# Relations of Iron,  Aluminum, and Carbon Along Transitions From Udults to Aquods

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## Introduction

**Background**:
- Spodosols - significant subsurface C pool; pertinent to global C dynamics
- Spodosol formation in SE USA thought to involve organo-metal complexation
- C mobilizes metals ("eluviation") at shallower depths to form E horizons
- Metals immobilize C at deeper depths ("illuviation") to form Bh ("Spodic") horizon

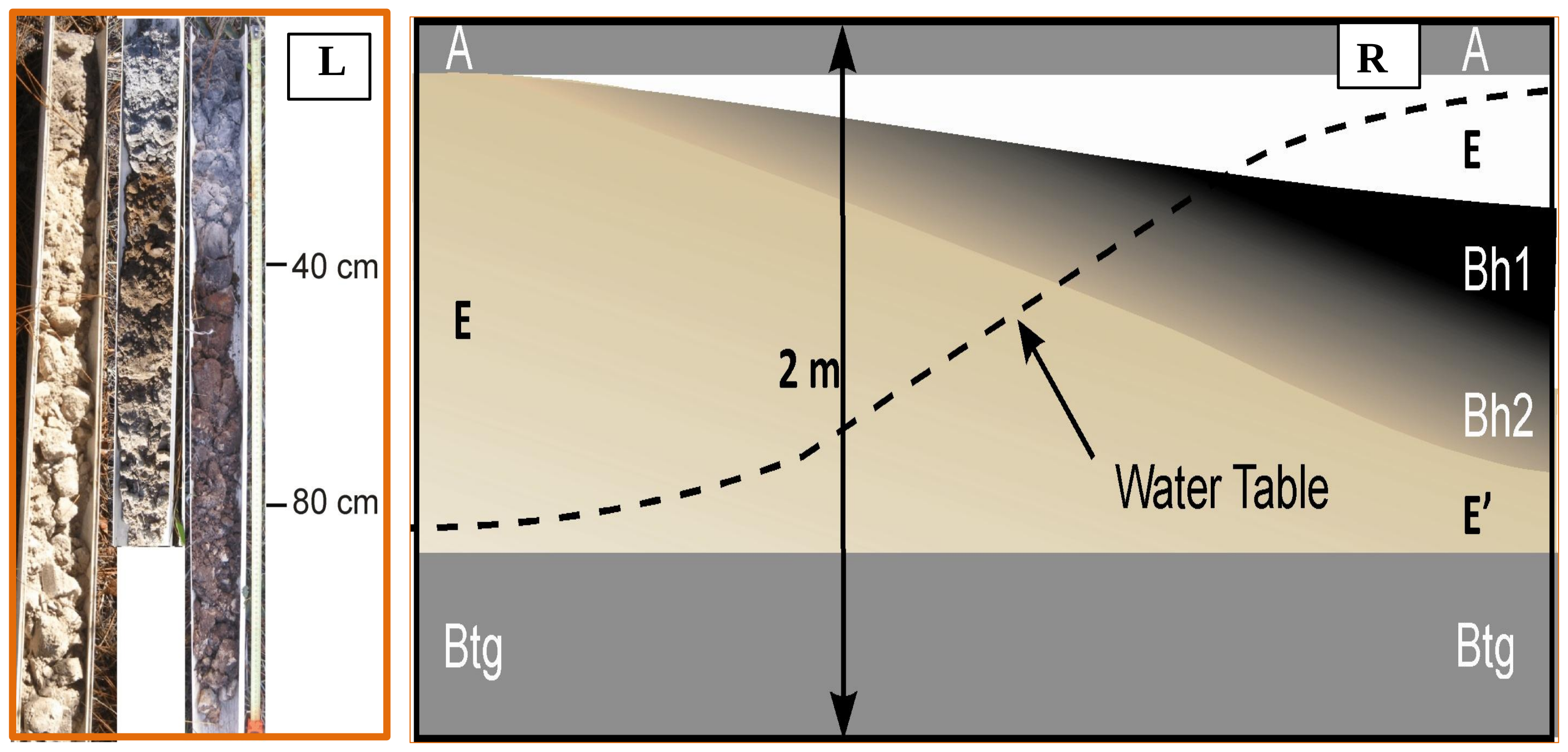
**Observations**:
- Southern Spodosols associated with fluctuating water tables (commonly Aquods; poorly drained)
- Al >> Fe in Spodic of most southern Spodosols, but …
- Fe can be significant in Spodic of northern Spodosols
- Bh horizons become shallower and weaker as seasonal high water table deepens (Fig.1)

**Questions:**
- Why do water tables favor mobilization of Al, a non-redox-sensitive metal?
- Why is Al-C association more prevalent than Fe-C in southern Bh horizons?

**Hypotheses:**

H1 - Depletion of Fe resulting from wetness and chemical reduction leaves Al more vulnerable to organo-complexation and redistribution, fostering development of Aquods.

H2 - Near-surface saturation induces microbially-mitigated changes in organic acid activities and species that promote metal complexation. (Not addressed in this poster).



Pics. by Luke Gommerman

Drawing from "Spodosols" in Handbook of Soil Science (Schaetzl and Harris, 2012)

Figure 1. Left (L) – soil profiles of driest, intermediate, and wettest soil at transect 3. Right (R) – schematic of typical trends in water table and Bh along transitions.

Site 3: Sandhill community with sparse understory and open canopy of longleaf pine (*Pinus palustrus*).

Site 3: Flatwoods community with dense understory of saw palmettos (*Serenoa repens*).

## Objectives

- Determine metal & C forms and particle-size distribution along transects from Udults to Aquods.
- Evaluate implications for Aquod formation.
- Consider implications for climate change effects on C flux in coastal plain soils.

## Methods

- Soil samples collected by horizons using auger close to each well
- 5 or 6 wells 2 m deep installed along 4 transects from Udults to Aquods.
- Pyrophosphate- oxalate-extractable Fe, & Al ($Al_{(P)}$ & $Fe_{(P)}$)
- Oxalate-extractable Fe, & Al ($Al_{(AAO)}$ & $Fe_{(AAO)}$)
- Pyrophosphate-extractable C ($C_{(P)}$) and total C by flash combustion
- Particle size by pipette method
- pH and EC

Driest ←==============================================================================================→ Wettest

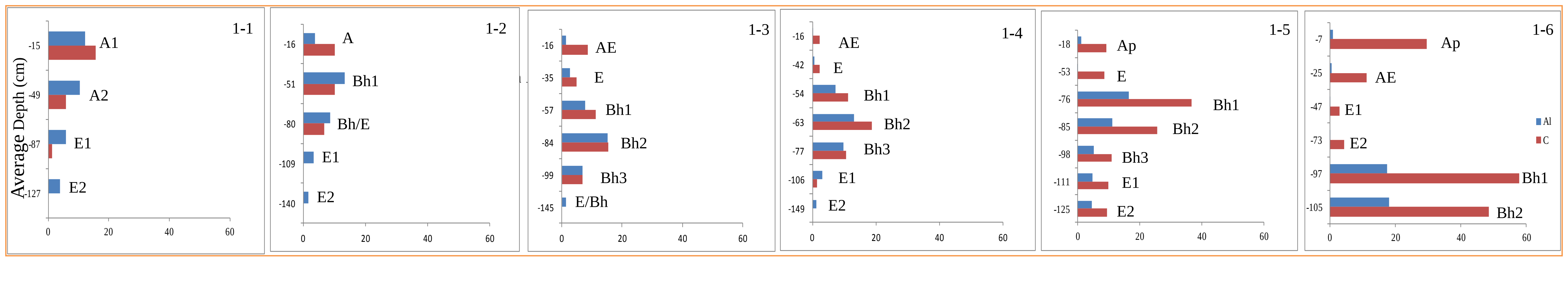


**Figure 2:** $Al_{(P)}$ & $C_{(P)}$ (x10 $^{-1}$) concentrations with depth for transect 1 profiles. Hydrologic gradient is from 1-1 (driest) to 1-6 (wettest). Other transects showed similar trends.

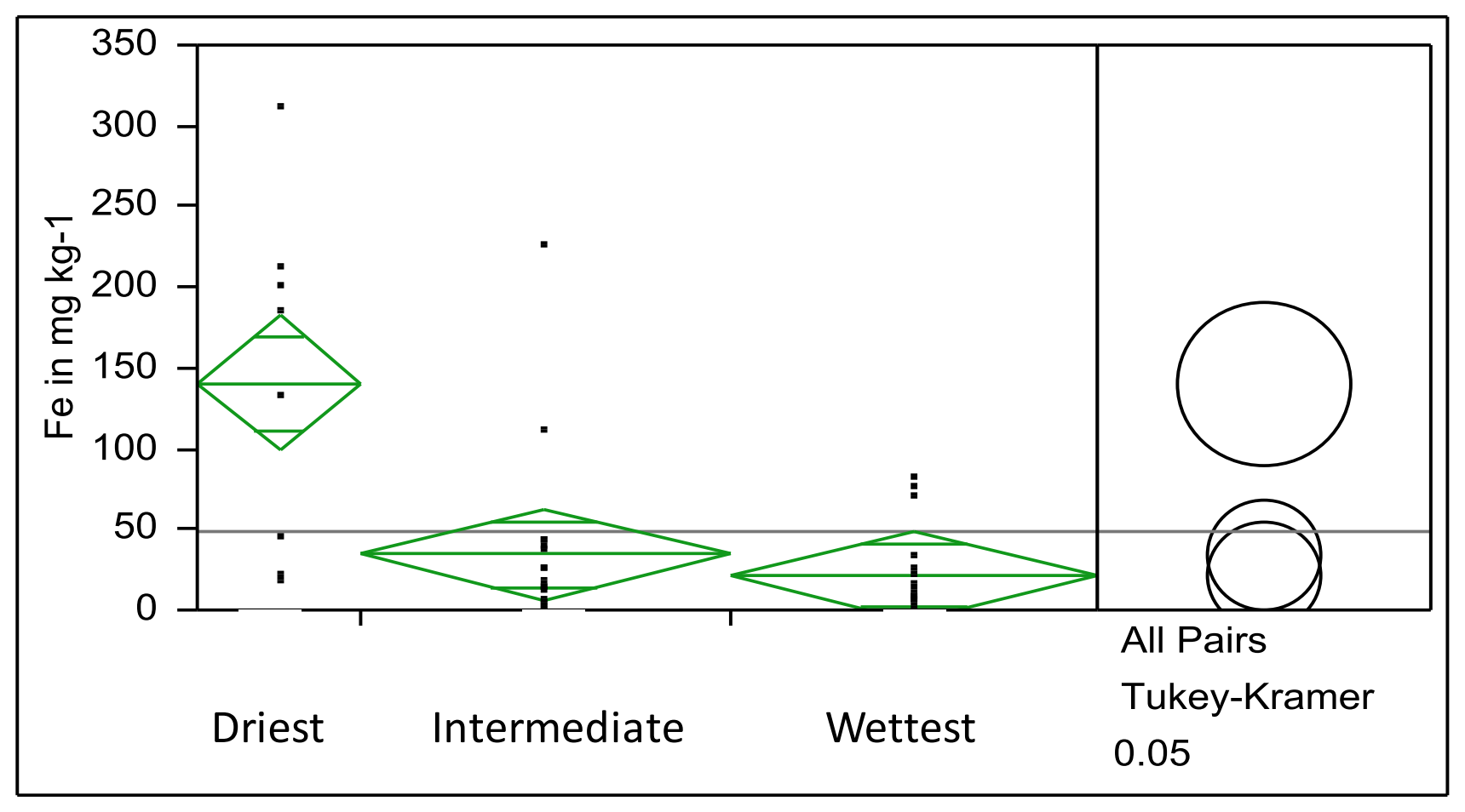


**Figure 3:** Evidence for declining Fe in Bh with increasing moisture on landscape.

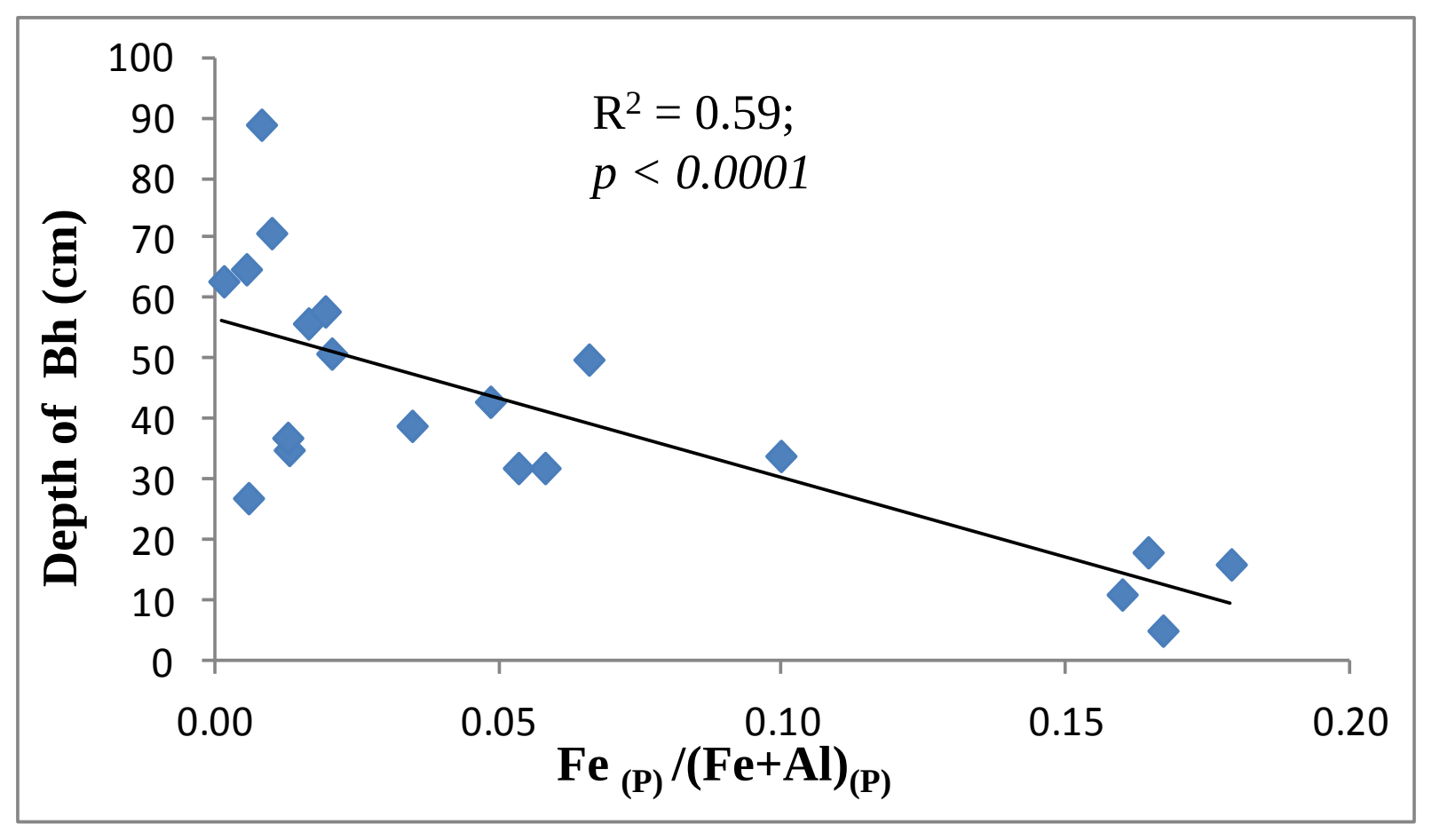


**Figure 4:** Evidence for declining Fe in Bh with increasing depth of  upper Bh.

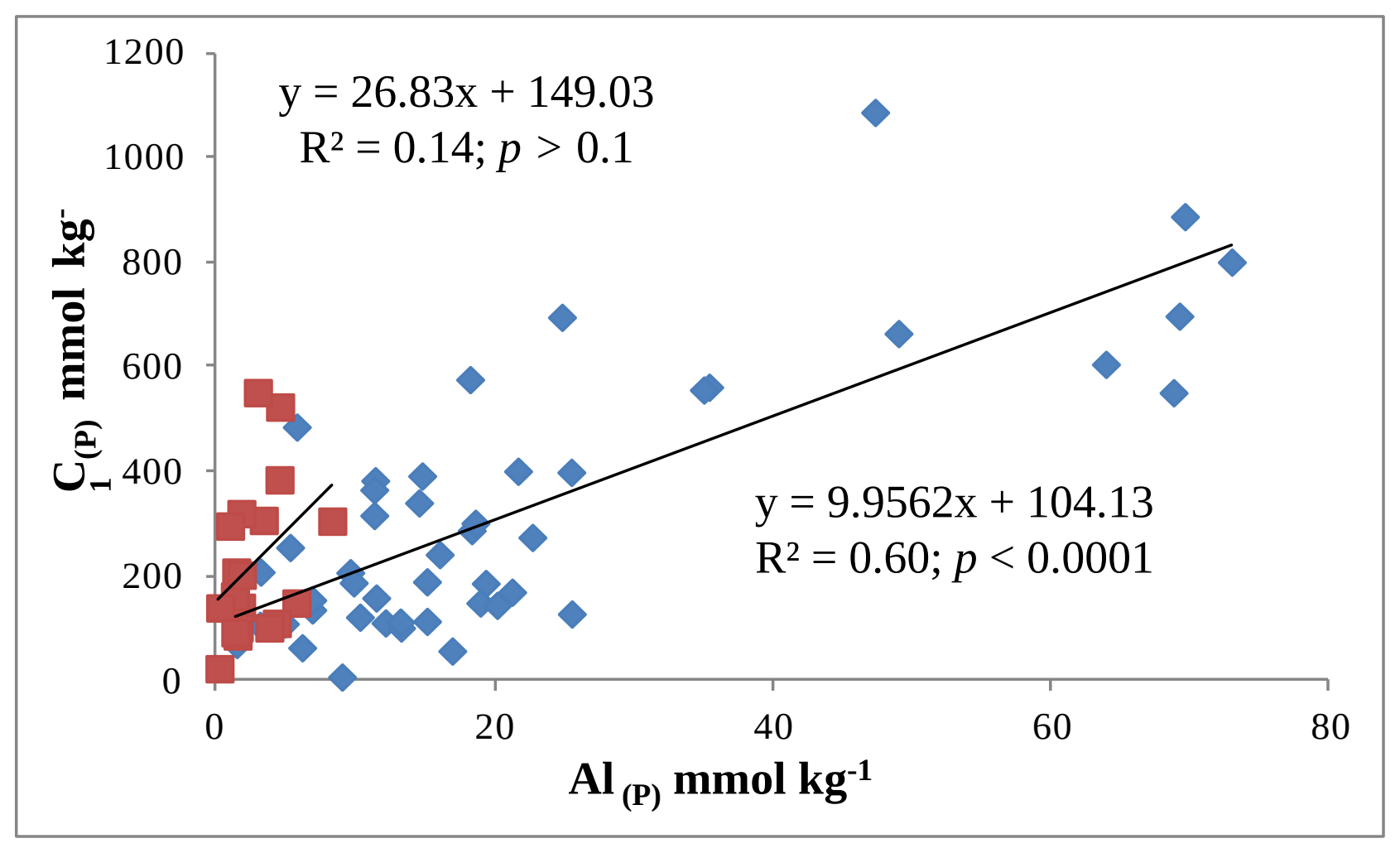


**Figure 5:** Relations between pyrophosphate C & Al. Red = Ap; Blue = Bh .

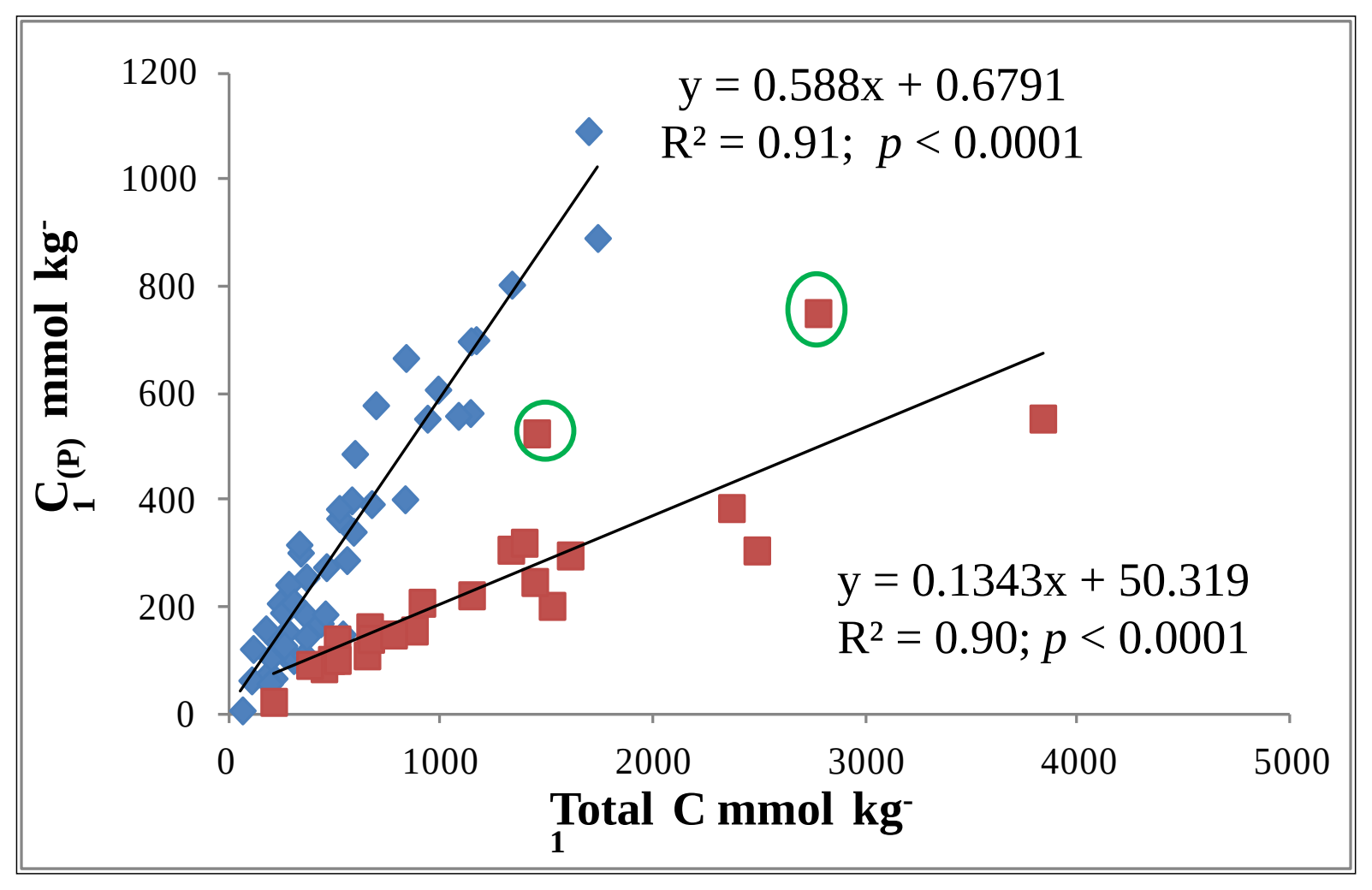


**Figure 6**: Relation between Pyrophosphate C and total C. Red = Ap; Blue = Bh. 0 are statistically found to be outliers, $R^2$ with those ○ is 0.73.

**Table 1:** Comparisons between Ap and weak Bh horizons in driest side of two transects of a site.

| Transect # | Well # | Horizon | Lower depth | Color | $Al_{(P)}$ | $Fe_{(P)}$ | $C_{(P)}$ |
|---|---|---|---|---|---|---|---|
| | | | cm | | <--------mmol kg $^{-1}$ | ---------- | ---> |
| 3 | 1 | Ap | 5 | 10YR 4/1 | 8 | 2 | 306 |
| | | Bh | 17 | 10YR 4/2 | 19 | 4 | 149 |
| | 3 | Ap | 11 | 10YR 4/1 | 4 | 1 | 110 |
| | | Bh | 30 | 10YR 4/3 | 21 | 4 | 170 |
| 4 | 1 | Ap | 16 | 10YR 4/1 | 6 | 2 | 149 |
| | | Bh | 30 | 10YR 4/4 | 25 | 6 | 128 |
| | 3 | Ap | 18 | 10YR 4/1 | 3 | 1 | 308 |
| | | Bh | 30 | 10YR 4/3 | 18 | 3 | 288 |

## Conclusions

- Fe depletion gradient along the hydrologic continuum corresponds to C-Al accumulation gradient (Bh horizon development).
- Trends in distributions of Al, C, and Fe support H1 – that Fe inhibits podzolization in Florida soil parent materials.
- Effects of (i) near-surface wetness on microbial processes influencing organic acid production and (ii) vegetation type (sandhills vs. flatwoods) should also be investigated.

## Implications

- Redox sensitivity of Fe may be a hydrologic link explaining restriction of southern Spodosols primarily to poorly drained settings.
- Direction and magnitude of C flux on coastal flatwoods landscapes can be influenced by hydrologically-linked organo-metal interactions.
- Hence climatic alteration of water table dynamics could affect storage or release of C.

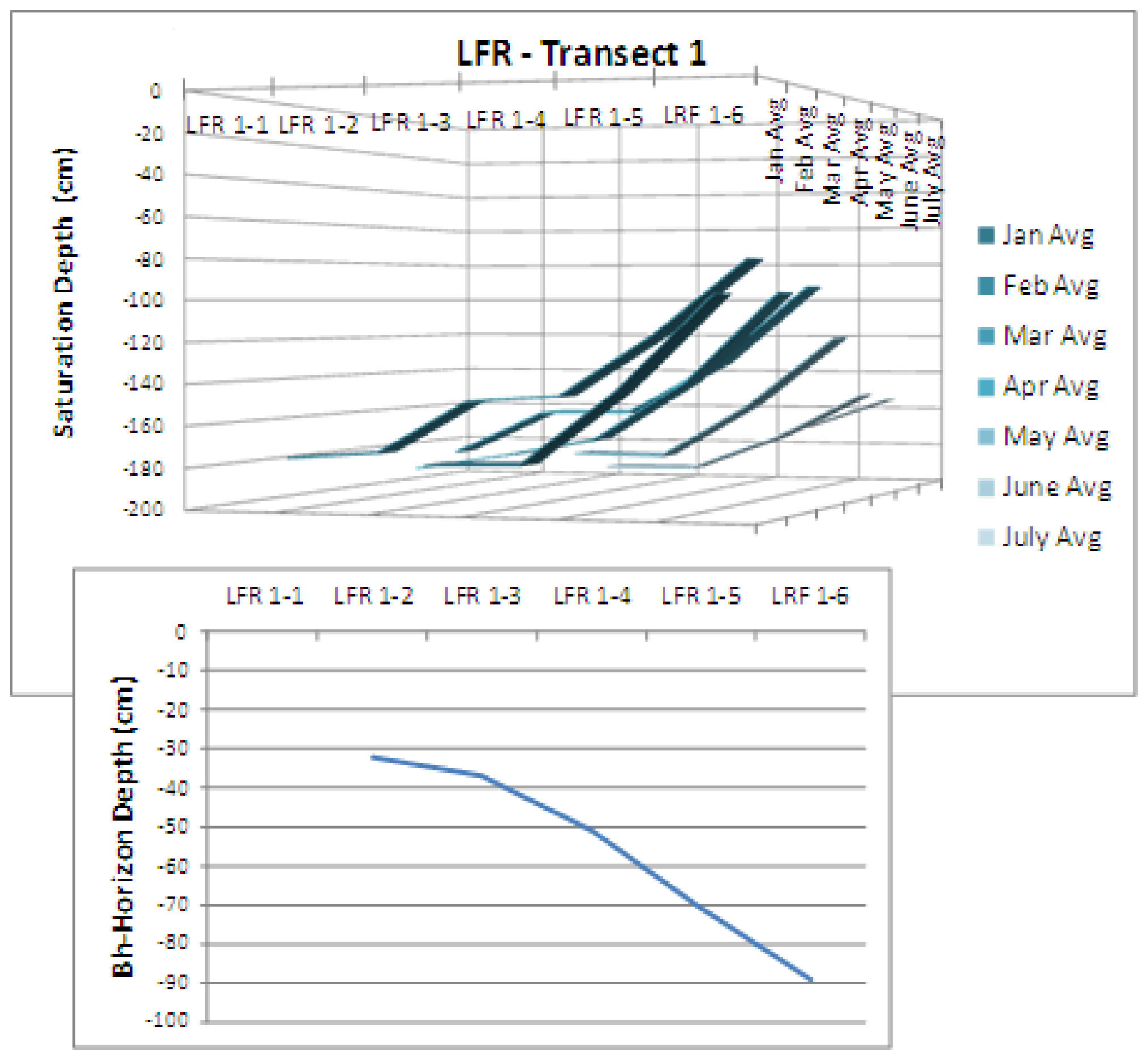


**Figure 7 :** Relation between  saturation depth and depth of Bh over a period of several month.

## Results &Discussion

- Soil profile distributions of Al & C show shift to greater depths as wetter part of landscape is approached (Fig : 2), corresponding to increasing expression of E (Al loss) and Bh (Al & C gain).
- Fe follows different trend – becoming depleted toward wetter part of landscape in transition from Udults to Aquods (Fig: 3). Proportion of Fe also decreases with increasing depth of Bh (Fig. 4).
- Al & C are strongly associated in Bh (Fig. 5) but Fe & C not significantly related. Pyrophosphate-extractable Al much higher in Bh than overlying A horizon, even for shallow, weakly expressed Bh (Fig. 5; Table 1).
- (Al/C) or ($C_{(p)}$ /total-C) ratios are chemical indicators that can distinguish Bh from A horizons (Fig. 5 & 6).
- Depth of Bh is strongly related to saturation depth (Fig. 7).
- C & Al appear jointly mobilized and immobilized, favoring chelate-complex theory over protoimogolite theory of podzolzation for these soils.
- Landscape hydrologic gradient parallels gradients in Fe loss, C-Al association and subsurface C accumulation.

## Acknowledgments

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## Reference

Schaetzl, R., and W.G. Harris. 2011. Spodosols. p. 33-113 to 33-127. *In*: Handbook of Soil Science, 2nd ed. P.M. Huang, Y. Li and M.E. Sumner (eds.). CRC Press, New York.