Some Soil Snooping: Reflections of an Unprofessional.

Conrad Vispo
Hawthorne Valley Farm
OUTLINE

1) Down the Soil History Rabbit Hole: *What have we done & what can we hope for?*

2) Comparing Soil Testing Technique: *Who’s a farmer to listen to?*

3) The Perils of Replicate Sampling: *Is one sample always enough?*

4) Introduction to the Hudson Valley Farm Hub
1) Down the Soil History Rabbit Hole: *What have we done & what can we hope for?*

2) Comparing Soil Testing Technique: *Who’s a farmer to listen to?*

3) The Perils of Replicate Sampling: *Is one sample always enough?*

4) Introduction to the Hudson Valley Farm Hub
Ours was probably a predominantly forested landscape for most of the millennia following glaciation.
Ours was probably a predominantly forested landscape for most of the millennia following glaciation.

How have our soils likely evolved since then?
Forest soils accumulate nutrients from the top down (primarily organic matter deposition) and the bottom up (mineral weathering). Farming mixes up the picture.
Three ways to look at Soil History:

• How do post-ag forests compare to ‘ancient’ forests? (Literature review)

• Compare current soil conditions of field core to hedgerow or forest.

• Look for trends over time
Why is this interesting?

• Helps us understand our impacts.
• Helps us understand what we might aim for.
People have also looked at agricultural effects by exploring the effects of land use on forest soils...
and FOREST REGROWTH
1900's to present

HISTORY – 19th & 20th Centuries

image of the Harvard Forest dioramas, from Foster & O'Keefe
# Summary of the Literature on Soil Effects of Land Use History

<table>
<thead>
<tr>
<th>Soil Trait</th>
<th>Uncleared Forest</th>
<th>Post Ag. Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>=?</td>
<td></td>
</tr>
<tr>
<td>Fungi</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

**OM:** Ca. 70% less organic carbon. However, not infrequently the reverse due to fertilization.

**Phosphorus:** Some depletion but fertilization effect also common.

**Nitrogen:** Even 50+ yrs post farming; effects on soil processes.
Taking this into the present....
You can ‘do this at home’:

How do current forest soils compare to adjacent field soils?

Or, more generally, how do soils under perennial cover compare to those under annual cultivation?
Compare field to...
Cropfield vs Forest Comparison (Farm Hub)

- % Sand
- % Silt
- % Clay
- Water Capacity
- Surf. Hard.
- Subsurf. Hard.
- Agg. Stab.
- OM
- Soil Protein
- Root Path. Pres.
- Respiration
- Active Carbon
- pH
- P
- K
- Mg
- Fe
- Mn
- Zn
- Pot Min N
- Soil Health Score
Cropfield vs Forest Comparison (Farm Hub)

The graph compares various parameters between cropfields and forests. Parameters include % Sand, % Silt, % Clay, Water Capacity, Surf. Hard., Subsurf. Hard., Agg. Stab., OM, Soil Protein, Root Path. Pres., Respiration, Active Carbon, pH, P, K, Mg, Fe, Mn, Zn, Pot Min N, and Soil Health Score. The standardized parameter values are shown on the y-axis, with cropfields represented by yellow bars and forests by green bars. The graph highlights differences in nutrient levels and soil health parameters between the two environments.
Following the consequences of cropfield conversion to perennial vegetation.
K and P depleted after veggie to pasture transition, fate of OM not so clear.
C: Fallow

A: Perennial Wildflowers (& a few grasses)

B: Perennial Grasses (& a few wildflowers)
What happens as soils revert from annual cropland to perennial vegetation?
1634: “Since the land [on a Dutch Farm in Rensselaerwyck] is overworked and poor…” - Kiliean van Rensselaer.

1774: “The soil is generally much thinner in and lighter in the Southern, than in the Northern Parts [of the Hudson Valley] and having been longer under culture and subject to bad Husbandry, is much more exhausted.” - William Tryon, Governor.

1786: “As to agriculture, they [Stockport-area Farmers] raise large crops of wheat, plowing sometimes 200 acres, using no manure, which, until of late, they rode out to the river, in the winter, so that it might go off in the spring, with the ice. The quantity of land plowed, makes up for the present poverty of the soil, which, however, after frequent plowing, becomes incapable of producing more.” – Alexander Coventry.

1813: “This [Columbia County] may confidently be pronounced one of the best farming districts in the state; though from the want of proper management, much of it now appears exhausted, and timber is very scarce.” – Horatio Spafford.
The early 1800s saw apparent declines in yields. Those farmers had strong impetus to learn more about their soils. That corresponded with the work of agricultural chemists like Davy, who suggested ways for exploring soil chemistry.
farther east, or in the western soils, while the lime is much greater. It was undoubtedly
derived partly from the Primary district, and partly from the shales and limestones of Jeff-
erson and St. Lawrence counties; from the latter of which, also, the lime must have been
derived. The primary of the district referred to embraces extensive formations of primary
limestone, many boulders of which have been found south of Rome. The granite and
gneiss belong to those varieties whose felspar contains potash.

SOILS OF THE HUDSON RIVER VALLEYS.

As a general rule, we have found only slight differences in the soils of the Mohawk and
Hudson river valleys. The alluvial flats are much the same, and so is the upland soil;
but in the last named valley the tertiary clay is more extensive, and it is not unfrequently
accompanied with its peculiar sands. In fact, on both sides of the river, from Glen's falls
to Kingston on the western side, and Sandyhill to Fishkill on the eastern side, sand, with
its clay beneath, is a strong feature in both of these long narrow belts.

Surface soil taken from the first ridge west of Coxsackie.

Just ploughed while in sward.

<table>
<thead>
<tr>
<th>Analysis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water of absorption</td>
<td>4.59</td>
</tr>
<tr>
<td>Vegetable matter</td>
<td>5.52</td>
</tr>
<tr>
<td>Silex</td>
<td>82.89</td>
</tr>
<tr>
<td>Peroxide of iron and alumina</td>
<td>6.04</td>
</tr>
<tr>
<td>Carbonate of lime</td>
<td>0.50</td>
</tr>
<tr>
<td>Magnesia</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99.69</strong></td>
</tr>
</tbody>
</table>

The Albany clay, or, as it is in other places called, Post-tertiary clay.

This clay, so far as it is regarded as a soil, may properly be considered in this place.
In connexion, we must also speak of the sands which accompany it. The whole may be
regarded as one formation. Below it is a stiff blue clay: above, by weathering, this
becomes a drab-colored clay, terminating finally in a gray or yellowish sand. The com-
position of the clay is as follows:

<table>
<thead>
<tr>
<th>Analysis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water of absorption</td>
<td>4.25</td>
</tr>
<tr>
<td>Organic matter</td>
<td>1.17</td>
</tr>
<tr>
<td>Sulphate of lime</td>
<td>1.00</td>
</tr>
<tr>
<td>Silicates</td>
<td>69.02</td>
</tr>
<tr>
<td>Peroxide of iron and alumina</td>
<td>17.24</td>
</tr>
<tr>
<td>Potash</td>
<td>0.14</td>
</tr>
<tr>
<td>Carbonate of lime</td>
<td>4.00</td>
</tr>
<tr>
<td>Magnesia</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99.82</strong></td>
</tr>
</tbody>
</table>
Gross Level Then/Now Comparisons for Organic Matter.

There are likely reasons why direct comparisons should be made with caution, but they were analyzing OM using combustion. The bottom line would seem to be that are modern farmlands may be noticeably less rich in organic matter than historical ones.

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>% Organic Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland</td>
<td>8.7</td>
</tr>
<tr>
<td>Hay/Pasture</td>
<td>5.1</td>
</tr>
<tr>
<td>Forest</td>
<td>6.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>% Organic Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland</td>
<td>ca. 4.25</td>
</tr>
<tr>
<td>Pasture</td>
<td>3.6</td>
</tr>
<tr>
<td>Hayfield</td>
<td>3.1</td>
</tr>
<tr>
<td>Forest</td>
<td>7.5</td>
</tr>
</tbody>
</table>

A possible ‘rule of thumb’ might be that we can reasonably expect many soils to hold least twice their current organic matter levels.
In converting forest to cropfield, we have apparently simultaneously depleted OM markedly and, in some cases, increased K & P substantially.

It would appear that soil life and its effects may have also been reduced, although the patterns may not yet be 100% clear (we’re looking at this more closely now).

K & P enrichment may fade relatively quickly (in 5-10 years or less) if fields are allowed to revert to perennial vegetation, OM and soil life rejuvenation may take longer.
OUTLINE

1) Down the Soil History Rabbit Hole: *What have we done & what can we hope for?*

2) Comparing Soil Testing Technique: *Who’s a farmer to listen to?*

3) The Perils of Replicate Sampling: *Is one sample always enough?*

4) Introduction to the Hudson Valley Farm Hub
How do the tests Compare?

(Shouldn’t they all say more or less the same thing?)

Cornell Soil Health Test

William A. Albrecht

Rick Haney

Solvita
Notice that these are all relatively good soils, and their spread is rather small.
Albrecht Rating and Cornell Soil Health Rating

Albrecht Score vs. Cornell Soil Health Rating

Cornell Soil Health Rating (left axis)
Albrecht Rating (avg. rating, right axis)

Scatter plot showing the relationship between Albrecht Rating (avg. rating) and Cornell Soil Health Rating.
Fungi to Bacteria (from Soil Food Web) versus Cornell Soil Health Rating

Cornell Soil Health Rating

Total Fungi/Total Bacteria

Ideal

Cornell Soil Health Rating

Total Fungi/Total Bacteria

Ideal

Cornell Soil Health Rating

Total Fungi/Total Bacteria

Ideal
For generations you have been solving for problems above ground, now with Trace Genomics, you can solve problems below ground.

Growers and their agronomists rely on soil data at every phase of the growing cycle from pre-planting to post harvest. The data serves as the missing link they need to know what to plant, how to improve soil health, which treatments to employ and much more. The complex associations taking place within the soil have been a mystery, until now.

With Trace Genomics, you reach a new level of understanding that eliminates guesswork at every phase. First, we digitalize the living soil, applying a proprietary soil DNA extraction and sequencing process to index and quantify millions of microbes in the soil. Then we decode that data, conducting high speed, cost efficient data analysis to compare against a large and growing set of soil data. Lastly, we support good decision-making by enabling data-driven, evidence-based recommendations for the best actions to take.
Differing analytical results amongst tests can be expected, although, of course, measures of the same exact parameter should more or less correspond.

However, more commonly, labs differ in what parameters they measure and value. Lack of correspondence can be disheartening and cast doubt on the whole premise of soil testing.
1) Down the Soil History Rabbit Hole: *What have we done & what can we hope for?*

2) Comparing Soil Testing Technique: *Who’s a farmer to listen to?*

3) The Perils of Replicate Sampling: *Is one sample always enough?*

4) Introduction to the Hudson Valley Farm Hub
Results from Seven Different Columbia County Farms

color indicates farm, solid symbol = hay, open = pasture.

These data are all from replicate, pooled samples analyzed by Cornell Soil Health Lab.
Results from Seven Different Columbia County Farms

Color indicates farm, solid symbol = hay, open = pasture.
Results from Seven Different Columbia County Farms

color indicates farm, solid symbol = hay, open = pasture.
Results from Seven Different Columbia County Farms

color indicates farm, solid symbol = hay, open = pasture.
Results from Seven Different Columbia County Farms.

Color indicates farm, solid symbol = hay, open = pasture.
Results from Seven Different Columbia County Farms

color indicates farm, solid symbol = hay, open = pasture.
Even when one collects pooled samples, there can still be substantial variation in results from the same management unit, even if one more or less replicates the distribution of one’s subsamples.

How many pooled samples should one really be taking if one wants to compare two fields or two points in time?

Of course, that depends on your question and how precise an answer you need.
And now, the real reason you came to this talk...

the Hudson Valley Farm Hub Soils.
OUTLINE

1) Down the Soil History Rabbit Hole: *What have we done & what can we hope for?*

2) Comparing Soil Testing Technique: *Who’s a farmer to listen to?*

3) The Perils of Replicate Sampling: *Is one sample always enough?*

4) Introduction to Hudson Valley Farm Hub soil testing
Flood-prone areas planted to low, permanent cover
Thanks to Anne Bloomfield for these maps!
You get what you test for
– In terms of the chemical tests that this farm had been managing with when under commercial sweet corn, these soils are excellent!

---

**Measured Soil Textural Class: sandy loam**

**Sand: 66% - Silt: 28% - Clay: 5%**

<table>
<thead>
<tr>
<th>Group</th>
<th>Indicator</th>
<th>Value</th>
<th>Rating</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>physical</td>
<td>Available Water Capacity</td>
<td>0.20</td>
<td>83</td>
<td>Rooting, Water Transmission</td>
</tr>
<tr>
<td>physical</td>
<td>Surface Hardness</td>
<td>252</td>
<td>15</td>
<td>Subsurface Pan/Deep Compaction, Deep Rooting, Water and Nutrient Access</td>
</tr>
<tr>
<td>physical</td>
<td>Subsurface Hardness</td>
<td>495</td>
<td>3</td>
<td>Subsurface Pan/Deep Compaction, Deep Rooting, Water and Nutrient Access</td>
</tr>
<tr>
<td>physical</td>
<td>Aggregate Stability</td>
<td>4.3</td>
<td>6</td>
<td>Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff</td>
</tr>
<tr>
<td>biological</td>
<td>Organic Matter</td>
<td>0.9</td>
<td>7</td>
<td>Nutrient and Energy Storage, Ion Exchange, C Sequestration, Water Retention</td>
</tr>
<tr>
<td>biological</td>
<td>ACE Soil Protein Index</td>
<td>2.9</td>
<td>10</td>
<td>Organic Matter Quality, Organic N Storage, N Mineralization</td>
</tr>
<tr>
<td>biological</td>
<td>Root Pathogen Pressure</td>
<td>3.5</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>biological</td>
<td>Soil Respiration</td>
<td>0.3</td>
<td>19</td>
<td>Soil Microbial Abundance and Activity</td>
</tr>
<tr>
<td>biological</td>
<td>Active Carbon</td>
<td>152</td>
<td>6</td>
<td>Energy Source for Soil Biota</td>
</tr>
<tr>
<td>chemical</td>
<td>Soil pH</td>
<td>6.5</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>chemical</td>
<td>Extractable Phosphorus</td>
<td>11.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>chemical</td>
<td>Extractable Potassium</td>
<td>122.4</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>chemical</td>
<td>Minor Elements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mg: 74.1, Fe: 1.7, Mn: 7.6, Zn: 1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Overall Quality Score: 49 / Medium**
How did the soils change between 2016 & 2018?
The plan is to repeat the soil-health mapping every three years – after 15 years or so, perhaps we’ll be able to start talking about trends!
Field vs Forest (one strawberry field at Thompson-Finch Farm)

Microbial profile from Trace Genomics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Field</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbial N activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbial P activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbial K activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labile Carbon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacterial Diversity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungal diversity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summed Path. Abund.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standardized Parameter Value

- Microbial N activity:
  - Field: ~0.6
  - Forest: ~1.4

- Microbial P activity:
  - Field: ~1.2
  - Forest: ~1.2

- Microbial K activity:
  - Field: ~0.8
  - Forest: ~1.4

- Labile Carbon:
  - Field: ~1.0
  - Forest: ~1.0

- Oxygen status:
  - Field: ~1.0
  - Forest: ~1.0

- Bacterial Diversity:
  - Field: ~1.0
  - Forest: ~1.0

- Fungal diversity:
  - Field: ~0.6
  - Forest: ~1.8

- Summed Path. Abund.:
  - Field: ~1.0
  - Forest: ~1.0