The grain sizes of superparamagnetic (SP) magnetite or maghemite in bulk soil samples are important as they represent pedogenic processes controlled by climatic condition. Here, we introduce a new model for estimating the mean grain size of SP magnetite based on the relationship between the upper limit of FDS (frequency-dependent susceptibility) and SP magnetite grain volume. The model was developed by taking into account the contribution of non-superparamagnetic (NSP) component through SP and NSP mixing simulations. Simulations using data of synthetic magnetite SP grains and various SP-NSP compositions infer that the model is accurate to 4%. The method was then tested with published FDS data of various soil types. For the Welsh soil, the estimated mean grain size of SP magnetite is found to be 13.20 nm compared to the published value of 13.24 nm. For other type of soils, such as the loess/paleosol sequence, aerobic soil, and laterite, the estimated mean grain sizes of SP magnetite are all fall within the range of 12 to 34 nm. The effectiveness of the proposed method in estimating the mean grain size of SP magnetite simplifies pedogenic analysis in soil sequences. The method could also be implemented in differentiating diagenic versus layering in sediment sequences.