terms would improve the model fit. Additional regression diagnostics determined that no individual points were outliers or had undue influence on the model shape. Together, θ_v and ρ_b had a significant effect on root growth, explaining 33% and 61% of the variation in RLD for the Clarksville and Argent soils, respectively. The influences of ρ_b and θ_v on RLD were independent of each other. RLD decreased linearly with increasing ρ_b and decreased as θ_v became wetter or dryer than 0.25 and 0.30 $cm^3\ cm^{-3}$ for the Clarksville and Argent soils, respectively. Bulk density had a greater influence on shortleaf pine growing in Clarksville soil than loblolly pine in Argent soil. At higher ρ_b, the θ_v range in which growth occurred was narrower for the Clarksville-shortleaf pine than the Argent-loblolly pine; at a ρ_b of 1.6 Mg m^{-3}, shortleaf pine roots grew within a θ_v range of 0.13 to 0.43 $cm^3\ cm^{-3}$, while loblolly pine grew between 0.15 and 0.58 $cm^3\ cm^{-3}$. Best growth occurred when θ_v was near 0.25 $cm^3\ cm^{-3}$ for the Clarksville-shortleaf and between 0.30 and 0.35 $cm^3\ cm^{-3}$ for the Argent soil (Fig. V.3).

Root length density of ponderosa pines growing on the Dome soil did not fit the general model (Fig. V.4). There was a significant interaction between θ_v and ρ_b; therefore, the interaction term $\theta_v * \rho_b$ was added to the general model. With the expanded model, ρ_b and θ_v explained 81% of the variation in RLD for the Dome soil. Root length density decreased with increasing ρ_b; however, that affect was moderated by θ_v. The significant interaction of θ_v and ρ_b had the affect of lowering the θ_v at which best growth occurred as ρ_b increased, while decreasing growth to a greater extent on the wet end of the water gradient. Predicted best RLD of ponderosa pine on the Dome occurred in the θ_v range of 0.25 to 0.35 $cm^3\ cm^{-3}$ (Fig. V.4).

In contrast, the $\theta_v{}^2$ term was not significant for the Cohasset-ponderosa pine; the RLD response surface was planar (Fig. V.4). Bulk density and θ_v had a significant effect on RLD and explained 77% of the variation in RLD. As ρ_b increased, RLD decreased. However, increasing water content improved growth along the ρ_b gradient.

Root and shoot growth

We compared RLD with shoot growth because it is a better measure of the plant's ability to obtain water and nutrients than root mass or length (Kramer and Boyer,

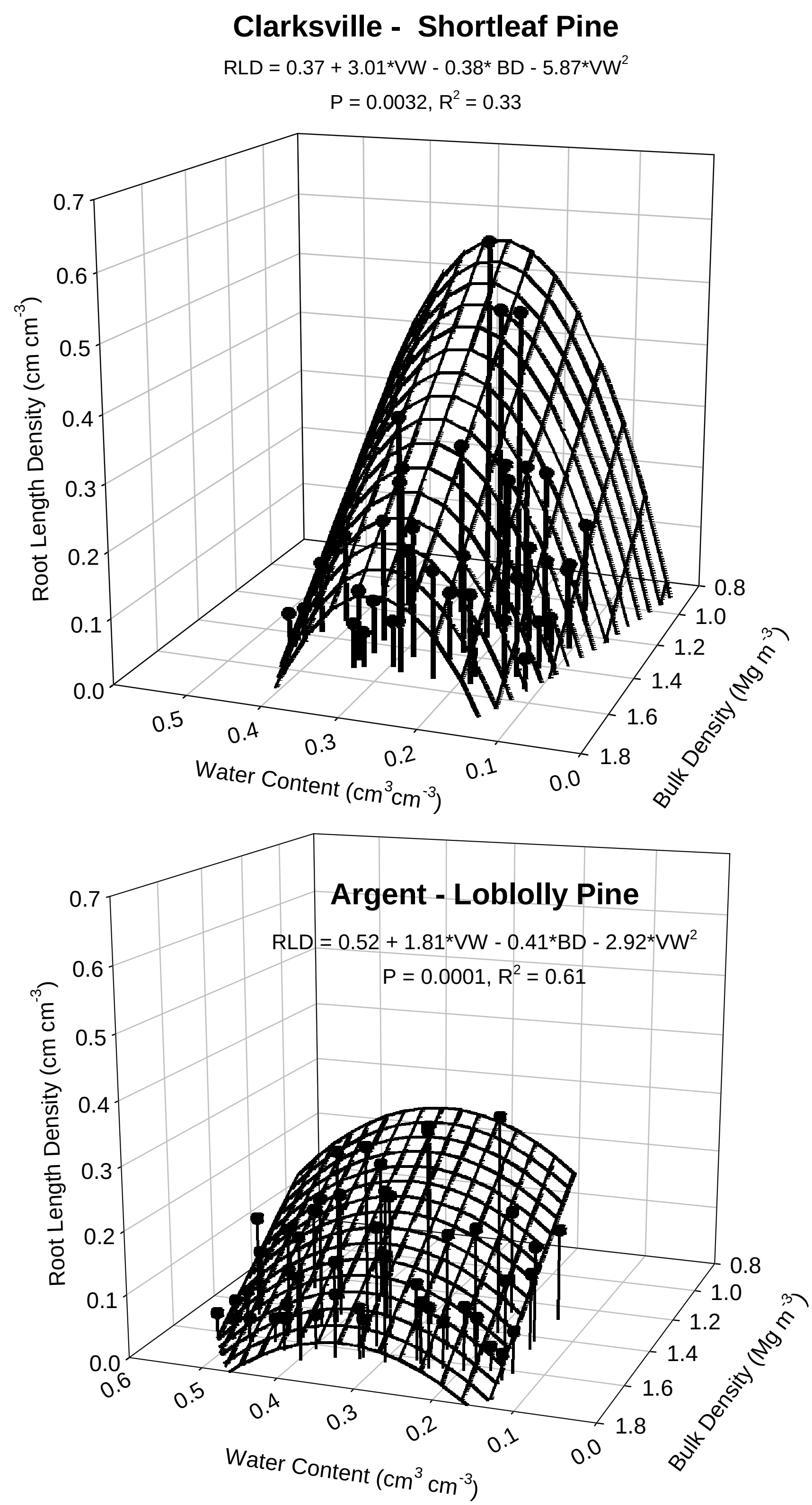

Figure V.3. Root length density of loblolly pine and shortleaf pine seedlings grown on Argent and Clarksville soils, respectively, as a function of bulk density and water content.