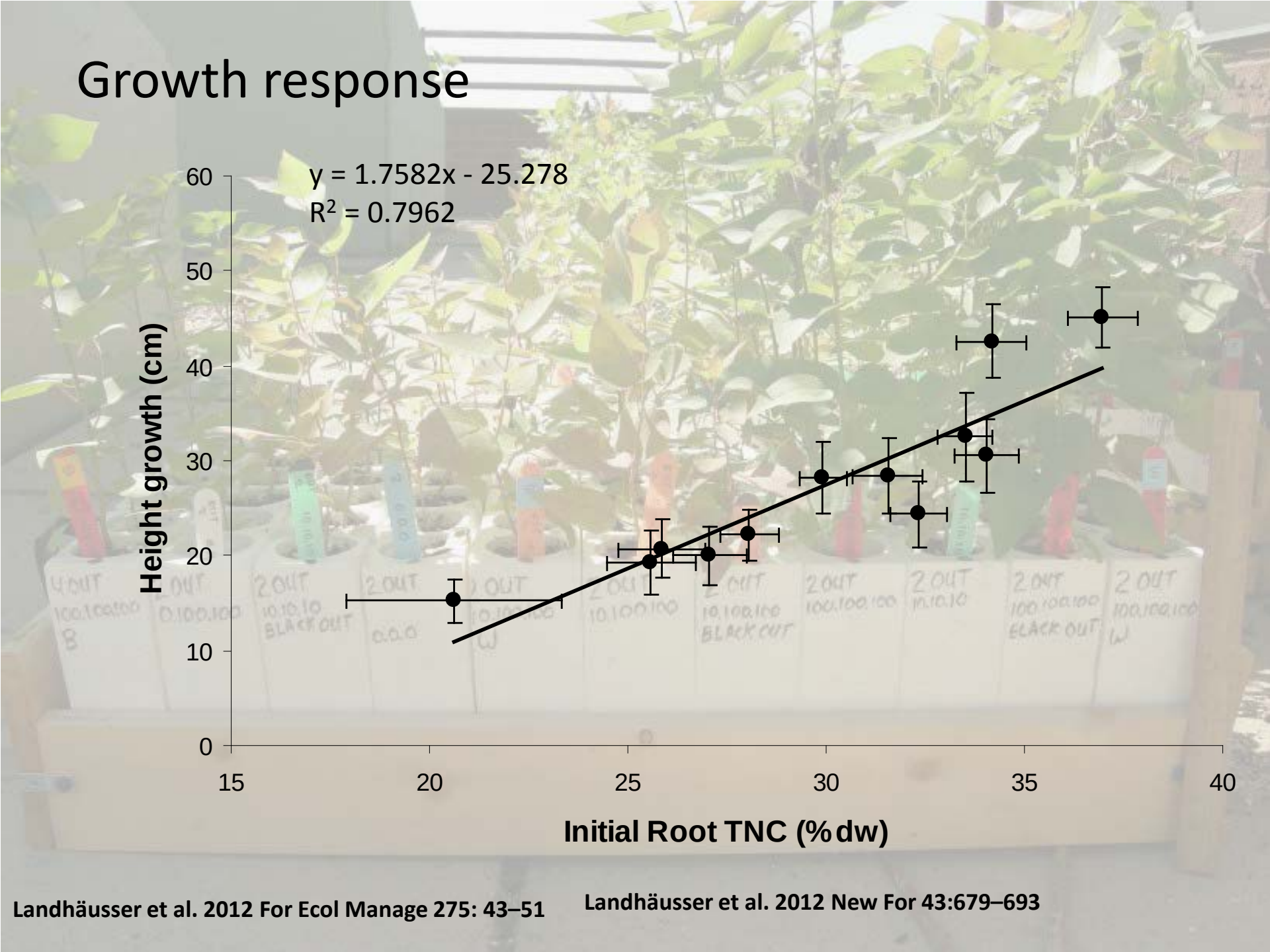
Indeterminate growth strategy





Galvez et al. 2011 Tree Phys. 31: 250-257

Growth response

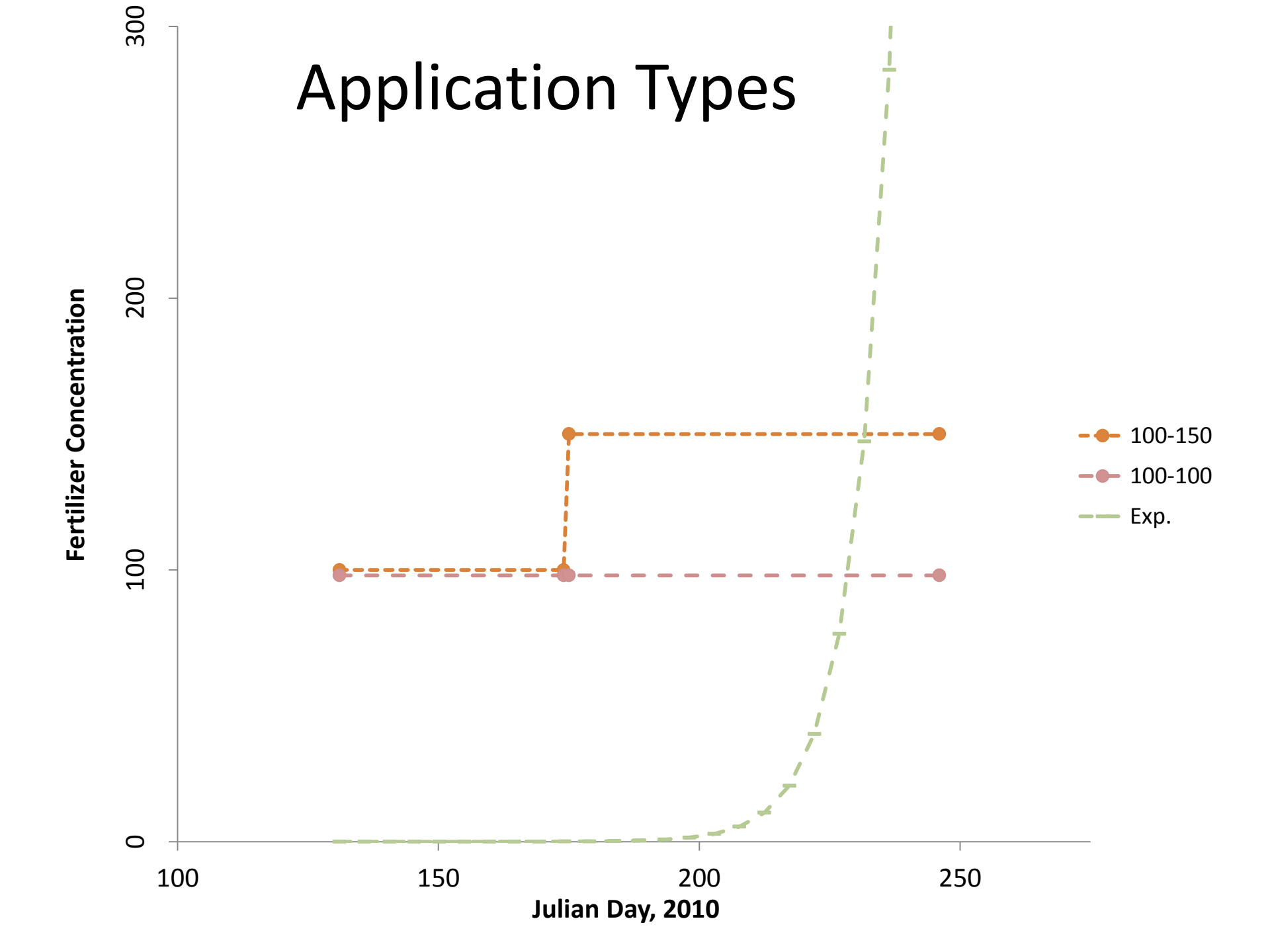


Landhäusser et al. 2012 For Ecol Manage 275: 43–51

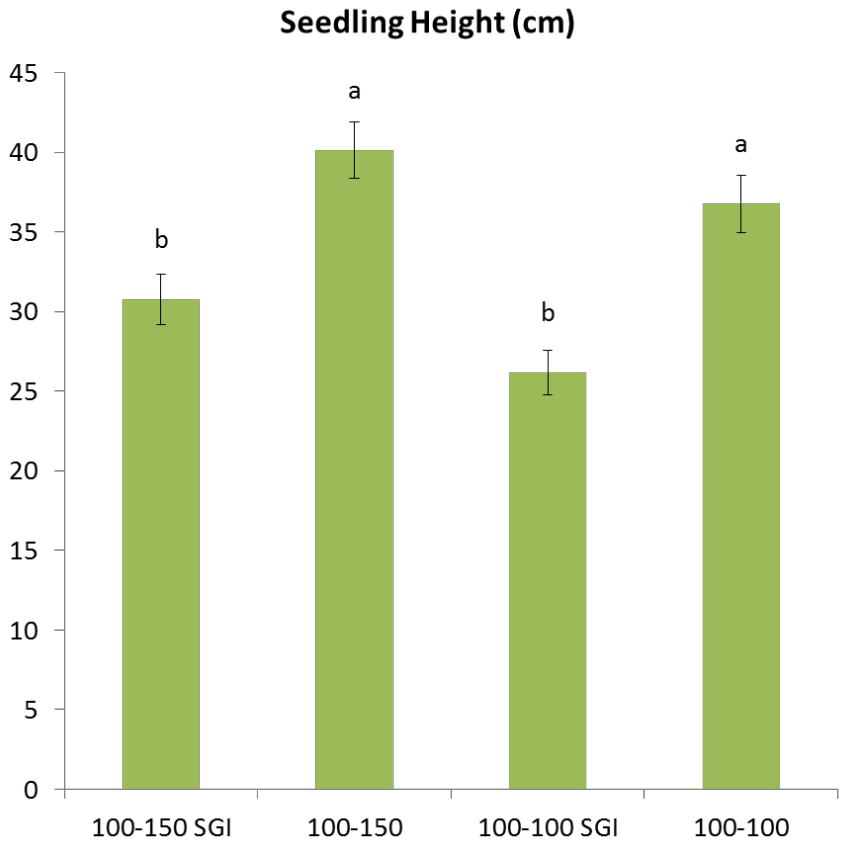
Landhäusser et al. 2012 New For 43:679–693

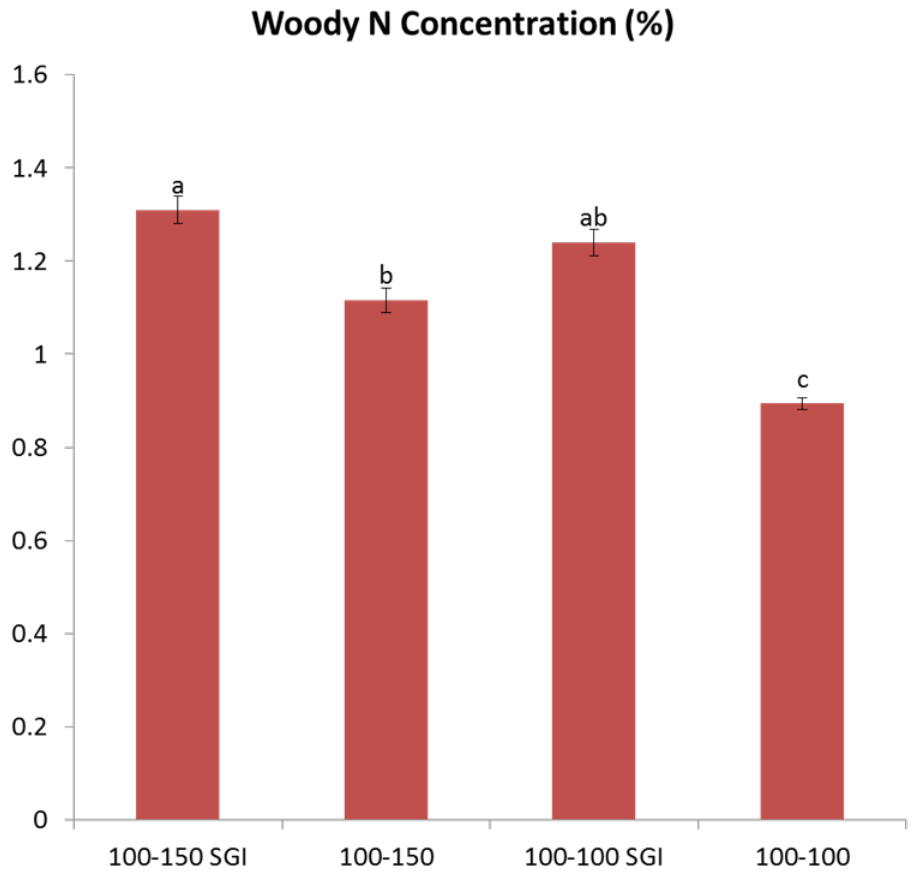
How does shoot growth termination affect dormant tissue nutrient concentration?

Treatment	Fertilization		SGI
	Early (May 12 - Jun 24)	Late (Jul 12 - Sept 4)	
200-200 SGI	200	200	Yes
150-200 SGI	150	200	Yes
150-150 SGI	150	150	Yes
100-200 SGI	100	200	Yes
100-150 SGI	100	150	Yes
100-150	100	150	No
100-100 SGI	100	100	Yes
100-100	100	100	No
EXP	Exponential		No
25-25	25	25	No
0-0	0	0	No


Application Types
Fertilizer Concentration
300
200
100
0
100
150
200
250
Julian Day, 2010
100-150
100-100
Exp.

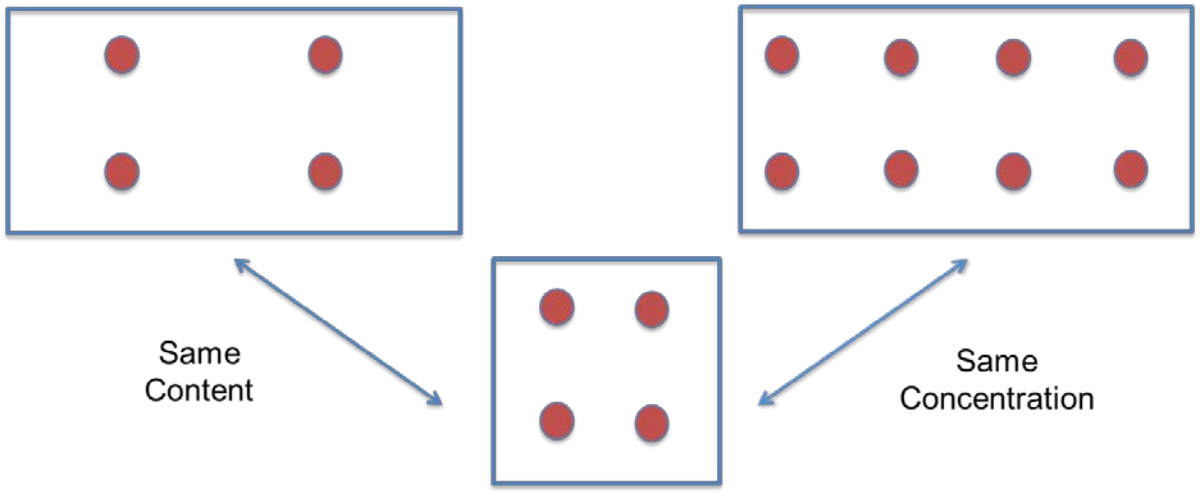
Physical effects of shoot termination



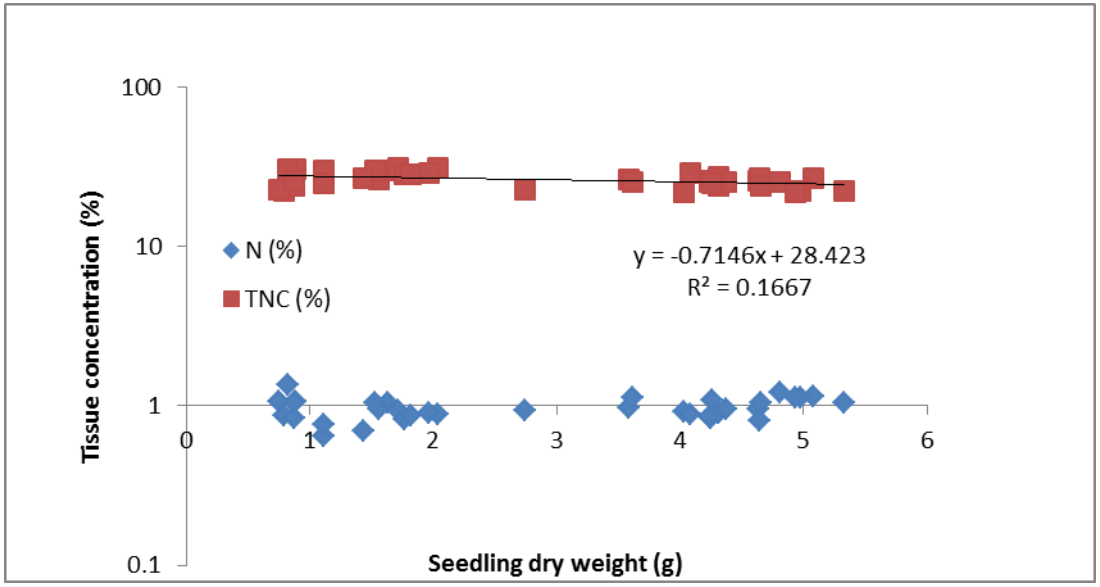


Is there a connection between carbon and nutrient reserves?

- No correlation between nutrient and TNC concentrations
- However strong link between nutrient and TNC content driven by seedling size.

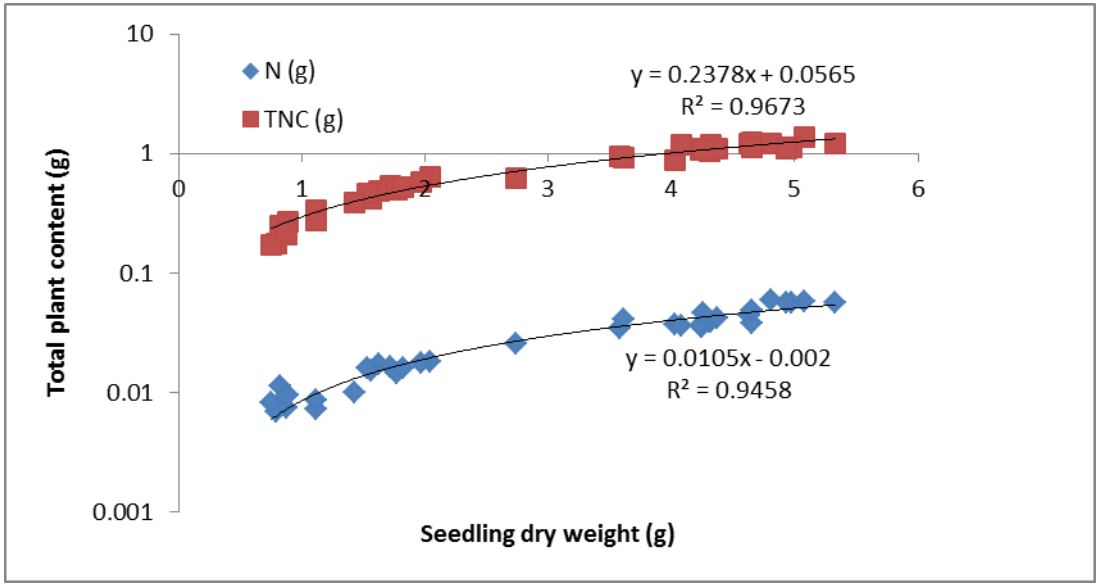


Impact of seedling size

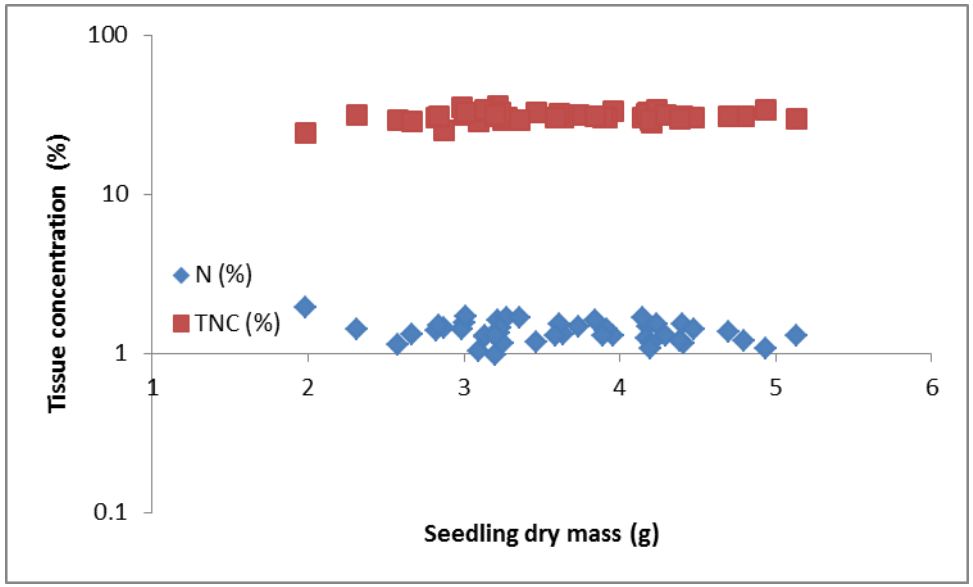


Seedlings without artificial shoot termination

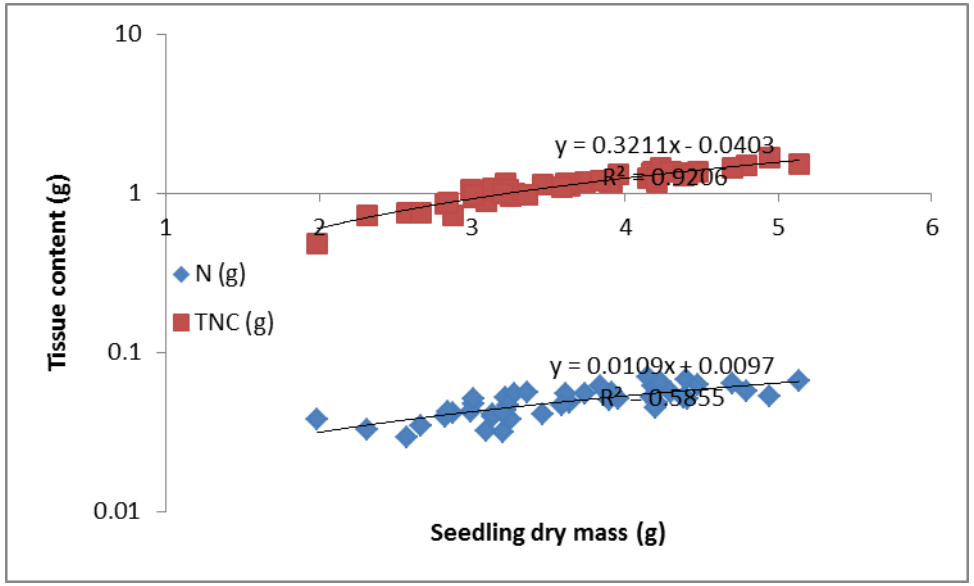
- Reduction in TNC concentration with increasing size
- No effect on N concentration
- Increase of content with size



Seedlings with shoot termination



- ~20% higher TNC & N concentration
- No effect of seedling size on TNC concentration
- Increase of content with size



Conclusion

- Premature shoot growth termination appears to be a prerequisite to accumulate nutrients and TNC in tissues of seedlings with an indeterminate growth strategy
- Bud set cannot be directly followed by leaf senescence
- Bud set has to be “strong” (seedlings will reflush under high nutrient regime (exponential regime)) negative impact on TNC reserves
- There is a potential disconnect between TNC and N accumulation in tissues.
- Seedling size does not have to be negatively correlated with TNC reserves, nursery practices could be adjusted.
- More to come…

Acknowledgements

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Suncor Energy
Shell Canada
Capital Power