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Estimating Spatial Variations in Soil Organic Carbon Using Hyperspectral Data and Map Algebra

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Soil organic carbon (SOC) sequestration is a component of larger strategies to control the accumulation of greenhouse gases that are causing global warming. To implement this approach, it is necessary to improve the methods of measuring SOC content under normal field conditions. Among these methods are indirect remote sensing and geographic information systems (GIS) techniques that are required to provide non-intrusive, low cost, and spatially continuous information that cover large areas on a repetitive basis. This study evaluates the effectiveness of hyperspectral data in improving existing remote sensing methodologies for measuring SOC content. The study area is Big Creek Watershed (BCW) in Southern Illinois, USA. Composite soil samples were collected from 303 representative pixels along the Hyperion coverage area of the watershed. Two linear multiple regression models predicting SOC were calibrated and validated: an all-variables model and a raster-variables only model. Map algebra was implemented to extrapolate the raster variables only model and produce a SOC map for the BCW. Hyperion data improved the predictability of SOC compared to multispectral satellite remote sensing sensors with a correlation coefficient (R) of 0.37 and a root mean square error (RMSE) of 3.19 metric tons per hectare to a 15-cm depth in the validation sample. Hyperspectral data cannot capture small annual variations in SOC, but can measure decadal variations associated with changes in tillage or crop rotation with fair accuracy; RMSEs are as low as 34 percent of field-measured changes in SOC due to changes in tillage and as low as 59 percent for changes in crop rotation. These ranges of error likely need to be reduced further if hyperspectral data were to be used as the basis of carbon sequestration credit programs. Hyperspectral data combined with map algebra can measure total SOC pools in various ecosystem or soil types to within a few percent error.