Title: **"Simulating the Long-Term Impact of Humus-Building Measures on Soil Physical Properties in Agroforestry Systems"**

This project aims to simulate and evaluate the long-term effects of different humus-building measures on soil physical properties in agroforestry systems. Using advanced dynamic soil functions, the study will investigate the long-term effects of different treatments such as cover cropping, organic amendments and alternative soil management on soil structure, texture and composition. The research will provide insights to optimize humus-building strategies, promote sustainable soil health and support resilient agroforestry ecosystems.

The Genuchten-Mualem model is used to describe the soil-water characteristic curve and is used to describe the relationship between soil water content and soil water potential.

$$\theta(\psi) = \theta_r + \frac{\theta_s - \theta_r}{[1 + (\alpha|\psi|)^n]^{\left(1-\frac{1}{n}\right)}}$$

Here, θ is the volumetric water content, ψ is the soil water potential, θr is the residual volumetric water content, θs is the saturated volumetric water content, a, n, is inverse of the air entry suction parameters, and n is a function of the pore size distribution index.

$$K(\theta) = K_s\left(\frac{\theta - \theta_r}{\theta_s - \theta_r}\right)^{\frac{1}{2}}\left[1 - \left(\frac{1 - \left(\frac{\theta - \theta_r}{\theta_s - \theta_r}\right)}{[1 + (\alpha|\psi|)^n]^{\left(1-\frac{1}{n}\right)}}\right)^n\right]^2$$

Where: K is the unsaturated hydraulic conductivity, Ks is the saturated hydraulic conductivity.

Organic matter affects soil properties, including water retention and hydraulic conductivity. To model its influence on the van Genuchten equation, adjustments to certain parameters are needed, depending on changes in soil organic matter content:

I. Residual Water Content (θr): Since organic matter has a high water-holding capacity, soils with more organic content tend to have a higher residual water content. As organic matter content varies, the θr parameter in the van Genuchten equation should be adjusted based on the soil organic content.
II. Saturated Water Content (θs): Organic matter also impacts the maximum water-holding capacity of the soil. Soils with higher organic content may have a higher θs value. Therefore, the θs parameter in the van Genuchten equation should be adapted accordingly.
III. Pore Size Distribution Index (n): Organic matter affects soil structure and pore size distribution. Adjusting the n parameter accounts for the effects of organic content on soil pore properties.
IV. Other Model Parameters (α): Depending on the specific interaction between soil and organic matter, other empirical parameters in the van Genuchten model may need adjustment to accurately represent this relationship.

Objectives:

1. Conduct a comprehensive literature review to identify functions that describe the changes in physical soil properties over time resulting from different humus-building measures in agroforestry systems, with a focus on changes in organic content.
2. Implement advanced functions in R or Python to simulate the long-term effects on the changes in soil physical properties under different scenarios.
3. Quantify the long-term effects of specific humus-forming measures such as cover cropping, organic amendments and alternative soil management on soil structure, texture and composition.
4. Evaluate spatial variations in simulated physical soil properties on agroforestry plots where different humus-forming measures have been implemented.
5. Incorporate these functions into the ExpertN agroecosystem model to enhance its capacity for simulating agroforestry system functions.

Expected Outcomes:

1. Quantified and differentiated impacts of specific humus-building practices on soil structure, texture, and composition.
2. Spatially explicit analysis revealing variations in simulated soil physical properties across agroforestry plots.
3. Correlations between simulated soil physical properties and key indicators of soil health and fertility.
4. Informed recommendations for optimizing humus-building strategies in agroforestry systems.