Species-level diversity of belowground structure in savanna woody plants:
Evidence from a new excavation method

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Determinants of Woody Cover in Savannas




Photos by L. Wang

Percent Grass Cover:

0-10%	5-15%	10-40%	2-20%

Savanna Woodland ⟵ ⟶ Open Savanna

Determinants of Woody Cover in Savannas

Fire

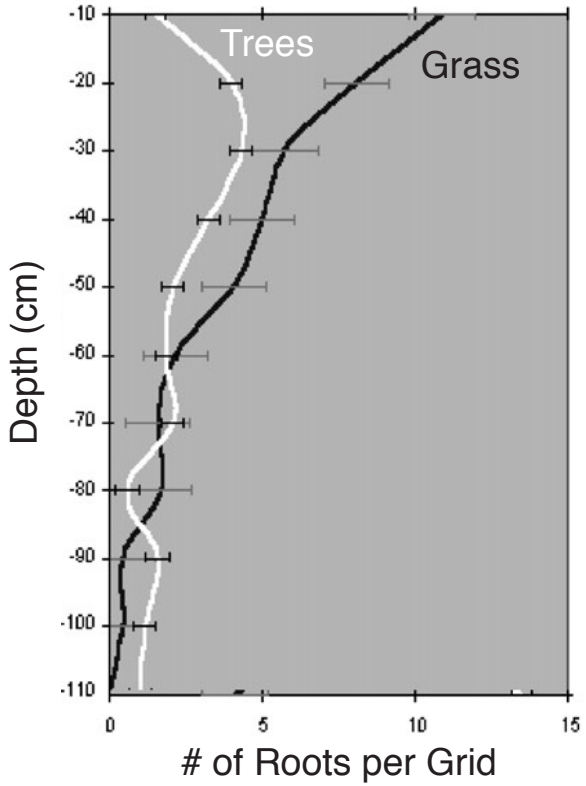
Resource Competition

Megafauna Activity

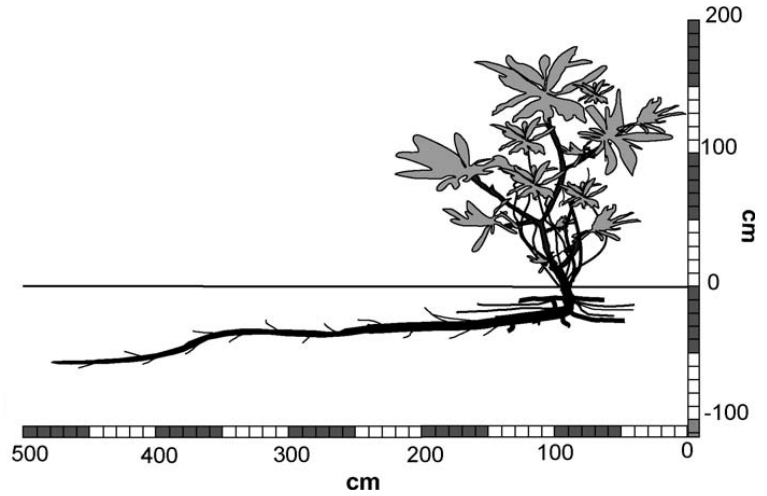
Determinants of Woody Cover in Savannas

Disturbance Exclusions

Determinants of Woody Cover in Savannas



Hipondoka et al., 2003

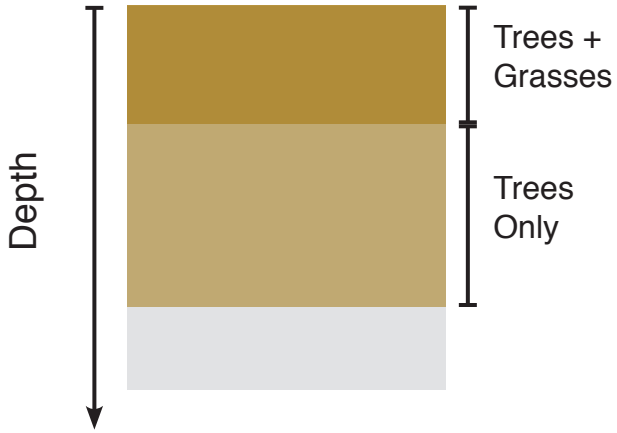


Hipondoka and Versfeld 2006, 2003

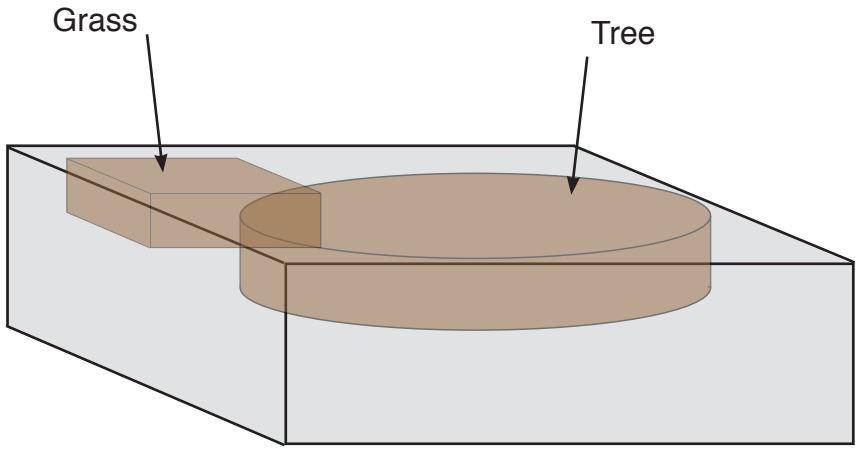
Belowground Competition

Determinants of Woody Cover in Savannas

The Modeled Root Zone

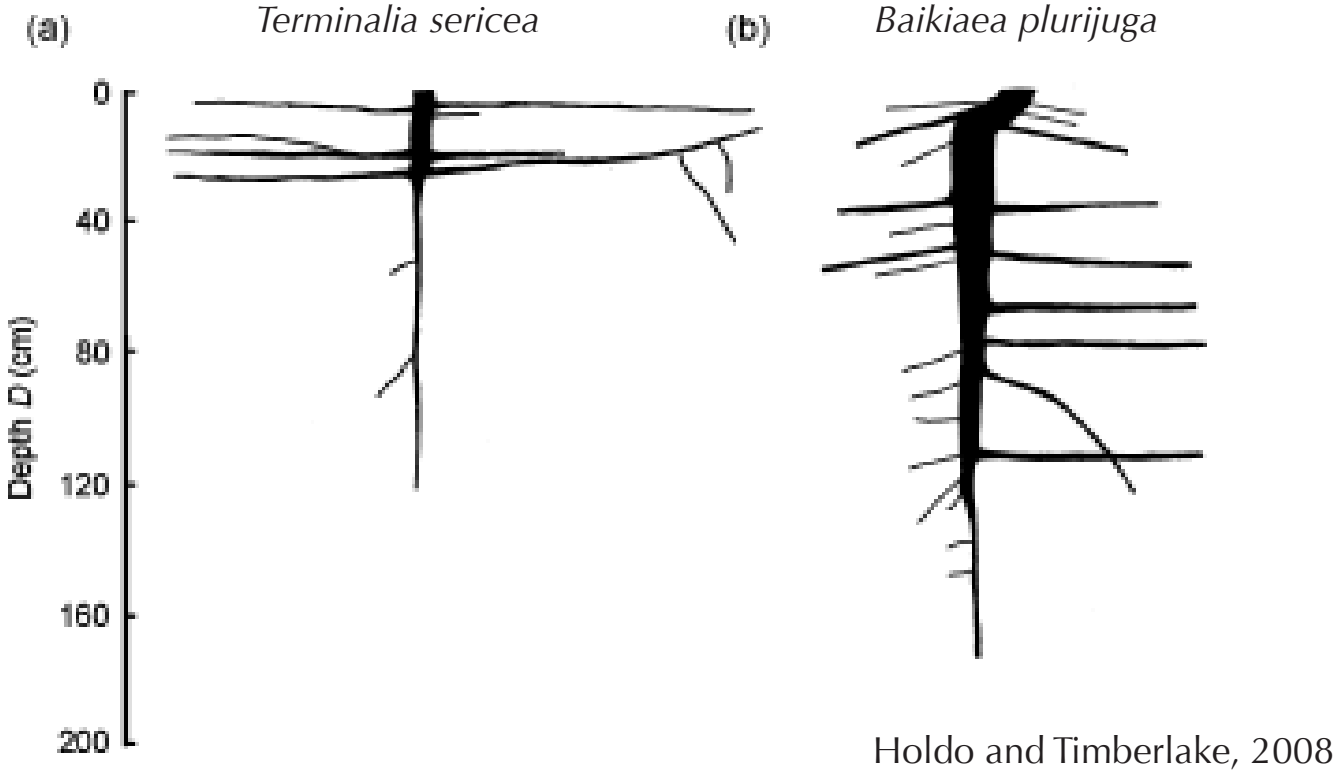


Density-based



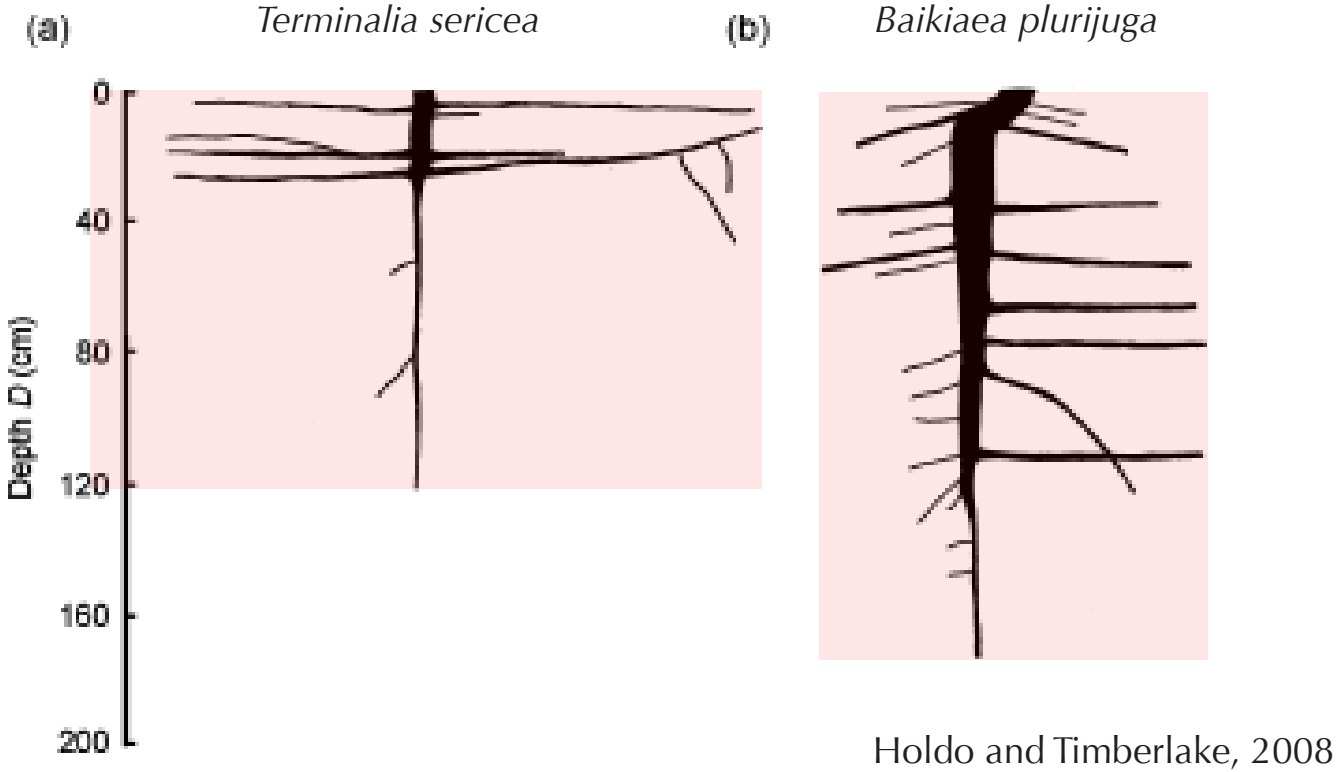
Individual-based

Representing Diversity



Holdo and Timberlake, 2008

Representing Diversity



Holdo and Timberlake, 2008

Research Goals

Measure roots in a way that supports the development of realistic, individual-based models.

Quantify observed diversity in root system structure.

The AirSpade

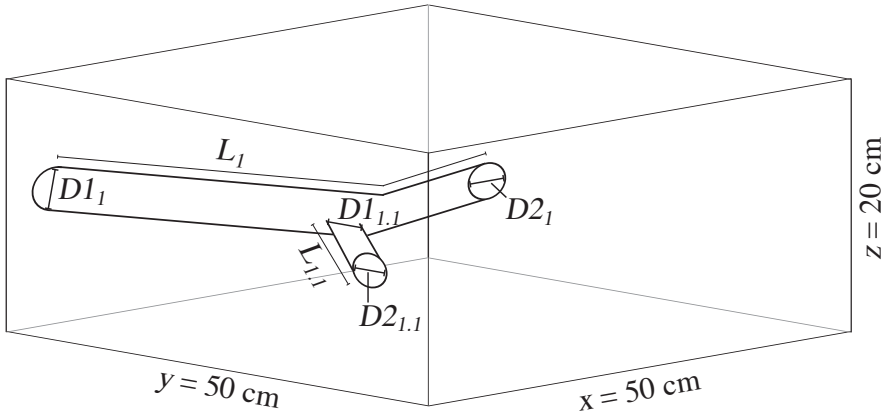
Concept Engineering, Verona, PA

2-3 times faster than manual excavation

Leaves roots > 2 mm diameter in place and intact

Root Mapping

Grid System



A “Voxel”

Root Mapping

Tagged Roots

Following Roots

Challenges

Overburden

Maximum Depth ~1.5 m

Quantifying Diversity - The Kalahari Transect

Shakawe
539 mm MAP

Bokspits
177 mm MAP

Tshane
358 mm MAP

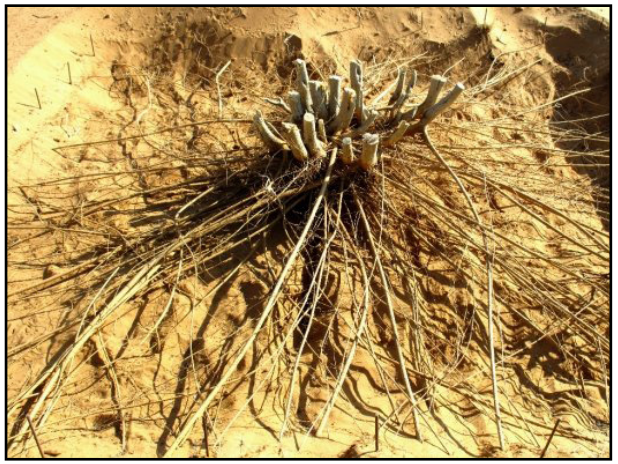
Quantifying Diversity - Species

Shakawe (Rainy)

Terminalia sericea
Drought deciduous
small tree or shrub

Ochna pulchra
Semi-evergreen tree

Bokspits (Dry)

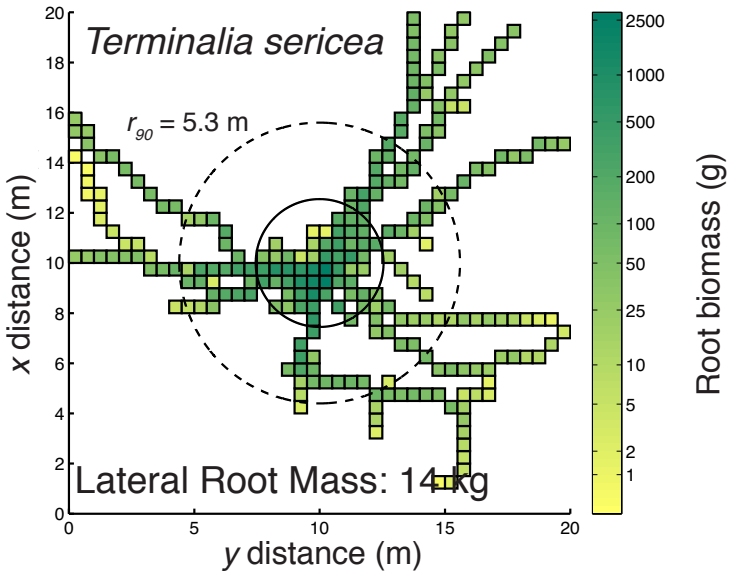


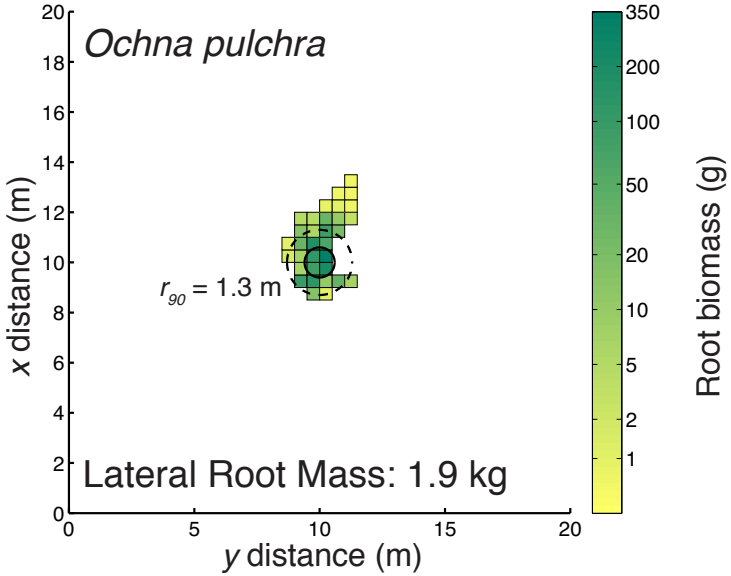
Acacia mellifera
Drought deciduous
shrub

Boscia albitrunca
Evergreen tree

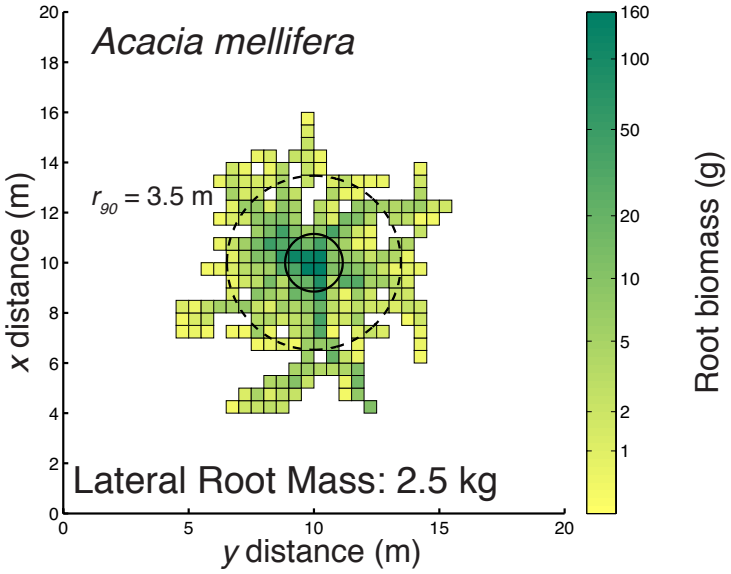
Lateral Root Distributions

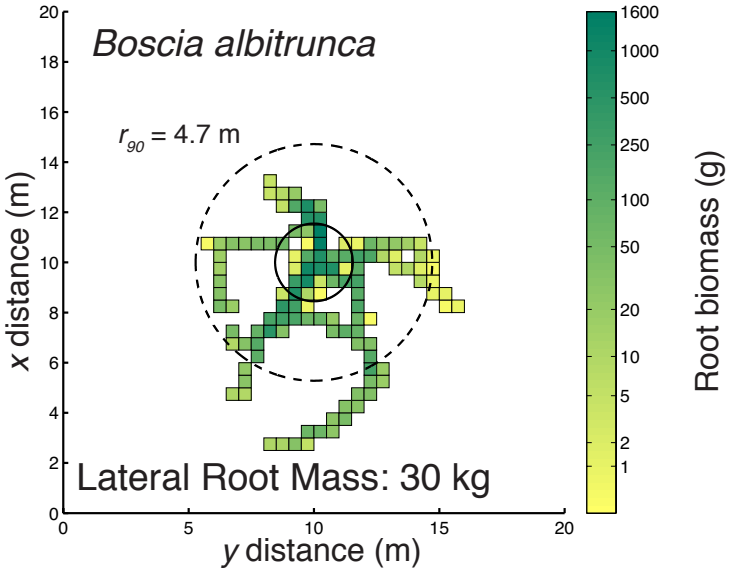
Shakawe



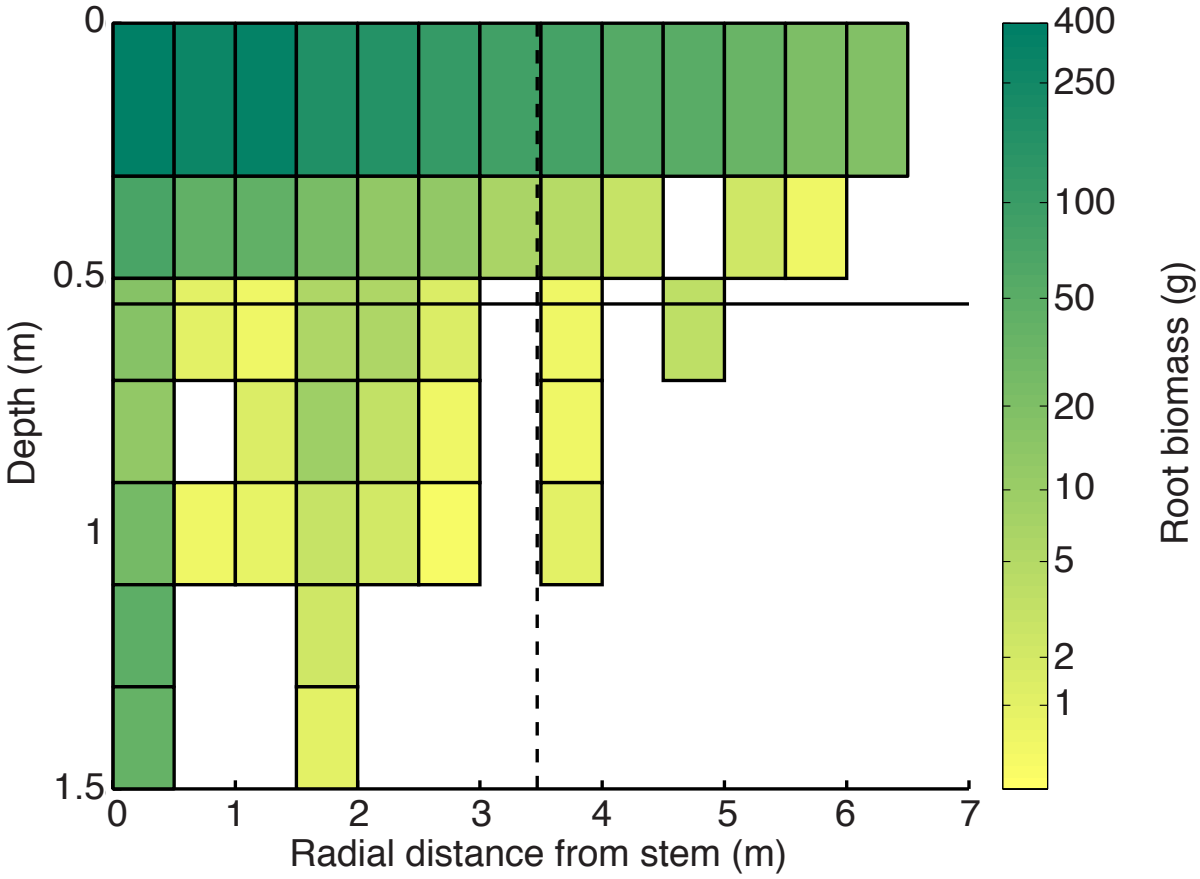


Bokspits





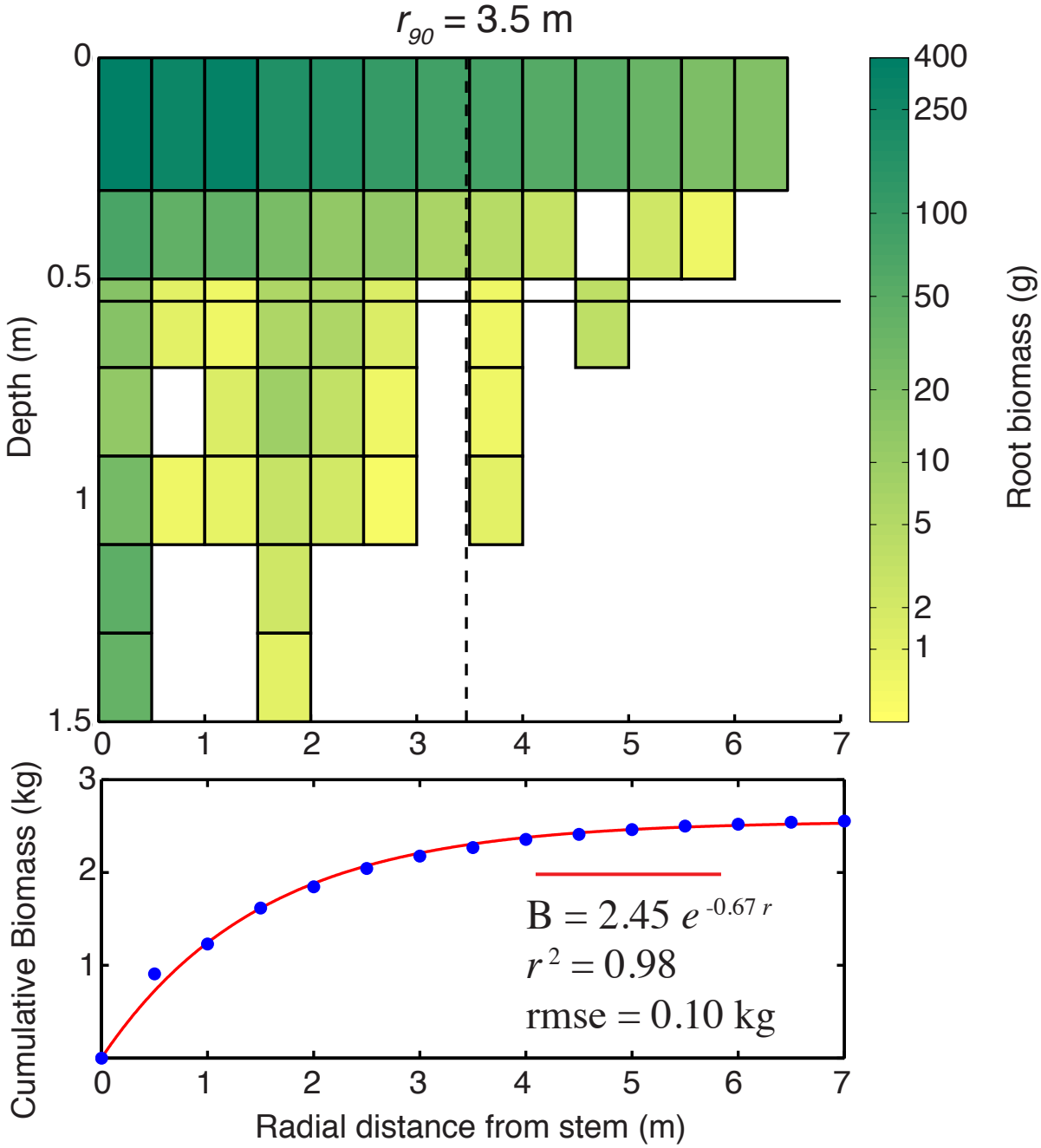
Lateral and Vertical Root Distributions



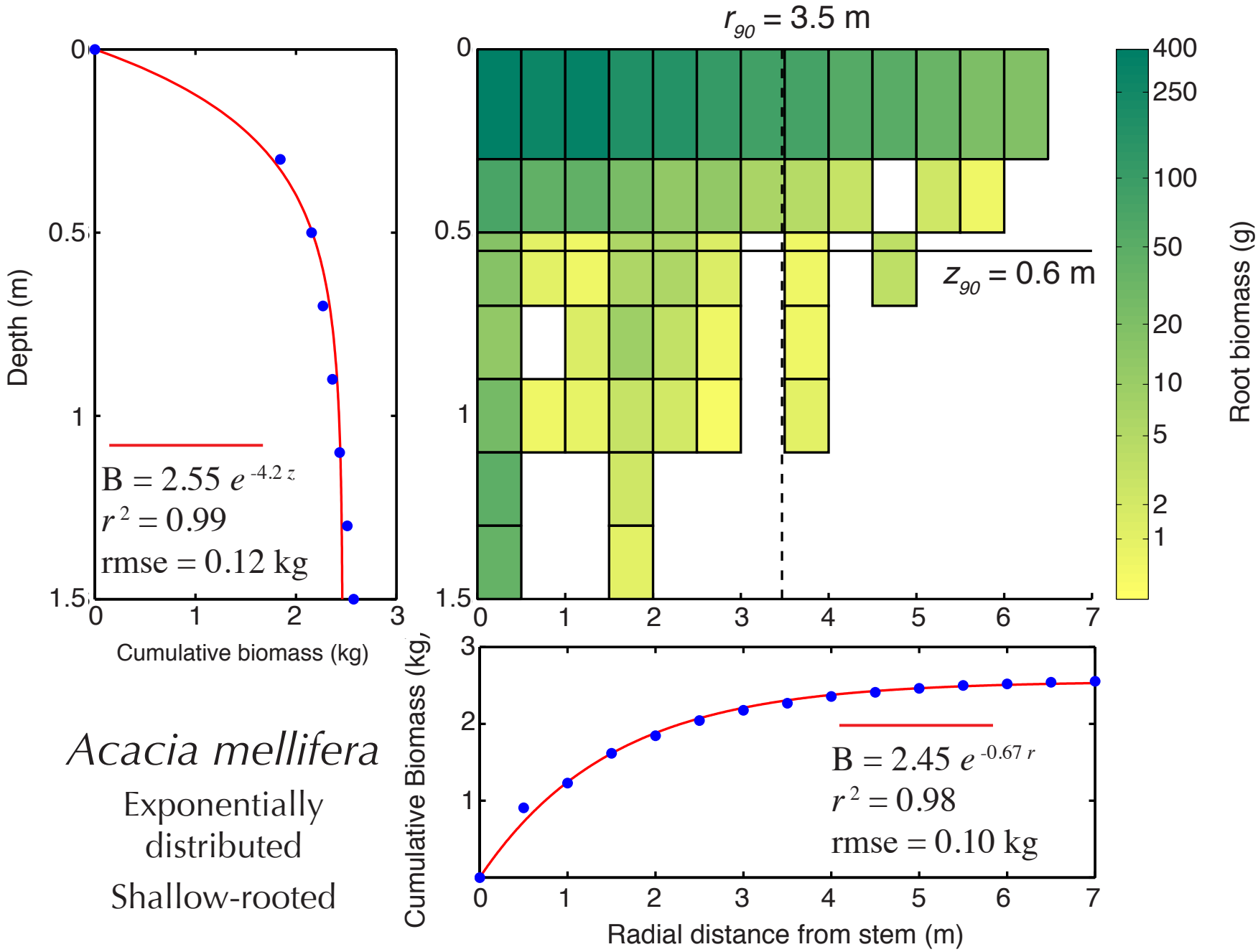
Acacia mellifera

Vertical Root Distributions

Acacia mellifera



Lateral and Vertical Root Distributions

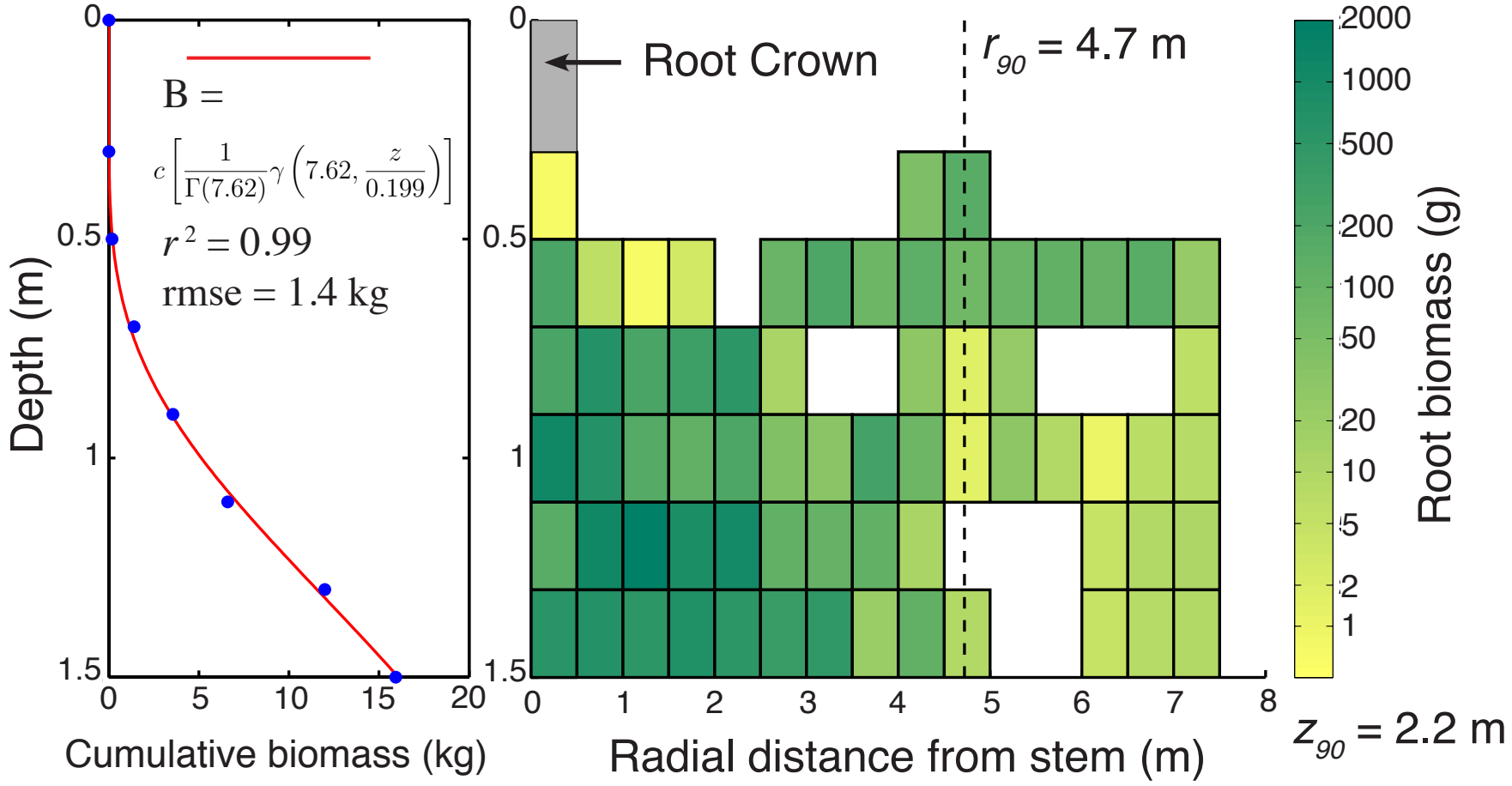


Acacia mellifera

Exponentially distributed

Shallow-rooted

Lateral and Vertical Root Distributions

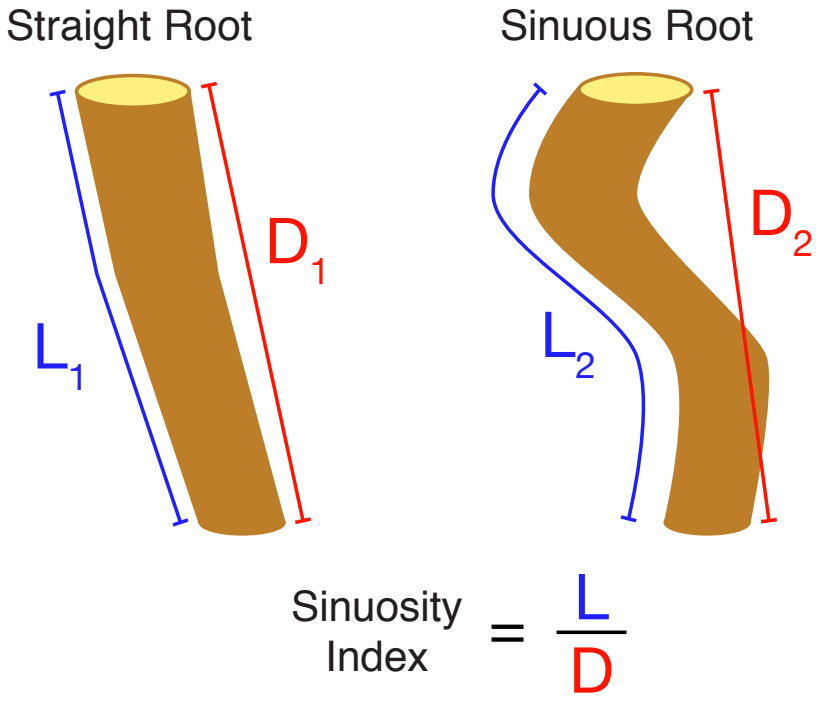


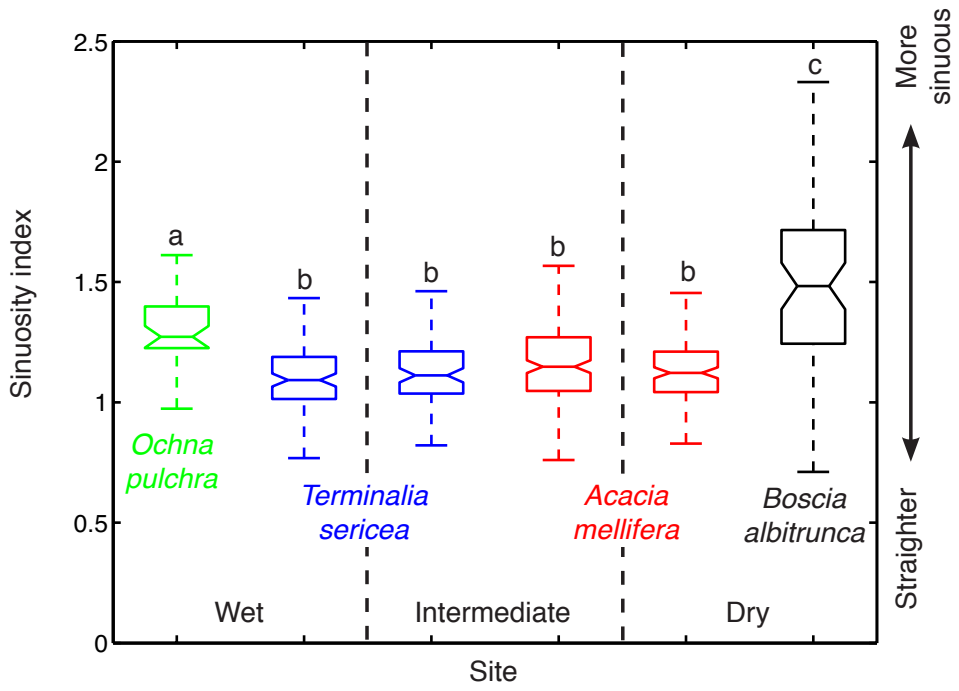
Boscia albitrunca

Gamma distributed

Deep-rooted

Small-scale Structural Diversity



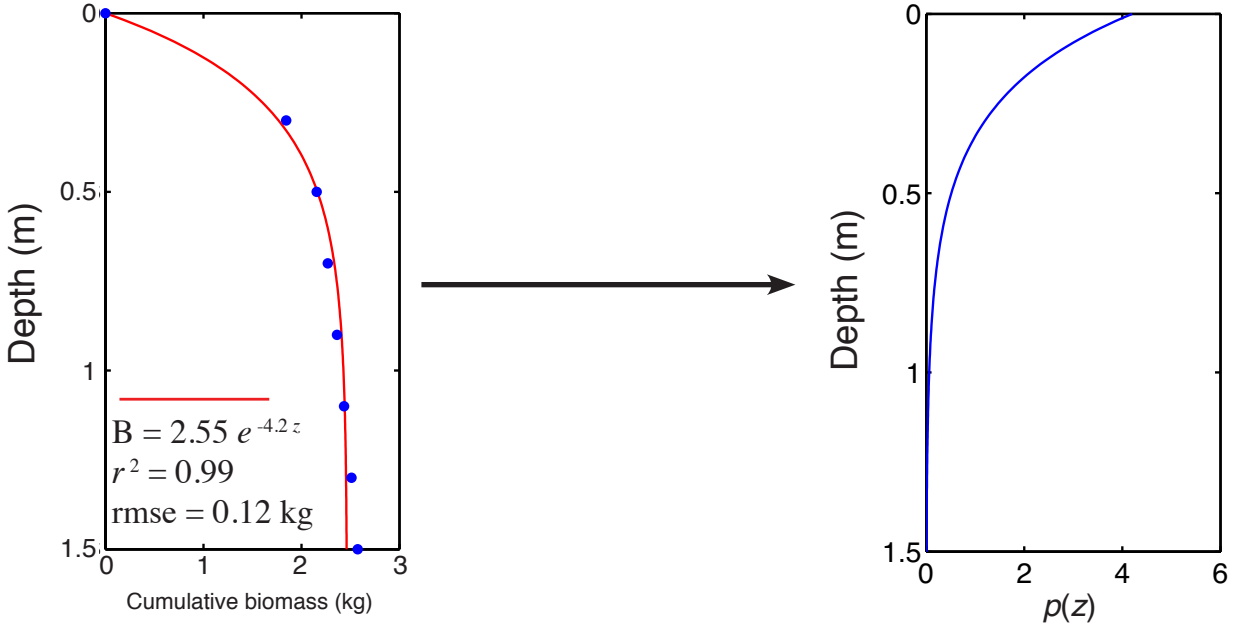


Probabilistic Rooting Distributions

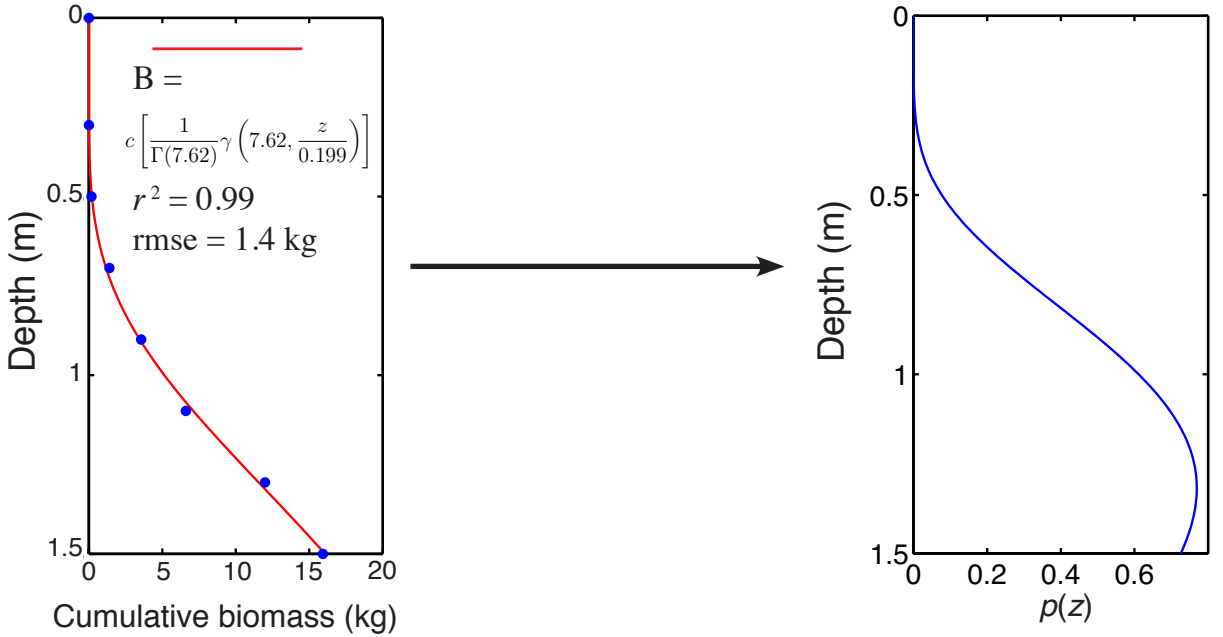
Cumulative Distribution Function

Probability Density Function

Acacia mellifera
Exponentially distributed

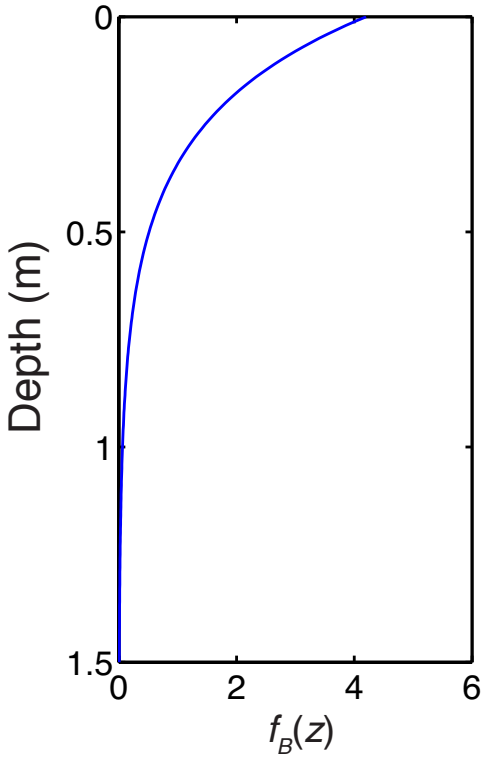


Boscia albitrunca
Gamma distributed

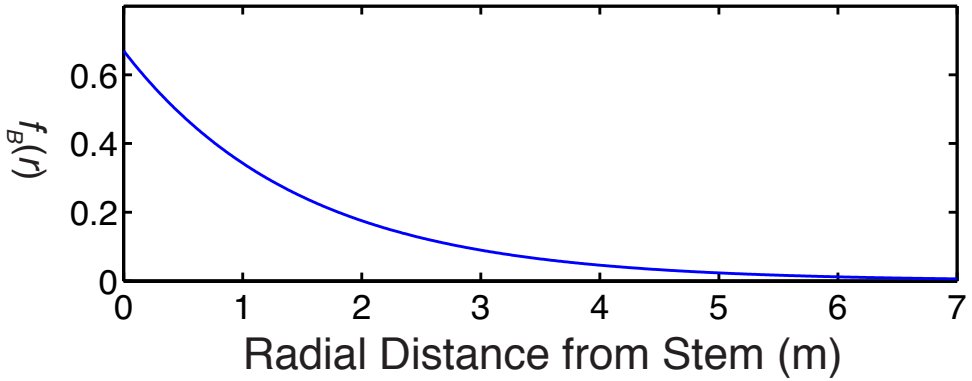


Probabilistic Rooting Distributions

Vertical Marginal Density Function



Lateral Marginal Density Function



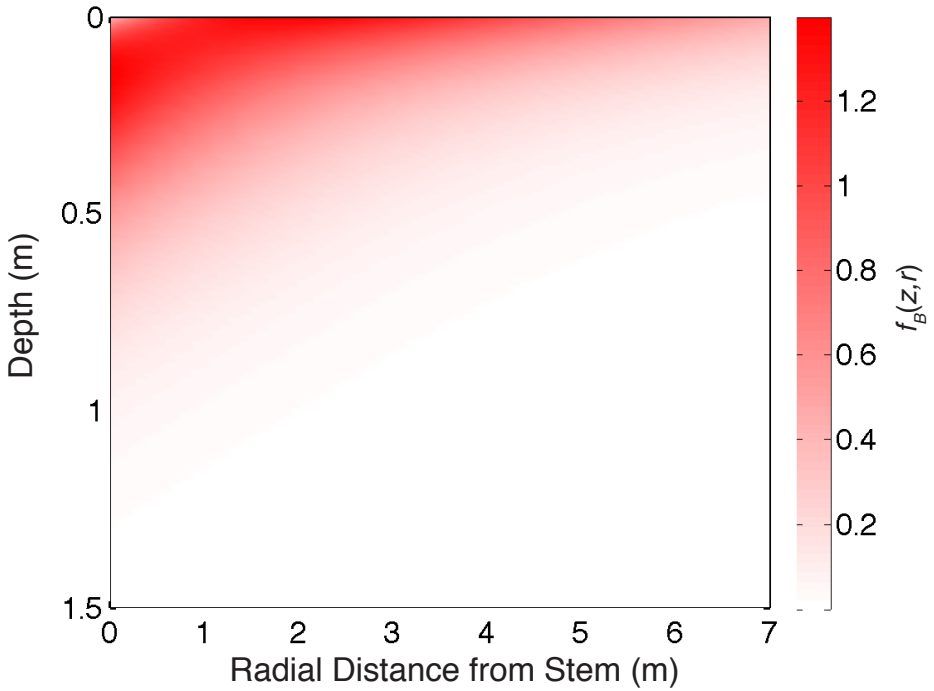
Joint Density Function: Farlie-Gumbel-Morgenstern Model

$$f_B(r,z) = f_B(r)f_B(z)\{1 + 3\rho[2F_B(r) - 1][2F_B(z) - 1]\}$$

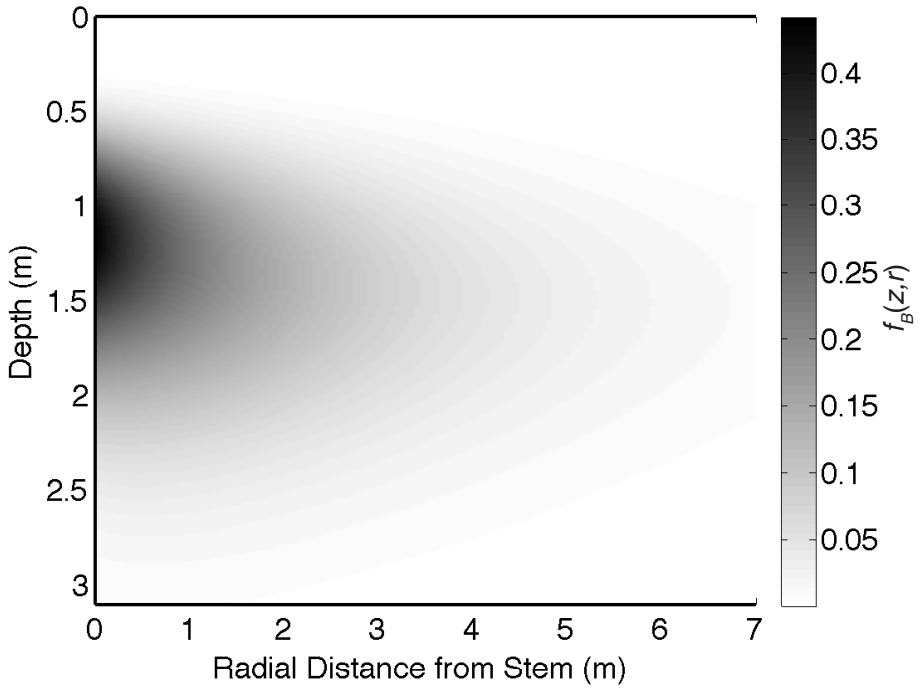
$$F_B(r,z) = F_B(r)F_B(z)\{1 + \rho[1 - F_B(r)][1 - F_B(z)]\}$$

Probabilistic Rooting Distributions

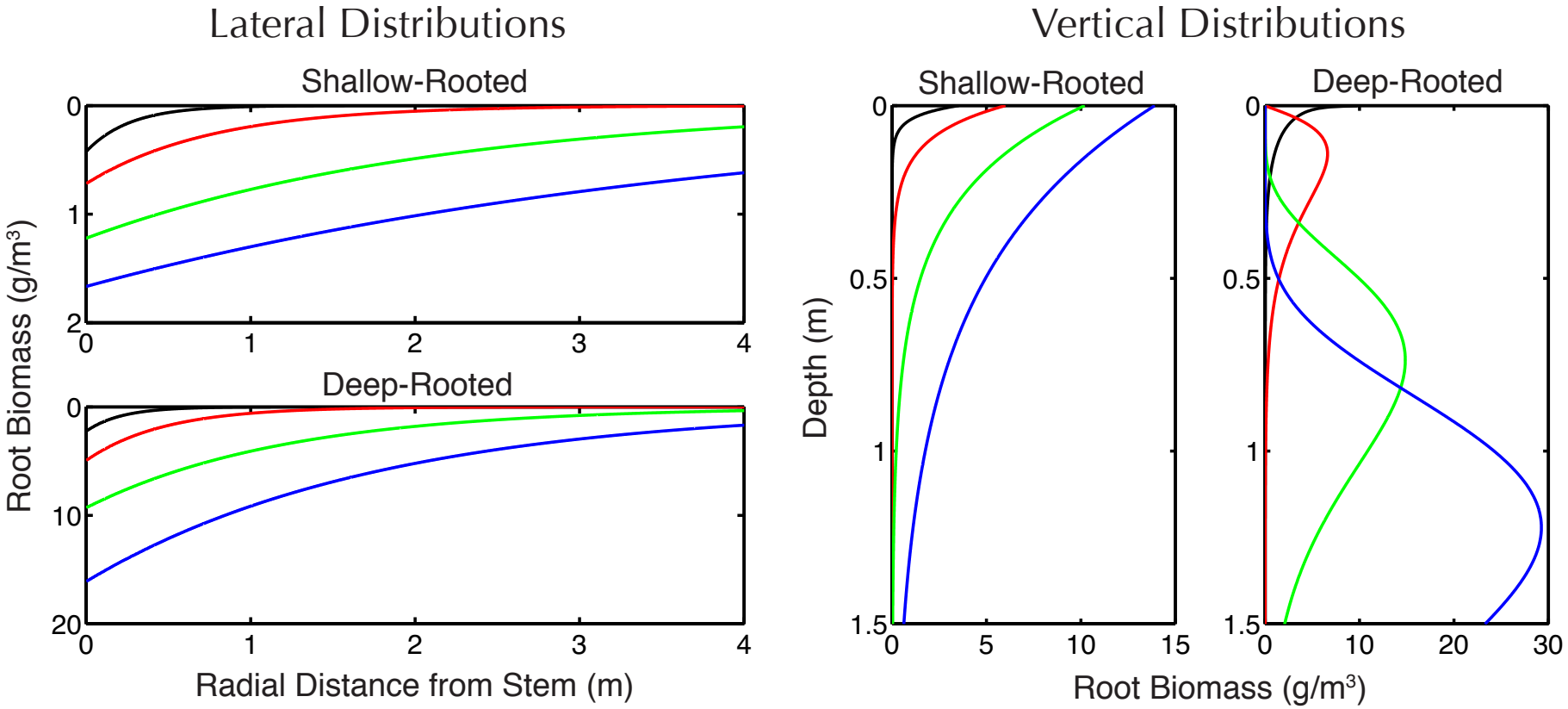
Acacia mellifera



Boscia albitrunca



Probabilistic Rooting Distributions



Canopy Radius

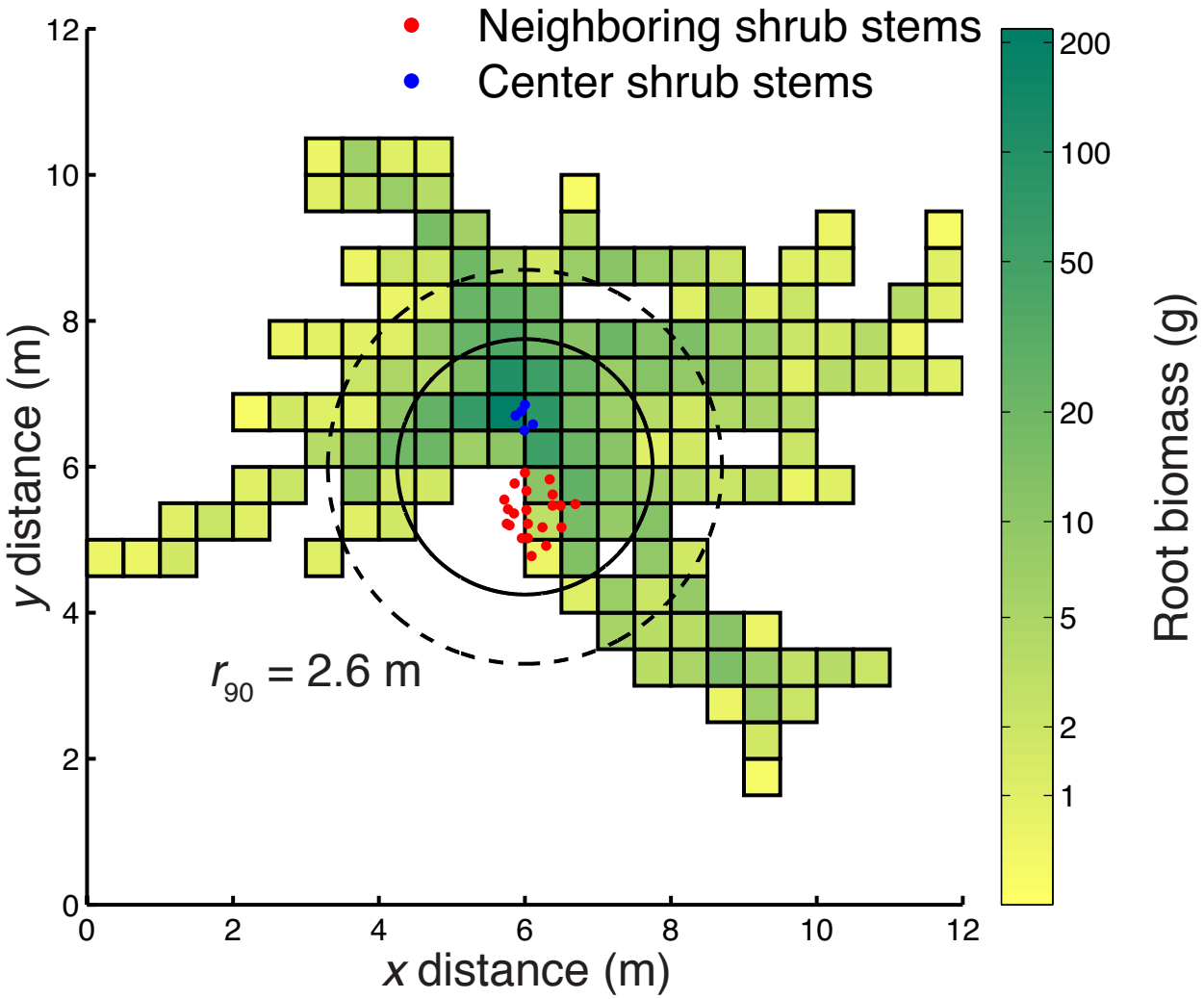
0.5 m

1 m

2 m

3 m

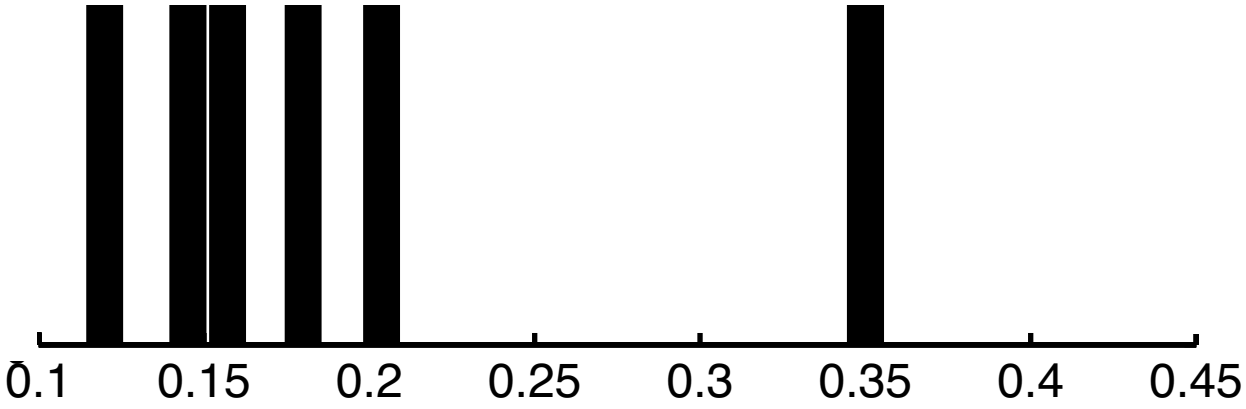
Root System Interactions



Root System Interactions

Lateral distribution: $B(r) = a_r e^{-b_r r}$

Verical distribution: $B(z) = a_z e^{-b_z z}$



More lateral spread

$\frac{b_r}{b_z}$

More vertical spread

Acknowledgements

O. Mathata, U. Mathata, D. Perrot, D. Rachal, M. Mafa, M. Tatlhego, M. O'Connor, M. Lu, M. Patterson, C. Bonthius, J. Chen, R. Muñoz-Rogers, H. Riffel, R. Wellbeloved-Stone, A. Pollard, and J. Martin.

Funded by NSF grant DEB 0717360

Thursday Poster

1340 h **B43 A-07** ***POSTER*** Ground penetrating radar measurements show a spatial relationship between coarse root biomas and soil carbon abundance: F C O'Donnell, K K Caylor, **C Gerlein**, A Bhattachan.