Phosphorus Fractionation Chemistry Across the Great Plains

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Abstract:

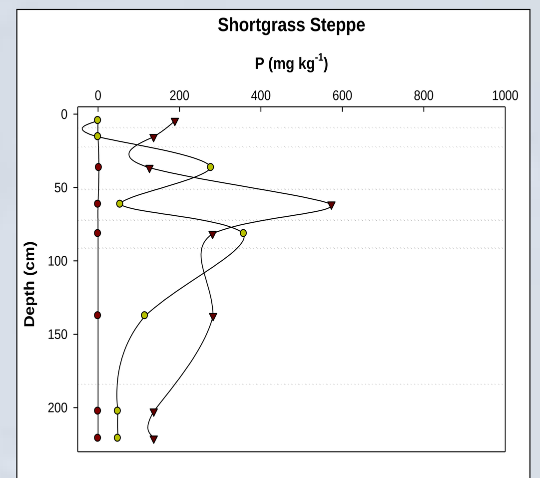
Phosphorus is one of the three important plant nutrients found in soils an has been used with great success as an index for soil and ecosystem development (Aguilar et al., 1988; Honeycutt et al., 1990; Vitousek et al., 2004). In general, phosphorus is has minimal solubility in soil because it participates in a number of secondary reactions after release from primary minerals as a result of weathering. Studies of the biogeochemical cycling of P in humid ecosystems has lead to important insights about soil and ecosystem development. Arid and semi arid ecosystems have largely been ignored under the assumption that chemical transformations are minimal. We conducted research on the biogeochemistry of P along a bioclimatic gradient in grassland ecosystems of the Great Plains.

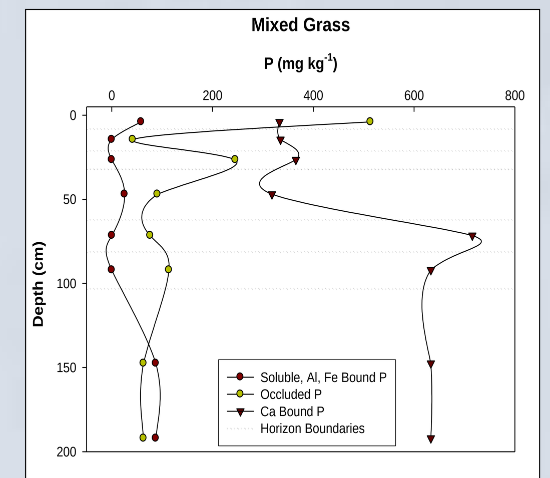
The overall goal of our research is to use a systematic approach to characterize and further quantify the P transformations in biogeographically diverse grassland ecosystems. Identifying P quantities originally contained in central Great Plains soil will allow us to assess 1) the relative importance of P in the biogeochemical behavior of grassland soils, 2) help us quantify the degree of chemical weathering in semi arid-humid grassland ecosystems, and 3) elucidate cultural use and potential productivity of these ecosystems prior to use of commercial fertilizers.

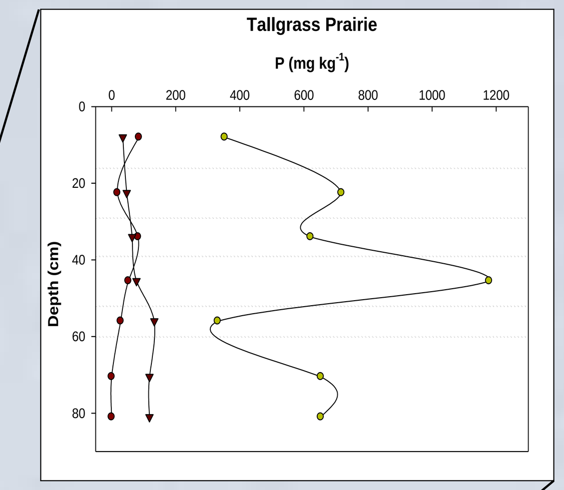
We sampled soils along a bioclimatic gradient that represent three grassland ecosystems, namely, the shortgrass steppe, the mixed-grass prairie, and the tallgrass prairie in eastern Kansas. The soils were collected from sites studied within the Long-Term Ecological Research Program in areas that had not been used for agricultural practices other than grazing. We conducted a sequential extraction procedure to identify the following P fractions: soluble, Al-bound, Fe-bound, occluded, and Ca-bound.

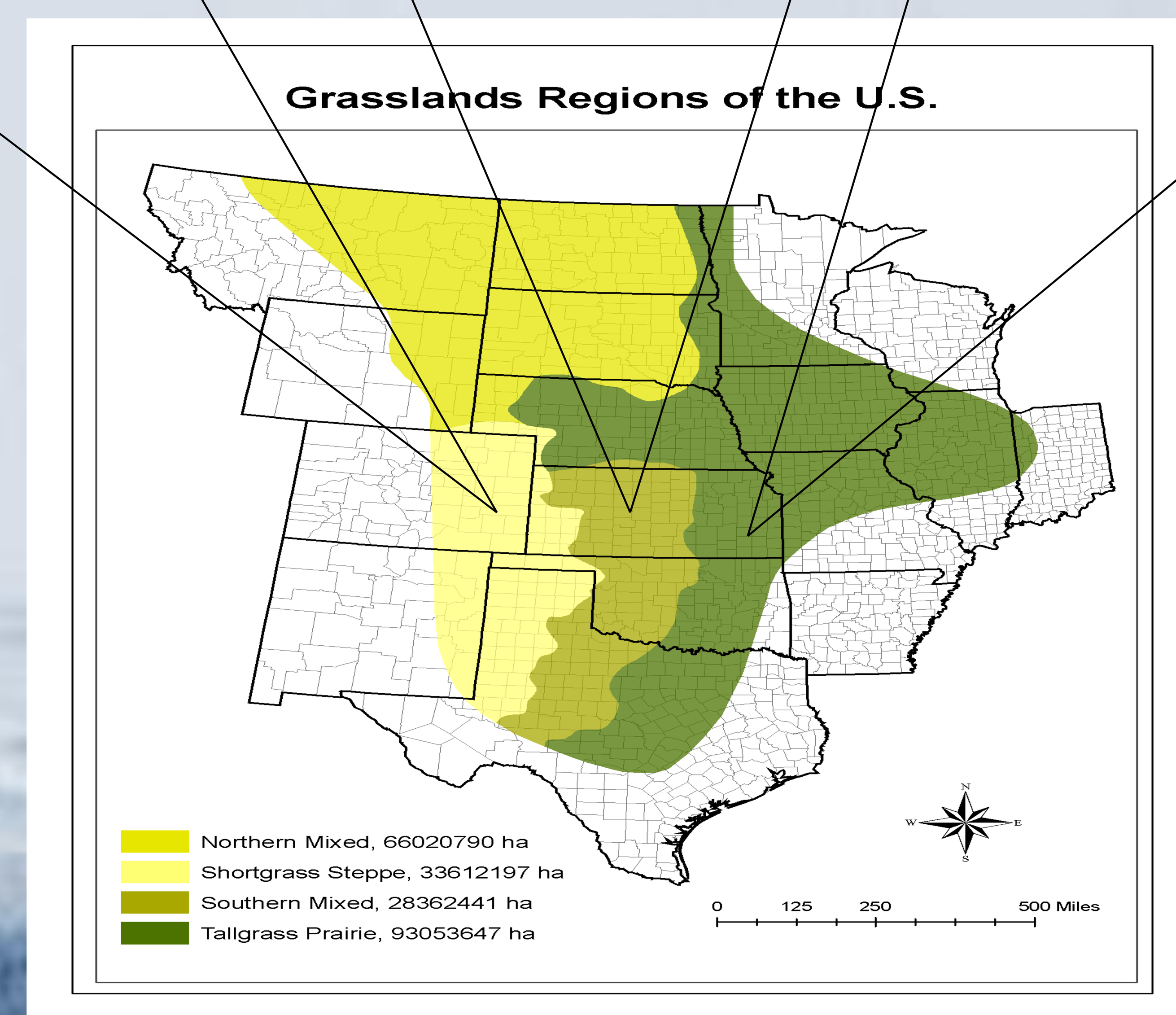
Our results suggest that soluble P is generally below detection limits at theses sites, illustrating the high turnover rate of available P in these undisturbed systems. The Al-bound fraction was variable across all sites. The Fe-bound P contributed to the total P fraction only from the mixed grass and tall grass prairies. The occluded P fraction was greatest in the shortgrass steppe, decreased dramatically as mean annual and primary production increase from west to east.

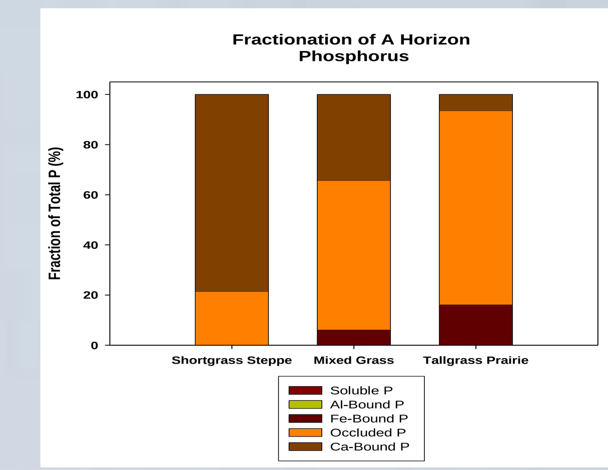
Data:

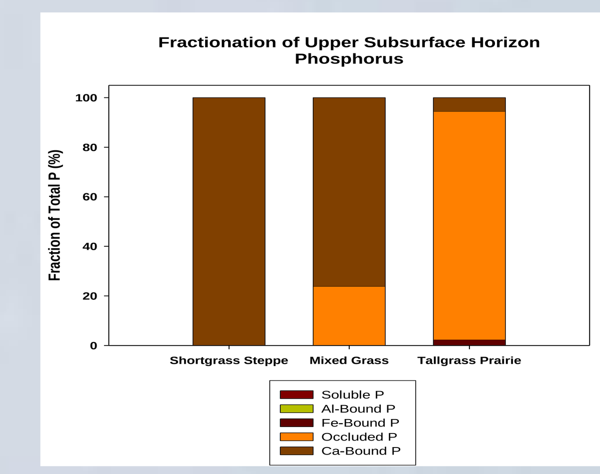


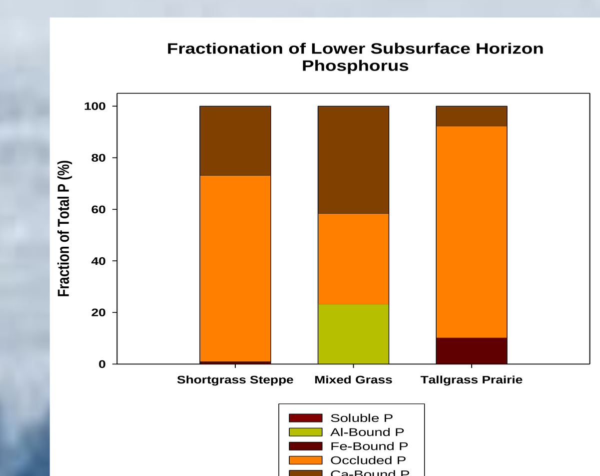












Materials and Methods

The samples were taken from 3 grassland sites (see map) from eastern Colorado and central and eastern Kansas.

Sequential Extractions for Inorganic P in Non-Calcareous soil samples

(Experimental Steps)
1. Soluble Inorganic P
2. Al-Bound Inorganic P
3. Fe-Bound Inorganic P
4. Occluded Inorganic P
5. Ca-Bound Inorganic P

Sequential Extractions for Inorganic P in Calcareous soil samples

(Experimental Steps)
1) Soluble & Loosely Bound P/ Al-P/ Fe-P
2) Occluded Inorganic P
3) Ca-Bound Inorganic P

All solutions were analyzed colorimetrically using an ascorbic acid procedure (Rodriguez et al. 1994) on a spectrophotometer at 882nm.

Key Results:

- Phosphorus concentrations reached a maximum in the A horizon in the Mixed-grass site, suggesting greater biocycling.
- Most sites demonstrated greater proportions of secondary P minerals in subsurface horizons relative to surface horizons.
- Ca-bound P decreased and Occluded P increased in both the A and upper subsurface horizons, from the Shortgrass Steppe to the Mixed-grass system to the Tall-grass Prairie, reflecting increases in MAP and ANPP.

Conclusions:

Changes in the P fractions across the 3 grassland sites is related to soil development and weathering associated with these ecosystems. Additionally, available P concentrations (i.e. soluble) were low across all sites, suggesting rapid turnover of this labile pool into the organic fraction and quite possibly into other more stable inorganic fractions.

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