TEMPORAL PATTERNS OF FINE-ROOT PRODUCTION AND MORTALITY DURING FOREST PLANTATION DEVELOPMENT.

Mark D. Coleman

USDA Forest Service, Southern Research Station

Acknowledgments

- Alexander L. Friend
- Christel C. Kern
- Richard E. Dickson
- J. G. Isebrands

- USDA-National Research Initiative
- USDA Forest Service Northern Global Change
- USDA Forest Service North Central Research Station
- USDA Forest Service Southern Research Station
- Department of Energy-Savannah

- Tina Scupian
- Bill Gerrish
- Raymond Lange
- Amanda Stimart
- Juanita Mobley
- Frank Lenning
- Walter Woolfolk
- Tom Kurkowski
- John Barone
- Sam Leininger
- Christy Prenger

What factors control root growth activity?

- Inherent factors
  - Seasonal and developmental timing
  - Species differences
  - Root size class
- Environmental factors
  - Soil depth
  - Nutrient content

Mature Poplar vs. Pine

Wisconsin

- *Populus tristis* X *P. balsamifera* vs. *Pinus resinosa*
- Closed canopy
- Six replicates

e multi-year experiments

Establishing Poplar

Wisconsin

de
r tr
spa

Establishing Poplar vs. Pine

South Carolina

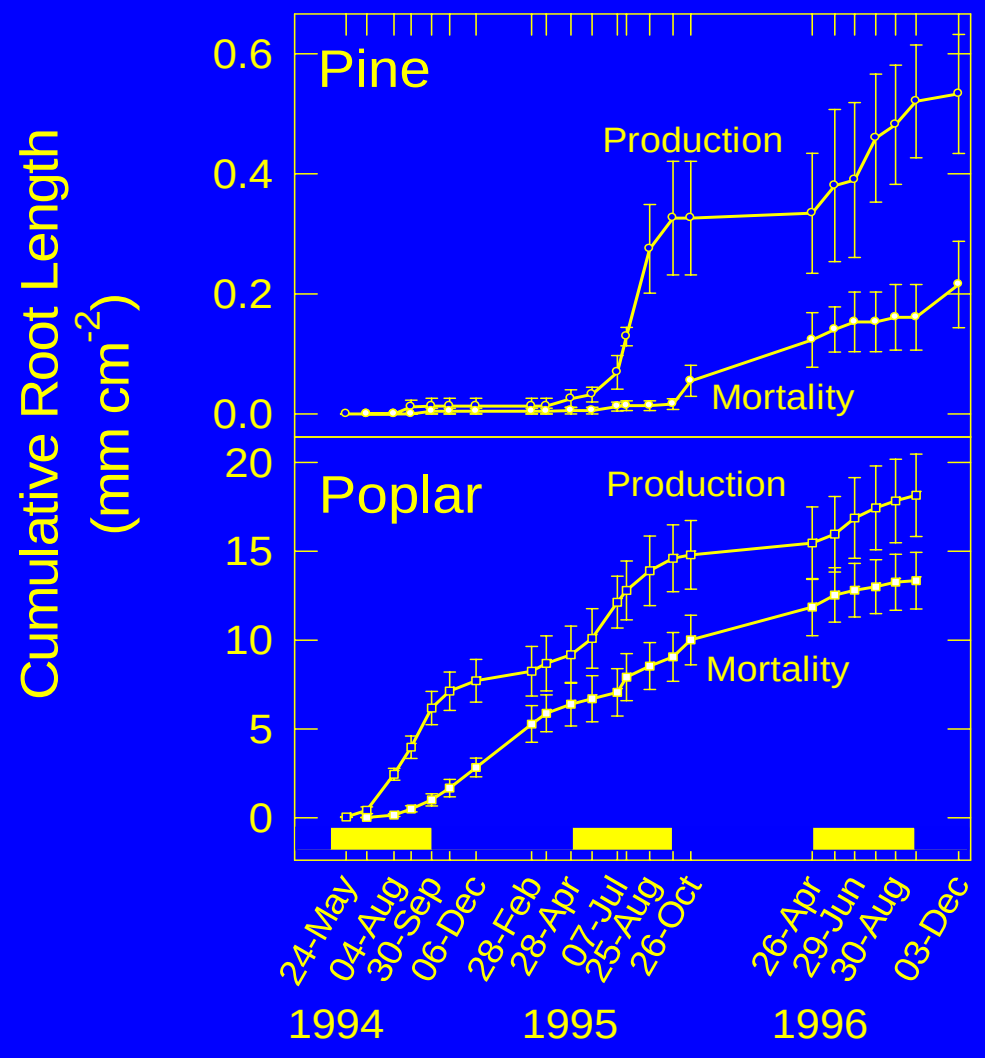
- *Populus deltoides* (ST66) vs. *Pinus taeda*
- Three-year-old
- Long-term monitoring plans

Minirizotron techniques monitor fine-root dynamics

Root parameters

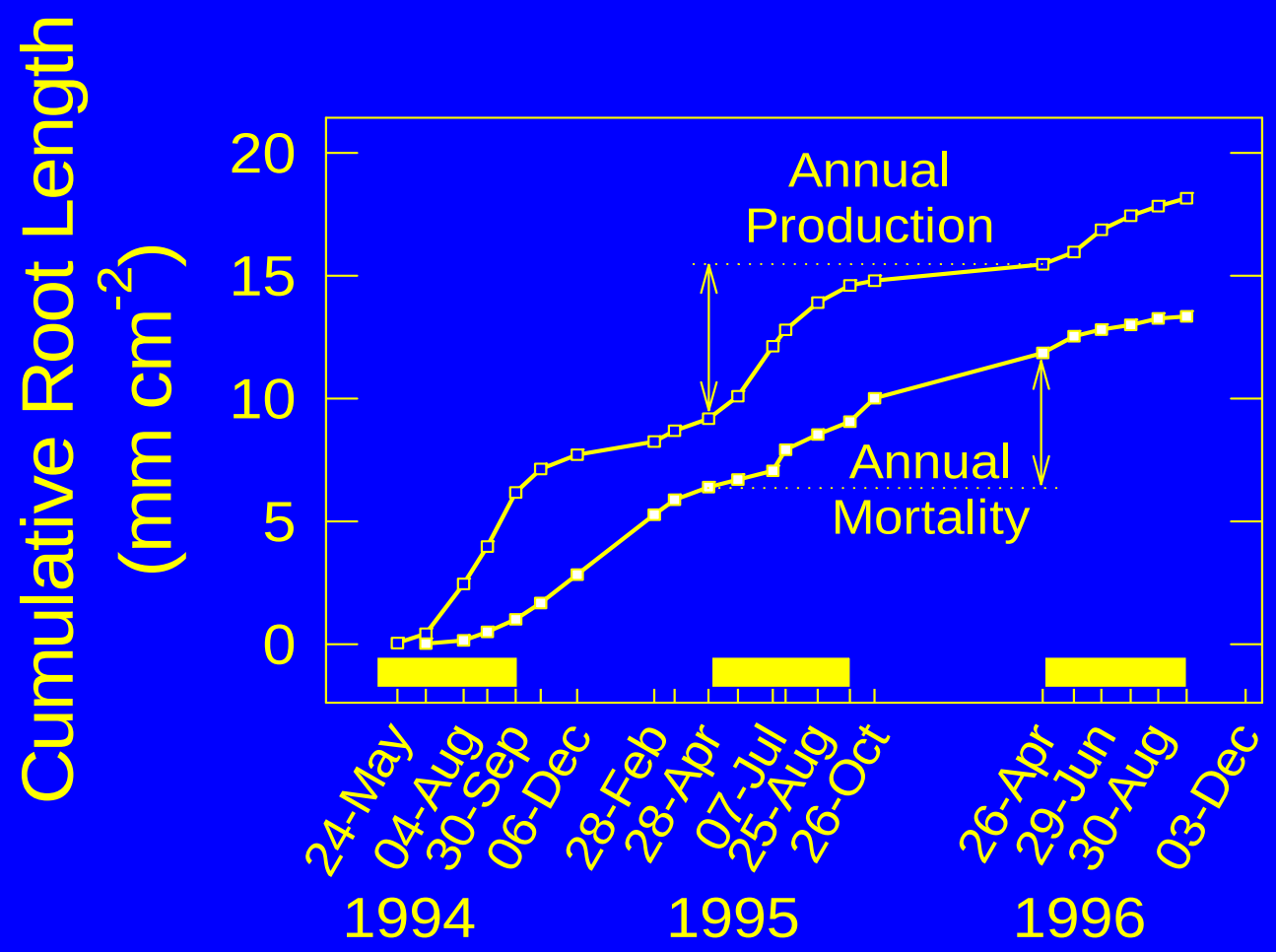
- Production & Mortality
- Standing crop
- Spatial-Temporal Distribution
- Turnover & Longevity

Mature Poplar vs. Pine, Wisconsin
Cumulative Production and Mortality



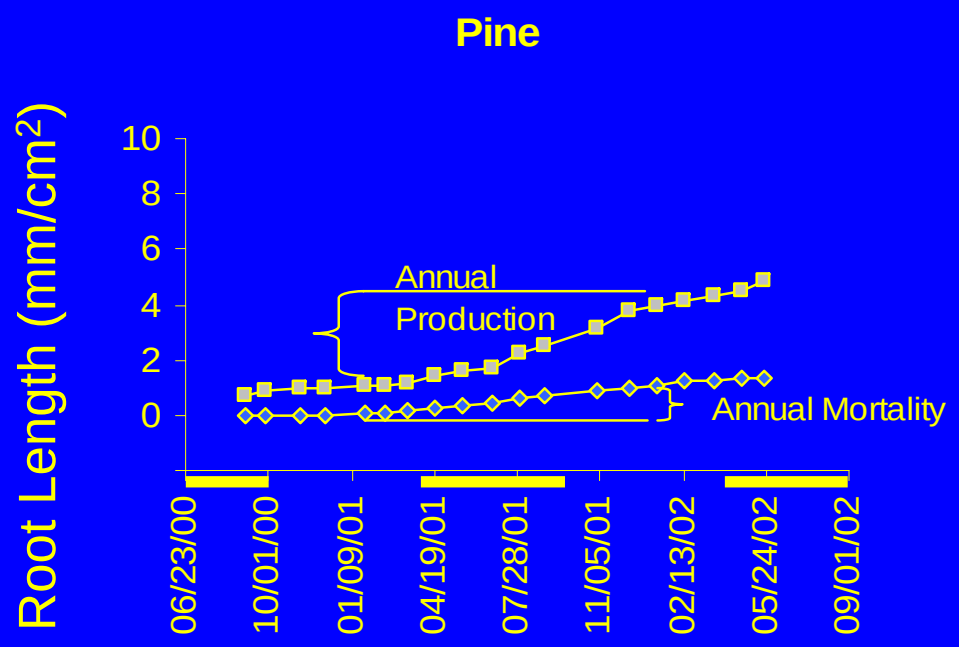
Coleman et al. 2000 Plant and Soil 225:129

Mature poplar: production equals mortality

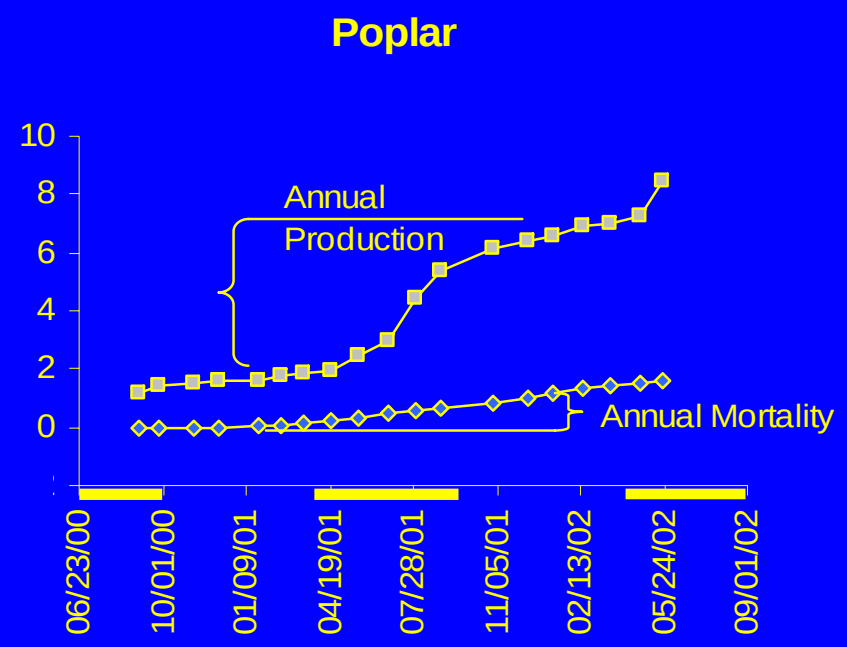


dP/dM = 1.06

Establishing stand (South Carolina): production exceeds mortality



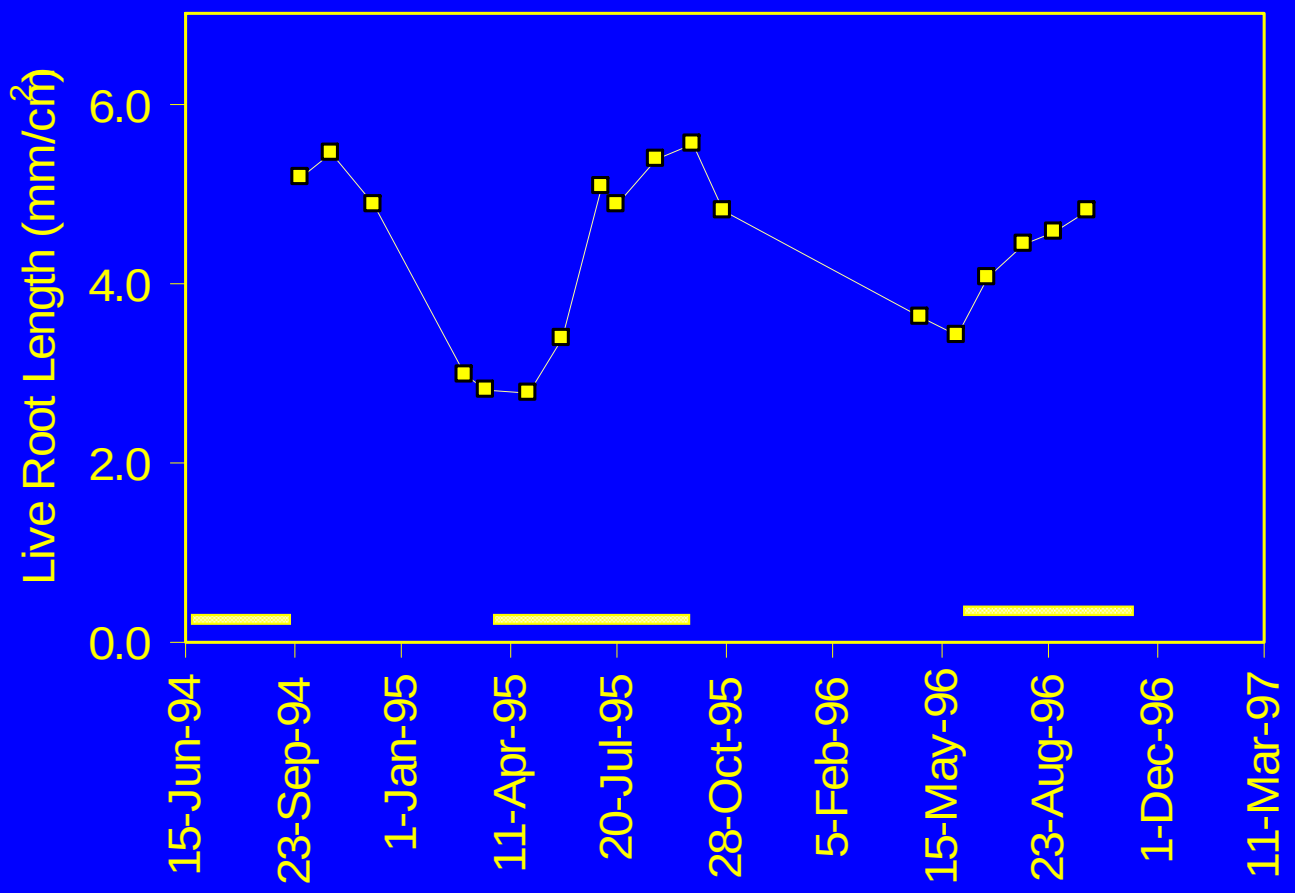
dP/dM = 2.9



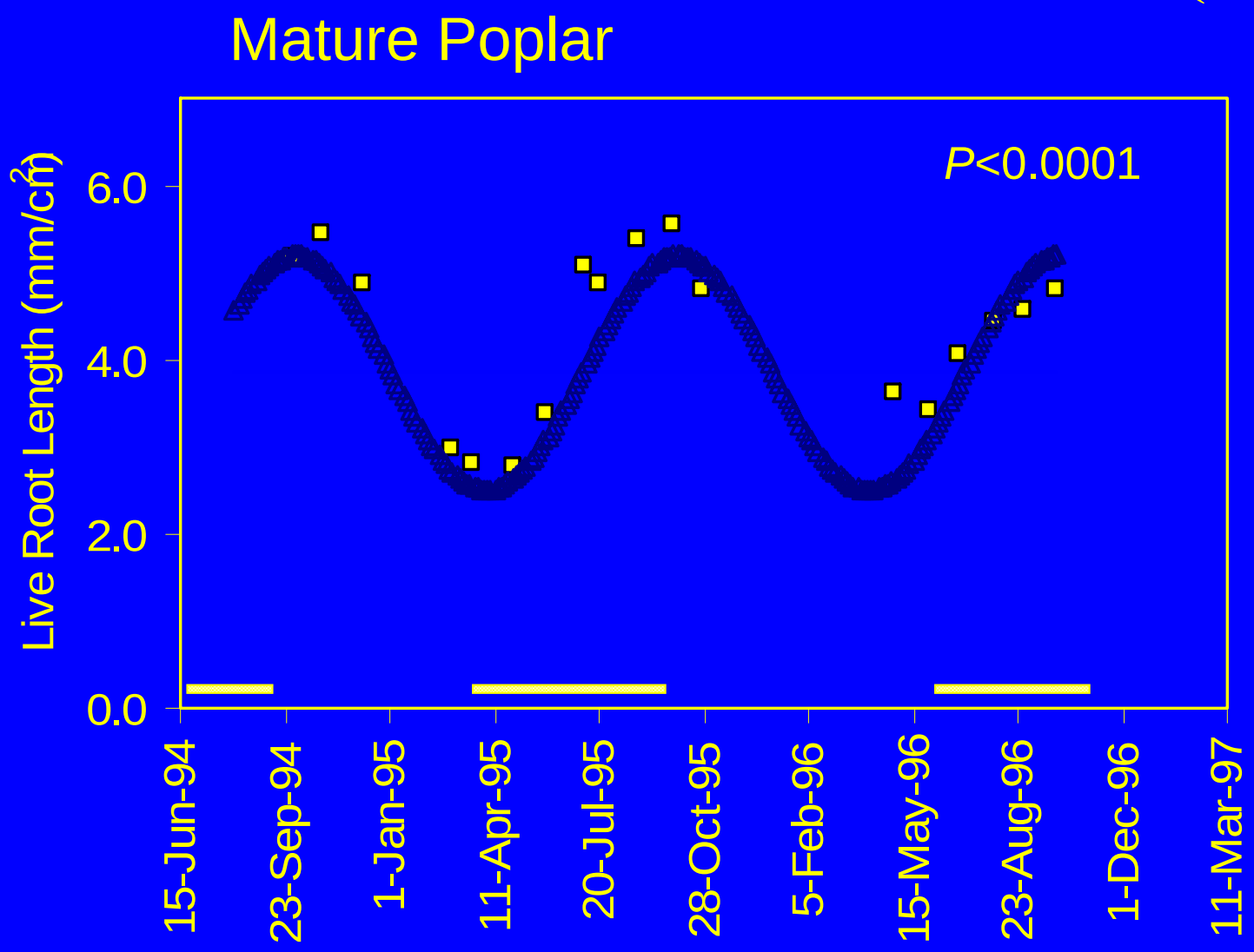
dP/dM = 5.0

Annual standing crop waveform

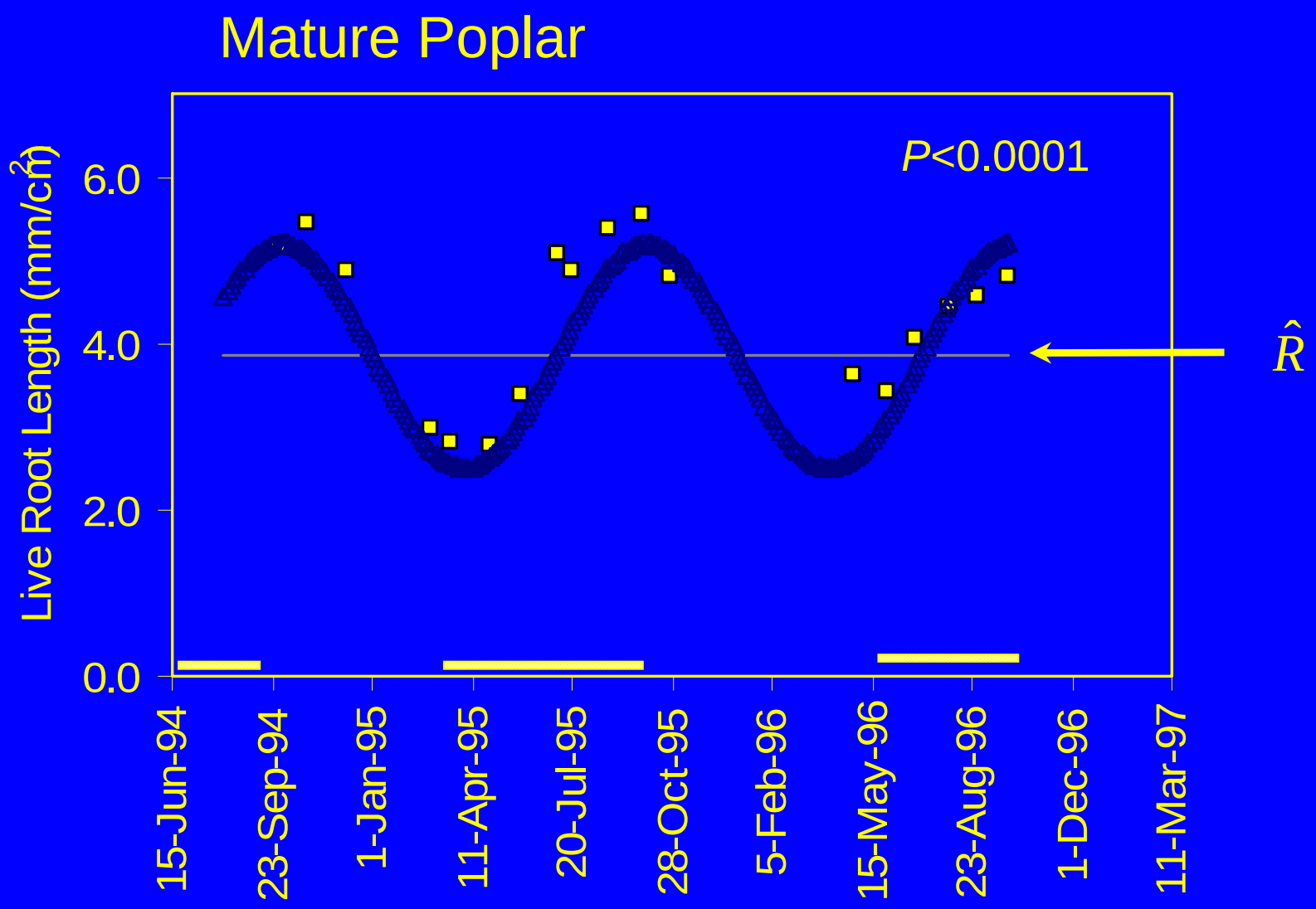
Mature Poplar



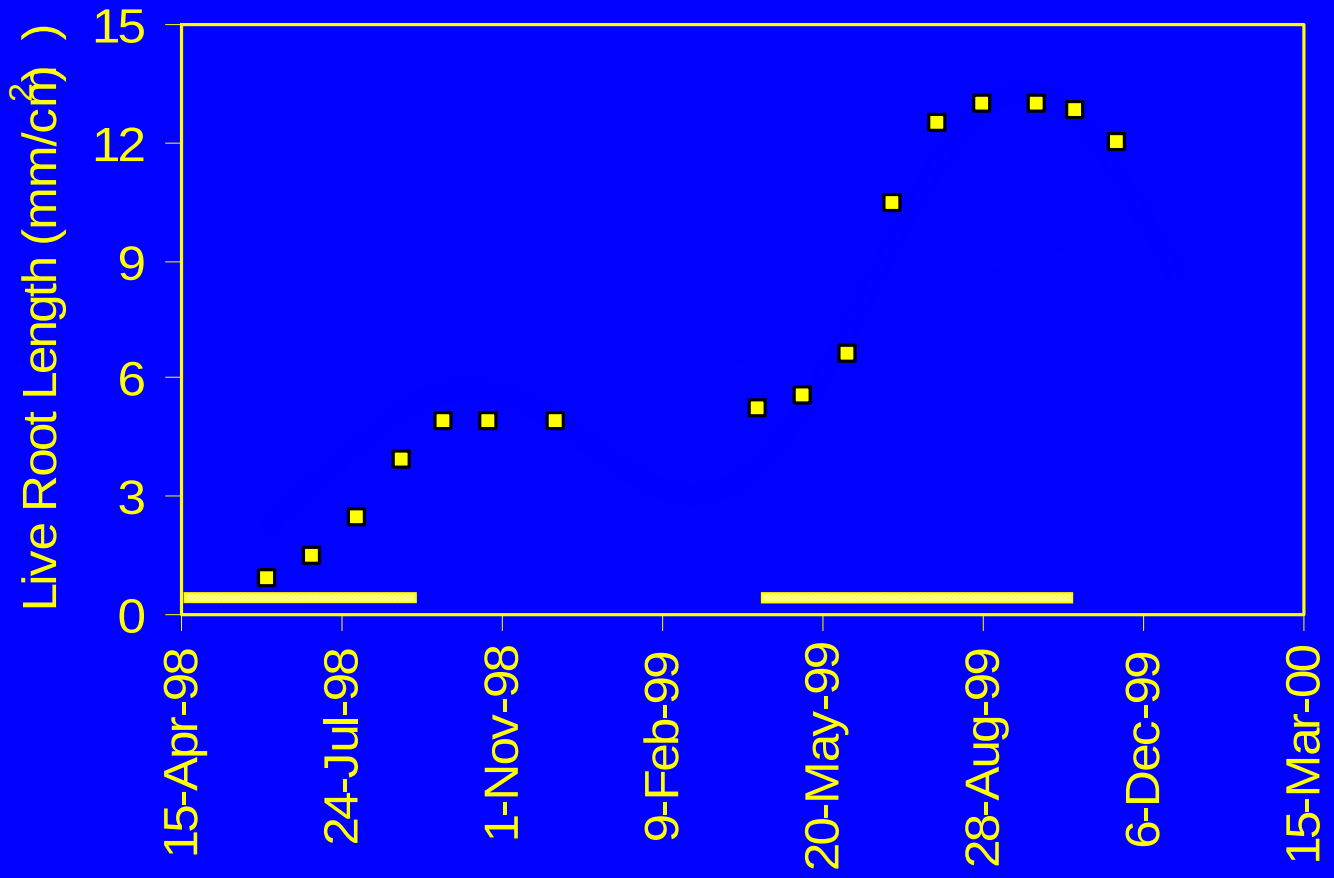
Waveform model: $R = \hat{R} + R_{\max} \sin 2\pi \left(\frac{d - G_{t=0}}{365} \right)$



Waveform model: $R = \hat{R} + R_{\max} \sin 2\pi \left(\frac{d - G_{t=0}}{365} \right)$

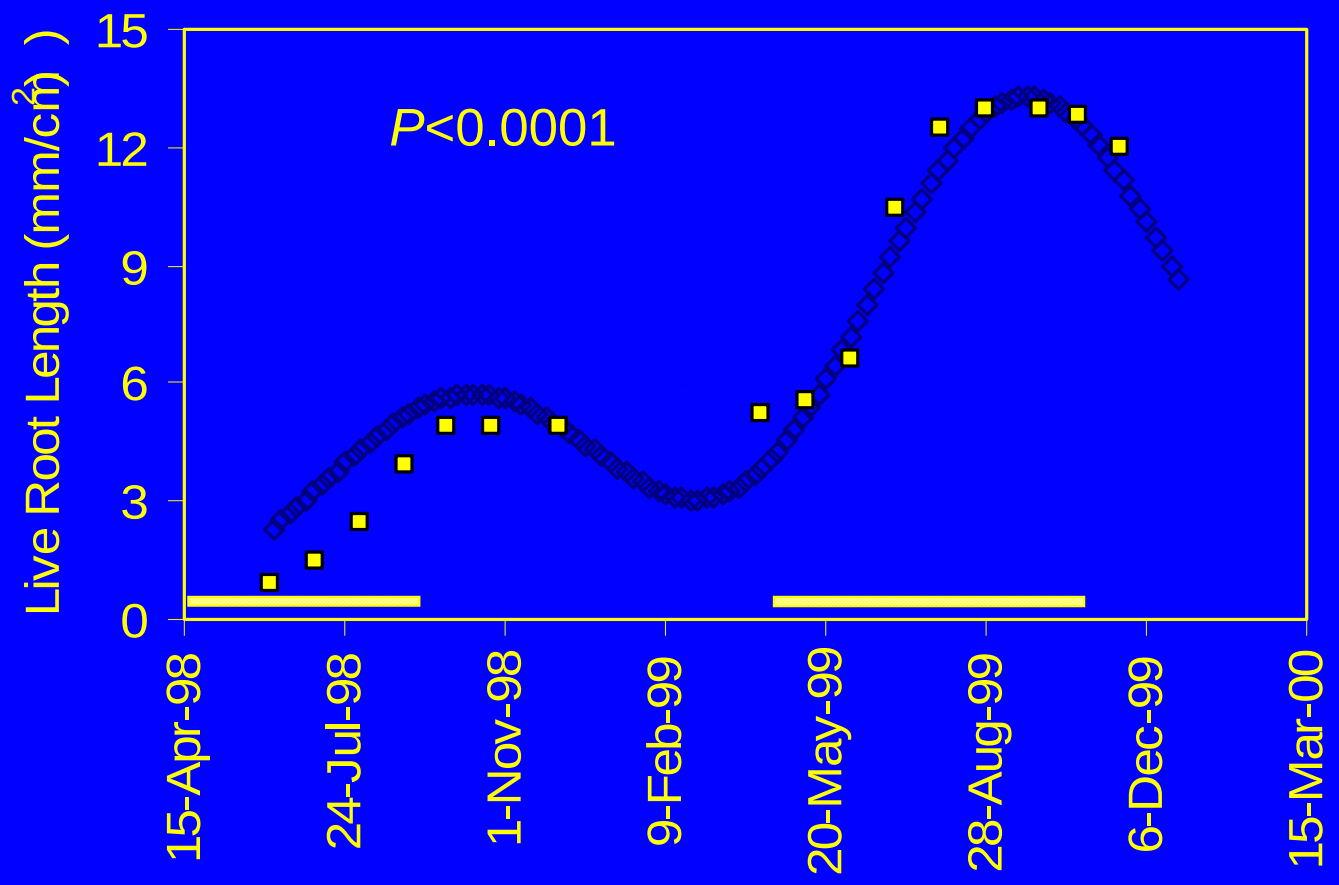


Establishing Poplar (Wisconsin)



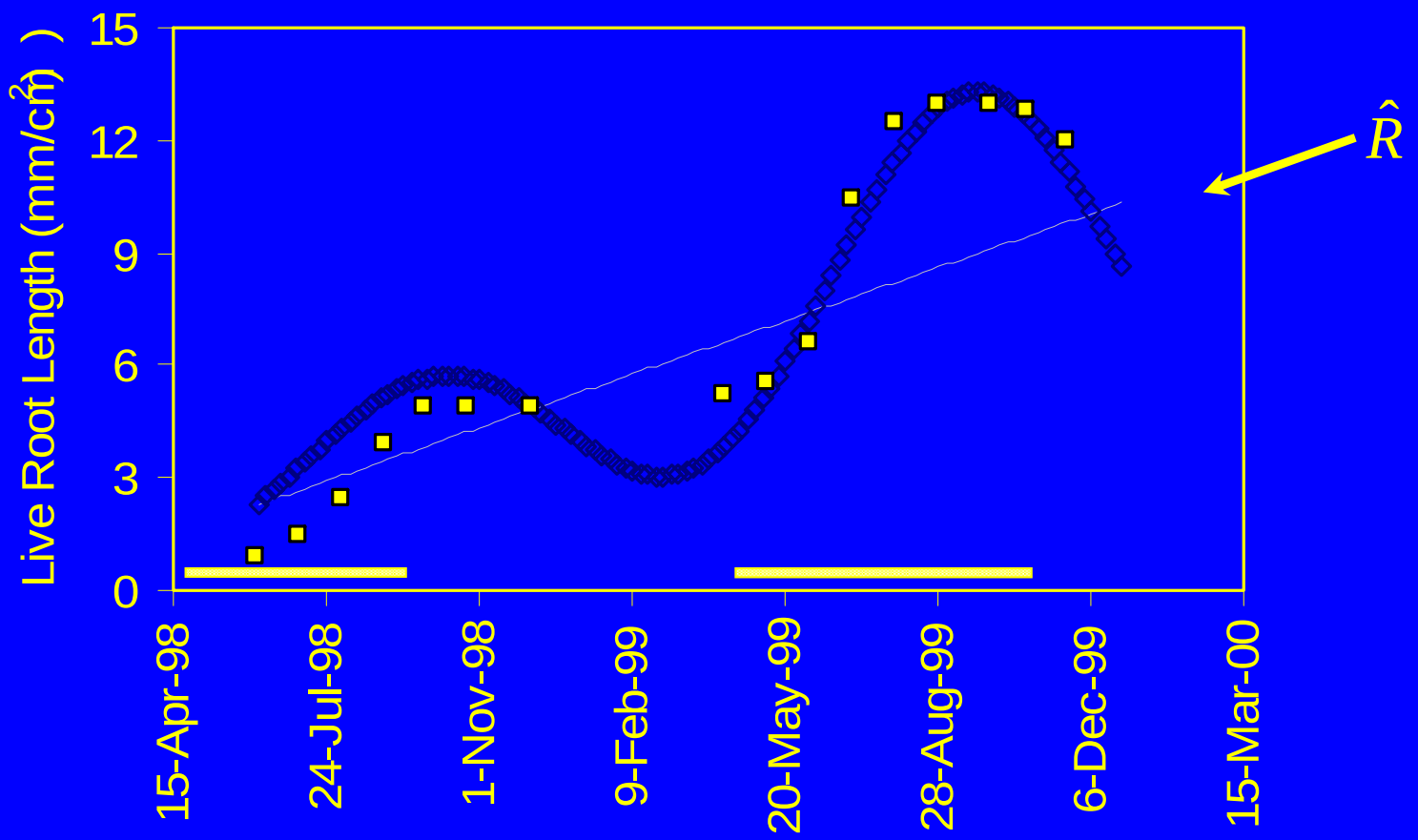
Damped waveform to account for development:

$$R = \beta\hat{R} + \beta R_{\max} \sin 2\pi\left(\frac{d - G_{t=0}}{365}\right), \quad \text{Where } \beta = \left(\frac{d}{k_m + d}\right)$$

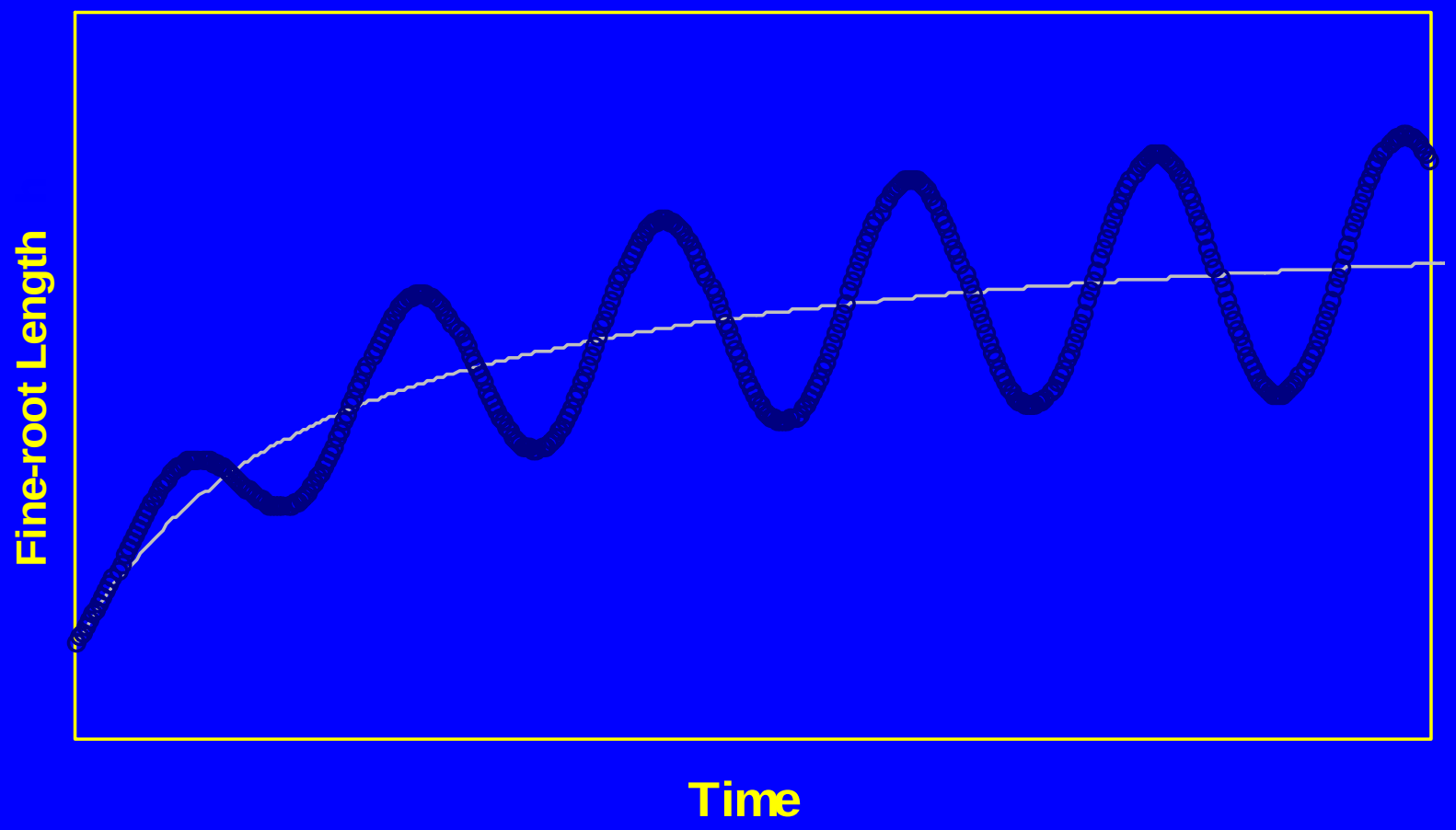


Increasing Baseline

$$R = \beta\hat{R} + \beta R_{\max} \sin 2\pi\left(\frac{d - G_{t=0}}{365}\right)$$

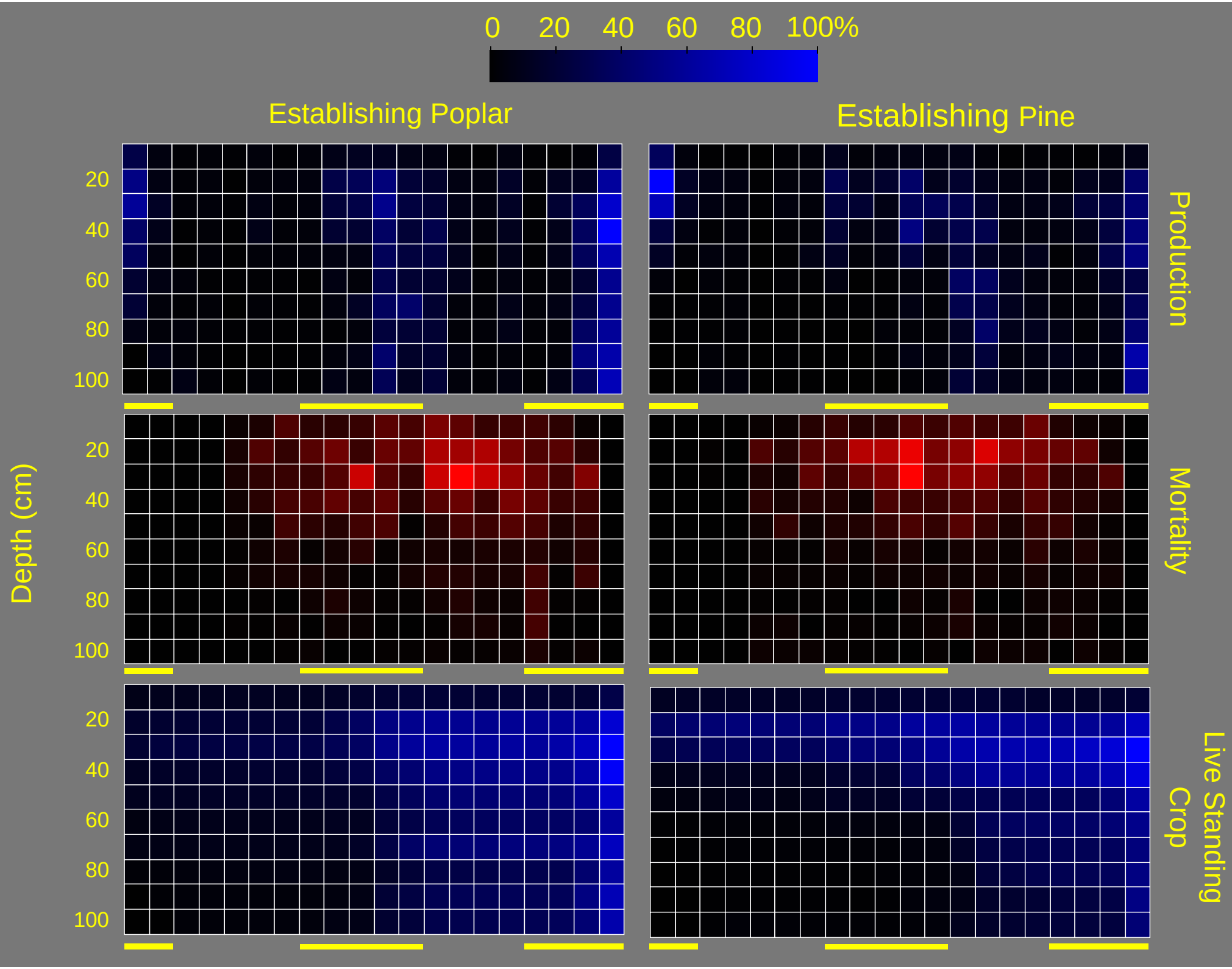


Predicted live-root standing crop



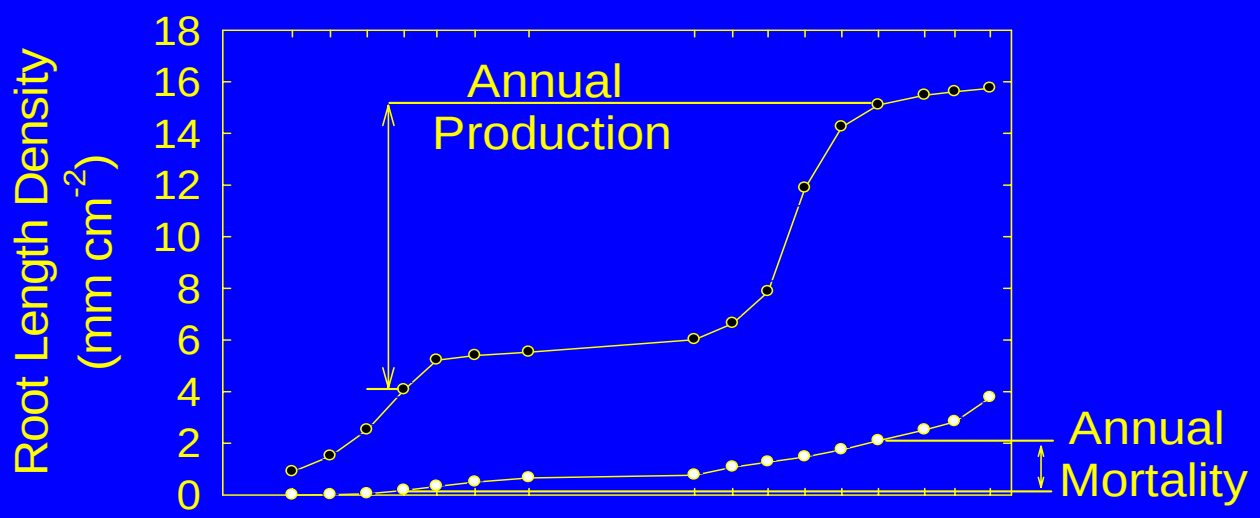
Temporal vs. Spatial distribution

- Production, Mortality and standing crop average all roots
- Need information of spatial distribution to understand:
  - How resource availability interacts with acquisition surface area and uptake processes

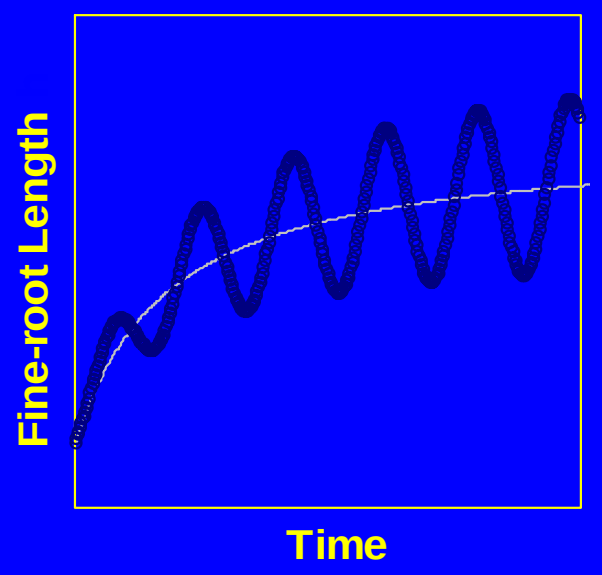

0
20
40
60
80
100%
Establishing Poplar
Establishing Pine
Depth (cm)
20
40
60
80
100
Production
Mortality
Live Standing Crop

$$\text{Turnover} = \frac{\text{Replacement Rate (g m}^{-2}\text{ yr}^{-1})}{\text{Standing Crop (g m}^{-2})}$$

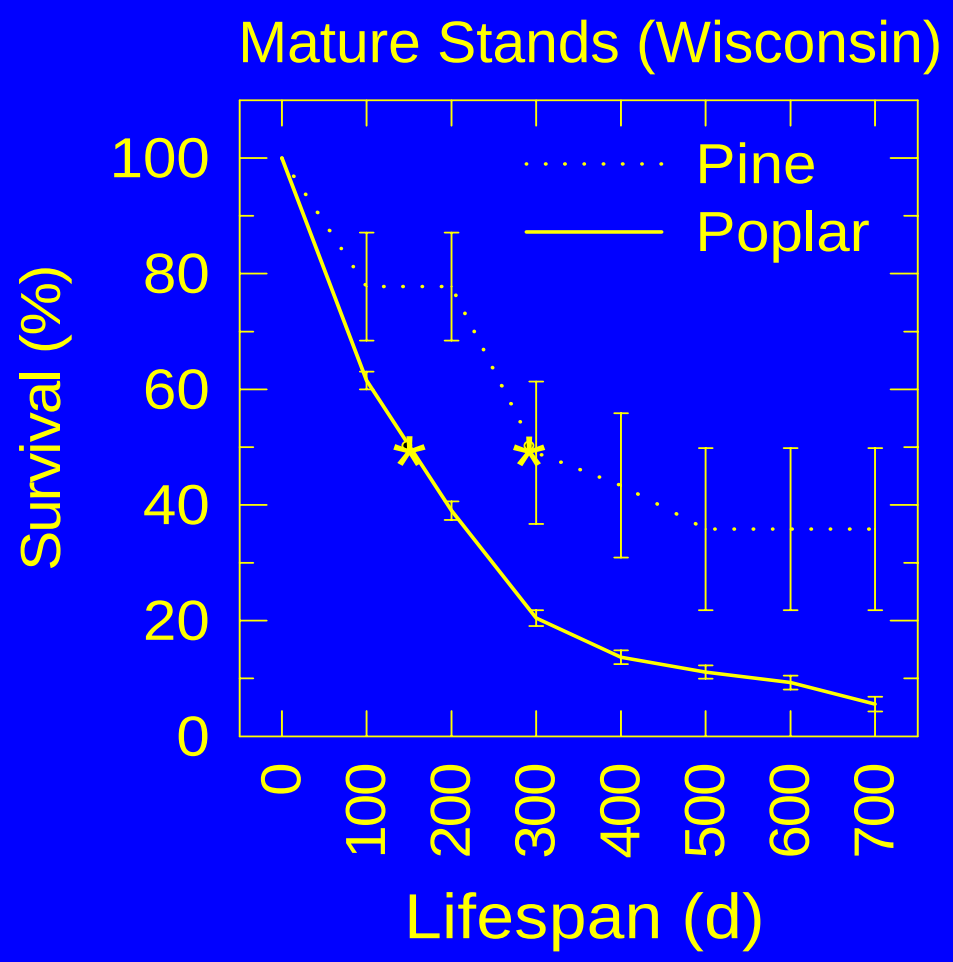
Replacement Rate



Standing Crop



Survival analysis



Lee 1992.
Kalbfleisch and Prentice 1980

SAS Proc Lifetest
Proc Lifereg

Coleman et al. 2000 PlantSoil 225:129

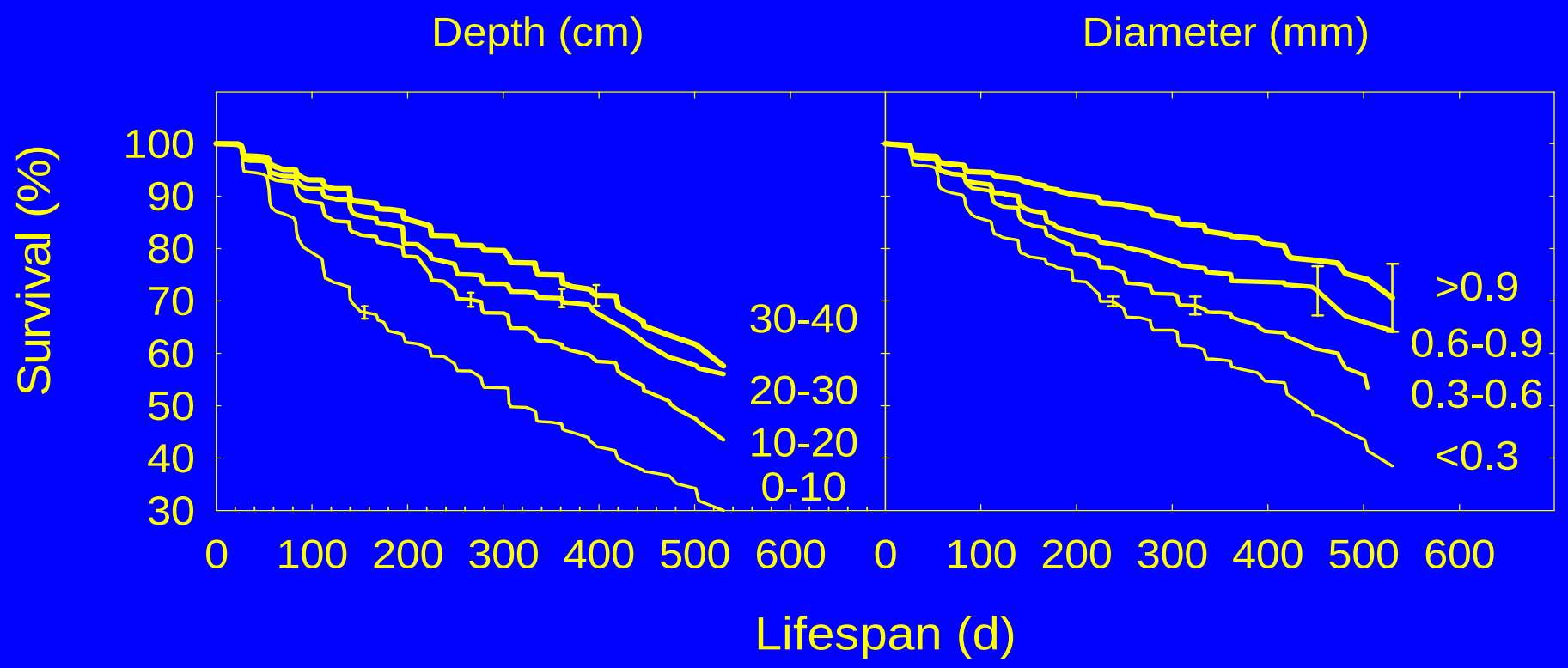
$$\text{Turnover} = \frac{\text{Replacement Rate (g m}^{-2}\text{ d}^{-1})}{\text{Standing Crop (g m}^{-2})}$$

$$= \text{d}^{-1}$$

$$\text{Turnover} = \frac{1}{\text{Residence Time (d)}}$$

$$= \frac{1}{\text{Lifespan (d)}}$$

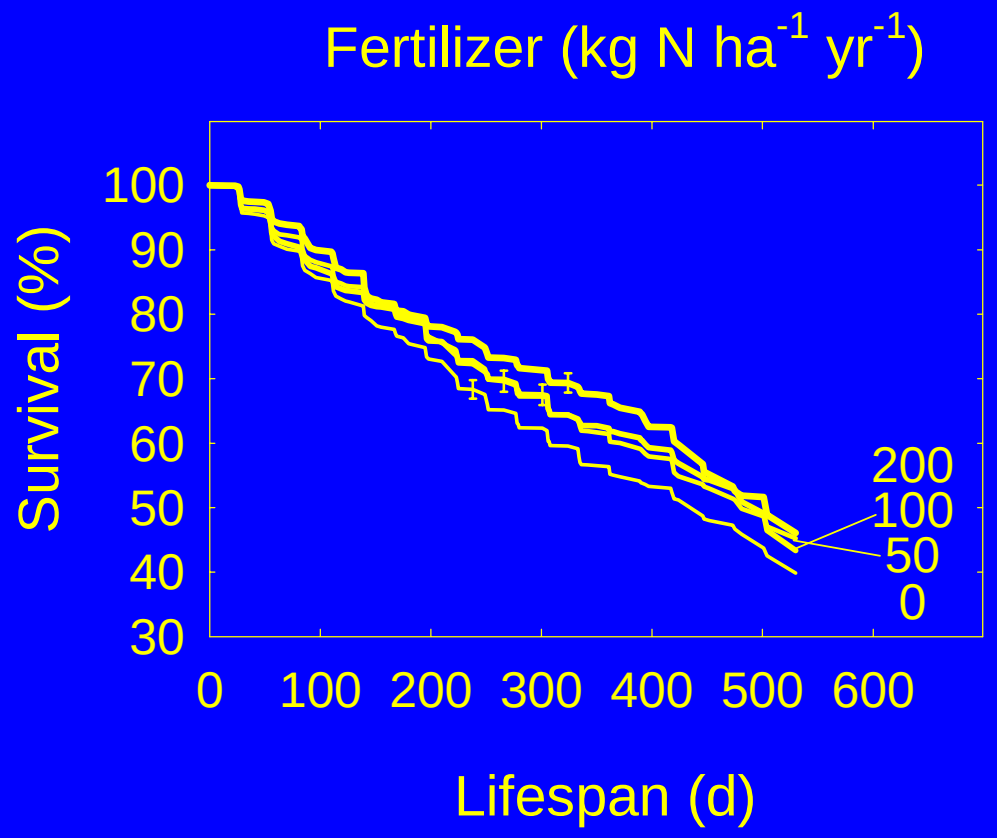
Establishing Poplar (Wisconsin)



Depth (cm)	Median Lifespan (d)	Turnover (yr^{-1})
0 to 10	307	1.19
10 to 20	436	0.84
20 to 30	565	0.65
30 to 40	620	0.59

Diameter (mm)	Median Lifespan (d)	Turnover (yr^{-1})
<0.3	438	0.83
0.3 to 0.6	511	0.71
0.6 to 0.9	663	0.55
>0.9	728	0.50

Establishing Poplar (Wisconsin)



Fertilizer N(kg N ha^{-1})	Median Lifespan (d)	Turnover (yr^{-1})
0	435	0.84
50	480	0.76
100	491	0.74
200	503	0.73

Conclusions

- Fine-root dynamics are dependent upon many internal and external factors.
- Waveform models help describe live root standing crop, but are of less value for distinguishing control factors.
- Graphical methods help visualize spatial-temporal fine-root dynamics.

Conclusions

- Calculating turnover using production and/or mortality normalized by standing crop is dependent upon choice of parameter used.
- Survival analysis effectively distinguishes among factors with solid theoretical foundation.
- Lifespan (1/ turnover) is a sensitive, powerful tool for distinguishing factors control fine-root turnover.