The Long-term Effects of Deforestation and Farming on Soil Infiltration Rates and Soil Horizons

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<u>ABSTRACT</u>

Four locations in the Champlain Valley were studied in an attempt to determine to what extent farming and deforestation affect soils. Three of the sites that were examined were located in Charlotte, VT, and the other was located in Shelburne, VT (Fig. 1). These sites with varying reforestation ages were studied during October and November 2001. Another purpose of the study was to determine how long it takes for soil to return to its natural state after the land has been farmed or deforested. The data that we collected at these sites supported our hypothesis that farming and deforestation affect the infiltration rates of soils. The data suggest that the longer the land has gone without being farmed or deforested, the higher the infiltration rates of the soil. From oldest to youngest the infiltration rates were calculated to be 3.8 cm/min, 3.2 cm/min, 2.6 cm/min, and .09 cm/min respectively. Another hypothesis concerns the rehabilitation of deforested soil. This hypothesis states: given enough time, soil will return to its natural state and the soil stratigraphy will vary between the sites that have been farmed and deforested and those that have not. Our data also supports this hypothesis through the finding that the older the sites, have more developed the soil profiles than the younger sites. The percentage of loss on ignition (LOI), which is an indicator of organic material present in the soil layers, correlates with the length of time that the land has been forested. The older the forest the more organic material present in its soil layers. The average percent LOI of the soil layers ranged from 68% to 9%. Soil samples were also collected to determine whether or not there was a correlation between pH of soil layers and the age of the soil. The average pH measurements ranged from 4 to 7.

INTRODUCTION

General studies concerned with soil development suggest that over centuries, soil layers become more distinct, horizon thickness changes, pH levels change and infiltration rates increase (Heller, 1970). The relationship between deforestation and geologic processes in Chittenden County, VT is an area of study by geomorphologists (Bierman, 1997). However, the long-term effects of deforestation and farming on the infiltration rates and soil horizon in Chittenden County have not been studied in detail. This study presents, analyzes, and discusses data that was collected at four sites in Chittenden County.

The record of the diversity and percent of forests in Vermont dates back to the late 1700s (Siccama, 1971). Original Champlain Valley land surveys describe a heavily forested landscape dominated by white pine and white oak northern hardwood communities (Siccama, 1971). However, the influx of settlers in the early 1800s introduced a pattern of deforestation that eventually resulted in an 80% decrease in forested land (Albers, 2000). Farming and grazing livestock was the impetus for the clearing of land in Chittenden County.

METHODOLOGY

To evaluate our hypothesis, we utilized direct sampling, historical, and geologic research. Historical and geologic research was conducted at the University of Vermont (UVM) Bailey Howe Library, the Charlotte Historical Society, and the UVM Environmental Program. Four sites of varied ages with similar bedrock types, surficial materials and land-use history were identified based on this research. Historical deforestation and farming records along with the 1974 Chittenden Soil Survey and the Vermont surficial and bedrock map (Doll 1970, 1960) verified the different ages of the deforestation and land-use.

We excavated soil pits, collected samples from each soil horizon, and took GPS measurements at each site. The organic content of each horizon was measured by the % loss-on-ignition (LOI) process at the UVM Lake Lab. Soil horizon samples were dried for 48 hours, weighed, and burned at 455 °C for three hours. After cooling, the remaining materials were weighed and the LOI was calculated.

Infiltration rate was another procedure used to evaluate our hypothesis. The infiltration rate measurements were taken by inserting a 500 ml can into the ground adjacent to the soil pit. An initial 2cm of water was added to the soil sample in the can. Over a period of thirty minutes, additional 2cm units of water were added when the water fully infiltrated the soil. We kept a record of the total volume of water, the total length of water and the minutes between the addition of water. With this data, we calculated the infiltration rate (cm/min).

The third procedure we used to evaluate our hypothesis was the measurement of the soil pH. The color of the different layers was determined through the use of the Munsell Color Chart.

<u>DATA AND RESULTS</u>

WILLIAMS WOODS

Located at 18T 0639299, UTM 4903364 on Greenbush Rd., Charlotte, Williams Woods acted as the control site, as it is considered an old growth white pine and white oak-transitional northern hardwoods community (Poleman, 2000). Owned by the same family for 157 years, portions of Williams Woods have never been deforested. The oldest trees here are 275-300 years old (Moscowitch, 2000). The bedrock underlying Williams Woods is Cutting dolomite (Doll, 1961). The parent material is composed of lake bottom sediments (Doll, 1970). The predominate soil type is Vergennes clay of the Covington association (Soil Survey of Chittenden County, VT, 1974). There are four major soil horizons at Williams Woods. Each layer has a distinct LOI, pH and color (Fig. 2). The range in pH is 4 to 5 (Fig. 2.). The range of percent LOI is from 92% to 12 % (Fig. 3a.). The infiltration rate is 3.8 cm/min (Fig. 3b).

SHELBURNE POND

Shelburne Pond is located in Shelburne, VT and has a GPS coordinate of18T 0646248, UTM 4915708. The white pine-white oak northern hardwood forest that surrounds Shelburne Pond is 197 years old (Carlisle, 1973). Between the years 1730 and 1804, the portion of land under observation was used for sheep pastures and farmland (Carlisle, 1973). The site bedrock is Cutting Dolomite (Doll 1961. The soil type is the Farmington extremely rocky loam (Soil Survey of Chittenden County, VT 1974).

There are four major soil horizons at Shelburne Pond. Each layer has a distinct LOI, pH and color (Fig. 4, Fig. 5a). The pH ranges from 6 to 7 (Fig. 4). The LOI ranges from 3% to 22% (Fig. 5a). The infiltration rate is 3.2 cm/min (Fig. 5b).

MT PHILO

Mt Philo is located on Mt Philo Road in Charlotte, Vermont. The GPS is 18T 0641874, UTM 4904127. Last farmed in the spring/summer of 1900 (Carlisle, 1973), the base of Mt. Philo is covered by a white pine-white oak northern hardwoods forest (Poleman, 2000). The Mt. Philo bedrock is Stony Point Shale (Doll, 1961). The soil at the base of Mt Philo is Stockbridge and Nellis extremely stony loams (Soil Survey of Chittenden County, Vt, 1974).

There are five major soil horizons at Mt. Philo. Each layer has a distinct LOI, pH and color (Fig. 6). The pH ranges from 7 to 8 (Fig. 6). The %LOI ranges from 2% to 16% (Fig. 7a). The infiltration rate is 2.6 cm/min (Fig. 7b).

CHARLOTTE FIELD

Located on Greenbush Road in Charlotte, VT (18T 0639399, UTM 4903234), the field adjacent to Williams woods is currently in use by the Falby family. At the time of this study, the field under observation was last tilled in the spring of 2000 (Falby, 2001). The underlying bedrock is Cutting dolomite (Doll, 1961). The surficial material is lake bottom sediments (Doll, 1970). The predominate soil is Vergennes clay of the Covington association (Soil Survey of Chittenden County, VT, 1974). There are three major soil horizons at Mt. Philo. Each layer has a distinct LOI, pH and color (Fig. 8, Fig 9a). The range of pH is 6.5 to 8 (Fig. 8). The %LOI ranges from 2% to 18% (Fig. 9a). The infiltration rate is .09 cm/min (Fig. 9b).

DISCUSSION AND INTERPRETATIONS

The soil profiles of the four sites indicate that there is a change in the depth and size of the AP horizon and other horizons (Fig. 10). The calculated LOI of the four sites indicates a trend based on the duration of forestation and the depth of the horizon. The LOI of the O layer at Williams Woods is much higher than the organic content of the other four sites (Fig. 11). The amount of organic material decreases as the time since tilling increases. One interpretation to draw from this trend is that older and developed forest soils have had a longer period to accumulate organic material.

The calculated LOI data also support the interpretation that the organic content of soils decreases with depth (Fig. 11). The contents of the soil horizons match this trend. As depth increases, pebbles and sand particles become more abundant. The proximity of the O and AP horizons to the organic content source (trees and woody plants) enables the organic material of these horizons to be retained through water percolation and deposition.

The infiltration rates of the four sites indicate that the infiltration rate increases with length of forestation (Fig. 12). One interpretation from this comparison is that the more developed the soil horizons, the greater accommodation of water by these soils. This occurs as a result of the greater depth of the tree roots and the varying pore space of the different sediments of the soil horizons. In a region with undeveloped soil horizons, the pore space does not differ since the type of sediment is the same for some depth. This also corresponds to the relationship between the decrease in pH with depth (Fig. 13). As more water percolates through the soil, the amount of hydrogen ion exchange increases. This lowers the pH of the deeper and older soil horizons.

CONCLUSIONS

The analysis of the data collected at Williams Woods, Shelburne Pond, Mt. Philo, and the Charlotte Field (Fig. 14) suggests that there is relationship between the stage of reforestation and soil development. As forest communities return to a previously farmed and deforested landscape, soil horizons become more defined and the soil's organic content increases in all horizons. The AP horizon will decrease in thickness and the infiltration rate increases with age. The pH of the soils decreases with the depth.

Soil development depends greatly on the influencing factors of natural forest communities and human activities. When a landscape is disturbed through deforestation and subsequent farming, the natural state of the soil is greatly altered. However, when a forest begins to reclaim a previously deforested landscape over a period of 200 years, the soil will begin to revert to its natural state. The sensitivity of the soil to deforestation is evident by the lack of well-developed horizons. Further research is needed to determine those specific landscapes that have the greatest risk of irrevocable change in response to deforestation.

References

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Location Maps of Williams Woods, Shelburne Pond, Mt. Philo and Charlotte Field
Chittenden County, Vermont
Figure 1.

a.

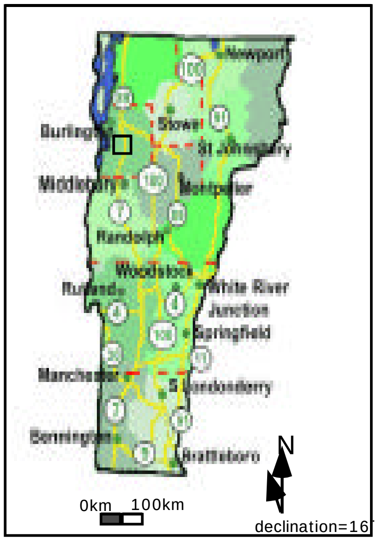
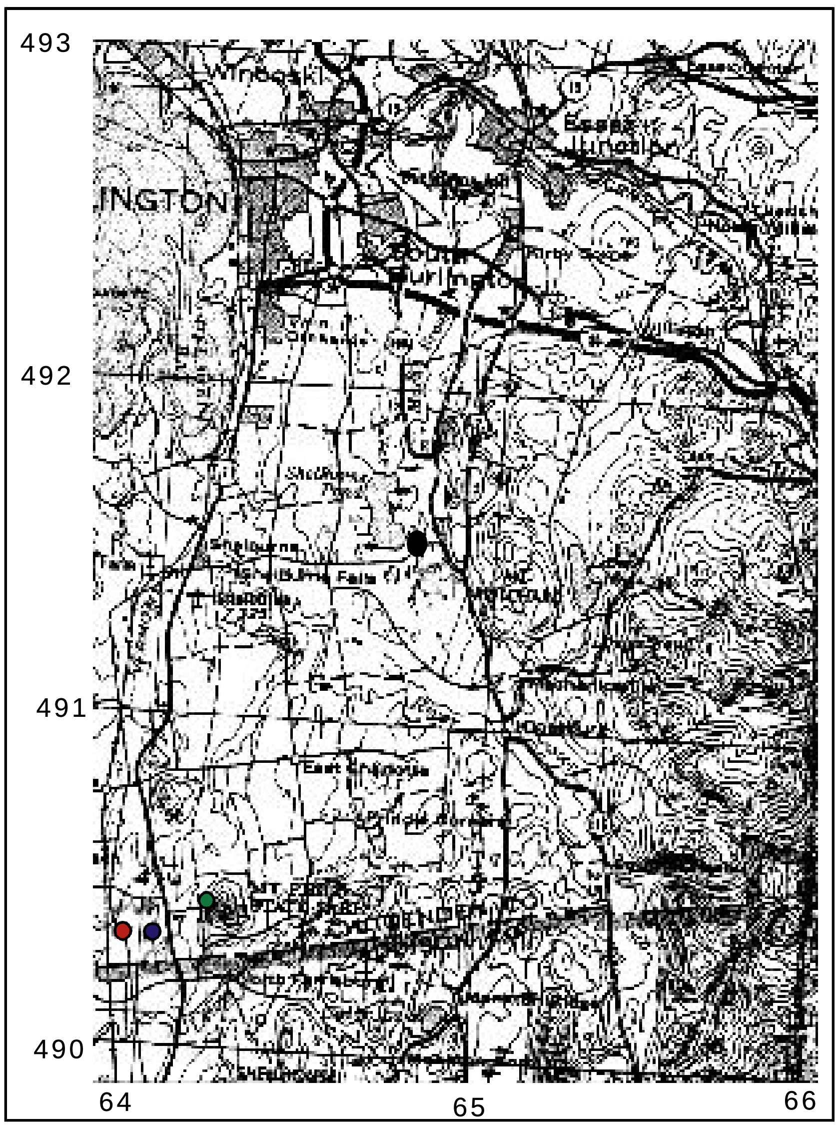
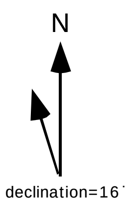


Figure a.
This is a state map of Vermont. The site of the study is indicated by the black box.

☐ site of study in Chittenden County

b.





Scale 1:250,000
0km 15km

Legend
- Williams Woods
- Shelburne Pond
- Mt. Philo
- Charlotte Field

Figure b.

This is a transverse meractor projection map of Chittenden County, Vermont. The four sites of study are marked by colored circles.

Williams Woods, Charlotte Vt
Soil Profile
Figure 2.

Altitude= 57m
18T 0639299
UTM 4903364

Figure 2a.

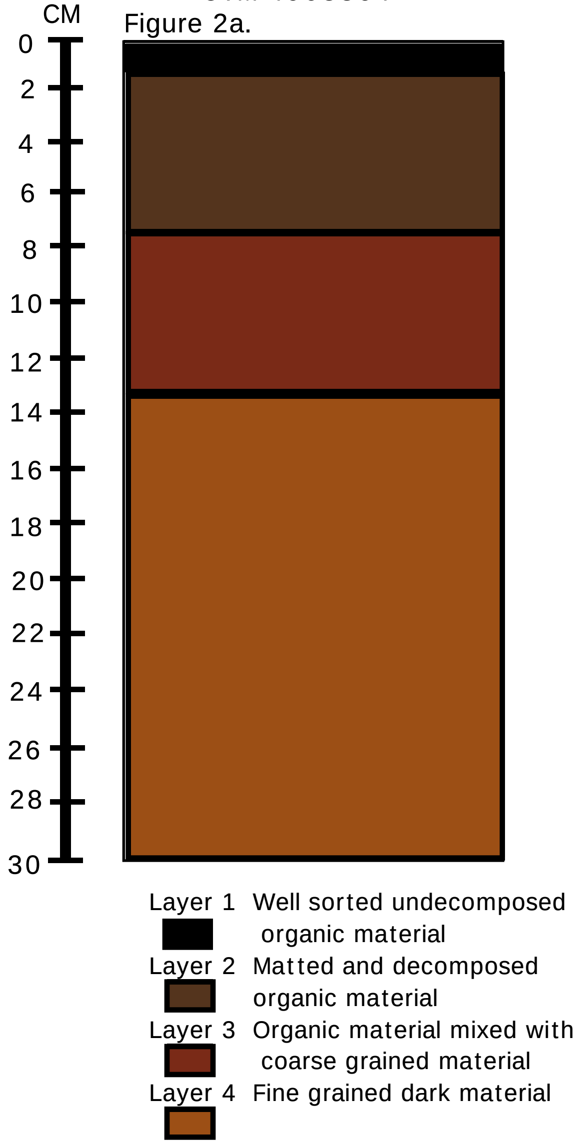


Figure 2b.

Figure 2a. and 2b.

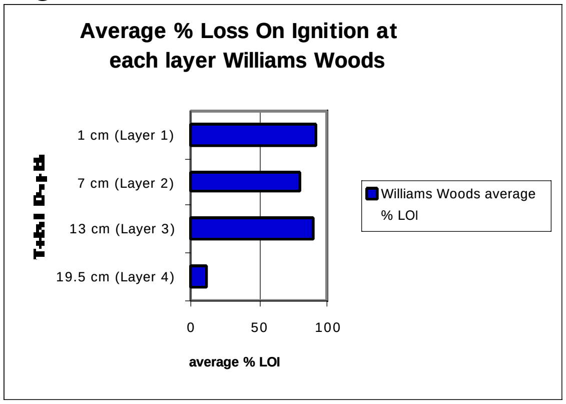
The soil pit at Williams woods revealed four distinct layers. Layer one is 1cm thick, layer two is 6cm thick, layer four is 6cm thick, the fourth layer continues deeper. The characteristics of each layer follows. With a color of 10R 2.5/1, layer one has a pH of 4 and consists of well sorted undecomposed organic material. Layer two has a pH of 4.5, consists of matted and decomposed organic material, and has a color of 10YR 2/1. The third layer consists of reddish-brown organic material mixed with coarse grained sand. The overall color for this layer is 10R 4/6. With a color of 5YR 7/2, layer four consists of fine grained silt/clay. This layer has a pH of 5.

The average calculated loss-on-ignition for the first layer of Williams Woods soil is 92 %. The second layer has an average 79 % loss-on-ignition (LOI). The third layer has an average of 90 % LOI. The LOI of the fourth layer is 12 %.

To calculate the infiltration rate, we added 3200cm^3 of water to a concentrated soil section with an area of 50.26cm^2 over a period of 16.96min. The result was an infiltration rate of 3.8 centimeters per minute.

Loss-On-Ignition and Infiltration Rate of Williams Woods
Figures 3a.-3b.

Figure 3a.

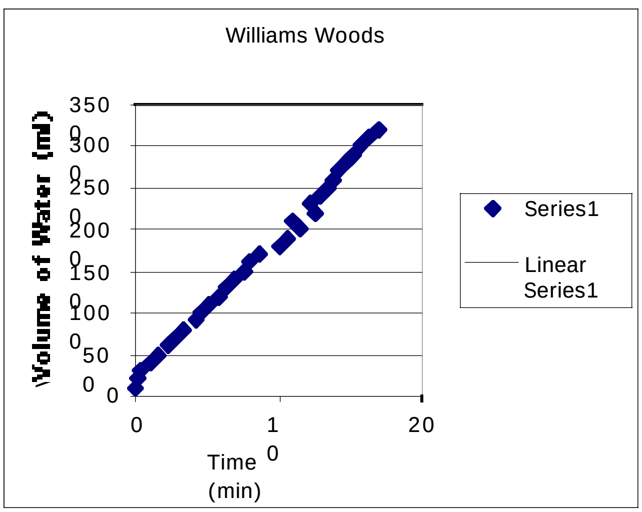


Williams Woods

Total Depth	average % LOI
19.5 cm (Layer 4)	12.
13 cm (Layer 3)	90
7 cm (Layer 2)	80
1 cm (Layer 1)	92

Figure 3a.
Williams Woods has never been disturbed, therefore the data and graphs represent the LOI of old growth forest. Layer 3 in Williams Woods does not fit the typical % LOI profile because it is a fallen tree. It is composed almost entirely of organic material, therefore its % LOI is 90.

Figure 3b.



Calcultating infiltration rate

$$\frac{3200mL}{16.96min} = \frac{189mL}{1min}$$

$$\frac{189mL}{1min} = \frac{189cm^3}{1min}$$

$$\frac{189cm^3}{1min} \times \frac{1}{50.26cm^2} = \frac{3.8cm}{1min}$$

Infiltration rate Start Time (1 cm incriments)	Total Time Elapsed (minutes)	total ml added to the soil
20:41;09	0	100
20:41;18	0.15	200
20:41;30	0.35	300
20:42;09	1	400
20:42;43	1.56	500
20:43;27	2.3	600
20:44;00	2.85	700
20:44;36	3.45	800
20:45;24	4.25	900
20:45;48	4.65	1000
20:46;22	5.21	1100
20:46;57	5.8	1200
20:47;32	6.38	1300
20:48;07	6.96	1400
20:48;45	7.6	1500
20:49;09	8	1600
20:49;48	8.65	1700
20:51;17	10.13	1800
20:51;47	10.63	1900
20:52;38	11.48	2000
20:52;05	10.93	2100
20:53;40	12.51	2200
20:54;20	12.15	2300
20:55;06	12.92	2400
20:55;33	13.37	2500
20:55;57	13.77	2600
20:56;20	14.18	2700
20:56;48	14.65	2800
20:57;20	15.18	2900
20:57;56	15.78	3000
20:58;29	16.33	3100
20:59;07	16.96	3200

Figure 3b.
This is a representatino of the infiltration rate of Williams Wodds. The infiltration rate of Williams Woods is 3.8 cm/min

Shelbure Pond, Shelburne, VT
Soil Profile
Figures 4a.-4b

Altitude= 153m
18T 0646235
UTM 4915714

Figure 4a.

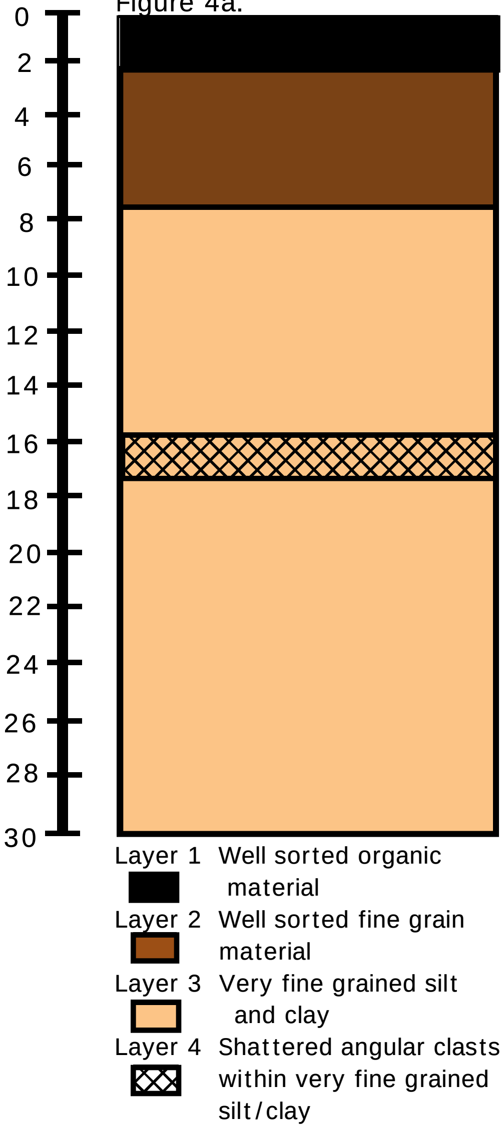


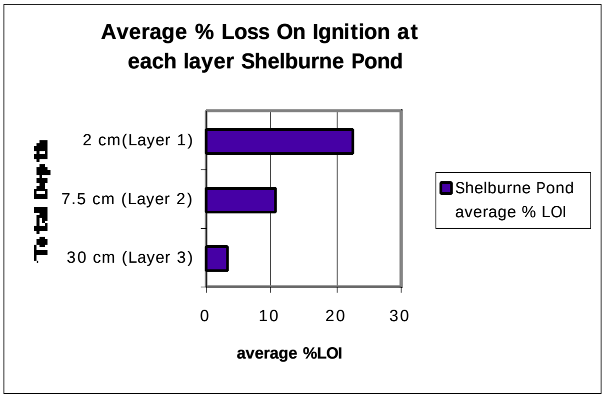
Figure 4b.

Figure 4a. and 4b.

The soil at Shelburne Pond consists of three distinct layers. Layer one is a well-sorted organic layer that is about 2 cm thick, has a pH of 7, and, according to the Munsell color guide, this layer has a color of the layer is 10 YR 3/3. The calculated average of the percentage of loss on ignition (LOI) for layer one is 22%. Layer two, which is a well-sorted fine grained material is about 5 cm thick. It has a pH of 6.5 and the color is 10 YR 6/3. The average LOI for layer two is 11%. Layer three is the thickest layer as it goes deeper than 30 cm. The pH of layer three is 6 and the color of the layer is 10 YR 7/4. Included within layer three is a thin layer of shattered angular clasts, which is found around 8 cm down from the contact of layers two and three. The average LOI for layer three is 3%.

Loss-On-Ignition and Infiltration Rate of Shelburne Pond
Figures 5a-5b

Figure 5a.

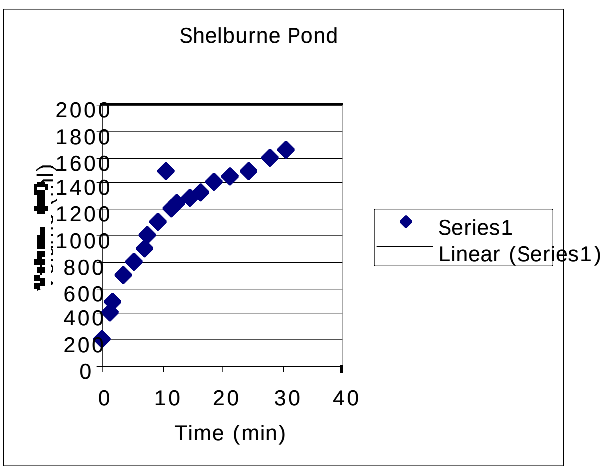


Shelburne Pond

Total Depth	average % LOI
30 cm (Layer 3)	3
7.5 cm (Layer 2)	11
2 cm(Layer 1)	22

Figure 5a.
Shelburne Pond was last farmed in the early 1800s. The data and graphs represent the LOI of a reforested landscape of 200-197 years.

Figure 5b.



Infiltration Rate

Start Time (2 cm incriments)	Total Time Elapsed (mintues)	total ml added to the soil
12:29;31	0	200
30;46	1.25	400
31;27	1.94	500
33;14	3.72	700
34;56	5.42	800
36;25	6.9	900
37;11	7.67	1000
38;57	9.44	1100
40;02	10.52	1500
41;06	11.59	1200
42;08	12.62	1250
44;01	14.5	1280
46;02	16.52	1325
48;10	18.65	1400
51;02	21.52	1450
54;02	24.52	1500
57;30	27.99	1600
1:00;01	30.5	1650

Shelburne Pond volume of can (ml)	rate (total cm/total time min)
500	3.2

Calcultating infiltration rate

$$\frac{1650mL}{30.5\ min} = \frac{164mL}{1min}$$

$$\frac{164mL}{1min} = \frac{164cm^3}{1min}$$

$$\frac{164cm^3}{1min} \times \frac{1}{50.26cm^2} = \frac{3.2cm}{1min}$$

Figure 5b.
This is a representation of the infiltration rate at Shelburne Pond.
The infiltration rate at Shelburne Pond is 3.2 cm/min.

Mt. Philo, Charlotte, VT
Soil Profile
Figure 6a-6b.

Altitude= 357m
18T 0641874
UTM 4904127

Figure 6a.

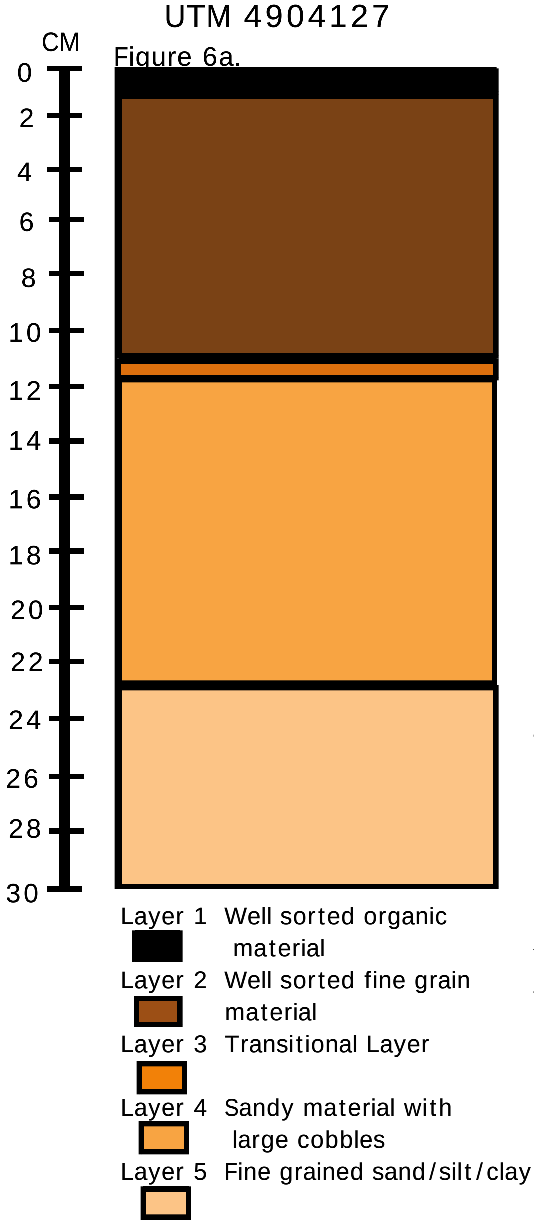


Figure 6b.

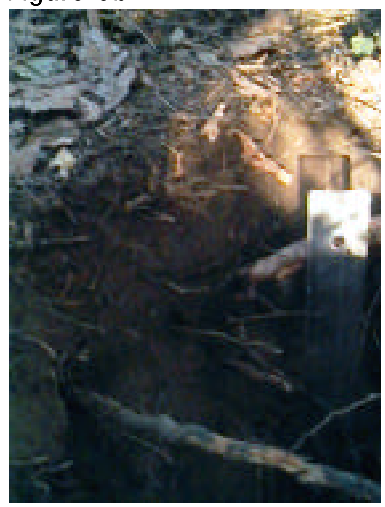


Figure 6a. and 6b.

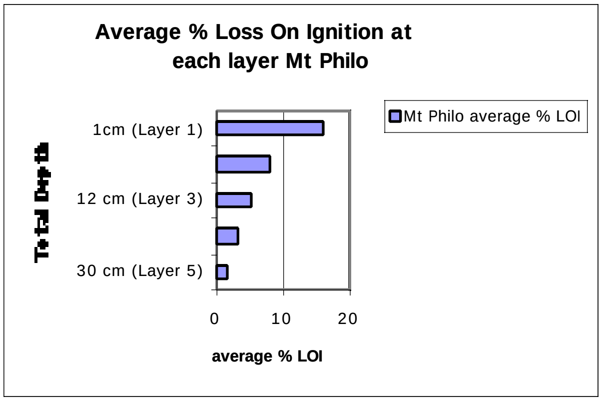
The soil profile at Mt Philo is composed of five distinct horizons. Layer 1 is 1 centimeter thick and it is a dark well sorted organic material. It is 10YR 4/3 in color and has a pH of 7. Layer 2 is 10 centimeters thick and it is a well sorted fine grained soil. It is 10 YR 3/2 in color and has a pH of 8. Layer 3 is .5 centimeter thick. It is the transitional layer between the fine and coarse sediments. It is graded with fine grains near the top of the layer and the coarse grains near the bottom of the layer. It is 10YR 4/6 in color and has a pH of 7. Layer 4 is 11 centimeters thick and it is composed of sandy sediments and large cobbles. It is 10 YR 5/4 in color and has a pH of 7.5. Layer 5 is 7 centimeters thick and it is composed of fine grained sands, silts, and clays. It is 10YR 5/6 in color and has a pH of 7.

The average percent LOI for Layer 1 is 16. Layer 2 is 8. Layer 3 is 5. Layer 4 is 3. Layer 5 is 2. (See LOI Mt Philo graph)

To calculate the infiltration rate, we added 1650cm^3 of water to a concentrated soil section with an area of 50.26cm^2 over a period of 14 min. The result was an infiltration rate of 2.6 centimeters per minute.

Loss-On-Ignition and Infiltration Rate of Mt. Philo
Figures 7a.-7b.

Figure 7a.

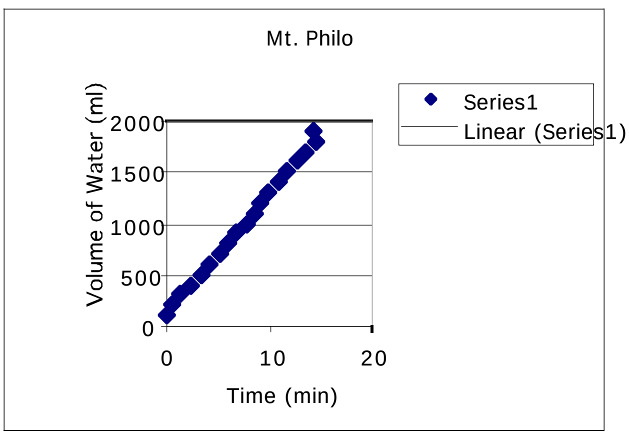


Mt Philo

Total Depth	average % LOI
30 cm (Layer 5)	1.63
23 cm (Layer 4)	3.256
12 cm (Layer 3)	5.166
11.5 cm (Layer 2)	8.135
1cm (Layer 1)	16.049

Figure 7a.
The last time of farming at Mt. Philo was 1900. The data and graphs represent the LOI of a reforested landscape of 100 years.

Figure 7b.



Infiltration Rate Start Time (1 cm incriments)	Total Time Elapsed (minutes)	total ml added to the soil
15:41;25	0	100
15:41;52	0.45	200
15:42;44	1.32	300
15:43;43	2.3	400
15:44;43	3.3	500
15:45;36	4.19	600
15:46;29	5.07	700
15:47;28	6.05	800
15:48;16	6.85	900
15:49;08	7.72	1000
15:49;56	8.52	1100
15:50;38	9.22	1200
15:51;25	10	1300
15:52;18	10.89	1400
15:53;09	11.74	1500
15:54;11	12.77	1600
15:54;59	13.57	1700
15:55;51	14.44	1800
15:56;46	14.35	1900

rate (total cm/total time)
2.6

Calcultating infiltration rate

$$\frac{1900\text{mL}}{14.35\text{ min}} = \frac{132\text{mL}}{1\text{min}}$$

$$\frac{132\text{mL}}{1\text{min}} = \frac{132\text{cm}^3}{1\text{min}}$$

$$\frac{132\text{cm}^3}{1\text{min}} \times \frac{1}{50.26\text{cm}^2} = \frac{2.6\text{cm}}{1\text{min}}$$

Figure 7b.
This is a representation of infiltration rate at Mt. Philo.
The infiltration rate at Mt. Philo is 2.6 cm/minute.

Charlotte Farm Field, Charlotte, VT
Soil Profile
Figure 8a.-8b.

Altitude= 65m
18T 0639399
UTM 4903234

Figure 8a.

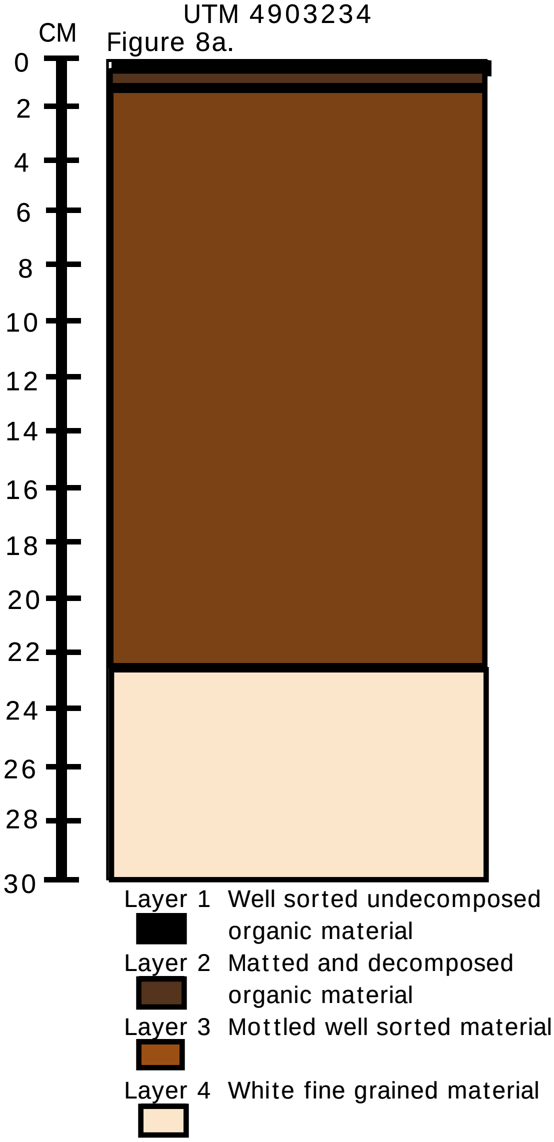


Figure 8a. and 8b.

The soil profile of this section of Charlotte has four distinct layers. A half a centimeter thick, the first layer is composed of undecomposed organic material. The color of this layer is 7.5YR 4/4 and the pH is 8. The second layer, half a centimeter thick, consists of matted and decomposing organic material. The pH of the second layer is 7 and the color is 10YR 5/3. Layer three is 23cm thick and consists of highly mottled well sorted clay/sand. With occasional red-iron stains and white stains, the overall color of this layer is 10YR 5/4. The pH is 7. The fourth layer of this profile begins at 25cm below the ground surface and continues past 34cm. The pH of the fourth layer is 6.5 and the color of the layer is 7.5YR 8/1. The material of this layer is very fine grained clay.

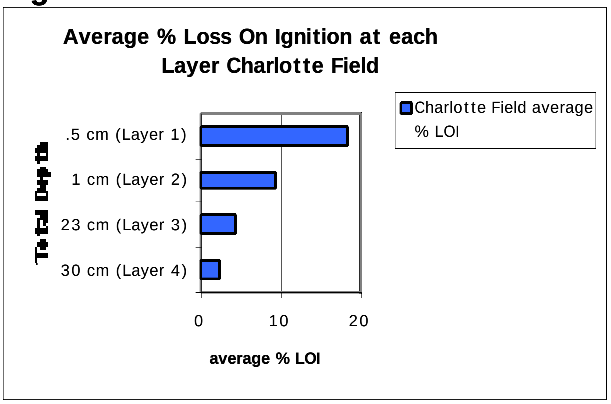
The loss-on-ignition of the first layer of the Charlotte field is 18 %. Layer two of the field has a loss-on-ignition (LOI) of 9 %. The LOI of the third layer is 4 % and the LOI of the fourth layer is 2 %.

To calculate the infiltration rate, we added 150cm^3 of water to a concentrated soil section with an area of 50.26cm^2 over a period of 31.5 min. The result was an infiltration rate of .09 centimeters per minute.

Figure 8b.

Loss-On-Ignition and Infiltration Rate of Charlotte Field
Figures 9a.-9b.

Figure 9a.

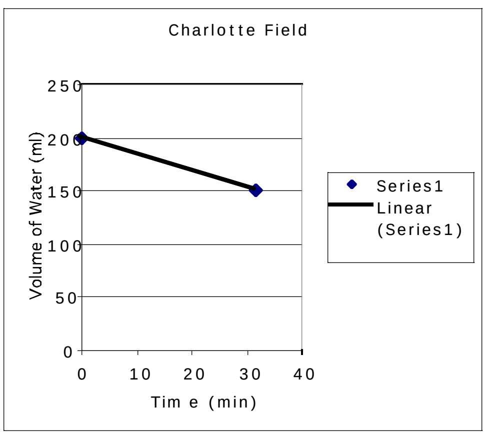


Charlotte Field

Total Depth	average % LOI
30 cm (Layer 4)	2
23 cm (Layer 3)	4
1 cm (Layer 2)	9
.5 cm (Layer 1)	18

Figure 9a.
The Charlotte field was farmed in Spring 2000. This graph and data serves as representation of the LOI of an actively farmed field.

Figure 9b.



Total Time Elapsed (minutes)	total ml added to the soil
0	200
31.56	150
volume of can 500ml	rate (total cm/total time) .09

Infiltration rate
starting time 19:42;00
poured in 2cm water
at 20:13;34 it had infiltrated half a cm.

Calcultating infiltration rate

$$\frac{150mL}{31.56\ min} = \frac{5mL}{1min}$$

$$\frac{5mL}{1min} = \frac{5cm^3}{1min}$$

$$\frac{5cm^3}{1min} \times \frac{1}{50.26cm^2} = \frac{.09cm}{1min}$$

Figure 9b.
This is a representation of infiltration rate at the Charlotte Field. The infiltration rate Charlotte is .09 cm/min.

Comparison of Soil Profiles from Chittenden County

Figure 10

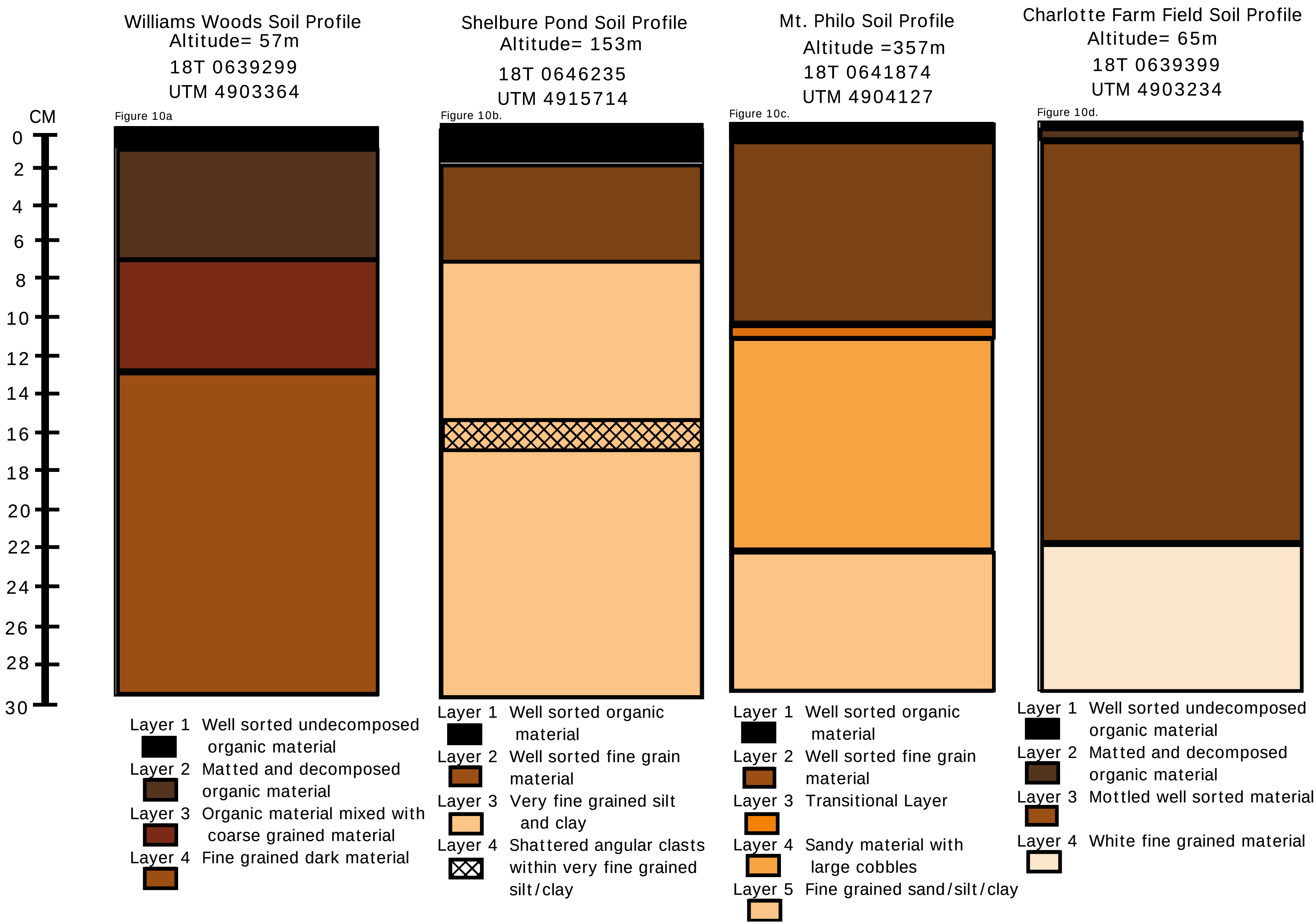


Figure 10.
This is an interpretation and comparison of the soil profiles at the four different sites. Williams Woods is the control site. As an example of an old growth forest, no clear-cutting or farming took place at Williams Woods. Farming ended at the site of Shelburne Pond in 1804 (Carlise, 1973). The area surrounding Mt Philo was farmed until 1900 (Carlise, 1973). The Charlotte field is still being farmed. The soil profile suggests an interpretation that the earlier the time of reforestation, the more developed the soil profile.

Figure 10a. The soil profile at Williams Woods has five distinct layers. An interpretation of the layers follows. Layer 1 is a well-developed Oi layer. Layer 2 is a well-developed Oa layer. Layer 3 is a decomposing tree. It is organic in composition, and very red in color due to oxidization and iron content. Layer 4 is the C layer composed of fine-grained silt and clay lake bottom parent material.

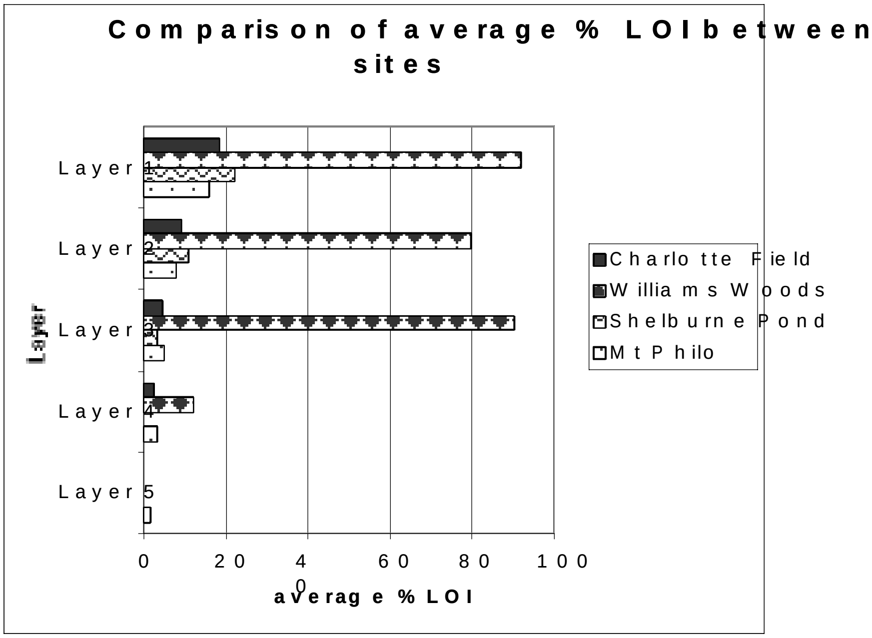
Figure 10b. The soil profile for Shelburne Pond shows three distinct layers and one semi layer within the third layer. An interpretation of the layers suggests that layer 1 is a relatively thick O layer. This is because it has been reforested longer and has had time to develop this thicker organic layer. Layer 2 is a relatively thin AP layer. It has probably gotten thinner through time as the organic layer has developed. Layer 3 is probably the C layer, composed of very fine-grained silt and clay lake bottom parent material. Within this layer three is a thin semi layer composed of shattered angular clasts with in the matrix of very fine-grained silt and clay.

Figure 10c. The Mt Philo soil profile is composed of has five distinct layers. An interpretation suggests that layer 1 is the O, or organic layer. This is composed of decomposing leaves and organic debris. Layer 2 is the AP layer; this is thinner than the Charlotte Field AP layer because it was plowed longer ago than the Charlotte Field. Layer 3 is the transitional layer between the AP layer possible stream parent material. Layer 4 is the possible stream parent material. The reason for the stream hypothesis is the presence of large cobbles and coarse sand. It has almost no organic material. Layer 5 is the C layer. It is composed of the surficial geological material which is fine grained sand silt and clay from the lake bottom.

Figure 10d. The Charlotte Field soil profile has four distinct layers. An interpretation of the layers follows. Layer 1 is the Oi layer; this is composed loose leaves and undecomposed organic debris. Layer 2 is the Oa layer; this is composed of matted and decomposed organic organic material. Layer 3 is the AP layer, or the plowed layer. This layer is very thick, probably due to the plowing methods used on the field and due to the fact that is the youngest soil profile seen. The AP layer is a mixture of the O, A, and B layers, produced by the plow. Layer 4 is the E layer. The E layer is low in organic matter because the organic matter has leached out of this layer. It is a concentration of sand and silt.

Comparison of Average %LOI
Figure 11.

Figure 11.



	Mt Philo	Shelburne Pond	WilliamsWoods	Charlotte Field
Layer 5	2			
Layer 4	3	12	2	
Layer 3	5	3	90	4
Layer 2	8	11	80	9
Layer 1	16	22	92	18

Figure 11.
Mt Philo, Shelburne Pond and the Charlotte field each have fairly typical % LOI profiles. Layer 1 (the organic layer) had the largest % LOI. Each successive layer has a lower % LOI due to the lack of organic materials as the depth increases. Williams Woods has the most organic material in all of its layers compared to the other three sites. There is a 92% LOI in Layer 1 at Williams Woods. Compared to a 16% LOI at Mt Philo, a 22% LOI at Shelburne Pond, and a 18% LOI at the Charlotte Field, this suggests that the older the forest, the greater percent of organic material.

Comparison of Infiltration Rates
Figure 12

Figure 12

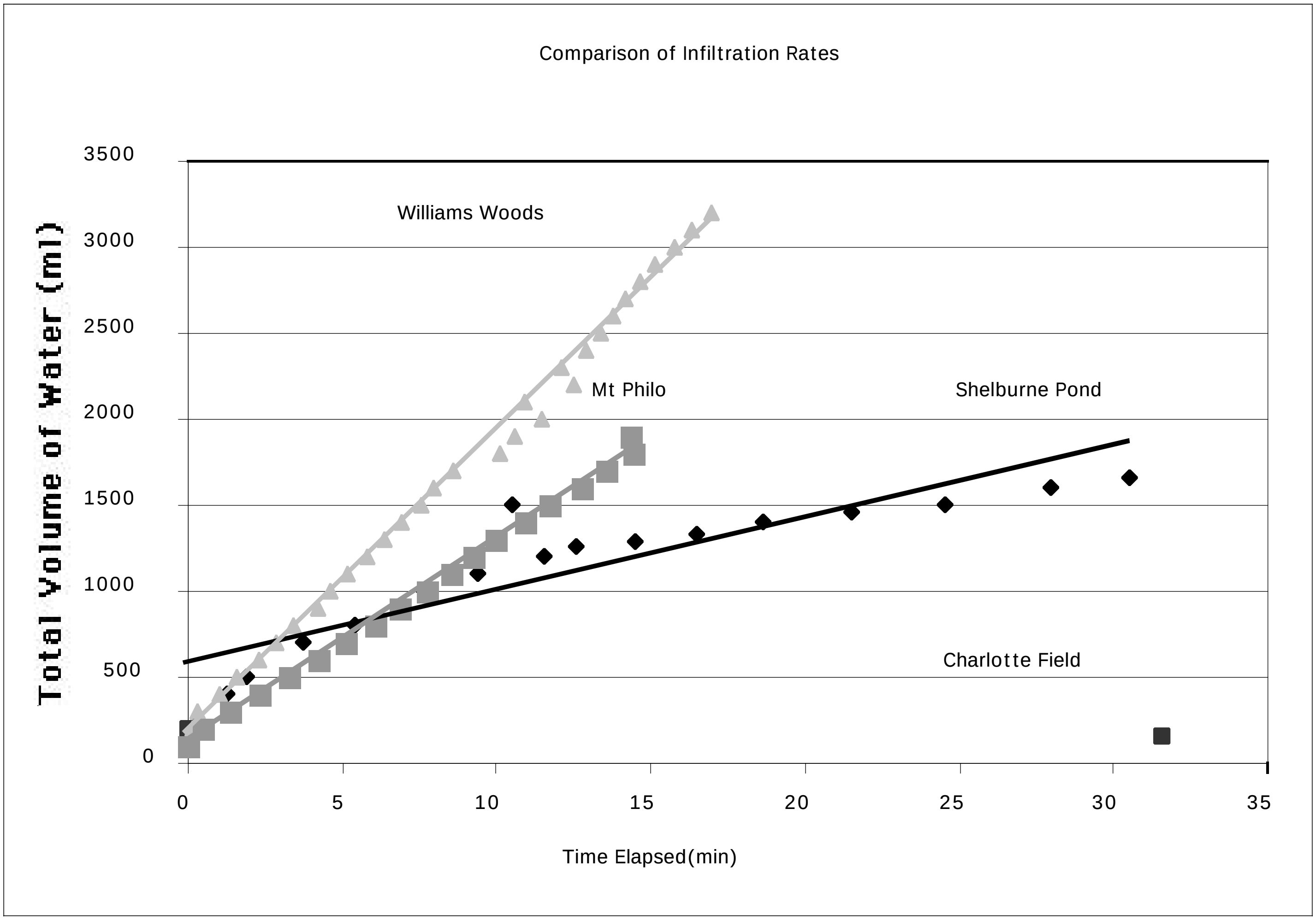


Figure 12.
This is a representation of the comparison of the infiltration rates of soil at all four sites. The infiltration rate at Williams Woods is so high because the soil profile at this location is well developed and contains no AP layer. Because of this, water is able to easily infiltrate the soil. The infiltration rate at Shelburne Pond is less than that of Williams Woods due to the fact that the landscape at Shelburne Pond has been disturbed by deforestation and farming. When soil is plowed, it becomes more compact, and although Shelburne Pond was last plowed between 200 and 250 years ago (Carlisle, 1973) the soil profile still contains the compacted AP layer (Figure 6a) which decreases the infiltration rate considerably. The infiltration rate of Mt Philo is less than that of Shelburne Pond and Williams Woods because Mt Philo was farmed last in the spring/summer of 1900 (Carlisle, 1973). The plow horizon here is thicker than that of Shelburne Pond (Figure 6). This compact AP layer is the reason for the lessened infiltration rate. The infiltration rate at Charlotte field is much less than that of Williams Woods, Shelburne Pond, and Mt Philo because it has such a large AP horizon (Figure 6) compared to the other three sites.

Comparison of Soil pH
Figure 13.

layer #	Williams Woods	Shelburne Pond	Mt. Philo	Charlotte Field
1	4	7	7	8
2	4.5	6.5	8	7
3	4	6	7	7
4	5	7.5	6.5	
5		7		

Figure 13.

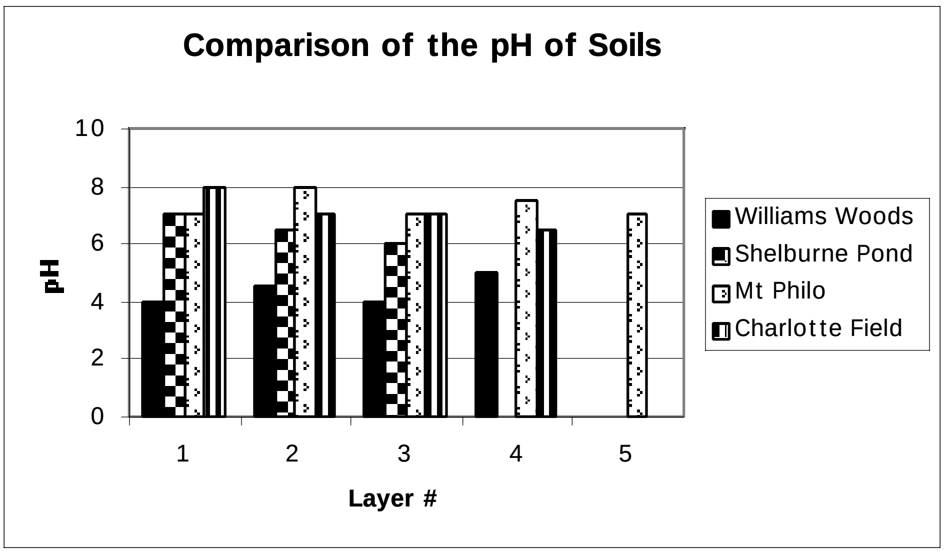


Figure 9.

There are two major trends in the pH data. The first is that the older soils tend to be more acidic. The soil at Williams Woods is both the oldest and the most acidic. This is due to the centuries of accumulation of organic materials, especially pine needles, which are themselves acidic. The pH of soils is also influenced by eluviation, which is the process of water percolating down the soil column while transporting both organic and inorganic materials (Poleman, 2000). As water passes through soil layers, H+ ions replace Ca+ and Mg+ ions that are present and those ions are then "washed" away by way of drainage. Since pH is a measure of the percentage of H+ ions, the more water that is able to infiltrate the soil, the more acidic the soil will be. The Charlotte field has the highest overall pH (most basic). This is due to the fact that water does not infiltrate the soil well here; therefore H+ ions are not able to replace the Ca+ and Mg+ ions. The second trend is that soils get more acidic with depth. This is due to the fact that the deeper soils are found in illuviation zones where eluviated materials are deposited. Some of the discrepencies in this data may be the result of human error in measuring the pH or may be due to the fact that some of the soils are in a recovery stage.

Summary Tables
Figure 14

Table 14 a

	Williams Woods	Shelburne Pond	Mt. Philo	Charlotte Field
Years since Tilling	n/a	197	100	1

Table 14 b
Comparison of pH

layer #	Williams Woods	Shelburne Pond	Mt. Philo	Charlotte Field
1	4	7	7	8
2	4.5	6.5	8	7
3	4	6	7	7
4	5		7.5	6.5
5		7		
AVG pH	4	6.5	7	7

Table 14 c
Comparison of %LOI

	WilliamsWoods	Shelburne Pond	Mt Philo	Charlotte Field
Layer 5			2	
Layer 4	12		3	
Layer 3	90	3	5	4
Layer 2	80	11	8	9
Layer 1	92	22	16	18

Williams W.AVG	Shelburne AVG	Mt. Philo AVG	Charlotte AVG
68	12	7	9

Table 14 d
Comparison of Infiltration Rate

	Williams Woods	Shelburne Pond	Mt. Philo	Charlotte Field
Minutes Elapsed	17	31	14	32
Total Volume of Water (ml)	3200	1650	1900	50
Total area of can opening(cm^2)	50.2	50.2	50.2	50.2
Rate (cm/min)	3.8	3.2	2.6	.09