Bai, E., Boutton, T. W., Wu, X. B., Liu, F. & Archer, S. R. (2009) Landscape-scale vegetation dynamics inferred from spatial patterns of soil δ13C in a subtropical savanna parkland. Journal Geophysical Research – Biogeosciences: In Press.

Abstract

Grass-dominated ecosystems in many regions around the world have experienced increased woody plant abundance during the past 100 yrs. In the Rio Grande Plains of southern Texas, subtropical woodlands dominated by C_3 trees/shrubs have become significant components of landscapes that were once almost exclusively dominated by C_4 grasslands. However, we know relatively little regarding the pattern and extent of this vegetation change at the landscape-scale. C_3 and C_4 plants have unique $\delta^{13}C$ values which are incorporated into the soil without significant fractionation during soil organic carbon (SOC) formation. In this study, we used soil $\delta^{13}C$ in conjunction with sequential aerial photography and spatial statistics to quantify landscape-scale vegetation dynamics in southern Texas. A 160 x 100 m plot was georeferenced and subdivided into 10 x 10 m cells on a sandy loam upland site (1-3% slope) comprised of woody patches in a grassland matrix. Two soil samples (0-15cm) were collected at points selected randomly within each grid cell, and analyzed for $\delta^{13}C$. Variogram analysis indicated that soil $\delta^{13}C$ had an anisotropic spatial pattern, with stronger spatial structure [(sill-nugget)/sill= 70.3%] and shorter range (11.90 m) parallel to the slope and weaker spatial structure [(sill-nugget)/sill= 57.5%] and longer range (19.09m) perpendicular to the slope. Kriged maps of soil $\delta^{13}C$ revealed the pattern of woody plant encroachment across this landscape. On soil $\delta^{13}C$ contour maps, centers of closed contour lines represented centers of woody patches, and revealed that larger woody patches were formed from small discrete clusters of woody plants that spread laterally and eventually coalesced. Areas where woody patches were expanding into grassland were characterized by low densities of soil $\delta^{13}C$ contour lines, and indicated the direction and extent of woody plant encroachment. Conversely, areas with high contour densities represented grassland-woodland boundaries that were relatively stable over time. Indeed, aerial photos from 1930, 1941, 1982 and 2003 confirmed that woody patches with low spatial variability in $\delta^{13}C$ corresponded to areas where C_3 woody plants had encroached during the past 30-75 yrs. While aerial photos can only reflect the vegetation cover at the photo acquisition time, kriged maps of soil $\delta^{13}C$ allowed us to reliably reconstruct long-term temporal dynamics of woody plant encroachment into grassland. This approach can also be applied to reconstruct changes in woody cover in areas where historical aerial photography or satellite imagery are not available. These data provide a strong spatial context for future studies aimed at understanding the functional consequences of this change in landscape structure.