Biogeochemistry of Soils Associated with Cryptogamic Crusts on Frost Boils

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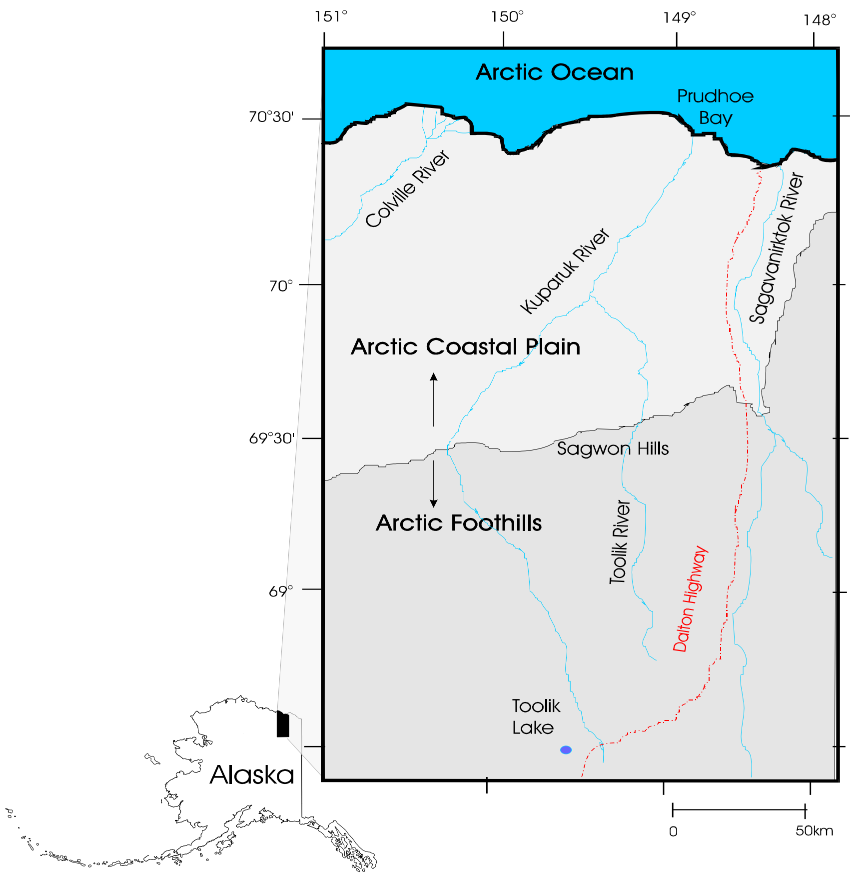
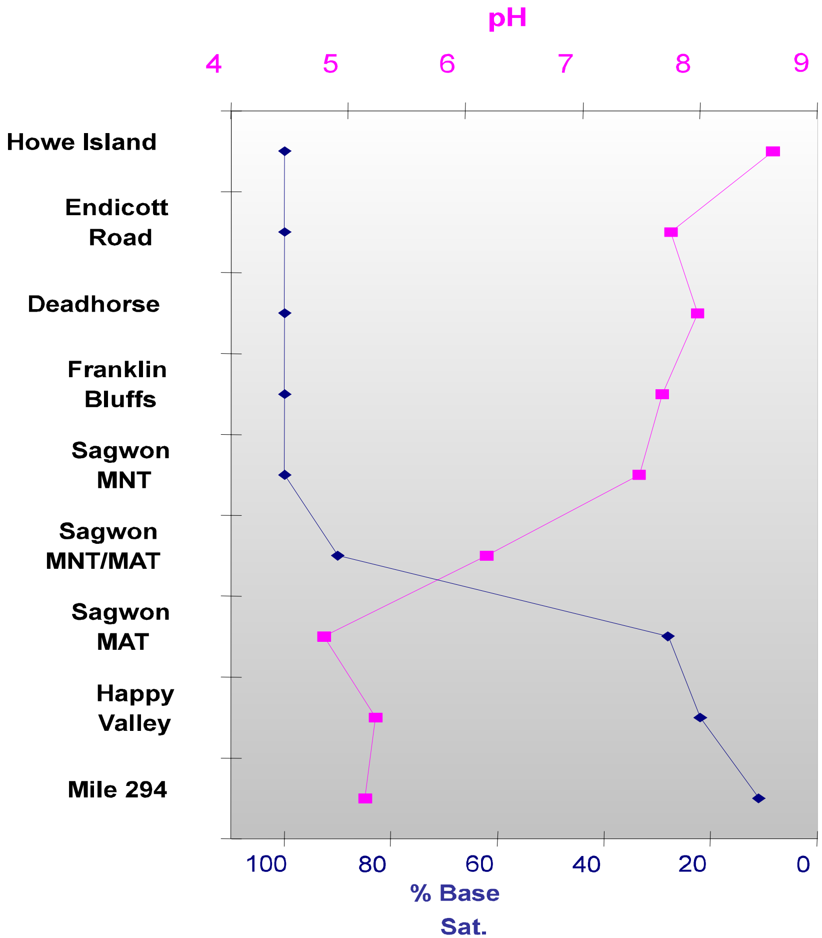
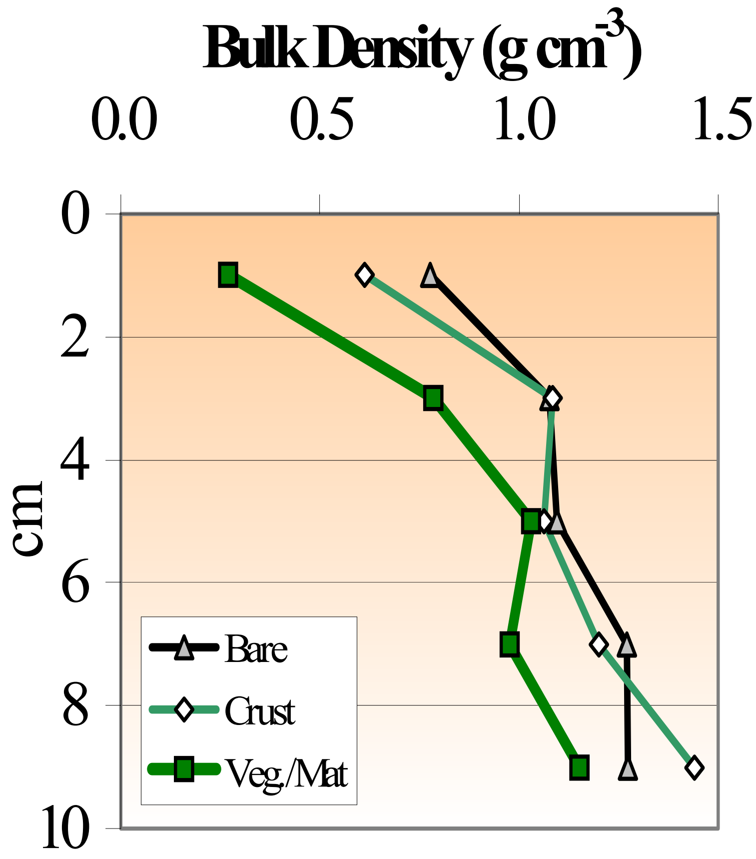


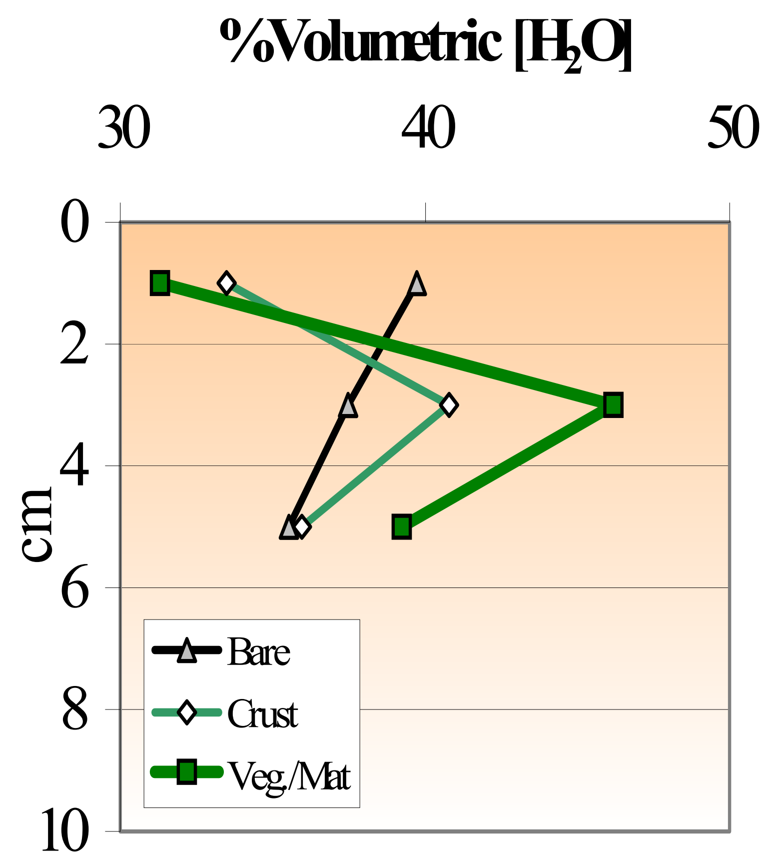


Methods

Soils were studied from 9 sites on frost boils over a 250 km latitudinal gradient in arctic Alaska (see Figure 1, map). Microsites located atop center areas of frost boils were sampled at cm-scale depth increments (photos Table 1a-C) in late August 2002. Various soil morphological and physio-chemical properties were determined in order to relate surface biotic activity to changes in soil biogeochemistry across the gradient. Microsites on frost boils were selected at each location by overall degree and general type of surface vegetative coverage:

Bare = mostly mineral soil exposed,
Crust = surface mostly or all covered with cryptogams and or lichen/mosses of <2 cm thickness, and
Veg./Mat = >2 cm thick moss/lichen dominated and/or *dryus* sp. mats present at full coverage
(See Figure 2 photo examples)


Bulk Density (g cm-3)
0.0
0.5
1.0
1.5
cm
0
2
4
6
8
10
Bare
Crust
Veg./Mat


%Volumetric [H2O]
30
40
50
cm
0
2
4
6
8
10
Bare
Crust
Veg./Mat

Results

A. Crusts and Soil Physical Properties

The effects of biological activity are apparent in boil surface soils.

1. Structure of the mineral soils goes from subangular blocky in bare areas to granular under vegetative mats
2. Soil physical properties at the surface under crusts are intermediate between bare and vegetated
3. While soil bulk densities are lowered to greater depth under vegetated sites due to organic matter additions, the affects of crust are limited to the near surface layer.
4. Crusts and vegetation mats had similar effects on preserving or increasing water contents under the surface. The surface layer was dryer with cover than bare probably due to the lower soil bulk densities. Lower soil bulk densities at the surface with crusts or vegetation mats preserved soil moisture below the surface while moisture levels were highest at the surface under bare soils.

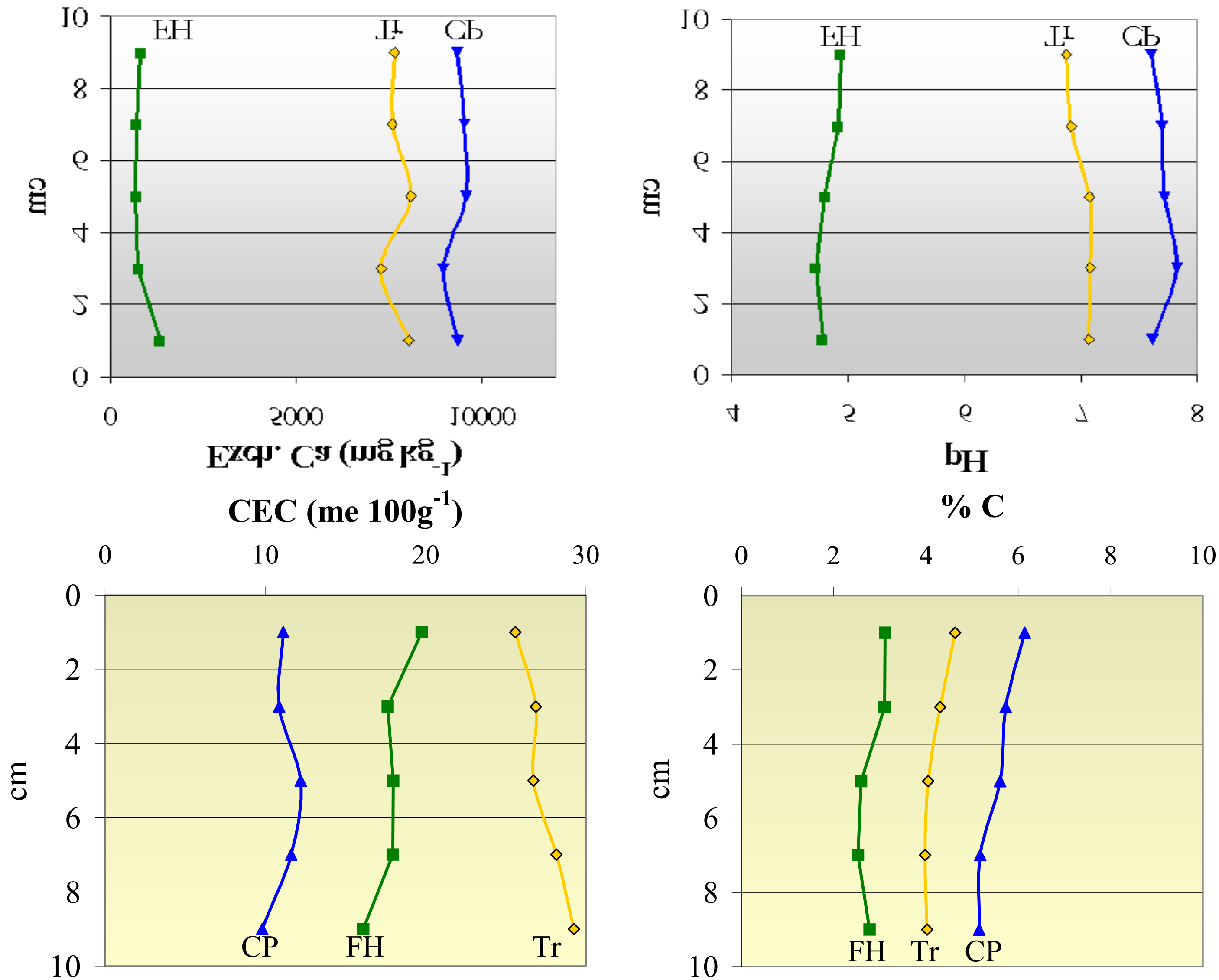


Figure 4. Key differences in average site soil properties (for Bare condition microsites) along the latitudinal gradient. Exch. Ca by ammonium acetate extraction, pH 1:1 water, CEC cation exchange capacity me pos. charge by 1N NH_4Oac exchange, and %C by LECO ignition analyzer. (FH=Foothills, Tr=Transition, CP=Coastal Plain locations)

Results

B. Crusts and Soil Chemical Properties

Soils along the Latitudinal Gradient

1. Crusts establish on bare soils within frost boils. Soil chemistry of bare micosites varys from north to south as indicated by the exchangeable cation status.
2. On the coastal plain calcium carbonate-rich soil substrate dominates but diminishes in the transitional (northern) foothills area.
3. The amount of soil Ca is highly correlated to soil pH across the region.
4. Soil CEC is highly correlated with soil carbon for each site (data not shown) but CEC is highest in the transition area soils probably due to organic matter quality differences i.e. the more highly decomposed nature of soil organic matter found there.

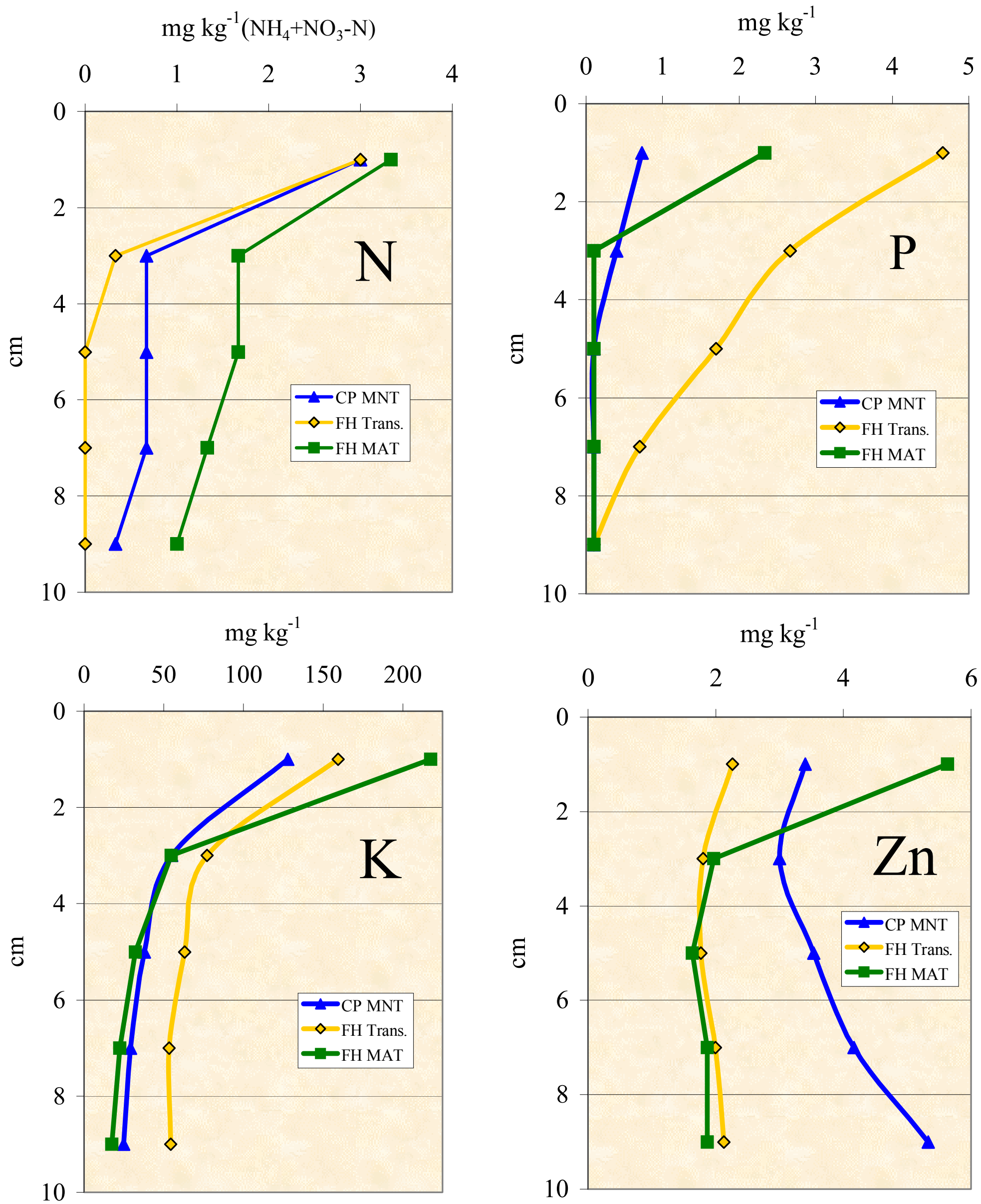


Figure 5. Soil nutrient distribution in surface layers under Crust microsites on frost boils averaged for comparing the coastal plain moist acidic tundra (CP MNT), foothills transition (FH Trans.) and foothills moist acidic tundra (FH MAT) sites. (N extracted with 1M KCl, P and Zn with Mehlich-3 soln., and K with 1N neutral NH_4OAc)

Results

C. Crusts and Soil Nutrients

1. Crust surface nutrient levels were increased compared to adjacent bare microsites on the same boil but less than levels on vegetated microsites (data not shown).

2. Crust nutrient distribution was similar in pattern to vegetated microsites but at lower soil levels.

3. Available N levels under crusts were similar in the surface layers of sites across the study while levels in lower layers may reflect a gradient across the area with substrate and environmental changes.

4. Crust P levels in the transition area were nearly 5 times those of the coastal plain and double those found for the foothills MAT crusts. This could reflect soil mineralogical differences such as P and K released from degraded carbonate mineral in the transition relative to the CP sites and increased labile organic-PK pools built up in the older FH Mat sites. Levels of micronutrients represented here by Zn levels also varied widely across the 3 gradient areas. These levels also are likely affected by substate chemisty differences across the study area.

Conclusions

1 Crusts influence surface soil chemical and physical properties in a similar manner to that found under adjacent vegetation mats but to a lesser degree of expression.

2 Crust may serve to prepare soils for thicker vegetative cover by releasing essential micro and macro nutrients to sufficient levels to support greater productivity. Gradient substrate chemistry differences across the study area are significant in terms of possible affects to the revegetation of frost boil disturbed microsites.

3 Levels of macro and well as micronutrients will be affected differently as crusts develop on different substrate materials and these differences could have major impacts on revegetation progression and vegetation composition.