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The legacy of intensive land use on soil health and function

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Reclamation of abandoned agricultural lands, reforestation of intensively cultivated lands, and improved management practices in agroecosystems are frequently discussed as potential carbon drawdown strategies with the co-benefit of improved soil health and function. Hawaii is a model system for embracing the heterogeneity of landscapes to understand predominant drivers of soil health, function, and potential carbon sequestration because of the subtropical climatic zone, tropical geographic location, and immense diversity of soils, microenvironments, and productive systems. Soils were collected from 22 sites across the islands of Maui, Oahu, and Molokai in Hawaii and included six soil orders of the U.S. taxonomy (Mollisols, Oxisols, Vertisols, Andisols, Inceptisols, and Ultisols) and the land use/managements of croplands (conventional and organic), grasslands (unmanaged and pasture), and forests (unmanaged and protected). Measurements relating to soil health totaled to 29 biological, physical, and chemical parameters and were done for three samples from each site. DNA extractions included analysis of bacterial 16S and fungal ITS marker genes. Multivariate analysis showed that dynamic aspects of land use and management explained greater variability (42 % Axis 1) within the parameters related to soil health than inherent soil properties and taxonomic classification (15 % Axis 2). Embedded within land use and management, the legacy of intensive cultivation on soil health, regardless of the current practices, was evident. Predominant similarities in soil health emerged among sites with a common agricultural history, even if currently in forest or organic agriculture. Further, direct comparison of land uses within soil classification also showed poor soil health that was more consistent with the intensive agricultural history, measured as disturbance, than the current management. For example, a high fertility (Mollisol), organic cropland site was more similar in soil health to conventional crop systems and unmanaged, previously intensively cultivated sites than other fertile soils and organic management systems. For this organic site, measures of biological health including 24-hr respiration burst and beta-glucosaminidase activity were less than half the values of conventional and abandoned agricultural Mollisols of similar soil series. We propose further division of land use classification to include the legacy of past intensive cultivation, a reduced list of soil health parameters to comprise a soil health index for Hawaii and other subtropical-tropical regions, and a cropland-specific analytical path more centered on decision-support and yield improvements for farmers seeking to improve both soil health and livelihood. More than a century of intensive sugarcane and pineapple agriculture degraded most of the productive lands in Hawaii. Recognition and understanding of the unique challenges posed by the reclamation, reforestation, or improved management of previously intensively cultivated lands is critical for realistic expectations of carbon drawdown and productivity and provision of adequate support for those willing to invest in improving degraded lands.