Determinants of Total Phosphorus and Available Phosphorus in Missouri Ozark Highland Forest Soils

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Introduction

- Phosphorus is important limiting factor of forest growth in many parts of world.
- Missouri Ozark Highland soils are predominantly acidic and highly weathered.
- Phosphorus pools can be affected by soil chemical, soil physical and geological factors.
- Therefore, significant potential exists that P concentrations in Ozark Highland soils will, in general, be quite low but also variable.

Objective

The objective of this study was to identify the importance of geomorphic and soil properties on total and available P concentrations in forested soils of the Missouri Ozark Highlands.

Materials and Methods

- The Missouri Ozark Forest Ecosystem Project (MOFEP) is a long-term experimental project started by the Missouri Dept. of Conservation in 1989.
- The MOFEP sites are located within the Ozark Highlands of south-central Missouri, and more specifically within the Current River Forest Breaks and the Current River Oak-Pine Woodland Hills land type associations (Fig. 1).
- Fifty pedons having profile depth >100 cm were selected for this research.
- Three soil horizons meeting the following criteria were selected from each pedon:
  - i. first mineral horizon (50 - A horizon samples);
  - ii. first Bt horizon or the first Bw horizon when no Bt horizon was present in the pedon (47 - Bt and 3 - Bw horizons);
  - iii. soil horizon encompassing the depth of 100 cm (47 - Bt horizons, 2 - Bw horizons, and 1 - C horizon).
- Soil characterization data for 50 pedons was obtained from Missouri Cooperative Soil Survey (http://www.soilsurvey.org).
- Soil samples were analyzed for total P (70% perchloric acid digestion), Bray-1 and Mehlich-3 available P, and Fe, Al and Mn oxide content (citrate bicarbonate dithionite method).

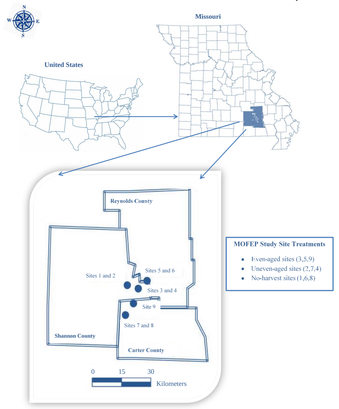


Figure 1. Location of nine MOFEP sites in three counties and there management treatments

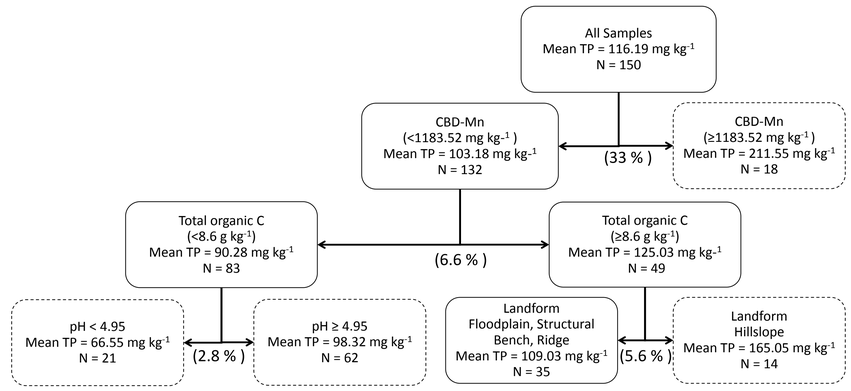
Missouri Ozark forest

Statistical Analysis

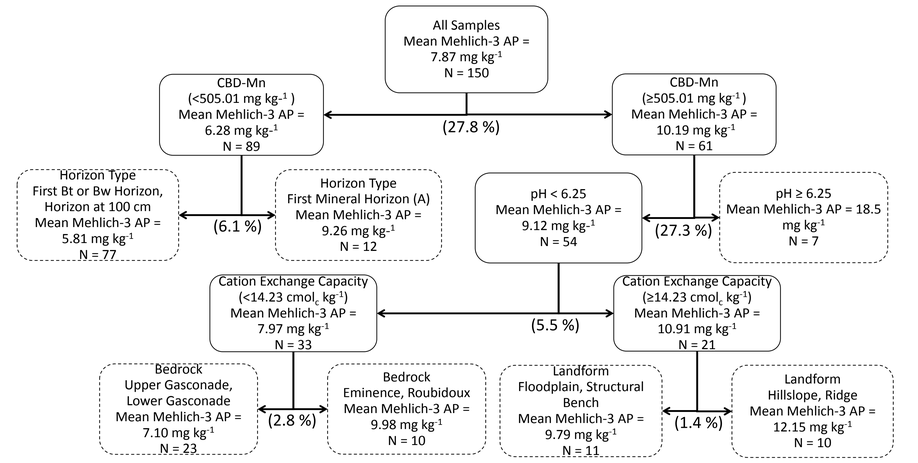
- Linear regression analyses were performed using the PROCREG procedure in SAS™ Statistical Software Version 9.3.
- Classification and Regression Tree (CART) analysis was used to analyze the role of soil and geomorphic factors associated with concentrations of various P forms in Ozark Highland soils.
- Three forms of soil P were used as continuous response variables for the construction of three different regression trees: total P; Mehlich-3 available P; and Bray-1 available P.
- Predictor variables used for investigating these forms of soil P included: (1) horizon or depth; (2) parent material; (3) underlying bedrock formation; (4) profile position or slope position; (5) landform type; (6) exchangeable Ca; (7) CEC; (8) soil pH in water; (9) clay content; (10) total organic carbon content; (11) Fe + Al oxide content; and (12) Mn oxide content.

Results

I. Classification and regression tree for total P.



II. Classification and regression tree for Mehlich-3 available P.



III. Classification and regression tree for Bray-1 available P.

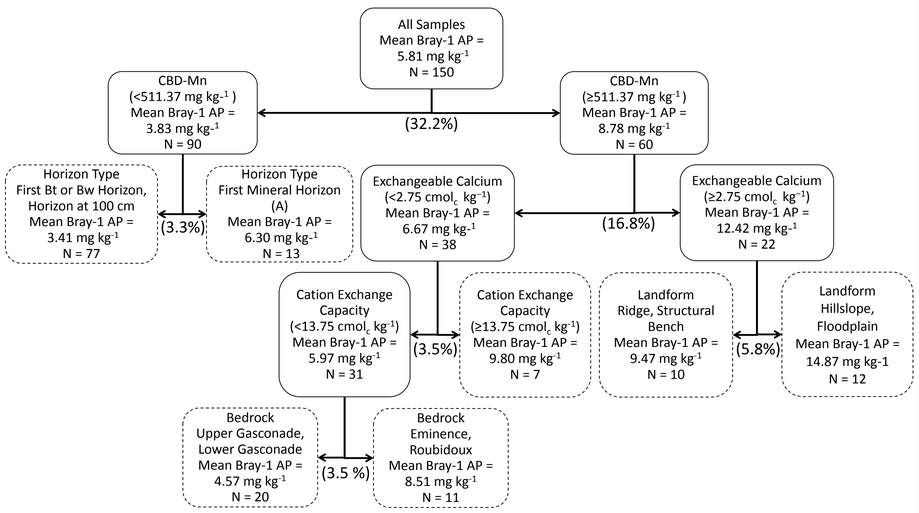
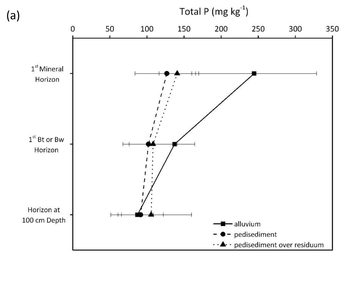
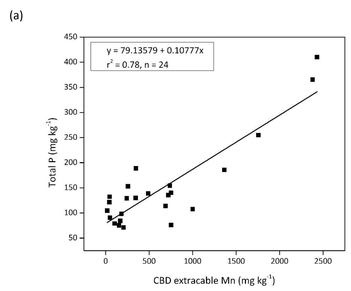
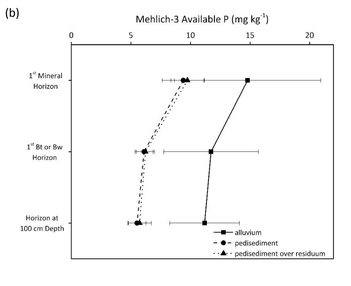
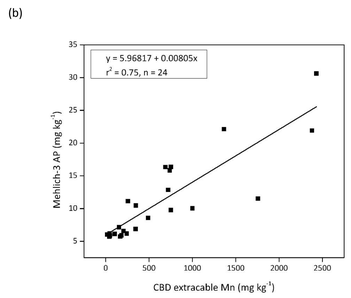


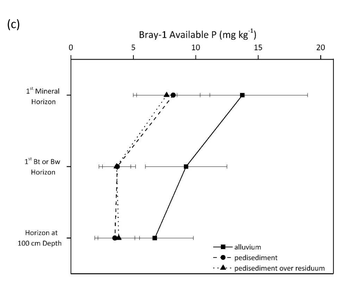
Figure 2. Classification and regression tree models.
Regression trees developed from classification and regression tree analysis for (I) total P, (II) Mehlich-3 available P, and (III) Bray-1 available P; concentrations are expressed in mg kg^{-1}. Each branch of the regression tree is labeled with the explanatory variable associated with partitioning of the response variable. Boxes represent the nodes including the number of horizons present in each split, the explanatory variable associated with each split, and the mean concentrations of Mehlich-3 available P, Bray-1 available P and total P. Dashed boxes represent the terminal nodes.











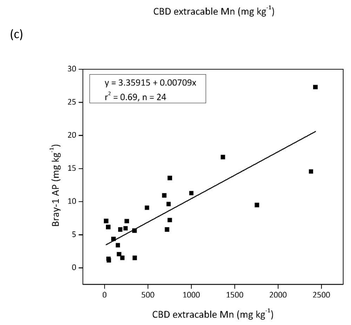


Figure 3. Plots representing mean concentrations of (a) total P, (b) Mehlich-3 available P, and (c) Bray-1 available P in the three soil horizons studied by parent material type. Error bars represent ± one standard error.

Figure 4. Plots representing linear regression coefficients between CBD-Mn and: (a) Total P; (b) Mehlich-3 Available P; and (c) Bray-1 Available P in soils overlying the Eminence bedrock formation.

- Concentration of available P and total P are highly variable in Missouri Ozark Highland soils (Fig. 3).
- Phosphorus concentrations were greater in first mineral horizon and availability of P decreased with depth (Fig. 3).
- Due to the high variability in soil samples and geological strata it was not possible to associate a single factor explaining concentrations of P forms in Ozark Highlands.
- The CART analysis identified (1) CBD extractable Mn and total organic C as important variables explaining 39 % of the cumulative variation in total P; (2) CBD extractable Mn and exchangeable Ca as important variables explaining 49% of the cumulative variation of Bray-1 available P; and (3) CBD extractable Mn and pH as important variables explaining 55 % of the cumulative variation of Mehlich-3 available P (Fig. 2).

Conclusions

- Further research is needed to elucidate the role of Mn oxides in regulating concentrations of P forms in Ozark Highland soils, and research described here can be used to formulate future research.
- This research will also help in identifying sites which are potentially vulnerable to nutrient depletions and can serve as aid for recommending harvesting operations.

Acknowledgments

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