Soil as Habitat with History.

The definition of soil is a bit muddied. It is worded in different ways by different people and runs the gamut from the physical/geological definition as basically a collection of rubble at the earth's surface to the agronomist's definition of it as a matrix for plant growth. For our purposes, we'll borrow from the middle ground and define a soil as *a particular collection of sediments located at the Earth's surface and that has evolved/is evolving because of its interactions with climate and life.* This definition embodies at least two important, intrinsic properties of soil: it is dynamic (that is, it "evolves") and life is part of soil. In other words, it has a meaningful *history* and it is *habitat* for life.

This chapter is divided into two sections. The first explores the recent, post-glacial origins of our soils, and the second looks at the history of our regional soils over the last 250 years or so, both how we have manipulated them and how our conception of them has evolved.

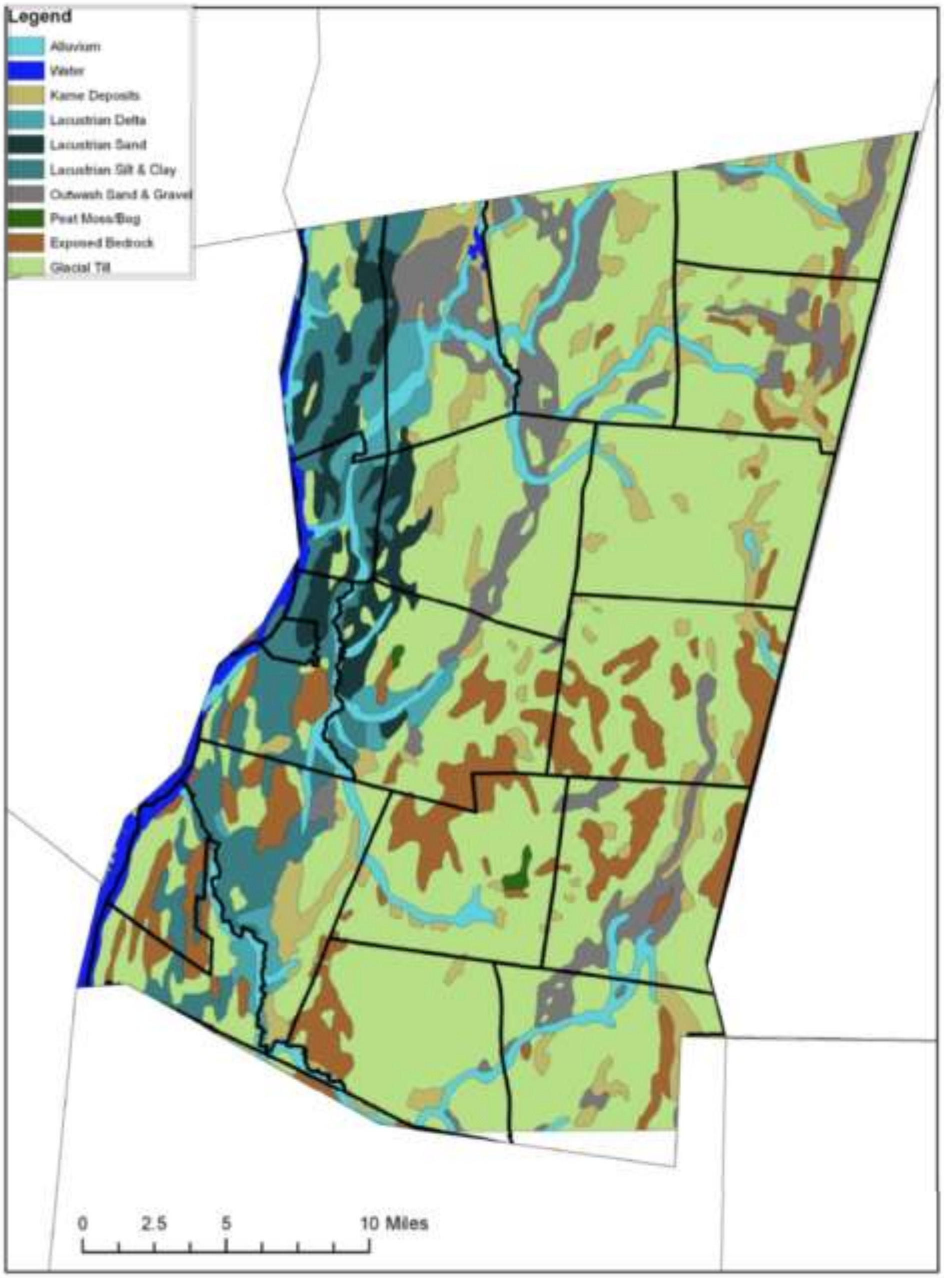
Ancient History

The history of our soils is not as 'ancient' as that of some other parts of the world, where the clock was not reset by a relatively recent period of glaciations. The surface of our land was largely scrapped clean by glaciations, but then relatively quickly 're-soiled' as glaciers melted and deposited debris and as life and weather began to convert rock to soil.

Soil time is an intermediary between the seemingly vast scale of geological time (except for some dramatic, short-term events like volcanism) and the very personal scale of biological time. To a certain degree, this is because you can think of soil as the product of rocks and life. Simple chemical and physical weathering can convert rocks to dust; but much of what makes the dust into true soil is life – the glue that sticks bits of earth together (courtesy of worms, fungi, and other organisms), much of its color (dark soil is high in 'organic matter'), a great deal of its chemistry (various microorganisms take the relatively 'inert' chemicals of the raw soil and convert them to forms that are accessible to plants and hence animals), and even the earthy smell (courtesy of a certain group of bacteria).

The basic post-glacial starting point of our soils can be understood with the help of what is called a 'surficial geology' map. Such a map shows neither the bedrock of a conventional geological map nor the precise earth types of a soil map. Instead, it shows you a bit of the history of the soil's *prima materia*. For example, in the associated map, most of the landscape is the pea-soup green which indicates "glacial till". Glacial till is the ice-swallowed soil of the pre-glacial landscape, together with ground bedrock. It is the material that a healthy glacier picked up during its life, and that was then deposited directly onto the land surface as the ice melted. Sometimes, this till was apparently shaped into long 'slugs' by the overlying ice and formed structures known as drumlins. Some of the clearest examples of drumlins in the county are east of Valatie. In the hillier eastern part of the County, exposed bedrock pokes up through the till carpet; except on the steepest slopes, these lands do have soil but it formed from post-glacial action on the bedrock without any contribution from a deposit of till.

SURFICIAL GEOLOGY

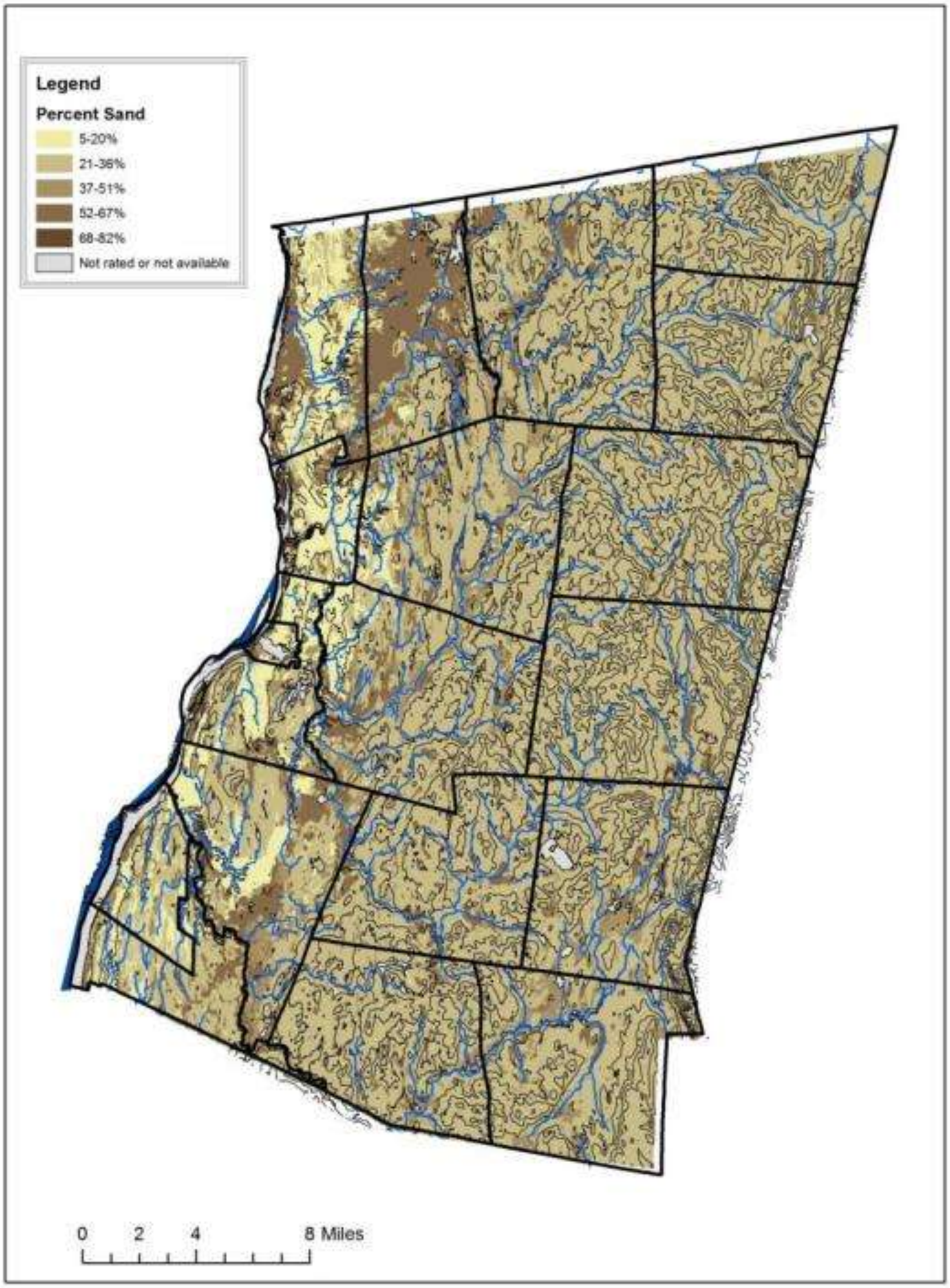


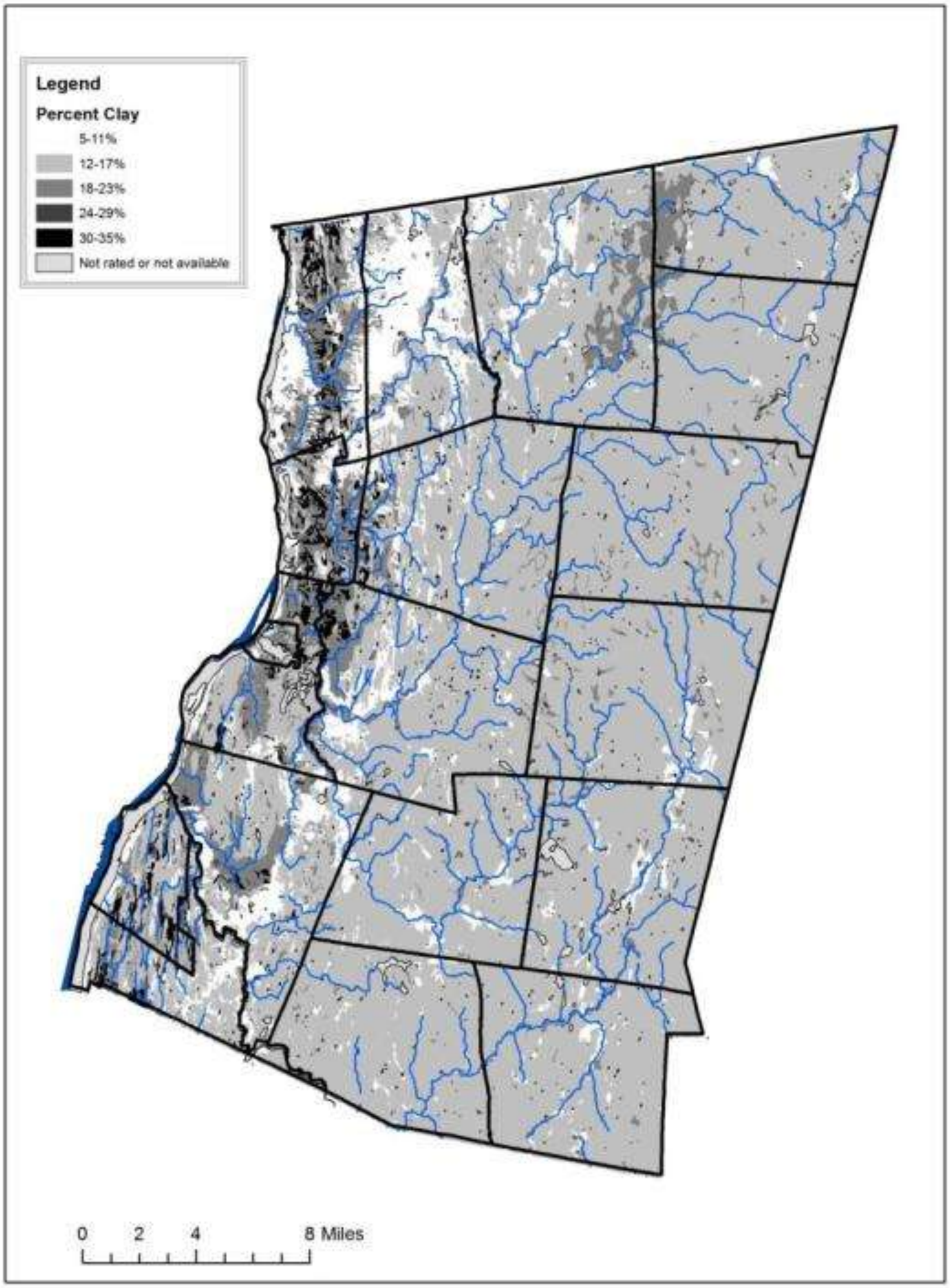
The other basic type of parent material, in addition to glacier-deposited material, is that which was processed and distributed by the action of water either as the glaciers melted or since then. It can be much the same material as till, but it has been carried and sorted by water. Picture the small fans of mud or sand that may, for example, be left behind when mud puddles dry. Those materials were transported to that spot by water and the texture of any particular part of the fan will have been determined by not only by the texture of the material the water picked up but also by the force of the water at any particular spot. Coarse material settles out of water sooner (i.e., at a higher water velocity) than finer materials. This differentiation in texture due to differences in water speed produces ‘sorting’. In the surficial geology map, the water-borne soil starters are indicated in tan, grey and shades of blue. Some were apparently deposited by glacial meltwater ponds and streams; those along the Hudson were left on the shores of Glacial Lake Albany, a late glacial lake that occupied much of the Hudson Valley. Not all of these materials are of glacial age – anybody who lives along an existing stream knows that modern floods can deposit layers of new soil.

Implicit in the above descriptions of soil formation is the definition of soil that was given in the first paragraph. Under that definition, dust, dirt or debris is not soil until it has settled somewhere long enough to begin taking on a particular 'personality' due to its interaction with weathering and biology. Thus, bedrock that has been freshly broken up and ground by a glacier is not a soil until it has been deposited and begun to evolve *in situ*. Likewise, for our purposes, old soil that a glacier picks up, effectively sterilizes, washes and remixes is not soil again until it is laid down and begins to evolve a particular character beyond just its geological ingredients. Put another way, soil doesn't exist without place, time and life.

The Ramifications of Ancient History

The processes associated with the glacial facelift help us understand our soils in at least two ways. First, as alluded to in the mud puddle analogy, how a soil was laid down influences its texture. The maps of soil texture make clear some of the sorting that was caused by water. While the glacial till soils tend to be mixtures of clay, silt, and sand, soils deposited by water are more frequently dominated by clay or sand. Picture a drying mud puddle and a little rill that ran out of it. Kneeling down to inspect it more closely, you'd find portions of relatively fine materials (where standing water evaporated leaving behind the fine solids that had been in suspension) together with coarser grained areas, where heavier materials were dropped as water speed slowed and yet was still fast enough to carry finer particles away. Our primary clay and sand deposits (needless to say, they don't directly overlap) are in the western parts of the County, where the shores of Glacial Lake Albany left sandy beaches in some cases and clayey deposits in others.


Legend
Percent Sand
5-20%
21-36%
37-51%
52-67%
68-82%
Not rated or not available
0
2
4
8 Miles



The second consequence of the above-described scenario is that bedrock composition influences the chemistry of the overlying soils. This is true for at least two reasons: 1) because much of the material ground off the bedrock was not carried far from its source and so the composition of the till is often similar to that of the bedrock, and 2) because the formation of soil parent material from bedrock didn't stop with the retreat of the glaciers, although it may have slowed.

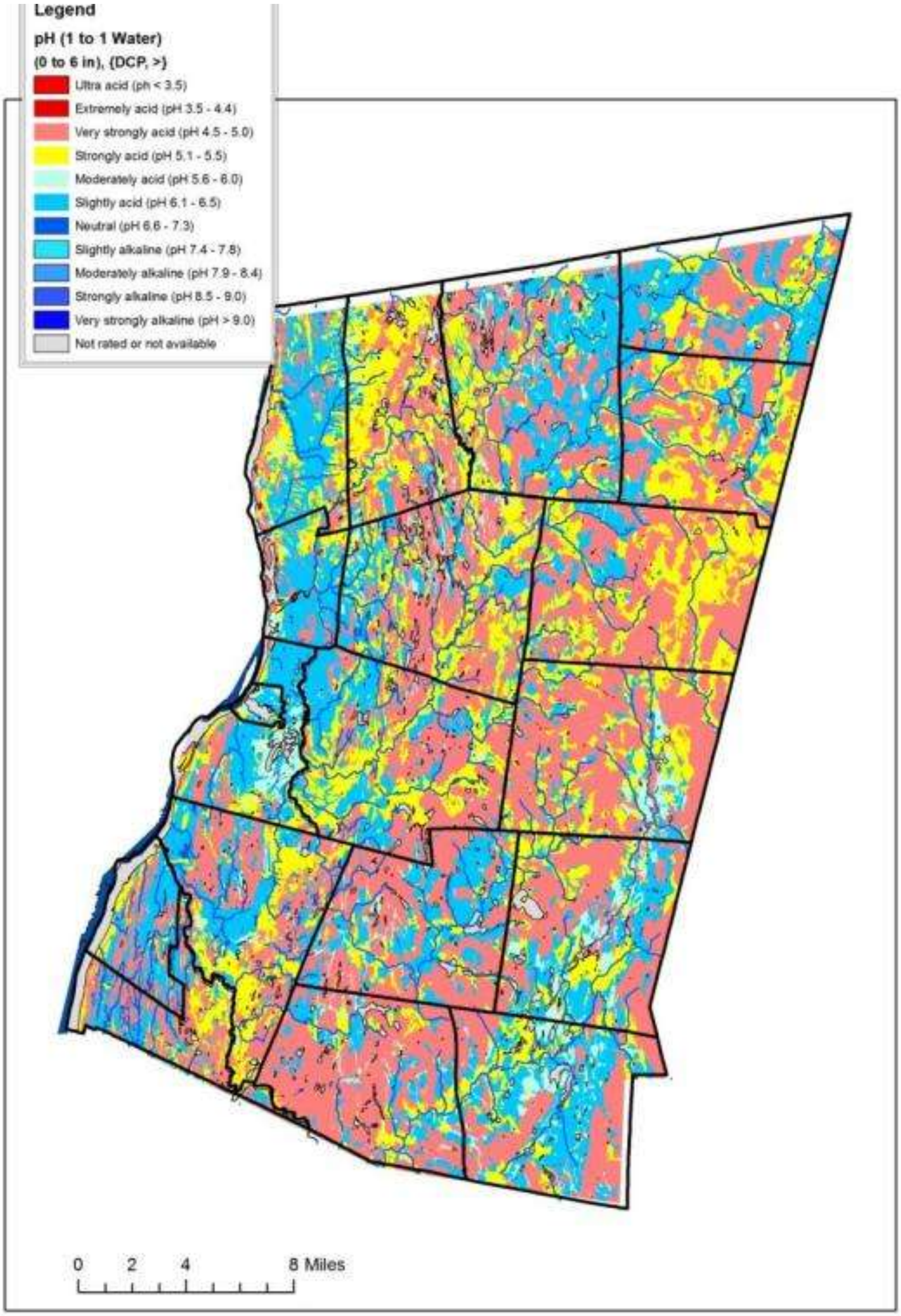
The variation in soil texture and chemistry resulting from varied starting points has had profound importance for plant species and, less directly perhaps, for animals.

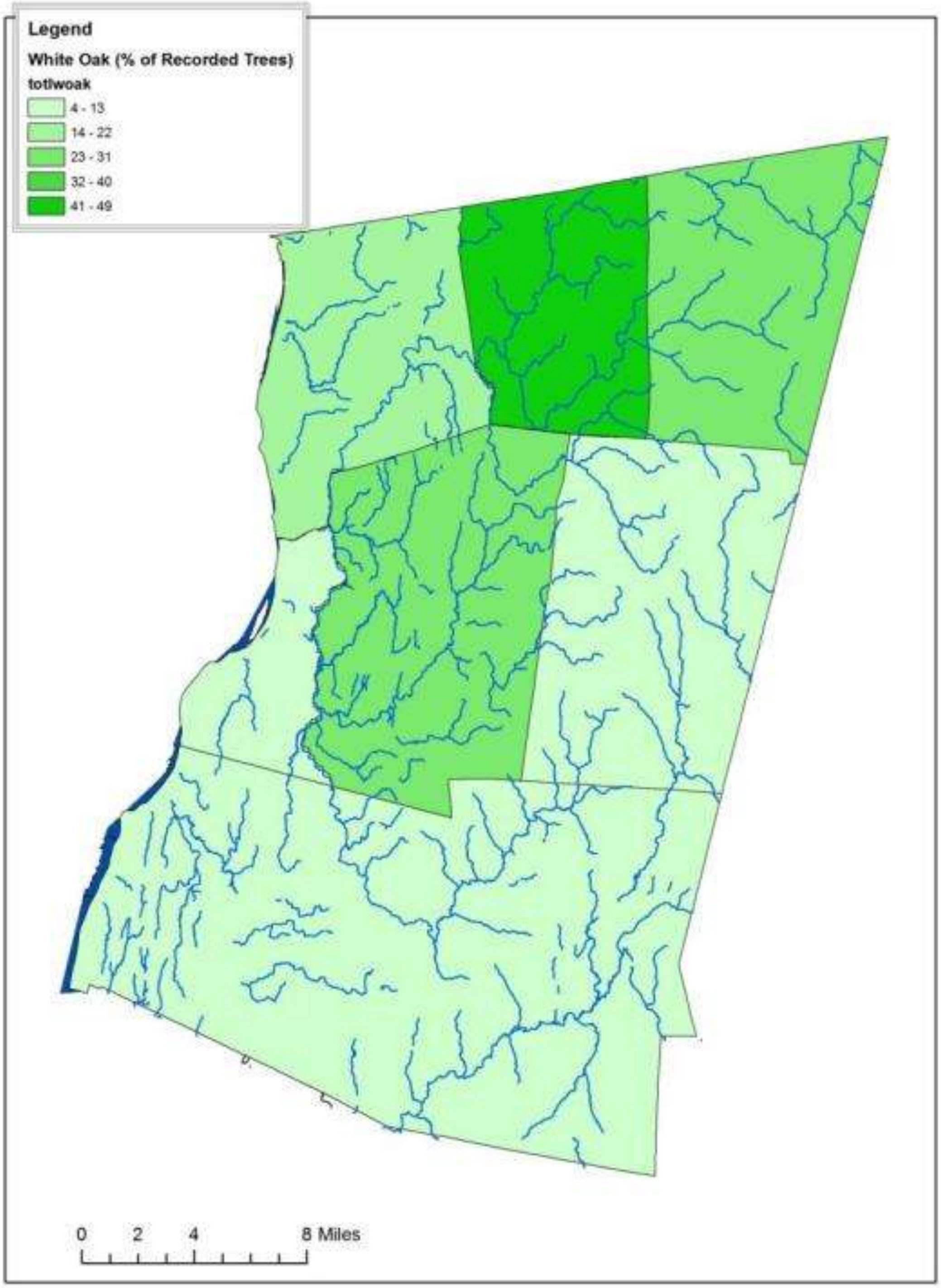
Soil texture affects drainage, with sands tending to drain easily and clay tending to block water movement. In addition, because of their chemical and physical structure, most clays have a relatively high 'cation exchange capacity' or CEC. Basically, the higher this capacity, the more plants nutrients can be held in the soil, and, under the right conditions, made available to the plants themselves. The ideal soil texture for farming will depend on the crops and technique, however in general a relatively mixed soil possessing ample but not dominating amounts of sand and clay (together with silt) is considered best. Such soils are termed 'loams'. Organic matter, which can also serve as a nutrient sponge, can help ameliorate the nutrient-leaking tendencies of sandier soils. One of the clearest examples of soil-texture's effect on our local vegetation was the Kinderhook Pine Plains. Pines (probably both Pitch Pine and White Pine) occurred on the sand plains north of Kinderhook. Descriptions from the early deeds and travel account refer to the "Pine Woods" in this area – a small, local version of the Albany Pine Bush. They have since largely disappeared due to agricultural clearing and residential development.

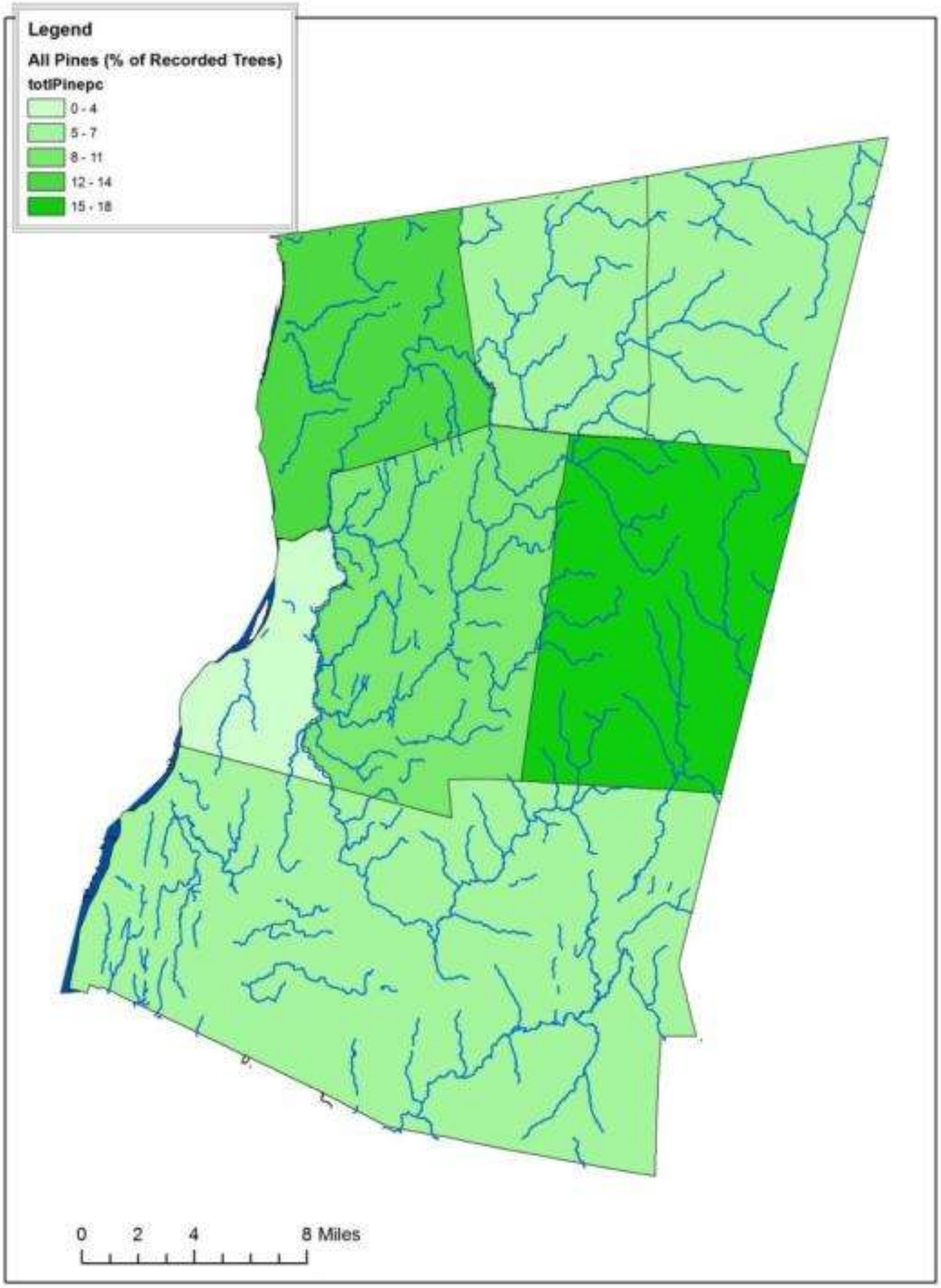
Soil chemistry is complex. Aside from the components of the air and water trapped in the ground, the most common ingredients of soil include iron, silica, aluminum, potassium, and calcium. Various other nutrients and micronutrients are usually also present. Almost all of these elements and related compounds can influence plant growth, because they are, to greater or lesser degrees, required by life. Locally, the clearest example of soil 'parent' chemistry influencing soil suitability is that of the relation between limestone and soil pH. While most of us realize that extreme soil pHs can directly damage plants and associated soil microbes, most of the interaction of plant health and soil pH is probably due to the fact that soil pH has a profound effect on the solubility of soil minerals. Within the limits of common soil pHs, most nutrients become more available to plants as soil pH rises. Limestone serves to raise soil pH (reduce its acidity) and so increase the availability of soil nutrients. For this reason, farmers will lime their fields if pH is low, and limestone-derived soils tend to have a surprising diversity of wild plants.

The most direct representation of soil quality for plant growth, at least in terms of crop plants, is the map of prime farmland produced by the USDA. "Prime" is defined relative to conventional farming of the 20th century, but at least represents soil quality from that perspective. "Prime soils" tend to be loams located on the County's well-drained flatlands (Fig.). Proximity to limestone bedrock is a plus.

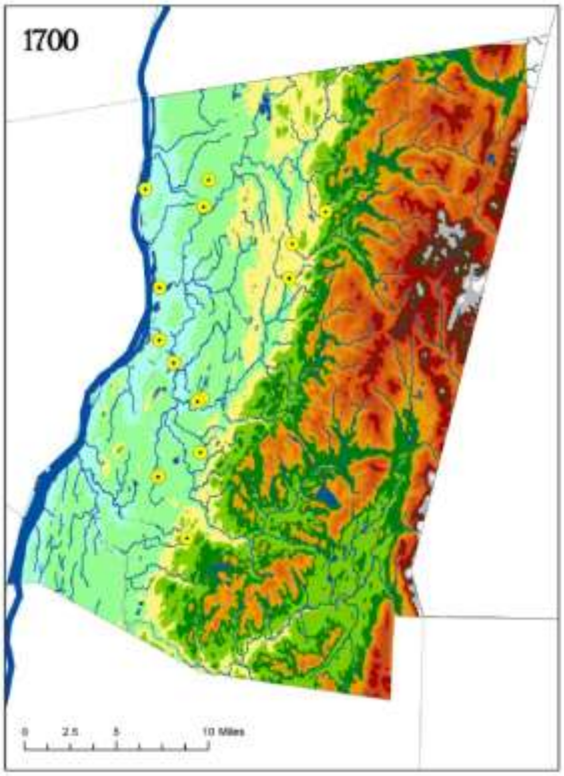
The interaction between soil conditions and animal life is more subtle. Soil texture influences the distribution of burrowing organisms. For example, certain native bees make their solitary nests in holes which they dig in the ground. The easiest soils for them to dig into are sandy ones. One April afternoon, we watched a swarm of busy bees burrowing into a sandy bank of Kinderhook Creek, just west of Valatie. Tiger Beetles prowled nearby, probably searching for the ants which also favor such soils. Soil chemistry affects animal nutrition. Mineral licks are better known in the West than in the Northeast. Deer, Caribou, Elk and other ungulates come to such spots in search of the salts demanded by their bodies. Various studies have, for example, found correlations between deer antler weights and calcium concentrations of the soil. Alexander Coventry, an 18th century Columbia County whose diary we'll shortly explore in more detail, reported a mud spot where passenger pigeons congregated. Snails and millipedes, which bioaccumulate calcium, tend to be most common on limestone soils. We found startling numbers of large millipedes on a limestone slope above Shaker Swamp.

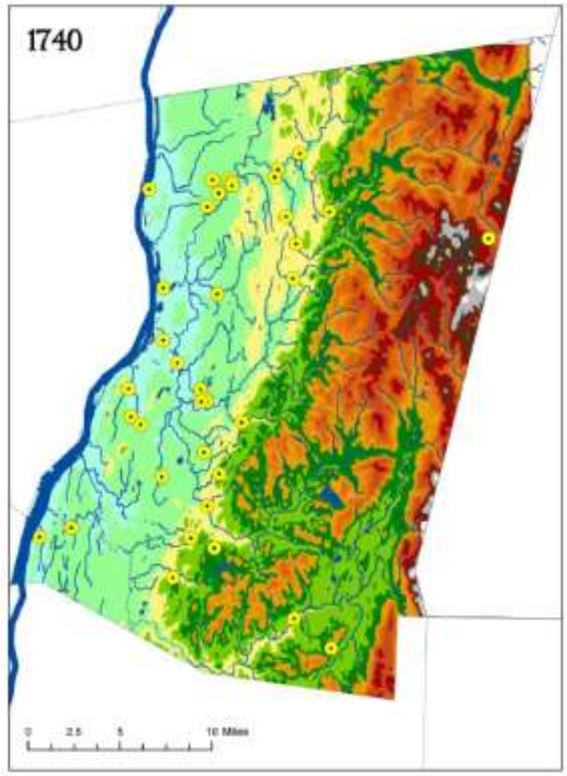

Legend
pH (1 to 1 Water)
(0 to 6 in), {DCP, >}
Ultra acid (ph < 3.5)
Extremely acid (pH 3.5 - 4.4)
Very strongly acid (pH 4.5 - 5.0)
Strongly acid (pH 5.1 - 5.5)
Moderately acid (pH 5.6 - 6.0)
Slightly acid (pH 6.1 - 6.5)
Neutral (pH 6.6 - 7.3)
Slightly alkaline (pH 7.4 - 7.8)
Moderately alkaline (pH 7.9 - 8.4)
Strongly alkaline (pH 8.5 - 9.0)
Very strongly alkaline (pH > 9.0)
Not rated or not available
0 2 4 8 Miles


Legend
White Oak (% of Recorded Trees)
totlwoak
4 - 13
14 - 22
23 - 31
32 - 40
41 - 49
0 2 4 8 Miles

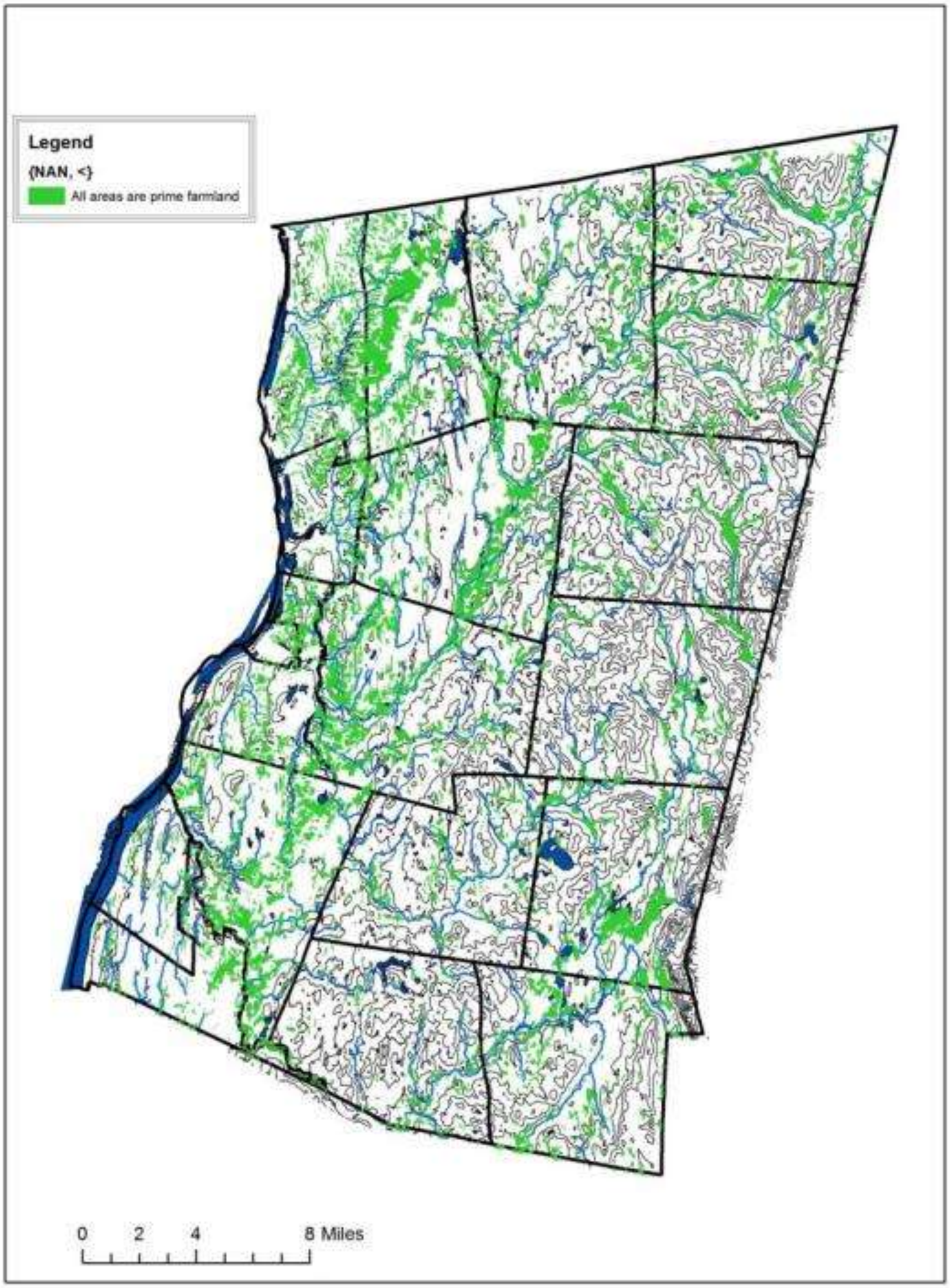


Pines occurred in two main regions of our early forests: around Kinderhook and in the east central highlands. The eastern pines were probably mainly White Pines scattered through deciduous forest. The Kinderhook pines were probably largely localized on sand plains north of Kinderhook.





Europeans first settled the good farming soils of the Hudson Valley portion of the County. Settlement of the prime soils of the Harlem Valley (southeast corner of the County) was probably discouraged by the fact that distance and surrounding hills made transport and agricultural commerce difficult prior to the arrival of the railroad.



Recent Soil History: Asking the Soil to Work for Us.

The General Interaction of Farming and Soil

When humans conceived of agriculture it was a momentous occasion (or set of occasions, because agriculture appears to have evolved independently in various lands), not just for humans but for soil organisms. Farming profoundly changes the ecology of the worked soils, and its expansion and intensification in Columbia County, especially after European settlement, likely signified the most dramatic alterations to our soils since the glaciers. In this section, we sketch the last 500 or so years of soil history in the County, highlighting four periods: shortly before European settlement, the Dutch period, the mid to late 18th century, and the 19th and 20th centuries combined. These sections are unequal in length and, due to the historical resources available, in approach. Taken together they provide a sketch of regional human interactions with the soil over the past 500 years.

Other human activities such as industry and residential development influence soils, but agriculture has had the most extensive impact in our county, and so we focus on it here. In considering how agriculture and soil history intertwined in the County, it is useful to first consider the various general ways such interactions might occur.

<u>Physical Consequences of Opening the Land</u>: Removing the forest cover from a previously forested patch of land causes marked changes in the temperature of the soil and, depending upon how that cover is removed, in the susceptibility of the exposed soil to erosion. The surface soil of open lands tends to experience more temperature extremes than that of soil beneath a forest: the cold winter nights are colder, the hot summer days hotter. One of the consequences, as pointed out by Robert Thorson, is that such soils experience more dynamic freeze/thaw fluctuations and, as a result, fields 'grow stones' as these cycles push up loose rocks.

<u>Changes in Vegetation</u>: Clearing of forest and conversion to agriculture removes certain kinds of plants and replaces them with others. This has profound physical and biological consequences. Living trees, for example, are thirsty organisms that absorb much of the water in the soil. Remove them and more of the rainwater may run-off or drain into aquifers. In addition, soil biologists are just beginning to understand the intricate interactions between plant and soil life. Different plant species, be they wild or cultivated, exude different compounds into the soils and suck different nutrients from it. Not coincidentally, the leaves of those different plants contain different nutrients and protective compounds which, in turn, make them more or less nutritious and tasty for soil critters once they fall to the ground. Each plant species, if not each individual, thus develops a set of unique ecological relationships with underground organisms. Changing the above-ground plant life changes those underground communities; those changes, in turn, affect many of the soil's biological processes; and finally, changes in the soil influence what plants can live in it. If this seems circular, that's because it is.

<u>Disturbance Depth and Intensity</u>: The consequences of hurricanes, forest cuts, and other physical disturbances for above-ground plant and animal communities are dramatic. In many ways, ploughing and soil cultivation are analogous disruptions for the soil communities – spatial relationships among organisms are mixed and individuals are damaged. The effects of ploughing may be especially profound for fungi because it breaks up their physical network of hyphae. As a web-like organism, fungi are more sensitive to physical disturbance than bacteria or other small unicellular animals, most of which may get tossed about but not physically broken by such activities.

<u>Direct Alteration of Chemical Conditions:</u> Fertilization, liming, and the additions of other soil amendments directly change the environment of the soil. They may provide food to some organisms (for example, through the introduction of compost), they may alter soil acidity (which, in turn, has major effects on the nutrients available in solution, possibly through effects on soil life); and they may change the physical structure of the soil (for example, through the introduction of coarse organic matter or even soils of distinct textures).

<u>Direct Introductions of Soil Life:</u> Just as invasive plants or animals occasionally arrive to above ground habitats and alter the ecology of those habitats, novel species can likewise arrive to the below-ground realm where they can, similarly, modify communities. Exotic earthworms are a dramatic and familiar example. It is thought that, prior to colonist arrival,

earthworms were essentially absent from glaciated portions of North America [REF]. Their introduction and spread is thought to be having profound effects on forest soil nutrient cycling in the Northeast [REF]. In an act akin to the re-introduction of the Turkey or to fish stocking, native soil life can be re-introduced or bolstered through the direct 'injection' of soil life booster shots (using, for example, compost teas or inoculations with mycorrhizal fungi). The effectiveness of such introductions, from an agricultural perspective, is debated. Ref to Peteet

Poisoning: Agrochemicals not only affect plants or target pests, they can have wider ramifications. Applying fungicides to a crop can, for example, affect beneficial soil fungi. Sometimes the relationships are less obvious: animal de-wormers can affect not only intestinal worms but also naturally-occurring nematodes in the soil. Finally, 'one person's panacea is another person's poison': certain chemicals, such as the fertilizer nitrous ammonia, which can help boost plant growth may, in the concentrations initially applied to the soil, be a poisonous to certain soil organisms

We can't precisely trace each of these classes of potential impacts through time, but they provide a useful backdrop to our historical narrative.

Be forewarned: much soil ecology work on modern soils is speculative; *historical* soil ecology work is doubly speculative!

Late Pre-Colonial Period

Agriculture did not arrive with the Europeans. Perhaps as long as 1500 years ago, indigenous people began cultivation in the Hudson Valley [REF]. Relative to later colonial agriculture, this farming was apparently limited in its extent, its duration in any one place, and its intensity. It probably arrived gradually. Prior to working cultivated fields, Native Americans were likely enhancing populations of favored wild plants, including nut-bearing and fruit-bearing trees, through scattered plantings and certain land management practices such as selective clearing or burning. Some suggest [REF], for example, that the northward extensions of Chestnut and Hickories into the Lake Champlain Valley were the result of their introductions by humans.

In contrast to the large Iroquoian fields farther west, indigenous agricultural clearings in much of southern New England and in our region were probably relatively small (ca. 2.5 - 5 acres? [Thomas 1979]), in part because good land was patchy. It seems reasonable to assume that the majority of indigenous farming was in the western half of the County, where flat land was more common and where the growing season was longer. It has been estimated that Native American corn cultivation was most reliable where a growing season exceeding 180 days could be counted upon [Donahue]. Currently, western Columbia County seems well within this zone, but growing seasons in the eastern hills appear to be a week or two less than that limit. Native American corn growing may not have been as reliable in such regions.

Pre-colonial indigenous population estimates are a controversial topic amongst anthropologists and archaeologists, perhaps because they can have a large impact on how we envision that early landscape. Was it wilderness? Was it farmland? We have no direct censuses of indigenous populations in Columbia County at the time of European arrival or earlier. Tragically, fatal smallpox epidemics swept through the Connecticut and Hudson River Valleys in the early 1630s; and all later Native American population estimates are of much reduced populations. Several different modern approaches to estimating Columbia County indigenous populations just prior to the arrival of the Dutch would suggest populations on the order of 1000-4000 in the County [Thomas, Snow, Dunn].

However, one historical document from just north of Columbia County is intriguing. It comes from the papers of Kiliaen van Rensselaer (ca 1590 – 1640), first patroon of Rensselaerwyck. He was an absentee landlord and never visited his manor, however the details in his documents were presumably supplied by his employees working along the Hudson.

In a 1634 report to the government in Amsterdam, he refers to lands located just north and northwest of Columbia County and states,

So that the territory of the Mahikans, who in their time were over 1,600 strong, has all together over 200 morgens of cleared land and far more than 16,000 morgens of mountain and valley, forest and marsh, with all kinds of game and fowl, the 1,200 cleared morgens being not only fat, clayey soil of itself but yearly enriched by the overflow of high water there when the ice breaks and jams.

These numbers would suggest a density of at least 1,600 people on about 36,000 acres, or a density of around .04 persons per acre. The description also suggests a landscape that was about 7% opened land, located mainly on the floodplains of, in this case at least, the Hudson River. Subsequent portions of the document strongly imply that those 1,200 acres of cleared land were primarily the work of the Indians; Dutch farms in the area were few and small.

If we take these densities and land use ratios and apply them to the western, Hudson-Valley portion of Columbia County where the climate for corn-growing was best, we can estimate a Mahican population of slightly more than 9,000 people (about 1/7th of the current population of the County) and around 14,000 acres of cleared land. Fourteen thousand acres would represent only around 3% of the County's total area, but nearly half of its floodplains (Knab-Vispo & Vispo).

There are numerous questions and assumptions in these calculations, such as, does "1600 strong" refer to the total population or to men only? If this was a tally of men only, then actual densities and hence total populations would have been more than three times higher.

And, what do we make of "far more than 16,000 morgens" (one colonial Dutch morgen equals about 2.1 acres)? Is it correct to apply densities and land characteristics from the banks of the Hudson to regions farther inland? We may never know the answers to these questions, however such calculations indicate that, given the existing data, one can quickly estimate relatively large indigenous populations and appreciable opening of the land.

Most if not all indigenous agriculture in the County was probably focused on 'flats' and 'intervales' [Dunn]. These were meadows near streams, lakes, river beds or other wetlands. Many modern corn fields are still located in such areas. Most of the earliest colonial farms were on these former indigenous agricultural lands. Local deeds describing land purchases from the Indians often refer to the purchase of meadows and flats, and early accounts explicitly refer to colonist agriculture on former Indian fields. These lands may not have been flooded seasonally (that could make farming awkward), but rather at longer intervals. Because the land was not turned extensively and much of the surface was left intact, those floods that did reach cropland may have caused minimal erosion and crop washout. Furthermore, as long as the floods didn't scour the land, they tended to replenish fields by depositing a layer of new soil.

One can probably envision Native American cultivation during the centuries immediately preceding European colonization as a series of relatively small openings fading on and off in the flatlands adjacent to our waters. Viewed over decades, these openings grew from weedy fields into brush and then young forest before again being opened for farming and a repeat of the cycle. Additional lands would have been influenced by the constructions of settlements themselves and, probably in decreasing zones of influence radiating from those settlements, other lands would have been influenced by hunting and the gathering of foods and of 'natural hardware supplies (e.g., rushes for mats, poles for construction, trunks for canoes, etc). Intentionally or not, fires apparently sometimes spread from the managed areas around villages into adjacent forests. Such fires were probably most common and extensive on the drier, sandier soils (van der Donck).

Goodhuys gerhing trans reference

The Mahicans apparently opened their garden plots by killing trees with girdling and fire. Crops were first planted while the dead trees were still standing. As trunks and branches fell, they were burnt (Hendrick Aupomok;van der Donck). The resulting fields were worked without a plough. Technically, corn, at the least, (Mt Pleasant CHECKED) was planted into shallow holes which, over several years of repeat planting, may have grown into small mounds as soil and weeds were piled up (van der Donck). It does not appear that there was extensive turning of the soil. Beds were weeded to some extent, probably by pulling or by bone-blade hoeing, but, by colonial European standards (Van der Donck), weeding was not intensive. Based on pollen records and archeological descriptions, common garden/edge weeds during this period in our region included Amaranth (*Amaranthus*), Giant Ragweed (*Ambrosia*), Goosefoot (*Chenopodium*), Tick-Treefoils (*Desmodium*), Smartweeds (*Polygonum* spp), Wild Sunflowers (*Helianthus* sp), Brambles (*Rubus* spp.), Ragweeds (*Ambrosia*) and various grasses [Asch Sidell, Petit] . At least some of these, such as the *Chenopodium* and *Rubus*, may well have been eaten too, and the division between crop and weed is fuzzy.

Squashes, beans and corn were apparently the main cultivated crops, although, as mentioned, numerous wild species may have been encouraged. Squashes seem to have arrived about 3000 years ago, corn is first recorded from the Hudson Valley about 1000 years ago, and beans show up about 700 years ago [Hart]. In the archeological record, co-occurrence of the classical "three sisters" in the Northeast is only known from about 550 to 675 years ago, only a couple of centuries prior to European arrival. Even then, it is not clear if they were initially planted together or simply were brought to a common hearth from separate locations. However, by the mid 17th century when van der Donck was writing, at least some Native Americans in the Hudson Valley were multicropping. There were good agronomic and dietary reasons for doing so, including the structure that corn provided for squash and bean vines, the nitrogen fixation accomplished by the beans, and the protein and carbohydrates the foods provided. [Hall; RICHTER facing East].

There is little evidence that local indigenous people used fertilizers other than wood ash and perhaps mulching with pulled weeds. The widely-cited indigenous use of fish as fertilizer may be a myth (Ceci). I've found no reports of *terra preta* soils in the Northeast . '*Terra preta'* are dark, carbon rich soils first identified along the Amazon. They apparently are human-made, although there is still debate as to whether or not they were intentionally created. Their abundant carbon compounds help store nutrients and so can make them particularly good farm soils. "Biochar" is, essentially, a modern attempt to recreate such soils. The absence of *terra preta* may in part be due to extensive post-indigenous cultivation, together with the relatively short duration of pre-colonial agricultural villages in the Northeast. There may have been at least 'incidental' fertilization around settlements as a result of a localized concentration of human food refuse and 'manure'. Native Americans in the Northeast did not have livestock prior to contact with Europeans, and so animal dung was not available.

Land was probably revitalized largely through fallows that let wild vegetation return to abandoned fields. Some of the plants that grew naturally in such overgrown fields may have been harvested in their own right. Pokeweed, for example, was both a natural weed of such fields and a valuable medicine (Sauer; Loskiel). Over time, the wild plants could restore many of the nutrients that crops removed. As already mentioned, beans themselves probably had a restorative effect on soils because, with the help of some microbial assistants, they are able to take nitrogen from the air and return it to a plant-accessible form in the soil.

Pesticides or herbicides were rare or absent. There are scattered reports of northeastern Indians using "corn medicine" and similar herbal seed soaks as a way to deter pests, especially birds. Elder, Hellebore, and Common Reed were among the plants used in these prepartions [Starna]. The apparently localized application of such 'medicines' and their organic nature would suggest that they had minimal ecological effects in time and space. It seems very unlikely that any living soil amendments, other than the introduction of new crops, were used. [insert early map with pictures of indigenous villages]

In sum, indigenous farming in our area was not without impacts on the soil – no agriculture can be – but it may have left substantial parts of the soil life intact because it was limited in both extent and intensity. Changes in temperature and humidity due to exposure of the ground probably resulted in direct changes in soil life and resultant biochemical processes; likewise, changes in the plant cover and associated root exudates and leaf litter no doubt also altered soil chemistry. Ecologically, at least some of the soil and ground-surface life that occurred in native agricultural openings was probably the same as what took advantage of natural openings in the forest, such as might be created by fire, windfall or flooding. In some ways, indigenous agricultural openings, with their crop/fallow cycles, simulated such events. Such similarity was enhanced by the apparent absence of significant external soil additives such as fertilizers or pesticides/herbicides. Without the ubiquitous non-native plants and invertebrates that now characterize much disturbed lands (most of our so-called weeds are European plants that arrived with the colonists), if we were to travel back in time and root around in an Indian vegetable plot, we would likely find many organisms typical of natural forest openings. Even today, a subset of the wild plants and animals found in gardens and farm fields are native species typical of natural disturbances.

The First Colonial Farmers: The Dutch

In some ways, writing about the impacts of Native American farming on soils is easy – there are so few real data points that one can easily craft a story that fits with what little we know. As we enter the period of colonization and move towards the present however, the data points become more numerous and, in some ways, more confounding.

We won't try to present a complete agricultural history of our county, instead, for this next period, we will take a view that is both more specific and more general. More specific in that we will retain our focus on the changing soil habitat, giving relatively short shrift to the larger context; more general in that a focus on soils requires us to include areas outside of the County in order to find applicable data.

We are entering the realm of measurements, however sketchy. There are direct measurements of crop yield (that is, the amount of crop produced per unit area), and there are even the beginnings of soil chemistry analyses. This will provide some of those informative yet puzzling data points mentioned above. However, there is also retrospective soil analysis. The soil impacts of farming from 100 or more years ago may still be measurable in the soils today, and so modern soil analyses can provide historical insights.

However, despite the presence of actual soil and yield information, 'circumstantial evidence' will still be a large part of our soil detective work. How was the soil managed, and so what probably happened to it?

Words with Figures

We have recorded words now – the accounts left behind by witnesses to the 17th, 18th and 19th centuries along the Hudson Valley. These words, in addition to a scattered few paintings and drawings, are the closest we get to snap shots of northeastern farming during this era. So, we'll let those who were actually there speak for themselves when possible.

Descriptive writers never make up more than a small percentage of any population and so, not surprisingly, in the early days of European settlement, when total colonists were relatively few, authors were scarce indeed. Aside from a limited pool, even those who did write often had 'ulterior motives'. Many early accounts of colonial agriculture and soils were written with the purpose of attracting companions or new settlers, rather than of providing objective descriptions; their accounts thus need to be taken with a grain of salt.

One of the most descriptive early witnesses to the Hudson Valley was Adriaen van der Donck. In 1641, he first came to the "New World" as the 21-year old legal assistant (some translations say lawyer, others 'sheriff') to Kiliaen van Rensselaer – that 'stay-at-home' Dutch lord of the Rensselaer Manor who was quoted earlier. Van der Donck retained his post, based in Albany, for four years before his broad interests and connections with the Native Americans apparently brought him into conflict with van Rensselaer. He soon moved south to what was then "New Amsterdam", where he helped negotiate a peace with the Indians and continued to develop his own political ideas and aspirations. He made proposals for the proper running of the Colony, specifically suggesting more local autonomy and an end to the Dutch West Indies Company's governing role. Not surprisingly, the then-governor of the Colony, who had been hand-picked by the Dutch West Indies Company, disagreed with his ideas. In an attempt to plead his case, van der Donck and two other members of his group went to the Netherlands in 1649. His pleas were initially accepted but then war broke out in Europe, delaying his return and leading the Dutch Government to revoke their decision in his favor. He was allowed to return to New Netherlands in 1653, after promising to retire from politics. He apparently died less than two years later at the age of 35.

His descriptions of the Hudson Valley were written in the early 1650s as part of his efforts to convince the Dutch Government that the New Netherlands Colony had a *raison d'etre* aside from that of being a business venture of the Dutch West Indies Company. As such, his words were meant to paint the picture of land that would be welcoming to yeoman settlers. Despite his apparent political aspirations, there is no doubt that he was intimately familiar with the land and peoples he described. A careful re-translation of his work was recently published, CITE, and the quotes below come from that work. Van der Donck was also the central figure in the popular book *Island at the Center of the World*.

Early in his description, van der Donck summarizes his case for settlement in the Hudson Valley, "*This river system and the many rich, fertile fields served by it are well suited for establishing sizable settlements, villages, and towns. … it would be sad to see such a gem stripped from our hands by foreigners."* Van der Donck feared that mis-rule would discourage Dutch settlement, weaken the Colony, and so open it to other powers. About 10 years after his death, New Netherlands was indeed ceded to the English.

He continues,

> Farther inland [i.e., away from the mouth of the Hudson] as in the colony of Rensselaerswijck….low-lying land may be flooded once or twice a year…but to those who prepare and provide for it this causes no damage. Sometimes a little stand of corn here and there is washed away, though the silt left behind as good as manures the land. …[aside from some mountains] there are also so many beautiful flats with meadows and pastures of great length and breadth… The soil normally consists of black earth mixed with clay down to about a foot or a foot and a half, and sometimes a bit more or less – but this is the way it commonly occurs… Amid the mountains [which he describes as tree-covered]…and by the rivers and shores, lie great and wide plains measuring hundreds, even thousands of morgens, which are very suitable for establishing villages, settlements, farms, and plantations… For summer crops, one plowing is enough, and if a winter crop of rye or wheat is to be sown next, the stubble is plowed under and the seed is sown right in… I can say that in the nine years or so I lived in that country, I never saw the land being fertilized; it is certainly seldom done. Soil quality is maintained more often by leaving land fallow… People whom I regard as quite competent sow their land with peas when it becomes weedy and they reckon it needs to be rested, because this is said to make the soil soft, rich, and clean… While it [corn and beans] is growing, two weedings are enough. Nor is the weeding very hard work, for the soil is not turned but merely cleared of weeds on top with a broad mattock. The first time, the weeds are piled up between the rows; the second time is easier as only the new growth is killed and the first lot is raked into small heaps around the cornstalks.

After recounting the stories of farmers who harvested crops from a single field for 11 years or who grew barley higher than men's heads, he concludes, "Therefore all expert interested persons judge that New Netherland is as fertile and fit for growing all kinds of grain as any part of the world thus far known to or possessed by Netherlanders."

Although these comments are not particularly detailed, they present an image of an agriculture with similarities to both the Native American agriculture that it rubbed shoulders with and eventually supplanted, and to the developing "alternative" agriculture of Europe. The results for the soils may have been, in some ways, the worst of both worlds.

Like the Indians, the first settlers were facing the clearing of forestland (even if that forest were only recent regrowth on former Native American fields), but theirs was an agriculture that soon aspired to more permanence than the rotations of Native American farming. Like the Indians (and probably in part because of the Indians), most Dutch colonists settled the intervales and flats first. Evidently, they tolerated periodic floods as nutrient-bearing events. Unlike Native Americans however these early settlers had livestock, and the lowest, most-frequently flooding patches were often made into pasture and hayland.

Despite having cattle, however, van der Donck and others (Lemon 1986?) suggest that manuring was relatively rare. Van der Donck states, "I can say that in the nine years or so I lived n that country, I never saw the land being fertilized; it is certainly seldom done." Writing from Manhattan in 1628, a priest who found few provisions awaiting him bemoaned the fact, "The ground is fertile enough to reward labor, but they must clear it well, and manure and cultivate it the same as our lands require. It has hitherto happened much worse because, many of the people are not very laborious or could not obtain their proper necessaries for want of bread." Nonetheless, records from Rensselaerwyck and Albany County (then including Columbia and Rensselaer Counties) include mention of the sale of manure and manuring was a requisite in some tenant agreements.

Despite never visiting the colonies, Kiliaen van Rensselear seemed to keep a close eye on his business in New Netherlands. One result of this distance paired with close attention is that his letters of instruction to his colony are often quite explicit, containing details that might have been lost to history had he been on hand to deliver them directly. Manuring and fallowing were hardly 'lost arts', as van Rensselaer makes clear in this 1634 set of instructions regarding how to manage a particular farm, "Since the land is overworked and poor, I have proposed to the lords commissioners to let it lie fallow for some years, leaving there some foals and calves, which by that time will attain their growth, and in the meantime to pay the rent as before and to deliver as much of my grain at the market price as my neighbors do. They found this not unreasonable, but said that the manure must stay on the farm, to which I replied that it was better for the land to lie fallow than to put the manure on and take it out twice over by farming, but that the young beasts should stay on it." Clearly, van Rensselaer, like his contemporary European colleagues, recognized the importance of manuring and fallowing; it is also clear that, even this soon into colonial agriculture, some farms were already "overworked".

We can encompass both van der Donck's account and van Rensselear's if we assume that the rules, as established in Amsterdam were only rarely followed on the ground in New Netherlands. In the 1600s, Dutch farmers were practicing manuring, cover crops and fallowing. The lack of their widespread application in the "New World" was perhaps not the result of complete ignorance, but rather of reduced motivation. All these practices require effort and planning; while land was plentiful, few farmers may have seen a reason to invest in them. It may also have been that the most successful farmers – the ones most experienced with the benefits of these relatively new techniques - had little reason to weather the risks of the sea crossing and of establishing a farm in a novel land. (CHECK. Finally, during the very initial stages of the colony, livestock (and their dung) and cover crop seeds may have been relatively scarce, discouraging manuring and cover cropping even by those who wished to do so.

From Wilderness to Farm: Snapshots of Late Colonial and Early Federal Agriculture.

The 18th century formed a bridge between the farming of the earliest settlers and the agriculture we know today. As such, it has tinges of both eras, harkening back to themes we've already discussed while presaging questions or trends that are still with us today.

This section is organized around four inter-related themes: 1) the balance of land vs. labor, and what that meant for the style of farming; 2) land tenure and the unit of farming, and how that might have affected soil treatment; 3) integration into commercial markets, and the consequences for crop and hence soil diversity; and finally, 4) agricultural innovation, and farmers increasing efforts to free themselves from the limitations of their land. While each of these themes had much earlier origins and persisted into later periods, this era will be used to introduce and explore them, conscious that we are but dipping into what are much larger issues.

With these themes in mind, the pages that follow provide a local illustration of 18th century agriculture through excerpts from the writings of two county residents from the late 18th and early 19th centuries: Dr. Alexander Coventry and Robert R. Livingston. The first was a Scotch immigrant, who came to his father's lands along the south bank of Stockport Creek. A medical doctor, farm manager and some time farmer, he kept a detailed diary during his residence in the county from 1786 to 1791. Because of his extensive diary, he will be our primary source. Robert Livingston was a more prominent figure, Lord of Livingston Manor, signer of the Declaration of Independence, holder of various state and federal positions, and President of New York State's primordial Society for Agriculture, in whose Transactions he published numerous articles.

Both of these men were exceptional: both were landlords, although Alexander Coventry's domain was much smaller (ca. 1000 acres shared with his brother) versus Robert Livingston's 160,000 acres. The Coventry land was worked by three to five tenant families; Robert Livingston had 1000s of tenants. Alexander Coventry was closely involved in managing the day-to-day use of his lands, and he was also an acute observer of what was happening around him. As such, while his lifestyle was not that of an independent family farmer, his diary can be used to indicate the general practices of the time. Robert Livingston's writings are interesting because of their experimental nature. Perhaps inspired in part by the 'progressive' experimental farms of people like Thomas Coke in England and Charles Read in New Jersey, Robert Livingston turned his attention to exploring and promoting the methods of farming that he felt would be most advantageous to regional farming as he perceived it. His work therefore helped highlight and explore some of the agronomic issues of his day in a local, Columbia County context, something that Alexander Coventry was in no position to pursue.

1.The Balance of Land and Labor.

In 1790, average population density in the European-inhabited North American colonies was less than 10 people per square mile; at the same time, the estimated population density in England exceeded 150 people/mi2. As a result, relative to England, land in the Colonies was cheap and labor expensive. Thus, North American farmers felt less pressure to wring every last harvest from a given acre of land and more pressure to get the most production from a given hour of labor. One farmer might be able to harvest more from lightly working 100 acres of farmland than from intensively working 25 acres, even if the per acre yield were higher in the latter. Lower yields are sometimes taken to indicate that North American farmers were poorer at their trade than European ones, when, in fact, both groups were farming in ways appropriate to the divergent resources available to them.

Alexander Coventry, 21 August 1786

> Dutch farming. They keep a vast number of horses.. The old, in winter they feed on wheat and rye…The colts run out the whole winter, though ever so severe, and live chiefly on the roots of the grass which they paw up… the Dutch don't know the use of kine, horses, nor land. They use no oxen…they 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. This obliges them to move, and they not being compelled to raise their own bread must sell. Often the purchaser is a New England man, who, being used to employ every known art to make his native barren soil produce a good subsistence, generally gets rich, lives well, and even his hogs have more pleasure in the appetite than the former Dutch family on the same farm…

This is one of Coventry's most detailed assessments of local agronomy. Coming relatively early in his residence in the US, it is surely tainted with preconceptions of what made for good farming. In this excerpt, Coventry provides quite a detailed description of an *extensive* form of crop management: low investment (in terms of manure) in each acre being compensated for by the quantity of land being plowed. It is difficult to believe that neighboring farmers were quite as profligate with their resources as Coventry suggests, however soil exhaustion was apparently occurring – an observation supported by the Hudson Valley observations of contemporaries. The last portion of his longer commentary is particularly interesting. Coventry was living in a multicultural world. He makes frequent reference to the Dutch, English, Irish, German, and Yankee farmers he encounters. The extensive Dutch farmer was replaced by the more intensive New England farmer, as the soil was worn out and population density built. It is not hard to believe that farmers who had experience with New England's hard-scrabble farming and higher population densities might relish a chance to work even 'worn-out' Hudson Valley farms, and might bring with them a tool box for soil renewal.

New Land. A key component of extensive farming was the availability of new land 'over the next hill'. While Coventry's everyday life seems to take place in a well-settled land, his trips make clear that much of the 'matrix' was still unsettled if not unclaimed lands. There were still 'internal frontiers' in the region, but Coventry lived in the County for part of the period when forest clearing was at a peak, and the location of new land was fast moving west. Some six years later, Coventry himself was to move to new land in central New York.

Alexander Coventry, 1 February 1788 [during a visit to the area of Greene County]

> About two years ago I was in this place, and except Dudley's, there was not a house to be seen for three miles, and now every lot of 100 trees, and almost every 50 acre lot, has a settler with a house and small clear around it, so that it is thicker settled than any place on the east side of the river, excepting the towns. The inhabitants are very poor but seem industrious.

Alexander Coventry, 2 February 1788 [during the same visit]

> Mr. Hine has lived here about 2 years: has his second crop in the ground, and provision to last until the harvests the coming season, last year he had 40 bushels, from one and a half bushels of sowing. The method he followed was this: he cleared his land completely, leaving scarce a tree standing in the autumn; early next spring, he burnt it over, letting it lie to the sun all summer. Then he dragged in his wheat in good season in the autumn. The piece was a stony ridge, and he could stand anywhere in it, and put the wheat heads cross his head, although I suppose he is about 5 feet 10 inches high. … He is an excellent manager, a good man, but as his wife says, "not handsome, but clever".

Alexander Coventry, 17 April 1790 [in or about Ancram/Copake]

> …stony, hilly, rough country, almost entirely wood, oak and hickory. This track, Livingston to whom it belongs, reserves for the use of this furnace and forges.

Mr Hine's tremendous wheat yields would suggest that some virgin soils had not yet been stripped of their initial wealth. It is hard to believe that he was able to continue his impressive wheat harvests for long into the future. The southeast corner of Columbia County was settled relatively late (and is still one of the least densely settled portions of the County), due in part to its rough terrain and border disputes with adjacent states. Coventry's account suggests that this slow growth also occurred because the Livingstons actively sought to maintain the forests that could fuel their iron processing.

DEAR LABOR. Much of Coventry's diary is composed of discussions of labor issues. He was to become a slave owner and recounts his difficulties with various laborers and tenants. His socio-economic rationalization for slavery is apparent in the first excerpt below, while the second describes just one of his agreements with a share-cropper (who soon left to work on another farm). Through specific references to other slaves, and through his own slave's participation in societal events such as the celebration of Pinxter and attendance at a funereal, his diary makes it clear that there was a community of African-Americans in the region. Other entries record the escape of one slave and the flight of a mixed-race couple. While never as widespread as farther south, slavery was very much a part of Hudson Valley agriculture. In 1790, slightly over 5% of Columbia County's population were slaves.

Alexander Coventry, 14 February 1787

> There are few portions of my life that I survey with more pleasure than the few days spent among the respectable Dutch families, farmers, on the Cocksacie neighborhood [modern-day Coxsackie, near Albany]. …Their farms produced all the means. I have never met with any portion of the human family who lived so independently.. In the first place their farms were large, of the richest soil, and within two miles of the Hudson river. Within 24 hours sail of New York. …. Each individual family had more or less black slaves who did all the work on the farm; this saved the masters and mistresses from the insolence of what is called hired help, who must be humored like spoiled children, or they will leave you at their own will. Although the blacks were slaves, yet I feel warranted in asserting that the laboring class in no country lived more easy, were better clothed and fed, or had more of life, than these slaves.

Alexander Coventry, 28 March 1787

> Agreed today with James White to work my farm on shares, to have half the produce, I finding the team and tackling; he doing all the work, mowing excepted, during which I find one man, and take 2/3 of hay. Term 3 years.

Livingston and his colleagues also provide insight into the transition from extensive to intensive agriculture. The excerpts below come from the first volumes of the *Transactions of the Society, for the promotion of Agriculture, Arts and Manufactures, Instituted in the State of New York* (the title of later incarnations was thankfully shortened to *Transactions of the New York State Agricultural Society*). These volumes report on papers presented to the Society during the 1790s. In some ways, Livingston was far removed from everyday farm life and challenges; on the other hand, he was ultimately responsible for managing more farms than any other man in the County and, if only for the profitability of his own enterprises, sought innovations that would enhance production.

As context for Livingston's remarks to the Society the following words, presented by Dr. Samuel Mitchell of NYC in 1792, provide an overview of the raison d'être for the Society and an interpretation of the current state of affairs, at least in the eyes of certain (elite) members of society at large. While the narrative is nominally about soil exhaustion due to what are connoted to be bad farming practices, one can also view this as a description of the changing context of farming, one in which politicians of long-established eastern colonies are beginning to realize that their continued pre-eminence in national politics is going to depend on a more intensive approach to farming lest their constituents disappear over the western horizon.

> Hitherto, the American husbandman has cultivated a soil, enriched for ages by the yearly addition of a fresh stratum of mould. From the first existence of vegetation upon the dry land, decayed plants have continually furnished a supply of manure, which the winds and rain have liberally spread abroad. As the supply was annually greater than the consumption, the earth, unexhausted by it productions, increased in fertility. The thick layer of vegetable mould which covered the face of the earth was a store-house of food for plants, and this quantity was greatly increased by the conversion of wood into

> ashes by clearing. It is not wonderful then, that for some years newly-cleared settlements should abound in produce, and require little more labour than that of ploughing and reaping; for during this period the provision is wasting, which for centuries had been accumulating. But the time will come, and indeed in many places now is, when the land, repeatedly wounded by the plough-share, and exhausted of its richness, shall be too weak, of itself, to make plants grow with their former luxuriance. This may be called the era of systematic agriculture, when man, taking the earth from nature's hand, bare of manure, is so to manage and dispose it artificially, that it shall yield him first a subsistence, and then an overplus to grow wealthy upon.

In an address some two years later, Livingston directly compares North American and English agriculture and is much more explicit in pointing out the motivations that led English and North American farmers to approach their lands differently.

Robert Livingston, 1794

> All these natural advantages being in favour of the American farmer, I shall be asked how it happens that the lands in Britain are more productive… the answer would be found in the low price of labour, and in the high price of land. More labour is therefore expended upon less land there, and the product is always in proportion to the labour, the soil and the climate. But does it yield more profit to the cultivator? —No man need be told that a garden where one man is constantly employed upon half an acre of ground, will produce more pulse than the same quantity of ground cultivated with a plough, in which way one man can tend ten acres ; but does it follow the one half acre is more profitable than the ten acres, even though the additional rent should be superadded ?..
>
> I know too that … improvements are much more usual in England than in America, where lands are cheap, and the farmers' capitals too small for expensive improvements….

Net Benefits of Extensive Farming. We can use one of Livingston's essays (entitled without, I think, any intention of double-entendre) as "Mr. Livingston on Culture" to help describe farmers' incomes and to put some comparative numbers into our accounts of North American and English agriculture. In this essay, which is more descriptively entitled, "On Vetches and the Benefit arising from the Cultivation of them as a Summer Fallowing Crop", Livingston presents an economic comparison between the theoretical profits of two 100-acre farms, one of which does not raise vetch and one of which follows Livingston's ideal, vetch-inclusive rotations. Livingston goes on to show how the use of vetches could enhance farmer profit, but here we will focus on his 'control' farm, the farm he presents as the conservative norm. It is evidently a tenant farm (it pays rent) and is described as using "common agriculture".

Based on this and other of his accounts, we can describe a 'typical' (but not necessarily average) Columbia County farm of the late 18th century as containing about 130 acres, of which perhaps 40 acres was actually tilled with only about 2/3rd actually in crops during any given year, the remainder being in fallow. The 90 acres that were not tilled would be divided between hay meadow, pasture and woodlands, together with smaller allotments for house, barn and yard. There might have been four horses and as many oxen, perhaps 5-10 cows, and a scattering of sheep and wide-ranging hogs. These livestock were probably fed both from the farm's own land and, as discussed later, from lands grazed in common. The woodlands provided fuel and construction material for home and market. Wood was also processed into charcoal and potash for sale.

Based on Livingston's production figures and using then-current prices derived from Coventry, we can estimate that such farmers produced approximately 130 £ worth of grain (i.e., corn, oats and wheat; I use £ here as the unit of currency, don't worry about its actual value – just consider the *relative* gains). Of this, the family of five would consume perhaps 60£'s worth (based on Bruegel's probates), leaving around 70£. Of which, if this were a tenant farm, some 5.3£ might go to rent and, perhaps 5£/yr for additional help (depending on family composition, a tenant might well try to do most work within the family, yet extra help might be hired during harvest). There were certainly additional costs: potentially some seed purchases (although seeds could be saved) and equipment repair (if not done on-farm). This would leave a bit less than 60£ as clear profit from grain growing. Using Livingston's semi-independent calculation of profit per acre, we come to about 47£ for 40 acres of cultivated land, but this assumes extensive use of paid labor. Likewise, if we assume that rent was based approximately on 10^{ths}, then the average Rensselaerswyck rent of 5.3£, implies a total production of 53£ (although it's not clear if this was calculated before or after family consumption).

Animal production is a bit more difficult to estimate. For the most part, it might be safe to assume that, on the majority of farms, livestock largely paid their way in kind, providing food and labor rather than cash. The notable exception was probably the role of dairy production in a woman's income. Coventry mentions his wife's occasional sale of butter and cheese, although recorded gains are relatively small (less than .5£; however, Coventry's records may be very incomplete). In sum, it seems reasonable to estimate that a farmer of a 130 acre farm, during a decent growing season, may have made perhaps 50-70£s of profit per year.

If current British pounds are a remote enough concept for most of us, then eighteenth-century New York pounds are nearly incomprehensible. However, we can use information from Coventry's diary to translate this into more comprehensible units. An acre of land was selling for about .5 to 5£, with the lower prices usually referring to uncleared lands in western NY, and the higher prices applying to local, clear lands, often with some infrastructure in place. A year's wages for a farm worker were around 20-40£ and that of a priest around 150£; while a modest horse might be valued at 5£, a cow at 6-7£, a restaurant meal at about .15£ and a doctor's visit at 1-1.5£.

With this as context, we can explore the question of the relative success of North American farmers – were they poor farmers whose ignorance led them to mistreat their land, or were they economically (in the broadest sense) astute farmers who balanced investment with output to maximize total gain? *American Husbandry*, a mysteriously anonymous book published in 1775 (talk about bad marketing: its publication was easily eclipsed by colonial events more dramatic than wheat cultivation!), provides some additional context. This work tried to assess which British economic groups would most benefit by immigration to North America. The author concludes that it was the small to medium sized land holder who had the most to gain; more affluent British farmers had much to lose and little to gain by crossing the Atlantic. If we focus on the first group, roughly comparable to the colonial farmer whom we have just described, then we can search for comparative information from England. Conveniently, in XXX a Thomas Robertson published a survey of British farm size. His figures can be used to calculate farm sizes of roughly 10-20 acres, depending upon what you take as the rent per acre. Clearly, British farms were smaller than their North American counterparts. Conversely, average yields were probably greater, concurrent average British wheat yields (overton & Campbell table viii) were more than 20 bu/acre vs. about 10 bu/acre estimated by Livingston; oats produced an estimate 32 bu/acre in England vs 20bu/acre stateside (the English produced almost no maize). British rent/acre was correspondingly about .7£/acre, while values cited by Livingston or derived from Rensselaerswyck records (Humphrey) convert to about .05-.2£/acre. The currencies were probably not directly equivalent and retail values differed, but these numbers seem to support the idea that, on a per acre basis, British farmland was expected to produce more money.

From a farmer's perspective, the key number was not yield per acre but net per farm. Given that landholders in our area appeared to have farms at least four times larger than their British counterparts (although proportional area in cultivation may have been lower) while their yields were about ½ to 2/3rd of the English contemporaries, their total productive capabilities were probably greater, suggesting that, at the least, a farm family's ability to produce food for its own subsistence was easier in the colonies. As our anonymous author puts it,

> I do not think a more miserable set of men are to be found than the little farmers in Britain; they work harder, fare worse, and are in fact poorer than the day labourers they employ, wheras in New England [and the same would likely have been said of the Hudson Valley which he generally deems to be better land], the little freeholders and farmers live in the midst of plenty of all the necessaries of life; they do not acquire wealth but they have comforts in abundance.

CONSEQUENCES FOR THE SOIL. As we have discussed above, relative to English farmers, eighteenth-century farmers in Columbia County both asked less of their land and gave less to their land *on a per acre basis*. In other words, they probably did not push their soils as hard in terms of expected yields, but they probably also gave each acre less care (in terms of manure, gypsum, and rotational management). Both approaches may have lead to soil exhaustion, but, one might suppose that the North American model was more apt to do so, albeit at a slower rate and over a longer time period. The initial response of North American farmers to reduced yields was often to seek new land; this was feasible because land degradation was slow enough to pay back the investment of establishing a farm before soil yields ran out , new land was relatively cheap, and land clearing itself could be profitable (via timber and potash sales and subsequent land speculation). Conversely, British farmers probably had to be more 'on top of' their soil conditions and sensitive to short-term declines in yields. Yet the times they were a-changing, and it is apparent that the *motivation* for more conscious soil management was rising in the long-cultivated regions of the Northeast, including Columbia County.

2 Evolving Land tenure and Work Units.

We have come to think of the compact, independent 'family farm' as the natural, if sometimes thwarted, unit of agriculture. However, during the Middle Ages of Europe and the early colonial period of North America it was uncommon. For example, as van Rensselaer's earlier comments suggest, much of early Dutch farming was on 'company farms', administered by the Dutch West Indies Company or the lords of large manors. In Europe, lords and abbeys owned large tracts. What private land existed, other than what was owned by estates, was scattered as small parcels across relatively large, common fields. (The use of "commons" in this sense is somewhat misleading: while a great many people worked in these large common fields and while labor-bartering surely occurred, there were still distinct, privately-owned beds within them, in much the same way that modern "community gardens" are in fact a patchwork of privately-worked plots). Aspects of this system were transferred to the colonies, and early settlements sometimes repeated the pattern of a centralized core village with distributed small, private holdings throughout larger fields. Supplementing these "common fields" was the commons at large – this was true common land in the sense that a variety of townsfolk could make use of it for gathering wood, hunting and, perhaps most important, for pasturing livestock. In this way, even people who owned no land were able to raise at least a few animals. Such land may have been owned by the town, or it may have been privately owned, but its shared use was part of 'common practice'. In part, such centralized colonial villages reflected the need for a fortified core village in the face of hostilities with the Native Americans. However, as that danger waned and as enclosure and associated agricultural techniques spread in Europe, the consolidated, independent family farm became the norm.

The transition from shared fields to consolidated farms should not be confused with that from tenant to freeholder. Tenant farmers work land owned by somebody else, usually in return for a payment to the landowner. Freeholders work land that they own. Shared field and consolidated farm agricultural systems do not dictate whether the farmers are tenants or freeholders. While shared fields may have typified some mediaeval feudal situations (in which case the lots were owned not by the farmer himself but rather by the lord), many early European colonists in North America (together with many European farmers of that time period) worked personally owned plots in shared fields. Conversely, many early Columbia County farmers worked consolidated farms that they did not own. Such an arrangement occurred not only in those portions of the County found within the Manors of Livingston and Rensselaerwyck, but also beyond the bounds of those manors where other multi-farm land owners (such as the Coventrys) made agreements with tenant farmers. (Many modern farmers also work land that they do not own.) Hatred of the manorial system led to at least two centuries of conflict in Columbia County, including armed revolts against manor lords or their agents.

GLIMPSES OF THE COMMONS. Perhaps one of the least familiar aspects of farming in Coventry's day was the free-ranging livestock: an arrangement that benefited the landless, frustrated crop growers, and discouraged those recommending more conscious management of manure.

Alexander Coventry, 21 August 1786

> The horses have broken several times into the meadow, and destroyed an excellent after-math ["aftermath" meant a hay harvest that occurred after the primary cut]. Oh, that there was not a horse in Claverack.

Alexander Coventry, 3 October 1786

> The hogs amongst the wheat, a great part of which they rooted out. Hunted them eith Chloe the bulldog, who fought nobly and would not fly from the whole of them. A hog that has been always accustomed to the woods, will fight wickedly.

Alexander Coventry, 9 May 1787

> Mr. VanAlstine's cattle, 18 in number, have got into my wheat and destroyed it, and injured my meadow, so that I shall neither have wheat nor hay.

As these and ample other entries make clear, keeping livestock out of crops was largely the responsibility of the crop-owner (rather than the livestock owner), and fences were designed to keep livestock *out* rather than *in*. This didn't always work: horses, cattle, pigs and perhaps sheep seemed to be regularly robbing hay, rooting up young orchards, and destroying crops in and around Coventry's farm.

As the following excerpts illustrate, the commons was also hunting and fishing ground (a persistent if now vanishing arrangement) – it is important to remember that such activity was probably an important part of the 18th century food system, and may have even lessened demands for domestic animal protein.

Alexander Coventry, 26 March 1786

> Got up before sun this morning, and went… to shoot ducks… We had a board covered with a sheet across the bow of the boat, and we had on white shirts and night-caps, to resemble floating ice.

Alexander Coventry, 15 August 1786

> Flocks of wild pigeons flying around to-day. They are about the size of tame of dove-coat pigeons. The cocks have red-breasts, and all are blue on the back. They light on trees and are not very wild. I shot at them with wheat, but did not kill any.

Alexander Coventry, 18 September 1787

> Went with Ludlow over the creek, to what they call Salt Lick, a marshy, springy piece of low clay ground, where the pigeons frequent often, supposed on a account of the saltish quality in the clay. We found Delemaitre and Kettle there, they had killed 20 pigeons each.

Alexander Coventry, 2 May 1790

> They have caught a good many fish at Primar Hook, taking about 100 at one haul, a party from our neighborhood, the Martins, went to fish the Schermerhorns fish, the latter cut their ropes.

Coventry mentions local hunting of various birds, of squirrels, and of pests such as wolves and foxes. Wildlife had no doubt already declined substantially by Coventry's period. He makes no mention of other small game (such as rabbits) or of deer. He does recount deer hunting during his trip to western New York, suggesting that deer may have been scarce in the County during his time. The "pigeons" referred to are clearly the now-extinct Passenger Pigeons and Coventry reports hunting them several times. ("Wheat" may have been slang for buckshot.) It was apparently a group affair, and, at one point, he recounts firing into a flock of at least 1000. Suckers, Striped Bass, and Shad were among the fish he described seeing caught. Catches, evidently, could be large: one year prior to his fish report of 1790, he describes catches totally 7000 Shad in the same location. His diary suggests that hunting and fishing were widespread, providing sport and subsistence.

Consequences for the Soil. The decline of the commons and the rise of the consolidated family farm had a variety of consequences from cultural to economic to agronomic, and it is difficult to isolate its effects on the soil. One can conceive of both positive and negative soil impacts. One impetus, amongst several, for consolidation and enclosure in Europe was that it gave farmers the ability to more closely manage blocks of land without being tied to synchrony with the other farmers in the common field. For example, pasturing of livestock in the stubble of a crop field could bring manure nutrients into the field, but on a shared field, no pasturing could occur until all holders had gathered their crops.

Some historians thus argue that consolidation and enclosure was necessary for the modernization of agriculture and the improvement of soil management through more complex crop rotations. But agricultural benefits may have also been lost: tight communities, held together by the need to coordinate the use of shared fields, may have allowed for more efficient use of the landscape than dispersed individual farms. The careful, community-planned sharing of seasonally-flooded meadows is a case in point. This arrangement may have enabled a wider geographic sharing of wet meadow nutrients than would have occurred under sole ownership of the meadows.

Logic suggests that tenant farmers, who did not own their land and who, as in the case of the Livingston Manor at least, had no right to sell or pass on their farms to their offspring, would have had less motivation for careful soil management than freeholders who could expect to benefit themselves or their offspring from improving the land's value. The well-known generalization described as 'the tragedy of the commons' implies that personal gain trumps community benefits as a motive for sound land management. Spafford in 1813 describes farming in the Livingston-owned portion of the County as notably backward compared to the rest of the County, concluding "*The lands are held by leases, of various duration, but principally for a single life, and its agriculture indicates the tenure of title*". However, our own small analysis of 19th century crop yields relative to percent of land held by tenants in various Columbia County towns showed no clear patterns.

3. Markets: Local/Global; Monetary/In-kind.

Many farmers during this period were farming primarily (although not solely) for family or, at least, community subsistence, rather than for broader markets. There is an on-going academic debate regarding the degree to which farmers were part of the market system during different time periods. We can skirt that by saying local farmers were definitely part of an economy beyond their farms (with wheat as one of the primary currencies), and yet most farms were diversified and had, as a primary goal, the direct production of family staples.

Coventry lived in a money-based economic system that was largely without money. Coventry's diary is replete with annotations on trades and barters. The value of trade items was often converted to currency, but no money actually exchanged hands. Instead, services (such as Dr. Coventry's care of a patient) were usually paid back in goods and other services. In part, this was because of a post-revolutionary collapse in the value of colonial paper money and the scarcity of alternatives.

Alexander Coventry, 15 December 1785

> Money is extremely scarce; no silver or gold, or no bank notes. What money exists, is in the hands of a few rich men… and they take exorbitant interest: there are no banks, confidence, or credit.

Alexander Coventry, 7 August 1786 [in Albany]

> The streets full of people, who have come from all parts of the state, to get some of the new paper money, for which they mortgage real estate to double the amount, and pay annually 5%. I suspect there were applicants for ten times the amount issued by the state. There is a great scarcity of circulating medium. The continental money is no better than blank paper. There are no bank bills and specie are very scarce. A few moneyed individuals purchase lands and everything at their own prices.

Coventry was operating during challenging economic times. Later in August 1786, just across the border in Massachusetts, the so-called "Shay's Rebellion" would take place as small farmers protested against State-led efforts to foreclose on tax delinquent properties and enforce the payment of other debts. The Federal government had issued currency to pay soldiers, but a post-revolutionary economic downturn, caused by war-time damage to commerce and subsequent British limitations on international trade, especially with the West Indies, led to inflation and quick devaluation of that currency. While Massachusetts, at the behest of wealthy land owners, tried to raise taxes to pay its arrears (thereby fueling more discontent), New York State took a more populist approach, and loan offices, such as the one whose opening Coventry recounts above, were one of the results. Such offices meant that individuals seeking loans could escape having to deal with the elite classes and their “exorbitant” interest rates.

Alexander Coventry, 25 November1789

> Cuff took a load of wood to Hudson for which he got 5 shillings in molasses and twist. He also took three skim milk cheeses and two pounds of butter for my wife and got a black silk handkerchief.

Alexander Coventry, 22 Jan 1790

> Cuff took two loads of wood to Hudson today and got 12/- for them. Took it mostly in trade; me a hat for twelve shillings, a shawl for Betsy, a set of tea cups and the rest for himself.

Alexander Coventry, 22 February 1790

> Took two ox sled loads of wood to Thurston…Paid Foot for my wife’s shoes, with 3 lbs. of butter at -1s per lb. and 1 bushel of potatoes at – 3s per bushel.

These excerpts illustrate aspects of the barter economy. Fuel wood was a main staple of Coventry’s commercial production, it was often valued in money but paid for in goods. Like many farm wives, Coventry’s wife had her own economic production – cheese and butter were often the woman’s domain - apparently she used the resulting gains to buy goods for herself. Cuff was Coventry’s slave.

Alexander Coventry, 9 July 1786

> *Report the appearance of a new war between France and England.*

The Hudson was the 18th century Interstate, with its direct river connection to New York City and thence the World. It was a key component of commercial life, and the market connections it facilitated helped determine which agricultural products were profitable. A later, wintertime entry, for example, noted that two of ice-bound Irish ships in the Hudson port were packed with cargos of wood and flax destined for the Old World. Coventry makes this and a few other passing mentions of the state of politics in Europe. Whether he realized it or not, this news was of much more than passing importance to Columbia County farmers. Much of the post-revolutionary boom in American agriculture can be attributed to war in Europe – that fighting robbed farmers and farmlands from European production and prompted large-scale imports from America. The agricultural newspapers of the next century spent much ink discussing the North American agro-economic downturn precipitated by peace in Europe, its return to agricultural production, and the consequent reduction in demand for North American farm products.

CONSEQUENCES FOR THE SOIL. Clearly, these quotes are not about the soil. And yet, economic context certainly affects a farmer’s relationship to the land. As farmers more deeply entered markets during the 19th and 20th centuries, they began to specialize their production focusing on, for example, dairy or fruit. Even during the 18th century, external factors were probably skewing farmers towards certain crops of commercial trade. Wheat in particular was easily sold and widely demanded. Manor lords often specified rental payment in wheat; tenants on the Livingston properties were required to plant certain acreage of wheat in order to supply lords of the manor with wheat for commerce. Wheat is a demanding crop in terms of soil nutrients, and probably accounted for much of the soil exhaustion reported during the 18th century.

A diversified farm provides more *opportunities* for rotating crops and circulating nutrients. Few practices drain soil nutrients as consistently as the long-term production of the same crop on the same piece of land. Opportunity does not equal practice, and one can question how much colonial farmers practiced crop rotations and nutrient recycling, even when practicing relatively diverse farming.

4) Agronomic Innovation and Tradition

One can highlight three realms of innovation during this period: the advent of upland 'artificial meadows', the search for new crops and breeds, and the increased use of manures. Floodplain meadows played an important role in colonial agricultural. They offered some of the best hay and pasture available, but, because they were limited in expanse, they also restricted the extent of animal farming (and hence of manure production). The key innovation was the widespread seeding of upland fields with European hay and pasture grasses. These species were able to produce high hay yields on relatively dry land. The upland fields were, however, outside of the revitalizing influence of the floodplain and so open to potential soil exhaustion. In response to the increasing pressure for intensification of farming and perhaps to fight soil exhaustion in upland meadows, there was increasing interest in manures and crop rotation. While these ideas were hardly new, there was renewed interest in their application. Finally, Coventry and Livingston both evidenced a keen interest in new breeds and crops as new plant (and animal) candidates for their upland meadows and as botanical collaborators in soil regeneration.

MEADOWS: OLD AND ARTIFICIAL. Wet meadows were not only lush but regularly fertilized by flood waters. These nutrients could then be transferred to farmland via hay and then dung. Brian Donahue's book on Concord MA details the role of such meadows in the 18th century sustainable agriculture of this town. To one degree or another, this practice was probably widespread and local evidence suggests it was a component of at least Shaker and Dutch agriculture. Such farming meant that the extent of mixed farming was limited by the availability of natural wet meadows; some colonial communities went to great lengths in order to assure that most farmers had access to wet meadows for hay. Escaping such a constraint was an important step in colonial farming, and upland "artificial meadows" (as they were termed) were thus an important advance, at least in the short term. Native upland grasses produced poor hay and short-lived pasture (?), so expansion of hayland and pasture into the uplands was associated with increased planting of better-adapted European species.

Alexander Coventry, 11 June 1786 (during a visit to a farmer across the Hudson)

> He showed me a piece of meadow, which he had drained, where the water stood three feet deep before draining. It resembles very much the moor or peat land in Scotland, consisting of decaying vegetable, trees, etc., and the wash of the neighboring hill. This substance is 6 feet deep on a clay bottom, and would make good fuel. It was planted with maize and potatoes, which, though planted late, look well. He values it very highly, and indeed it is excellent, being from its nature inexhaustible.

This was the 'old-fashioned' kind of good farmland – a managed, occasionally flooded wetland in which the rich soil was regularly replenished by water-borne sediments and hence was "inexhaustible".

Alexander Coventry, 1 July 1786

> Crossman and Ghose mowing the north hill of the Clayberg where is the nicest and stoutest grass in Claverack. The clover of which it consists, is all laid down and covers the ground six inches thick. The fox-tail is four feet high, and in its prime.

This was 'new' farming – the creation of what was called 'artificial meadow' by the planting of European forage plants, such as clover and "Fox-tail" (probably what we call Timothy today) on uplands.

Alexander Coventry, 4 August 1786

> Began cutting the hay. Cut it down and turned it once over, which is all sufficient for this kind of grass. It is called "Copper" or blue grass. It is the most substantial, and easily cured, of all the calmiferous grasses. The stalk is flat and solid, and contains the substance, the leave being small. It is short, and does not arrive at maturity until after harvest. It is natural to clay soil, seldom giving above ½ ton to the acre. It is only 6 or 8 inches high, but on rich land, as the Coxackie flats, it is much taller.

Blue Grass (probably *Poa compressa*) was another introduced grass. Coventry's comments reflect something of an experimental air, together with a roving eye that learned from the experiences of others.

The Introduction of New Crops. Finding the right crops and crop varieties is one key step in agricultural development. "Rightness" is determined both by plant (or animal) biology and by economics. Eighteenth-century Columbia County farming mixed the old with the new.

Alexander Coventry, 18 May 1786

> Alexander [his cousin] planting Indian corn. To prepare the land for planting, alight furrows are strod out about three feet apart; these are crossed by furrows at similar distances; where the furrows intersect 3 or 6 grains of corn, with a pumpkin seed, are dropped, and covered 1 ½ or 2 inches deep with the fine mould, with a hoe.

The planting of corn and squash together represents a Native American planting pattern of two native crops; this technique was adopted early and was maintained.

We do not know if Robert Livingston was the primary author of the following document, but the minutes of the Society report that its distribution was accompanied by a letter from Livingston requesting that this notice be posted in ship's cabins. So, even if he did not write it, he was clearly well familiar with it.

Robert Livingston (?), 1793

> INSTRUCTIONS to Captains of VesseIs sailing to any part of Asia, Africa, the North of Europe, the Southern or Western parts of North-America,
>
> First. PROCURE a small quantity, not exceeding one quart, of those kinds of grain which make the principal food of the inhabitants, and this even though it should be wheat, barley, rye, oats, or maize ; for though those grains are common in this country, yet there are varieties which may be extremely important, as was instanced in the accidental introduction of the white-bearded wheat, which was found to resist the insect: when every other species was destroyed by it.

The document had seven clauses in all, requesting not only the collecting of seeds of grain, but also of legumes and pasture grasses, together with various observations of livestock (but cautions that captains should not take this as an excuse to illegally smuggle out controlled sheep breeds, like the Merinos that Livingston was soon to be raising).

Alexander Coventry, 18 April 1790 [during a visit to northeast Dutchess County]

> Mr. Knickerbocker…seems a wealthy, warm farmer, in a very thriving way, owns a considerable farm…He keeps his cattle almost altogether on straw but allows each head 6 ears of Indian corn a day and this he gives at three different times.

Robert Livingston, 1794/1795

> *Turnips cannot be raised in our climate to advantage, as a food for cattle : the season in which they are sown being usually very dry, and the plants liable to be destroyed by the fly….*
>
> *Let us now examine those [advantages] we exclusively possess : The noblest of these is the maize or Indian corn ; neither the beans or turnips of Britain can be compared to this plant : First, it need not be planted till the last of May, so that the farmer is never hurried by it with his spring-work : Second, it is cultivated with a plough or horse-hoe; and as the plants are large, and placed at five feet distance, there is ample room for this ; and though it is also usual to hand hoe; yet as this is done after the ground is loosened by the plough, and when the plant is a foot high, and then only just about the stem, it is easier to hoe ten acres of this than one of the turnips or beans : Third, it defies the drought, and never fails to make ample returns to the husbandman that cultivates it with diligence... The grain furnishes a palatable and nutritious food for man, and is greatly superior to any foreign species for farm stock…as this crop is easily and necessarily kept clean, it is the best of all fallow crops…*

The want of turnips may be amply compensated by carrots… by cabbages and potatoes,..and by pumpkins, which are raised in very considerable quantities in our Indian corn fields, without any other expense than that of dropping a few feeds in the hills, and carting the crop…

The foddering of cattle with the concomitant increase in the ability to manage their manure and their comings and goings was one component of 'improved farming'. Clearly, it required a form of management other than the grazing commons. English "high farming" was, in part, based on the insertion of a forage root crop, such as turnips or mangels, into the rotation. Forage crops provided farmers with the ability to better manage their manure and to supplement hay with potentially better-yielding fodders. For the reasons that Livingston explains, maize became the fodder of preference here. His allusion to it being a good fallow crop refers to the role of fallows as a weed control measure – plantings of grains could get weedy if they weren't interspersed with a plowed fallow or the equivalent (i.e., a plow-hoed maize field). Livingston devoted entire articles in the Transactions to his experiments with Lucerne or Alfalfa, and with Vetches; given the widespread cultivation of these plants today one could credit him with prescience. His subsequent suggestions that Elk and Moose be domesticated, which appear elsewhere in the Transactions, have not, however, been realized.

Alexander Coventry, 22 February 1786

> [The visitor was a] man from whom Mr. Elias gets most of his oxen…He had some clover seed to sell at 2-6 a quart and I bespoke 8 quarts: also a pair of oxen at 8 pounds New York currency.

Alexander Coventry, 20 April 1786 [in and around Pittsfield]

> I bought 8 quarts of clover-seed for 1 pound.

Alexander Coventry, 25 September 1790

> John from Lenox here … He told me of a new kind of wheat they have got there, which grows larger, and has whiter flour: they call it "White Wheat". He says a man found a set or bunch of wheat in his field, which was larger than the other wheat, he sowed it by itself, and sowed it by itself, and from it – the rest propagated.

Alexander Coventry, 2 June 1791 [while on a trip to Western NY]

> Mr Tunnicliff's…ashworks which are very complete…have a greater variety of fruit trees than any man in the Northern part of the State. Saw here the best stock of cattle and sheep I have seen in the country: saw here a species of grass called orchard grass, which grows very large, and is quite early: they had the seed from Rhode Island. Mr Tunnicliff, Sr. …. Has good judgment and large experience: has crossed the Atlantic 9 times, and is, in my opinion, the best farmer I've seen in America.

Coventry's diary makes ample mention of the sharing of seed and cuttings; the Sept 1790 entry describes how some local varieties evidently came about: farmers were taking imported seeds, growing them out, and keeping an eye open for useful variability that they could then cultivate. The connection to the Old World was continual and formative; Coventry regularly grills emigrants about farming in their native lands.

Manures. As we'll explore more in an upcoming section, "manure" was more broadly defined historically than it commonly is today. Rather than referring only to animal dung, it included what are now called "green manures" (i.e., plant material that is left on the field) and almost all soil amendments including lime, gypsum, and ashes.

Alexander Coventry, 7 May 1789

> Finished carting manure yesterday; have ridden 56 waggon loads from here, and 27 waggon loads from the other house, in all, 83 loads.

Somewhat frustratingly, Coventry does not explain where the manure was being carted to, but he apparently had a supply. Aside from mentioning the construction of a 'dung hole' by the horse stable, he makes no other reference to his own manure management.

Alexander Coventry, 2 June 1786 [in Connecticut]

> About three miles from the beginning of the woods, you see a place where a man had cleared several acres, having burned all the brush and timber, so that the ground is covered with ashes.

Alexander Coventry, 5 July 1786

> Hauling logs off the east end of the Clayberg. Set fire to several stumps, in the afternoon, which we could not draw out….[6 July) The fire from the stumps had caught in the fence in two places and several lengths were burned.

Alexander Coventry, 18 April 1790 [during a visit to northeast Dutchess County]

> He raises a great deal of corn, and finds ashes exceeds all other manures for the corn. He has a small stone house to contain his ashes, and declares he would not sell them for 2 shillings a bushel. He puts a single handful around each hill when the corn is about three inches high, he plants in a shallow furrow, harrows the first time.

Alexander Coventry, 2 June 1790

> Finished putting ashes around my corn, put a single handful around each hill. A single bushel serves for 200 hills. Have used about 28 bushels.

Alexander Coventry, 25 March 1791 [across the river near Coeymans]

> The people being to have provision in abundance, and several have grain to sell, also: hay is pretty plenty: the woods get cleared fast, and the wheat looks exceedingly well. The people reap great benefit from saving the ashes off the fallow…the man whose wife I attended, saved one hundred bushels from one acre, which brought him 1s per bushel. They take them up while in coal, pretty much, and carry them in boxes, tubs, or a box fixed on a hand-barrow, to a place built up with logs like a log hut: but small, and convenient to or in the Fallow, and the coals consume entirely into ashes. And here they remain until winter etc: one man may take up 30-40 bushels in a day.

The ash referred to came not only from the burning of newly opened woods (and of fences!), but, as suggested in the last entry, also from burning the brush off of fallows. Evidently, ash management was an integral part of on-farm nutrient management and deserved dedicated care. Other entries in the diary mention the burning of young forest, although whether from a planned fallow or not is not stated. The frequency of such activity in the area is indicated by Coventry's regular mention, in his weather summaries, of smoky air. Interestingly, one of Conventry's most explicit mentions of using ash comes shortly after his visit to Mr. Knickerbocker… he watched and learnt.

Gypsum was another 'manure' that became popular at around this time. Also known in its processed state as Plaster of Paris (or simply, plaster), gypsum is similar to limestone except that the carbonate is replaced by a sulfate. As such, it can help raise the pH of acid soils and provide sulfur for growing plants. While sulfur is not normally considered a key limiting nutrient in agriculture, legumes, such as clovers and vetches, are particularly demanding of sulfur and so seemed to most benefit from the use of gypsum. Its use was widespread in Columbia County, at least in the early decades of the 19th century. It was frequently applied prior to a sowing of clover which was then followed by wheat. Its apparently widespread effectiveness suggested that, at the least, acidity was a limiting factor. While some acidification can be natural, it can also be one symptom of soil exhaustion – removal of natural buffers through cropping, increased leaching due to the removal of deep-rooted vegetation, and the production of acids by legumes may have all contributed to widespread acidification of regional farmlands.

Robert Livingston, 1792

> The use of Gypsum as a manure, seems in some measure to have created a new era in agriculture ; prior to this it was generally admitted, that tho' farming might rank among the rational amusements, it could not be considered as a profitable employment for those whose avocations or dispositions do not permit them to attend to that infinite catalogue of minutas, that high wages to the labourer, and the low price of produce render essential in our rural economy. The farmer's profit, being the joint result of the fertility of his ground and his labour, the excess of the first can only compensate for a deficiency of the last. Thus the acquisitions of the gentleman farmer, (who may lay his account in being worse served than the common husbandman) must be principally derived from the means which a larger capital affords him, of fertilizing his ground.

Livingston proposes an interesting balance between dealing with soil issues through management (labor) or amendments (money); in the end however, management could only go so far, and the use of amendments became widespread.

CONSEQUENCES FOR THE SOIL. Eighteenth century agronomic innovations were about releasing farmers from the limitations of their soils. Artificial meadows made animal agriculture practical on a much wider portion of the landscape, while increasing the need for new plants. These meadows, on lands than may not have been suitable for crops, probably opened new lands to soil exhaustion (see Table) and so increased the search for effective manures and soil amendments. This would eventually lead to the advent and widespread commercialization of synthetic fertilizers. While new breeds and new soil amendments did not necessarily lead to dramatic yield increases during the remainder of the 19th century, the fact that yields did not *decrease* dramatically in the face of on-going and extensive harvests suggests farmers were, from a production perspective, successfully managing their crops and soils (REF).

Percent organic matter as measured by Ebenezer Emmons in the 1840s and by Cornell in the 21st century. Emmons' work was broader and includes soils from a variety of locations in Eastern NY. Of interest is the relatively low levels of organic matter in grasslands during both periods, suggesting they were and are generally not replenished to the same extent as cropland. The relative abundance of organic matter in 19th century cropland relative to grassland and forest is notable when compared to 21st century conditions. The relative richness of the early croplands may be attributable to the greater importance of solid manures (vs. synthetic fertilizers or liquid manures) during that period. Because methods varied somewhat between eras, direct comparisons may be somewhat risky.

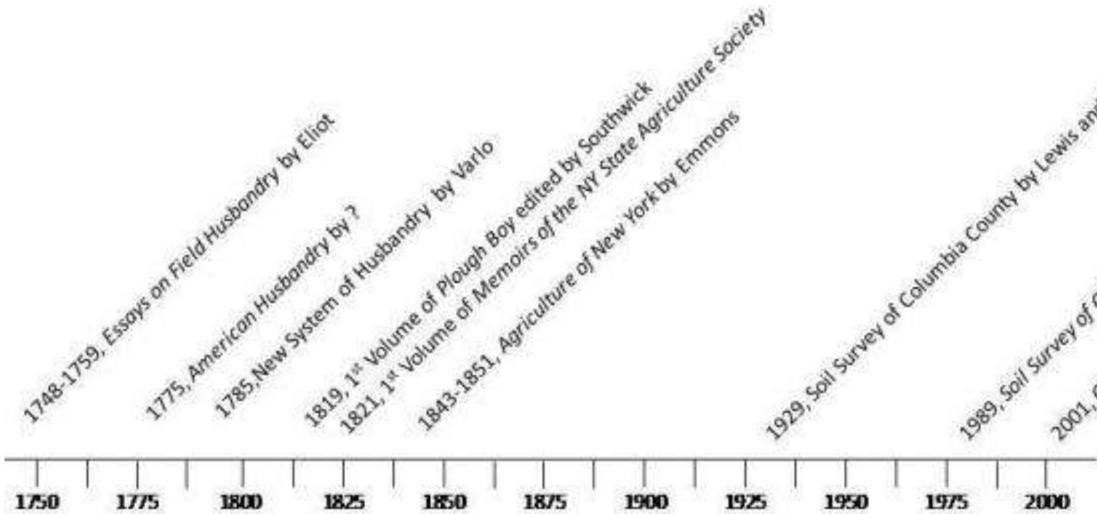
	Land Cover	% Organic Matter
1843 (NYS)	Cropland	8.7
	Hay/Pasture	5.1
	Forest	6.8
2000s (Col. Cty)	Cropland	ca. 4.25
	Pasture	3.6
	Hayfield	3.1
	Forest	7.5

Taken together, all of these snippets do not describe the state of 18th century Columbia County agriculture, so much as they describe its flow. Farming and the soils that underlay it were evolving as farmers coped with the agronomic and socio-economic consequences of a more developed agricultural state. Higher population densities coupled with increasingly distant open lands were emphasizing the need to produce more per acre of farmland, while the soil fertility consequences of long periods of minimum nutrient inputs were also becoming evident. Changing global and national demands and possibilities were drawing some farmers deeper into markets. Tenants, slaves, lords, and freeholders all interacted in a complex labor and land market with varying implications for attention to the soil. Meanwhile, the on-going search for new crops, animal breeds and soil amendments was supplying a constant trickle of new agronomic tools.

The four themes highlighted above are not explicitly about soils. However, in some ways, that is a key point of this section: soils are an unseen scapegoat of sorts, a habitat whose condition has been influenced by many factors only tangentially related to the immediate management of the soils themselves. The socio-economics of farming had a large hand in shaping the approach of farmers to their land and their soils, however it was only occasionally, and then often in retrospect, that the health of the soils themselves was considered.

These changes did not and have not ceased. For example, during the beginning of the 19th century, vastly improved transportation routes (which were to make huge strides with the 1824 opening of the Erie Canal and, soon thereafter, the arrival of the railways) put local farmers into direct competition with others farther west, and heralded major restructuring of regional farming. However, rather than follow each of these strains further, we will leave them here as a contribution to a description of this era's agriculture and as 'teasers' that readers can try to trace to the present day. Our consideration of the modern period will change its approach by focusing more explicitly on soils and asking, how has published view of soils and their fertility changed from the 18th century through to the present?

Changing Soils: The Evolving Vision of Soils and How to Manage Them in the 18^{th}-21^{st} Centuries.



A time-line showing the publication dates of the works referred to in this section.

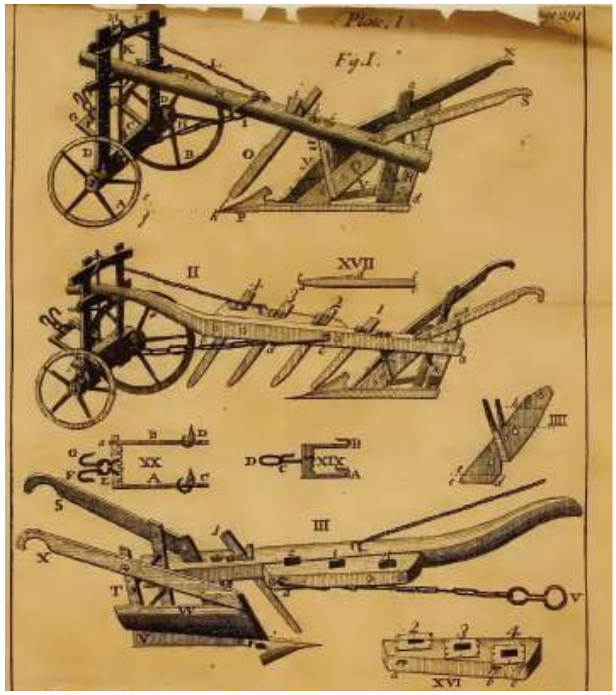
The last era of soil management to consider will encompass most of the 19^{th}, all of the 20^{th} and the start of the 21^{st} centuries, with references back to the 18^{th} century for context. This is a broad sweep of time, and much change in farming and landscape occurred during this stretch. It could reasonably be broken up into smaller periods. However, treating it as a whole lets us consider changes in perception that occurred relatively slowly and are thus most evident when viewed in the long term.

This time span saw a dramatic evolution in how agricultural scientists and then farmers viewed and so treated the soil. The goal in this last section is to illustrate this arc by describing some regional milestones in soil description. The time line above shows the works we will be considering; this is an eclectic blend, and many other publications could logically be included., but it's enough to get our hands dirty.

People are often caught between working with the everyday realities around them and trying to find over-arching explanations of those realities, explanations that may allow them to better predict and manage their reality. These two threads – practical existence and the search for explanations – are woven through the historical farming literature and, presumably, the minds of early farmers and 'agronomists' (although 'agronomist' is a modern term). Treatises on husbandry contain both 'try this, it's worked for me' and 'here's how this works, so do this' sorts of recommendations. These two perspectives interact: good explanations derive from the accumulation of observations, and explanations that don't result in workable applications fall by the wayside. Furthermore, it often becomes the fashion to explain independently-derived practical actions in the explanatory terms of the day, even if their strongest justification is simply the fact that they work.

In this quick, very parochial survey of soil science, I want to focus on the explanatory aspect. In other words, how did those writing about agriculture and soils envision the interaction between the two? In doing so, it will help us to focus on the question, 'what is soil fertility and why does it occur'? Unlike many other terms in agronomy, it seems likely that a farmer of 300 years ago and one of today, would quickly agree on the importance of fertility and a common working definition of it (something like, 'the ability of a soil to produce crops'). They might find themselves more at odds if they tried to discuss *why* a soil was fertile. In the next few paragraphs, we will try to trace implicit and explicit understandings of fertility through the literature I have mentioned.

Jared Eliot was well-placed to expound on the practical and the explanatory. He was a physician, cleric, and one of the earliest graduates of what became Yale. One biographer describes him as New England's Benjamin Franklin, and he was certainly not an 'everyday farmer'. And yet, his pastoral and medical duties led him to travel around New England and, observing the various methods tried by farmers in the region and having access to the then-burgeoning production of English farm books, he decided to write and experiment with agricultural methods. He communicated with a variety of well-known contemporary scientists including Franklin and John Bartram. Eliot was writing after the publication, in England, of Jethro Tull's seminal *Horse-hoeing Husbandry*, but before the early 19th century raft of soil chemical analyses that included the works of Humphrey Davys and then Justin Liebig. His voice will represent the starting point of our time series.



An image from Jethro Tull's 1720, Horse-Hoeing Husbandry, a book that had a large influence on Jared Eliot. For both Tull and Eliot, much of fertility management had to do with, as this image suggests, how one plowed the land.

One concept that seems central to Eliot's view of fertility is what we now call friability, that is the looseness and 'fluffiness' of the soil. In emphasizing friability, Eliot was explicitly echoing the influential words of Jethro Tull (the 17th century agronomist, not the rock band) who wrote ***Horse-hoeing Husbandry***. Tull's main thesis was that deep and intensive cultivation allowed air to reach soil surfaces, opened the way for plant root development and made more nutrients accessible.

Eliot quotes the following extract from Tull's book as the definition of its core proposition,

> The only Way we have to inrich the Earth, is to divide it into many Parts, by Manure or by Tillage, or by both: This is called Pulveration. The Salt of Dung divide or pulverize the Soil by Fermentation, Tillage by the Attrition of Contusion of Instruments, of which the Plough is the Chief. The Superficies or Surfaces of those divided Parts of the Earth, is the Artificial Pasture of Plants, and affords the Vegetable Pabulum to such Roots as come into contact with it. There is not Way to exhaust the Earth of this Pabulum, but by the Roots of the Plants, and Plants are now proved to extend their Roots more than was formerly thought they did. Division is infinite, and the more Parts the Soil is divided into, the more of that Superficies of vegetable Pasture must it have, and more of those Benefits which descend from the Atmosphere will it receive. Therefore if the Earth be divided, if it be by Tillage, it answers the same End as if it had been performed by Dung.

After some comments on the inscrutability of such language, especially for "common Farmers", Eliot goes on to make a translation, "The only way we have to enrich the land, is by Dung, or by Tillage separately, or by both of them together:

It is performed by dividing the Earth into many Parts, or, as the common way of speaking, it is done by making the ground mellow and soft, so that the Roots may pass and find their proper Nourishment…. Dung, or any other Measure, divides the Ground, sets the Parts at a Distance, and so gives a free Passage to the Roots of Plants. In this Action the Salts in Dung hath much the same Operation and Effect as Leaven, or Emptyings hath on Dough; it makes it rise, makes it light, that is sets the Parts at a distance."

What Tull and then Eliot seem to be saying is that tillage improves fertility for several reasons: it is the at the surfaces of earth particles that plants find their nourishment (and hence, the more surfaces, the more chance for nutriment; it is this surface area that Tull explicitly calls "the pasture of plants" in analogy to cattle pastures), that tillage (and dunging) not only increase this surface area, but also help plants dig deeper in their search for nutrients; and finally, as Eliot makes more explicit elsewhere, tillage opens the soil to receive the fertilizing benefits of air and water. As he puts it,

> The method… prepares the land… to receive the floating Particles of Sulphur, and the nitrous Salts of the Air, the Benefit of the Sun's Rays, which, when accompanied with a sufficient Degree of Moisture, enlivens and invigorates all Nature. When winter hath brought a universal Gloom upon the face of the vegitable Creation, Palesness and Death appears on all Sides: The Psalmist saith of it, Thou hidest thy Face they are troubled. Then speaking of the Sun, thou sendest forth the Spirit they are created, and thou renewest the Face of the Earth."

He goes on to single out the benefits of dew fall, and to cite an experiment that, by evaporating both rainwater and dew water, showed the greater nutrient content of the latter. Charles Varlo, someone who appears to have been an agricultural knight errant/snake oil salesman of sorts, published a two volume work in 1785 professing to provide a 'new system of husbandry' adapted to North America. Whatever its dubious value in achieving that aim, Varlo does provide a more explicit description of the link between tillage and life, "The nature of two bodies, mixing together thus, admits or rather opens a passge for the air to penetrate amongst it, so as to cause a fermentation; for nothing will or can ferment without air…..If he [the farmer-reader] does not open a passge into the body of the caly with some instrument, or compound, so as to admit, or make a passage for the air to penetrate therein, to raise it to action by fermentation, it will remain a dead inactive body; and if any seed happen to be bound or inclsed therein, it will never grow…"

The purpose of quoting the original language here is two-fold: it provides a bit of the flavor of the time, but it also reveals, at least in Eliot's case, the mix of the analytical and the spiritual. Eliot has a practical, sometimes even chemical , explanation for what is happening. He cites experiments and specifies nutrients. Yet, he also has recourse to another rational, a religious rational. And there is the perhaps implicit belief that this forms the ultimate 'why' behind reality. The hallowed mystery of life, combined with even greater chemical knowledge, will be made explicit in Featherstonhaugh's work.

Before leaving Eliot, it is useful follow the fate of the 'tillage as manure' theme a bit farther. Eliot was in correspondence with John Bartram of Philadelphia, a noted naturalist of his day, and asked for his comments on the Essays. Bartram responded by praising Tull, but then going on to caution., "Notwithstanding, if we continue to plant & till one spot of ground annually for many years.. ye fertilizing material will be exhausted, tho we artificially pulverize ye earth as much as we please…" This was an important observation and one that later came to be understood: tilling could loosen soils, aid plant growth and, to some extent, give plants access to previously unaccessible nutrients. However, in and of itself, tillage could not maintain these benefits indefinitely. Furthermore, while Bartram doesn't mention it in this letter (although he does in another letter to Eliot), plowing could also enhance the risk of soil loss through erosion when loosened soils were swept away by rains and floods. The interaction of plowing and erosion (by both water and wind) was to become a central focus of 20th century soil conservation concerns, prompted in large part by the Dust Bowl.

Eliot provides relatively little description of particular soils, that was not his focus. However, it will be useful, as we follow this history, to ask how our local or at least regional soils were being described. How do current understandings of soil fertility influence what people saw when they looked at the ground.

The anonymous author of American Husbandry described New York soils in 1775 will serve as a stand-in for a soil description from this period. Given the geographic extent of agriculture at that period, he was largely referring to

Hudson Valley soils (those of Long Island were noted separately). He wrote,

"The soil of the province is in general very good... the have notable tracks of rich black mold referring to a soil layer high in organic matter, red loam, and friable clays---the country swells into fine hills... the soil of many of these is rich and deep….seduced by the fertility of the soil. on first settling, the farmers only think of exhausting it as soon as possible... [they] depend on new land for everything, and are regardless of such management as would make their old field equal the value of the new ones." We'll come back to consider this description in the light of later works.

Next we'll consider a multi-author work that, while hardly a complete summary of the state of the art, serves as a good local check-in. As was occurring elsewhere, beginning in the late 18th century, New York State saw the rise of what might later be called agronomy, but which contemporaries called the science of "husbandry or rural economy". This was an attempt to derive and popularize a structured approach to the improvement of agricultural knowledge and practices. It followed a fashion established somewhat earlier in England and elsewhere in Europe. With some basis, these efforts were criticized as 'book farming' – in truth, most of those who had the time to read, write and experiment with agriculture were not those in the thick of it. Hence, some publications or recommendations sounded naïve and impractical to working farmers. Nonetheless, these efforts did, undeniably, have an influence, recognizable today in the efforts of Cooperative Extensions and formal agronomy-related university departments. One of New York States first efforts in this direction, was the already-mentioned and partially described work of the Society for the Promotion of agriculture… headed for most of its existence by Robert Livingston. In the second decade of the 19th century, this was reconstituted as the New York State Board of Agriculture, a group which began publishing its news and reports in the pages of the *Plough Boy*, a short-lived agricultural periodical out of Albany. In 182X, perhaps looking for a more formal forum for their proceedings, the Board began publication of the *Memoirs of the New York State Society of Agriculture,* and it is the first volume of these memoirs that shall serve as our milestone.

In 1819, Solomon Southwick, an Albany publisher, began to publish an agricultural weekly called the *Plough Boy.* In its first volume, he serializes a book that had come out some 6 years previous: Sir Humphrey Davys' *Elements Of Agricultural Chemistry In A Course Of Lectures*. Southwick seems to have been more moralizer, publicist (he signed his name as Henry Homespun, Jr in the first volume of his paper), and publisher than farmer, and yet he was a 'mover and shaker' in our region, and his inclusion of Davys' work suggests its influence. Today, Davy's lectures seem a bit removed from the immediate needs of agriculture, a fact Southwick seemed to acknowledge in his introduction to them, " Those who have never paid any attention to chemistry, may, in some instances, be at a loss to understand the meaning of some chemical terms with whcihc the work abounds…", but, he went on to add, "being the first work of its kind ever published, its near approach to perfection is not to be expected; - we believe, however, that it may be justly considered as an able and valuable performance – as exhibiting the intimate relations of agriculture with chemistry". This was a nuanced introduction, but over the next year, Southwick published regular installments in his monthly paper. In the concluding installment, published on Saturday, August 15th 1820, Davy sums up, "I trust that…in proportion as chemical philosophy advances towards perfection, it will afford new aids to agriculture".

By the second volume of the Plough Boy, the paper was being described as the official publication of the New York State Society of Agriculture, yet it mixed a fair dose of Southwick's moralizing with poetry, news headlines and odds & ends only tangentially related to agriculture. Perhaps to regain focus, in 1821, with Southwick publisher, the Board put out the first volume of The Memoirs of the New York State Board of Agriculture.This volume contains an interesting mix which linked to both local and national trends. Apparently in the hopes of shedding the moniker of book farming, the Board had appealed to farmers throughout the state asking them to report back on local agricultural conditions. However, the introduction to this first volume makes clear that such efforts were not very productive. As a result, instead of excerpting county reports, the publication is made up primarily by a long series of essays on "Rural Economy" by GW Featherstonhaugh. His work will serve as a somethat theoretical report on the state of soil knowledge in our region at this time. More practically, and closer to home, Amos Eaton co-authored a Geological and Agricultural Survey of Albany County at the Board's behest. This work is one of the first attempts at what will later be recognized as a 'soil survey'. Finally, the address of former president James Madison to the Albemarle (Virginia) Agricultural Society ?? is reprinted in the volume. This address, widely read at the time, was an eloquent and rather direct description of farming's ills as perceived by this former president and plantation farmer. In it, Madison articulates several issues that sound familiar today including the need to provide space for non-production considerations in the landscape (e.g., native plants and animals) and the fact that we will need to limit our own hunger for resources. Below, we will consider the works of Featherstonhaugh and Eaton in more detail.

One biographer described Featherstonhaugh as "a strange figure in a strange age". English by birth, Featherstonhaugh was apparently touring the world and, 1806, happened to be outside of Albany in Duanesburg, when, the biographer notes, he saved the life of Duane's daughter (methods for doing so are not explained), promptly married her, and undertook the farming of the 1000 acres she had inherited. Despite what may seem like a rather 'spur of the moment' attitude, Featherstonhaugh settled in, was an early promoter of Albany-are railways, and became secretary of the Board of Agriculture when it was established in 1821. Perhaps feeling somewhat responsible for the Board's lack of material for their first volume, he prepared his "Essay on the principles and practice of Rural Economy". This Essay, coming as it does after the relatively widespread publication of Davy's works, helps us understand how agricultural chemistry was being digested.

Featherstonhaugh begins his essay with something of a justification for book farming, "The deceit with which many men beguile themselves, that they understand a thing perfectly well, and wish to know nothing more about it, has been more injurious to the interests of mankind than any other of the long list of human prejudices; and in no department of knowledge has it been more fatally exercised than in practical agriculture." He goes on to describe how agriculrue is at the core of human fulfillment and thus ignorance of its "great principles" is especially troublesome.

He goes on, "Agriculture, or the cultivation of the earth, strictly speaking is but an art, which teaches the best way, under particular circumstances, of tilling the earth, in order to make it productive. But husbandry, or rural economy, is a science which involves the vegetable and animal economy of the whole creation, and their dependence on each other. It exhibits man as ration animal created for the pleasure of his maker, and explains to him the secure and benevolent way in which providence has enabled him to perpetuate the existence of his kind. By science is meant, not the knowledge of technical words, and theoretical systems, but the knowledge of the general relation of things useful to mankind, and which can be immediately comprehended by practical men of clear understandings : and it is hoped in the development of the science of husbandry, after the manner in which it is here planned, that notwithstanding the necessary recourse which must occasionally be had to chemistry, the subject will be treated in a perspicuous [i.e. clear] manner."

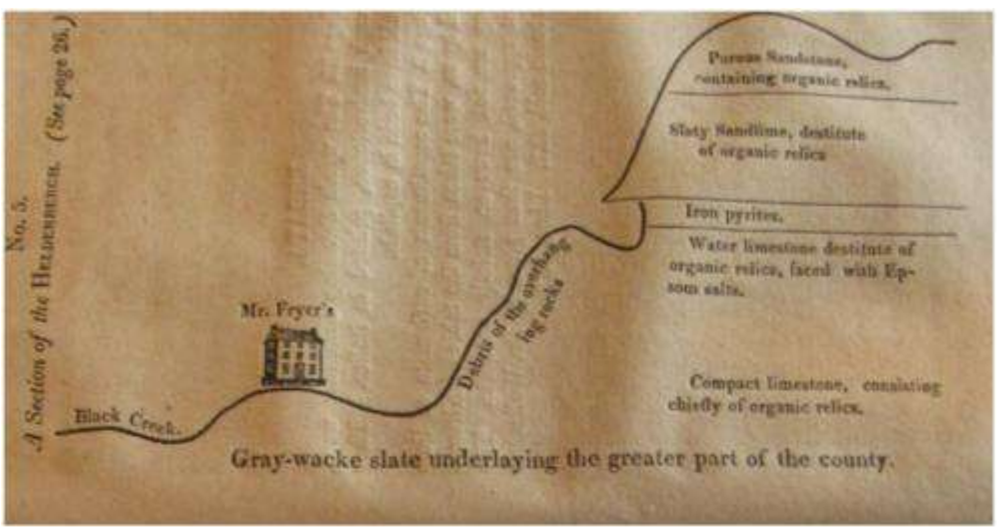
Perhaps a somewhat long-winded extract, but an important one: Featherstonhaugh is bridging a gap between Tull, Eliot and their intellectual kin, and Leibig and the world of agrochemistry. To say he had a foot in both worlds could be misleading because it was perhaps more of a single stream than two con-current ones. Agricultural chemistry, Featherstonhaugh can be read to argue, is man's moral duty to pursue in order for him to understand how to make the best of the providence provided to him. This general philosophy, couched in various terms – sometimes economic, sometimes nationalistic, some religious – is prevalent during this era. Featherstonhaugh is not by any means a lone or leading voice; he is a local exemplar. He is worth quoting as he demonstrates the origins of agrochemsitry not in the profit drive sometimes ascribed to it today, but rather in a deep conviction of its importance to agricultural improvement.

He continues, "These soils also are various in their appearance and properties, and the forms of vegetables and their properties appear to depend upon the particular nature of the soil they grown in, aided in some degree by climate and situation. We know that in sandy districts, the pine tree universally prevails; we may therefore very fairly conclude that the pine is the natural production of that soil. We know also that…black ash and spruce are the natural production of a rich vegetable mould, continually saturated with water. It being conceded that particular soils under the same circumstances, will always produce the same results; the next step to learn is, how many varieties of soil there are, and what the properties of each variety as they are connected with vegetation. This branch of knowledge is certainly important; for as man depends upon the fruits of the earth for his subsistence, he ought to be well acquainted with the properties of the different soils of which its surface is composed in order to combine in the most advantageous manner for his own use… The soil, such as we perceive it on the surface of the earth, and which we use for agricultural purposes, is a mixture of various kinds of earths, and vegetable and animal remains: and by the aid of chemistry, the elementary parts of which they are composed, can be separated from each other and distinguished. By thus analyzing fertile soils, the constituent parts of which they are formed are discovered, and the knowledge of that which constitutes fertility obtained."

Here is an explicit logical for soil chemistry: different soils produce different vegetation due to the different characteristics of those soils. Working in reverse, if we wish to encourage particular vegetation, ie., our crops, then we need to understand the soil characteristics that will produce them. So, he urges, what are our soils, what can they produce, and how can we manage them in the ways "most advantageous" for our own use? Agricultural chemistry provides one key.

Featherstonhaugh goes on to describe proper soil management more particularly, developing, for example, some of the ideas akin to those of Varlo and Eliot, in that he stressed the importance of plants receiving nutrients from materials dissolved in water, materials which, in turn, partially come from the atmospheric deposition of previously vaporized organic matter. He defined "manure" as, essentially, "mixture", meaning that its main purpose was the mixing, and hence opening, of soil materials. He also provides a perceptive description of nutrient cycling, describing how soils build plants; plants, as food, build 'higher' organisms such as humans; and how we decay and eventually rot, returning our components to the earth. However, the strand of Featherstonhaugh's work which we will pursue here is his call, essentially, for soil surveys – an agricultural resource still familiar to us today.

Conveniently, one of the first such surveys is in the same volume of the Memoirs. Geology was one of the hot sciences of the early 1800s. People had realized patterns existed in the rocks, that they told stories, and that they were intimately related to soils and mineral resources, and hence to the human condition. Amos Eaton, New Concord farmer's son, was both a geologist and a botanist hence excellently situated to execute a soil survey focused, as Featherstonhaugh suggests, on the interaction of land and production. He and an Albany physician, T. Romeyn Beck, were commissioned by the Board of Agriculture to conduct a survey of the geology of Albany County. Amos Eaton was a Columbia County native, born in New Concord in 1776, he withstood various buffets including a life-time prison conviction (he was later pardoned) to become one of North America's leading geologists and botanists and one founder of RPI.



An illustration from Eaton and Beck agro-geological work.

There can be no doubt that Eaton and Beck were conducting a soil survey. Their nicely explicit methods detail their communications with various farmers in the Albany County together with their collection and subsequent analysis of soil samples from various farms and attempts to correlate those results with agricultural behavior of the soils as reported by the resident farmers. In some ways they do a stunning and ground-breaking (no pun intended) job: Together we a detailed description of the geological formations, they provide a classification of soil types and, based upon samples pooled from various farms within each type, a chemical analysis of each soil type. They describe the type of agricultural management that has worked best on each type of soil and try to provide links between the chemical characteristics of the types and their underlying geology. These are still essential components of modern soil surveys. What is however, interestingly lacking is any explicit connection between soil chemistry and soil management. In other words, the chemistry is tabulated by soil type and management recommendation, apparently based largely on farmer input, are likewise presented for each type, but almost any attempt to link the two in a cause and effect way is absent. It is a bit as if the general, inherent importance of soil chemistry for agriculture were recognized, but nobody had quite figured out the nitty-gritty details of connecting them.

As an example of their soil descriptions, one can quote their description of Albany County riverside soils, they remark," The earthy part of this soil is not alone very favorable to vegetation, being chiefly a loose sand, but it is remarkably fertile, on account of the supply of vegetable matter derived from frequent inundations... when afield is much worn and exhausted, a deep ploughing ... seems to bring forward new stores of nutriment, which had been reserved below the proper action of heat and air."

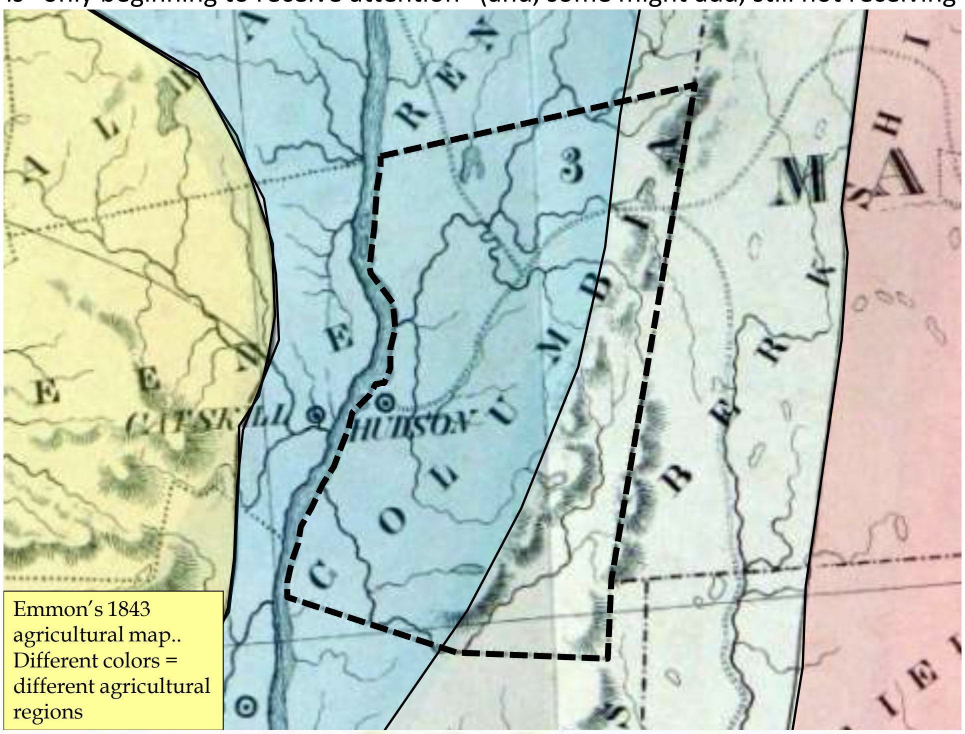
To add a little more local flavor, we can also cite Horatio Spafford's description of Claverack soils from a bare three years later,," very extensive alluvial flats, frequently fame Inundated and very fertile... The Claverack flats are proverbially rich, and nothing can exceed the abundant luxuriance of their products...... The use of gypsum is nowhere more beneficial than on those lands [the Canaan hills], warm and sweet, wanting nothing but vegetable matter, duly converted into mold"

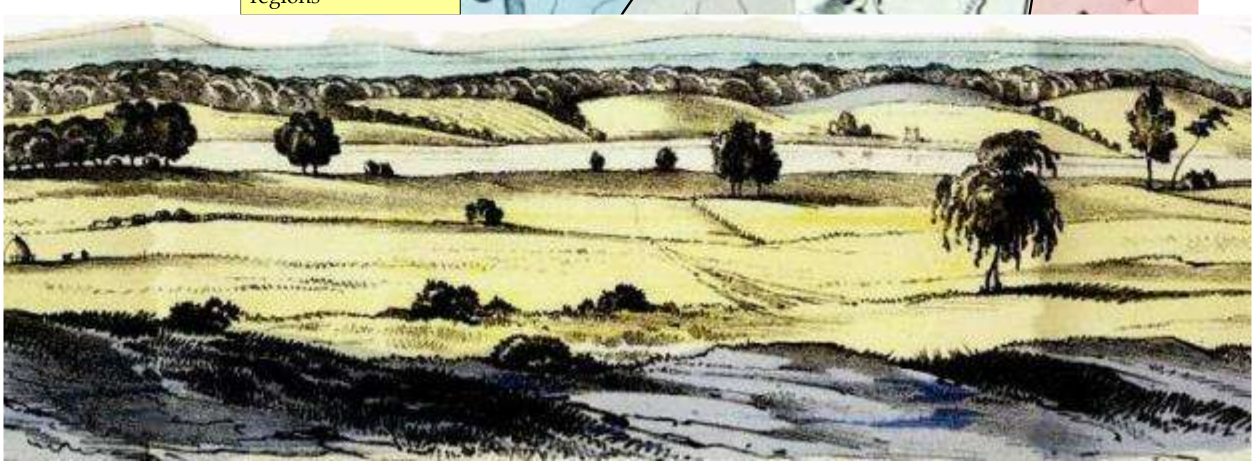
We can pause here to consider some common threads through these early soil descriptions. First, they speak of the innate fertility or richness of the soils. That description from American Husbandry is hardly specific, but, accurately or not, it heralds an inherent quality; likewise Eaton/Beck and Spafford describe nutrients arising from the land itself, albeit aided by certain natural and human additions. Eliot and Featherstonhaugh, while speaking more generally, present the view of soil as a nearly live entity deserving of nurturing. Second, correlated with this perspective, these authors bemoan soil exhaustion almost as a fall from grace – it reflects an anomalous condition connoting poor farming. This exhaustion can, in part, be ameliorated by tapping into natural sources of fertility, that is by fallows (what happened to old land when farmers went on to new land), by working floodplains, by plowing deeper so as to access new nutrients;' and/or by restoring and preserving organic matter (or "mold"). That said, none of these writers were adverse to using soil amendments to make grounds more productive or restore their fertility. Most of these additives were complex , namely manure, marl, green compost, and gypsum. The inclusion of the last item perhaps foreshadows future trends: for our County's farms it was an 'off farm input', meaning that farmers could not produce it themselves. Instead, gypsum was imported from other parts the Northeast, ground at plaster mills, and then purchased by farmers. This trend towards importing nutrient sources in one that shall grow over the next centuries.

Our next milestone is a much lengthier, if less focused, tome by hard-working Ebenezeer Emmons published between 1843 and 1851. Born in Western Massachusetts and a physician who trained at Williams College, Emmons had an early interest in geology and helped conduct a geological survey of Berkshire County. Pursuing his geological bent, he went to what was to become RPI, where he studied under Amos Eaton. As typifies many realms of ardent scientific pursuit, Emmons got into a bitter public debate with a colleague, in this case over the geological origin of the Taconic Mountains. He and James Hall, his 'opponent', had both been working for New York State Geological survey, during which Emmons produced an important volume on Adirondack geology. As fallout from the row over the Taconics, Emmons was 'demoted' to head of the agricultural survey while Hall, the political winner (Emmon's scientific view was later found to be more valid), was named leader of the geological survey. Emmons responded with a five-volume report on New York agriculture which, reflective of Emmons' wide-ranging interests, spans the gamut from a survey of state soils to volumes on NY apples and insect pests, with a long aside on Taconic geology inserted for good measure. It is Emmons' statewide soil survey which will form the next link in our historical chain.

For our purposes (this is our organizational structure, not his), Emmons' work can be said to possess three parts: a rationale, in which he lays out the logic of his approach; a data presentation, in which provides the information he collected; and an application, in which brings the first two parts together in order to provide practical recommendations for soil management.

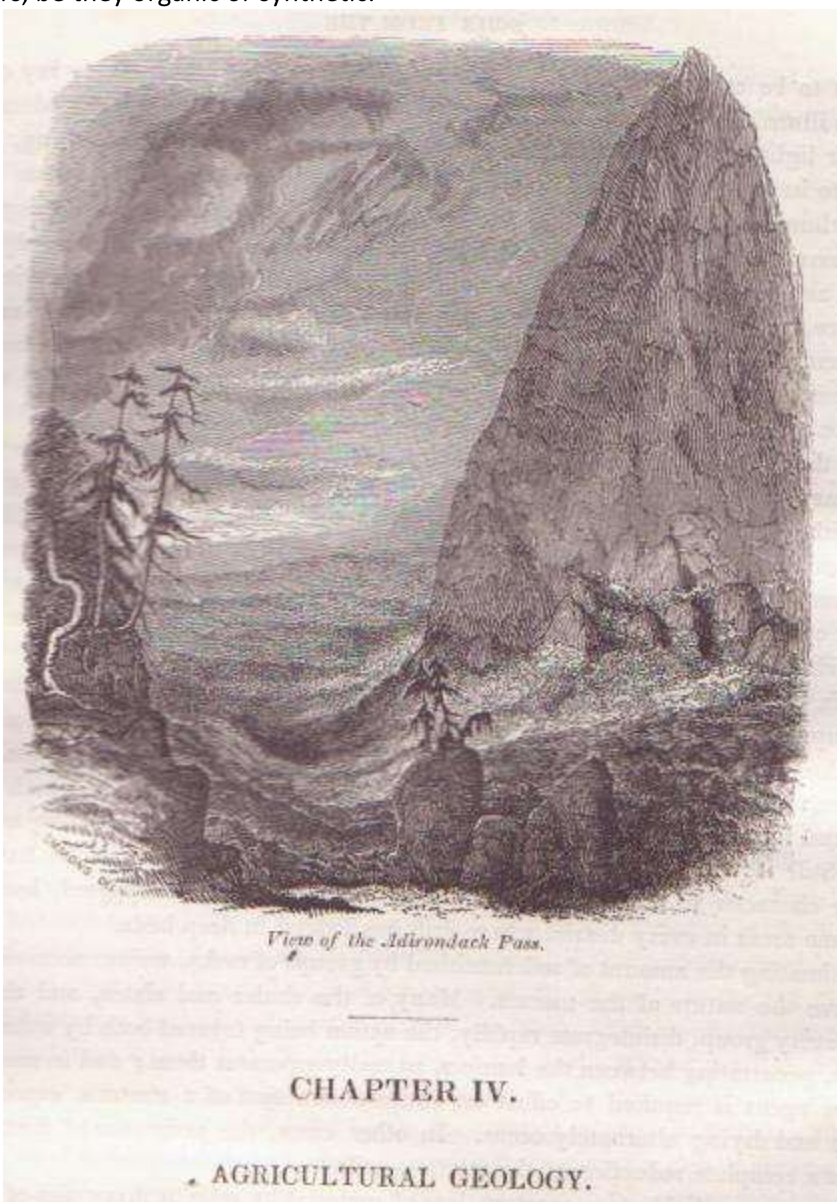
In explaining his approach Emmons explicitly links agriculture and chemistry. His writings are scattered with reference to Davy, Liebig and other researchers. He first echoes Featherstonhaugh by pointing out that different types of plants differ in their native soil preferences. There are, he says, "potash [i.e., potassium] plants and lime plants; that is some seem to require more potash, or lime, than others. This apparent selection of potash, or lime, is due … to the original constitution of the plant.” Building on this, he summarizes his tack, “What agriculturists now aim at, and it is the most they can do, is to put within the reach of each plant all the nutritious elements its nature demands. These elements have been determined by analysis of the different parts of plants…” One volume of his work is nearly filled with the results of such analyses of various plants. He is explicitly making a link that Eaton and Beck only scratched. As a specific example of his application of chemistry to farming, he uses the example of wheat. “Every bushel of wheat contains a large amount of potash, and of the phosphates; and as plaster [the manure most commonly applied by wheat growers] does not contain either, it is undeniable that the exhausting process is going on by this mode of cropping.” He continues with a more locally-relevant example of pasturelands which lose their nutrients via the export of milk. There is a nutrient budget, his is saying: what goes out must come in unless the soils are to degrade over time. Also, he makes clear a bit later, the nutrient composition of the crop will depend upon the chemical composition of the soil, a realm of management which is “only beginning to receive attention” (and, some might add, still not receiving due attention).





Two illustrations from Emmon’s work, in both cases different colors indicate different agricultural regions, reflective, at least in part of differences in soil quality.

Finally, he applies his approach to a definition of fertilizers, “The farmer is compelled to employ a class of bodies to restore to his land those elements which he has removed in his crops… the great reason why fertilizers are required, is in the consequence of the removal of the mature crops from the fields, and their consumption elsewhere. Any thing is a fertilizer which can restore one or more of the removed plant-aliments to the soil.” Notice how distinct this is from Eliot’s and Featherstonhaugh’s definition of manures as mixers of soils, and it lets Emmons evaluate various manures or fertilizers from the perspective of what chemicals they provide to the plants in comparison what chemicals are in the crops themselves and in the soils. He provides a very specific example, “In the vicinity of New York, Albany… and other towns in New York and New England where milk is largely consumed, it is evident that… the lands must deteriorate in richness by the milk alon which is consumed. Every forty gallons of milk contain one pound of phosphate. In the average yield of milk for one cow, per annum, there will be carried off phosphates which are equivalent to thirty pounds of bone dust. There is still to be reckoned the consumption of other matters…about fifty six pounds of bone dust [per cow per year] in all… Pasture lands, therefore, which are fed for many years, will show the losses they have sustained by the appearance of poorer kinds of grasses, moss, loss of vegetation in many places. That bone dust, or the phosphates, applied in some for or other, will restore greenness and fertility, need not be doubted… There will be economy in this procedure… as the feed deteriorates, so does will the milk, an hence, milks which is produced by well fed thriving cows yields a greater profit in butter and cheese.” This examples illustrates an essentially modern conceptualization of the role and value of fertilizers, be they organic or synthetic.



What happens when your Adirondack geologist is asked to write about agriculture.

The soil survey portion of Emmons’ reports, which actually precedes the rationale presented above, does, as one might expect, more explicitly link soil chemistry and agricultural management than Eaton and Beck’s survey. Being statewide, it is more general than their work, but our region is encompassed within Emmons’ “Taconic District”, one that, given his time at Williams and RPI and the previously mentioned scientific debate, probably held special significance for him. He presents soil chemical analysis for a variety of soils within the district, including samples from Chatham, State-line, and

Schodack. From these analyses, he draws some conclusions on “the means of improving the soils of the Taconic District”, specifically noting the dearth of lime, phosphate, and potash. As remediation, he recommends the application of, in addition to animal manure, lime, peat, and ashes; preferably in composted forms. These are not random suggestions: Emmons had information on the chemical constituents of each of the additives he recommended, and he was trying to match deficits to restoring amendments.

Emmons, while heralding chemistry as a provider of important insights, does not claim that it alone explains the world. Preceding his section on fertilizers is one on “Force”, “vital force” is, he explains, “something which we are obliged to admit, though we know nothing of it, except from its effects”. And yet, unlike Featherstonhaugh or Eliot, he does not resort to metaphysical or religious explanations. The eight pages he devotes to force are largely devoted to reports on the experiments of others exploring organizing principles of life.

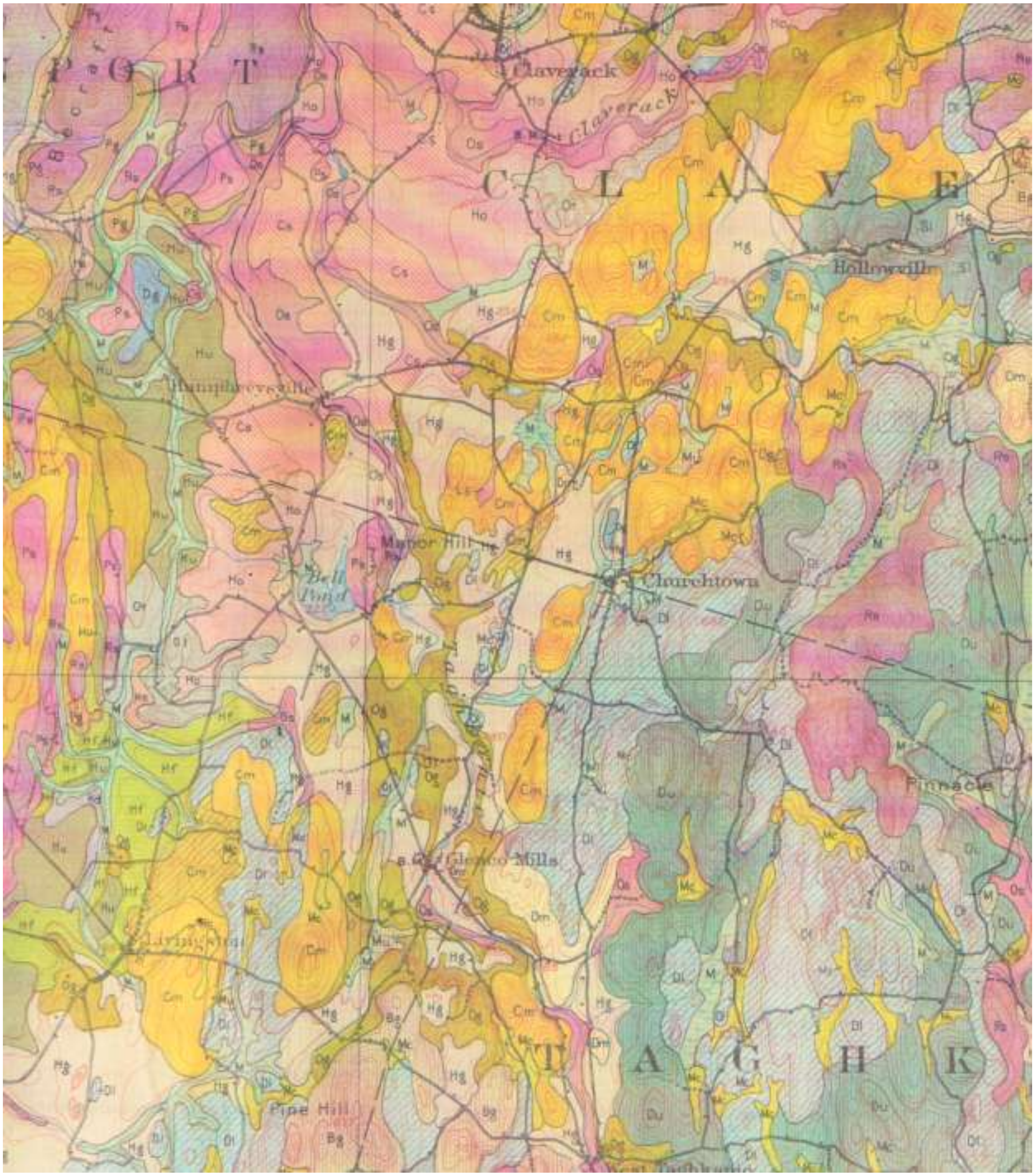
Despite or perhaps because of the wide-ranging nature of Emmon’s work, it is difficult to find a representative description of our own soils the following is derived from his summary of the Taconic District soils, "The best materials for increasing the mantes quantity of manures of this district, are lime and peat, of each of which there is an abundance. These materials are both wanted on every farm, without exception: it is proved by the analysis of every variety of soil in the district... Generally, the basis for improvement in the Taconic district is excellent, there being sufficient tenacity in the Soil to hold manure.-."

Emmons words may be used to highlight a changing perspective. Perhaps most notable is the "analysis" based description of the soil's qualities. Note too that the talk is more of improvement rather than restoration of natural fertility; one begins to feel that soil scientists are moving towards a vision of soil as a tank to be regularly re-filled, rather than a living substance to be nutured. Enmon's work in 1843 speaks less of innate richness, preferring to delve into its chemical definition, although His Consideration of soil exhaustion lake likewise focuses on its chemical definition.

Like earlier and later authors, Emmons does recommend soil additives, but, here is somewhat old school in his focus on locally-derived fertilizers or manures. In part, this probably reflected the relative lack of alternatives, and yet he mentions guano (derived from bird droppings collected largely from islands off the Chilean and Peruvian coasts; it was to become hugely popular) and “Leibig’s patent manure”. However, one of the logics of the entire series of reports of which Emmons’ work formed a part, was the resources of New York State. There is emphasis throughout on what can be attained locally or at least from the state itself, as opposed to purchased elsewhere.

About 80 years later, 1929, the first official soil survey of Columbia County was published, co-authored by H.G. Lewis of the USDA and D.F. Kinsman of the New York State College of Agriculture (that is, the state portion of Cornell). It is, perhaps, more interesting for what it *is not* rather than what it *is*. True, it presents a level of detail unseen in earlier works. The multicolored maps with soil types carefully outlined would likely have been the envy of earlier scientists, but, given adequate resources, not necessarily outside of their abilities. Its tables of temperature and agricultural statistics are apparently precise, but, again, not outside of what emmons, if not eaton, could have and sometimes did compile. Its soil classification scheme, based on nationally accepted standards, and breaking the county up into 21 soil series, embracing 36 soil types, 7 phases, and 6 types of miscellaneous materials" implied impressive classification skills but not necessarily new knowledge.

Most of the specific agricultural remarks are observational and even less detailed than those of Eaton. The summary of the agricultural landscape does little more than note that there are forests on the hills, that "crop rotation is commonly practiced by the better farmers... the use of lime is increasing,.. the value of organic matter in the soil is realized,.. there is a general recognition of the adaptation of soils to



A colorful map from the 1929 soil survey of the County.

crops… in the hill section some farms have been abandoned because of unfavorable soil and climate and the remoteness from markets." There is little additional discussion of soil chemistry or its relation to production. That the “better farmers” are practicing rotation reads almost like one of Eaton’s or even Conventry’s hopeful comments, and echoes even earlier recommendations. Read in the 20th century, it echoes with hints of stagnation, further emphasized by the concluding remarks on farmland abandonment.

An example of their description of one of our local soils is dry and to the point, "The surface of Hudson silly clay loam, to an average depth of 8 inches, is light-brown or yellowish- brown smooth silty clay loam...The upper part of the subsoil, to a depth varying from 12 to 15 inches is typically slightly mottled yellow, gray, and rust-brown silly clay loam... The surface soil is acid or very acid, and lime is not present above a depth varying from 3 to 5 feet... The relief is favorable to intensive cultivation... it is rather- hard to be managed under cultivation as it cannot be plowed when too wet or too dry...The surface soil is poor in organic matter and lime"

Talk of innate fertility is largely gone, although physical description of texture and color is much more extensive. Correspondingly, there is consideration of the practical physical practicality of farming such soils. Chemical results are mentioned, but almost in passing.

This survey might have pleased Emmons and earlier authors to some extent – the authors' affiliations with national and state institutions of agriculture, represented realizations of long-standing dreams amongst agronomists - , but they might also have been disappointed. Gone is the fresh fervor that one might alternatively call conceit or enthusiasm and that typifies a vibrant science. These are diligent authors, but not necessarily inspired ones. Unlike the preceding authors, a quick web search produces no ready scientific biography. Almost the only information that appears is the lists of other soil sources co- authored (not necessarily together) by these men. There are data here put there is little cutting of new ground. Surely a farmer looking for land or a government official assessing county resources would have found this survey a useful tool, but one guesses that Emmons and colleagues would have hoped that 75-150 years of study would have produced more insight.

It is unfair to fault Lewis and Kinsman for lack of insight; that wasn't their job. They were following a standardized model that produced an admirable set of surveys during this period. Furthermore, the humbleness of these surveys did perhaps reflect insights but ones of correction rather than linear progress. Soil scientists had realized, for example, that soil chemistry was not as simple as Emmons and his generation had hoped for. As a nearly contemporary textbook, authored by a Cornell professor, points out in its critique of soil testing;"no phase of soil science has received as much popular recognition as chemical analysis, nor is any other techwl quoted cal soil procedure so little understood in general and at the same time so greatly overrated"

This did reflect a key insight, namely, while chemical analysis might reveal the soil's total content of various nutrients, it could not so easily reveal what was actually available to the plant. in other words, one might count all the money in a bank's vaults without learning anything about how much of it might actually be available to that next customer who walked in the door. For much of the 20th century, soil chemistry, as a way of understanding soil function (as opposed to a way of applying fertilizer), would be stuck in this doldrum. A sense of disappointment is understandable: the enthusiasm of the soil improvers had not borne fruit in at least two ways: their improvements had not saved regional agriculture; farming in the hudson valley was now clearly declining in prominence (not that this was due to declining soil fertility), and its scientific method had not provided an all-seeing, practical explanation of soil's hidden world.

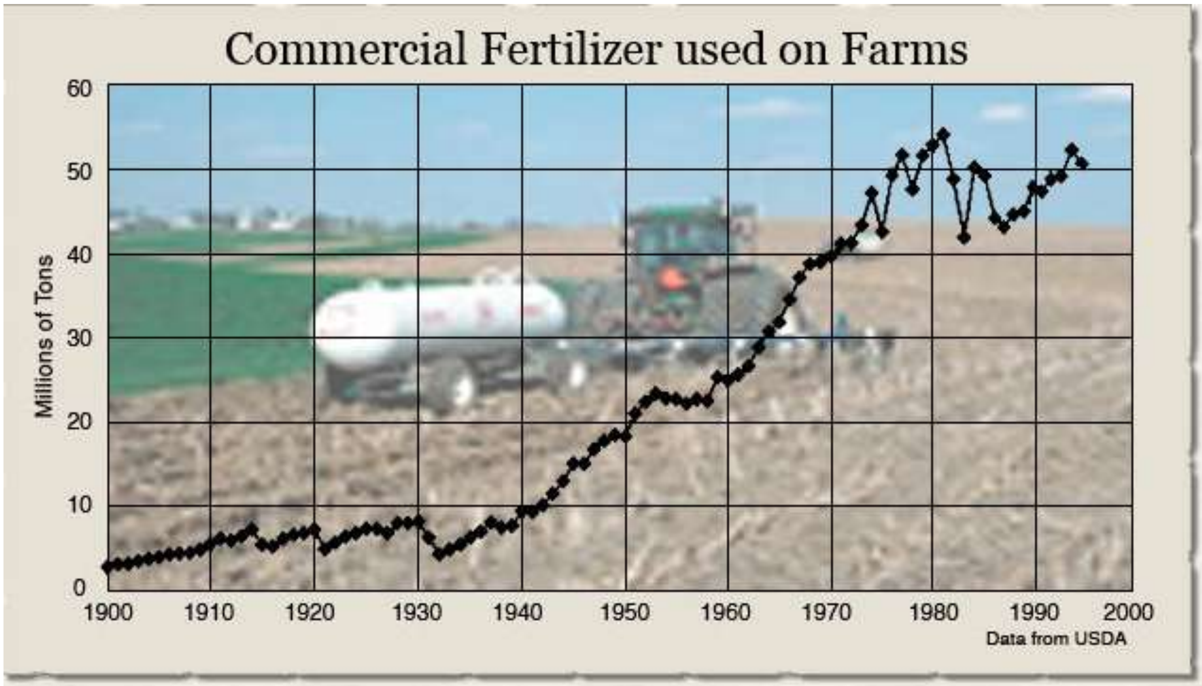
In 1989, the USDA published its second soil survey of Columbia County (the data have since been translated into a web application). With 266 pages and 27 map sheets, it is a much more detailed document than what had been published 60 years previously. Each of its more than 100 identified soil units is described in terms of depth, color, texture, chemical properties and current use. Soil distrubution is detailed by graphic overlays on aerial photographs. The extent of the fieldwork is impressive, and analyses and descriptions reflect new understandings of how soil is formed and behaves. For example, the idea of the soil 'pedon" as a unit of soil composed of various layers or horizons formed by the effects of weathering, biology and parent material results in a more orderly description of soil than in any of the previous works we have mentioned.

As the previous survey hinted might happen, this is only partially an agricultural document: aside from noting suitability for farming, the survey describes the derivation of building materials such as gravel, and the suitability of the land for house foundations and septic tanks, civil engineering, forestry, and recreation. Some of the document's perspective on agricultural soils might be illustrated by its standardized definition (these same words are found in various USDA soil surveys of the period) of "prime farm soils". "Prime farmland produces the highest yields and requires minimal amounts of energy and economic resources, and farming it results in the least damage to the environment….The general criteria for prime farmland are as follows: a generally adequate supply of moisture from precipitation or irrigation, favorable temperature and growing season length, acceptable levels of acidity or alkalinity, few or no rocks, and permeability to air and water."

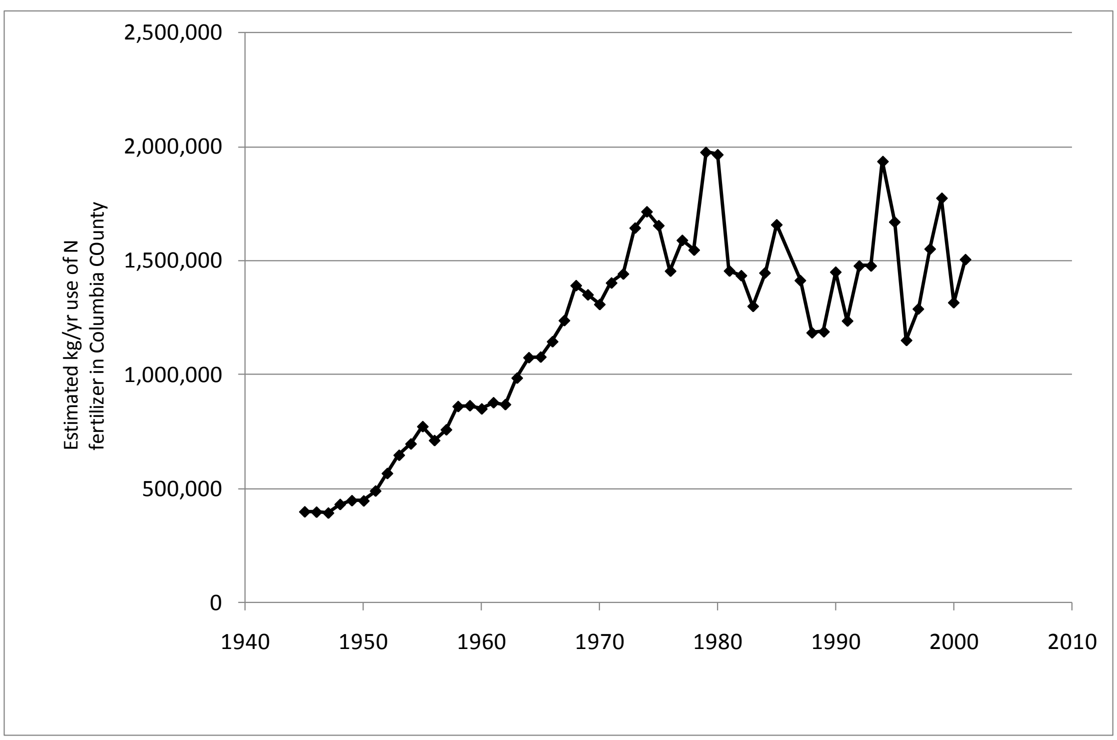
A map from the 1989 soil survey.

The 1989 Survey is long and detailed and so it is difficult pick a synoptic description of our soils. Yet, its section on "Use and Management of soils" in relation to crops and pasture is perhaps an appropriate illustration. It was written by the long-time county representative of the USDA, and contains the following sections in the following order: "Erosion";"Drainage; "Surface Stones boulders and outcrops's'; "available water capacity'; soil tilth"; fertility; and "special crops". Erosion, so highlight by the Dust Bowl and subsequent soil conservation efforts, understandably gets the pole position; it’s interesting to note how far back fertility is positioned.

Under “fertility”, the Survey provides the following description, "Fertility in the county is enhanced by lime and fertilizer... Nitrogen fertilizer is needed to supplement the nitrogen from organic matter in the soil. Management that builds up the supply of organic matter, such as the use of green- Manure crops, sod crops, and crop residue, improves the natural nitrogen content... The soilsin Columbia County are generally low in natural phosphorous... The addition of appropriate amounts of phosphate in the form of commercial fertilizer is essential for good plant growth... Most of the soils have a low to medium level of available phosphorus potassium.. Even soils that have a fairly high content of potassium, however, require additional potassium for optimum yields of most Coops. Lime is needed in most of the Soils in the survey area to raise the pH to an acceptable level for optimum yields of most crops. Additions of lime and fertilizer should be based on soil tests."



http://www.livinghistoryfarm.org/farminginthe50s/crops_06.html (N fertilizer)



While much in the 1989 survey would sound familiar to the previous authors – the physical descriptions of texture and color, for example, are extensive – something has happened to fertility. It has become an added ingredient. While earlier works bemoaned loss of innate fertility, by 1989 such loss is almost a given. Drainage, texture, and control of erosion establish your matrix, the nutrition of which can then be managed through inputs to produce the "optimum yields". This is a reasonable perspective for the Survey to take. Synthetic fertilizer application had become widespread with, few would argue, at least short term leaps in production. As a consequence, the list of which soil characteristics were most important to the farmer changed. Nutrients could be applied, but rocky or sticky soil, standing water, erosion, or similar physical conditions might be more difficult to overcome, and hence became the primary determinants of soil suitability. Soil chemistry has come of age as a source of new ingredients with which to create fertility.

Inputs themselves are not new, as our earlier descriptions illustrate. What is new are the elemental, synthetic fertilizers. Manures are not irrelevant, but they are secondary. There is no hint that local or on-farm nutrients might be preferable to distant imports – advances in transportation and cheap fossil fuels meant that proximity of source was no longer a consideration.

Finally, in re-reading these more recent descriptions in relation to the earlier works, one might say that soil has lost some of its living quality. To be honest, one can find passing references to microorganisms and other soil life in the 1989 report, but soils are no longer "warm and sweet" or even "rich"; it is almost as if soil has become the "dead inactive body" that Varlo warned against.

This perspective is changing. There is growing awareness amongst students of soils that soil life is an important ingredient of a healthy soil. An awareness perhaps spurred on by the realization that an energy-efficient approach to soil fertility maintenance might require a more collaborative relationship with the soil's natural ecology. The Cornell textbook that was quoted earlier was already remarking on its importance in determining which soil nutrients a plant was actually able to obtain. Since the 1989 survey, no new soil surveys of the County have been done, but new analytical tools reflecting a renewed respect for soil life, have become available.

For example, the Cornell Soil Health Test describes [add example of report] soils according to a variety of descriptors in addition to physical and chemical attributes. It has added biological parameters such as nitrogen mineralization rates and aggregate stability (a physical condition largely reflecting the relative presence of biological glues) which are meant to indicate the functionality of important biological processes. A description of soil nematode communities was found to be a valuable indicator of overall soil condition, but was left out because of its high cost. Tests available from other laboratories measure soil respiration or estimate bacterial and fungal densities. As the Cornell working group notes in its manual, Over the years the concepts and understanding of the importance of the soils' physical and chemical properties have been well accepted. However, it has not been until recently that the importance of understanding soil biology and biological properties has become a focus."

In defining their moniker, the manual that accompanies the new Cornell tests describes "Soil Health" by equating it with soil quality and then quoting a definition of the latter as, "the capacity of a soil to function, within ecosystem and land use boundaries, to sustain productivity, maintain environmental quality, and promote plant and animal health". They then note that NRCS keeps much of this definition but also adds the distinction of inherent and dynamic soil quality characteristics, defining the former to be, "the aspects of soil quality relating to a soil's natural composition and properties". They go on to describe how human activity (what they call dynamic qualities) can alter certain soil properties. They list important soil functions, and conclude, "when soil is not functioning to its full capacity…more inputs… are necessary."

This is heady stuff. In both its enthusiastic tone and its return to crediting soil with a certain vitality worth nurturing, it reminds one of some of our earliest examples. We are perhaps also where Featherstonhaugh, Eaton and Emmons were in another way too: just as they grasped the importance of soil chemistry but were unsure of exactly how it converted to soil fertility, we now realize soil biology's importance, can even describe some of its actors, but we struggle to make links to soil function. With notable exception (e.g., mycorhyzal fungi), we cannot yet, describe soil microbe, protozoan and fungal communities in ways that provides direct predictions of resultant soil quality, be that for natural or cultivated vegetation. Perhaps, although the memory of Emmon's foiled optimisms provides a shade of caution, we will be able to develop a biological understanding that converts our working conception of soils from one of an inert physical matrix through which we pump nutrients on their way to becoming food, into one that sees soil as a living collaborator to be nurtured as we seek to derive from it the nutrients we need for our own life. Can we, in effect, recognize soil has a habitat for both its own pool of organisms and for us.

CORNELL SOIL HEALTH TEST REPORT (COMPREHENSIVE)

Name of Farmer: Chazy Plots	**Sample ID: E147**
Location:	Agent: Bob Schindelbeck, Cornell University
Field/Treatment: CH 14	Agent's Email: 0
Tillage: 7-9 INCHES	Given Soil Texture: SILTY
Crops Grown: COG/COG/COG	Date Sampled: 4/25/2007

	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	22	25	aeration, infiltration, rooting
	Available Water Capacity (m/m)	0.18	63	
	Surface Hardness (psi)	107	78	
	Subsurface Hardness (psi)	400	13	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	2.1	14	energy storage, C sequestration, water retention
	Active Carbon (ppm) [Permanganate Oxidizable]	462	21	Soil Biological Activity
	Potentially Mineralizable Nitrogen (μgN/ gdwsoil/week)	2.0	0	N Supply Capacity
	Root Health Rating (1-9)	2.3	88	
CHEMICAL	*pH	8.3	0	Toxicity, Nutrient Availability (for crop specific guide, see CNAL report)
	*Extractable Phosphorus (ppm) [Value <3.5 or >21.5 are downscored]	9.5	100	
	*Extractable Potassium (ppm)	20	11	Plant K Availability
	*Minor Elements		56	
	OVERALL QUALITY SCORE (OUT OF 100):		39.1	**Very Low**

Measured Soil Textural Class:==> silt loam

SAND (%): 17.0 *SILT (%): 77.0* *CLAY (%): 6.0*

Location (GPS): Latitude=> 0 Longitude=> 0

An example of a soil result report from the Cornell Siol Health Test.

This chapter has spanned a wide gamut of time and perspectives. If one were to reach down and collect a handful of soil, it might in some ways bear the physical and biological impressions of that history. Perhaps, were it taken up from along a stream, it might have once experienced the slow, pulsed removal and return of nutrients as indigenous agriculture, with its relatively short croppings interspersed by long fallows, worked the surface. Finding the land cleared or in young forest, early Dutch colonists may have also worked the land, perhaps surprised by its initial fertility, but perhaps also driving its nutrients to new lows before moving on to new ground. A New England settler, having already learnt about soil exhaustion the hard way, and through rotation and careful manuring, may have rebuilt the soil's nutrient and life at least enough to make a good subsistence living. Over the next 150 years, the soil may have felt a more intensive use – higher harvests may have been requested of it, and , in keeping with the increasing commercialization of agriculture, the variety of crops that it grew may have become more limited. And yet it also got new help: leguminous crops, with their ability to restore nitrogen may have been more frequently planted; lime or gypsum may have ameliorated its acidity; novel, more concentrated fertilizers such as bird guano may have been spread atop it. Finally, about 60 years ago, the soil would have begun to be turned by heavier, faster machines, perhaps resulting in more regular and deeper upheavals, and its annual pulse of nutrient content would have become much more dramatic; larger crops removed more nutrients, but synthetic fertilizers meant quicker, more concentrated replenishment of plant accessible nutrients, although not necessarily in ways that built its own reservoirs of life and nourishment. The soil in your hands, once relatively most and crumbly like a fresh muffin, became more apt to be dry and powdery.

What will happen next is unclear. We now know better in terms of what might constitute a more lively soil, better able to produce crops without heavy juicing with synthetic fertilizers, but it is not clear how this realization will be applied on the vast majority of our agricultural lands. In the short term, at least, pumping nutrients through a soil matrix might be the cheapest, easiest way to produce the most food, a consideration which in no way should be belittled. Some would argue, however, that such cheapness will not long remain, and that we might again need to treat that clump of life in our palm a bit more respectfully while asking it to collaborate with us a bit more actively.

(I don't mean to slander the Dutch, this is a matter more of historical sequence than ethnic skill.)

Earthworms and Ground Beetles.

What more aptly-named duo than these to provide a natural history link to all the human history discussed above? These two groups of organisms have contrasting levels of interaction with the soil. While Earthworms live embedded in the soil that they also eat it; Ground Beetles spend more time, at least as adults, scuttering across the top of the ground and are not known to ingest the soil itself. Yet, both groups are closely tied to the soil upon which they live and so are appropriate to discuss here.

Earthworms.