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Measuring the Retained Water and Sequestered Organic Carbon Contents of Soil Profiles in Aroostook and Piscataquis Counties, Maine, USA

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National Soil Project

Initiated 2008 at Northeastern

Agricultural top soils

Measuring:

- Moisture content
- Ash content → OM content → TOC
- Humic acids content, gravimetric, Ghabbour et al (2012)[1]
- Humin content, gravimetric
- Fulvic acids content, Visible spectrum, Ghabbour and Davies (2009)[2]
- DOC content, UV spectrum, Tipping et al (2009, 2012)[3,4]

1- Ghabbour EA, Davies G. et al. *Annal. Environ. Sci.,* 2012, 6: 1-12.
2- Ghabbour EA, Davies G. *Annal. Environ. Sci*., 2009, 3: 131-138.
3- Tipping E, et al. *Environ. Chem.* 2009, 6: 472-476.
4- Carter HT, Tipping E, et al., *Water Research,* 46:4532-42, 2012.

National Soil Project

1000+ samples from all 50 US states including:

- 195 from NSSL
- 40 from the Agricultural Lab Proficiency Program
- 23 from the Maine Soil Program studying soil quality and OM decreases with depth.

Rice

Wheat

Maize

Potato

1700's

1940's

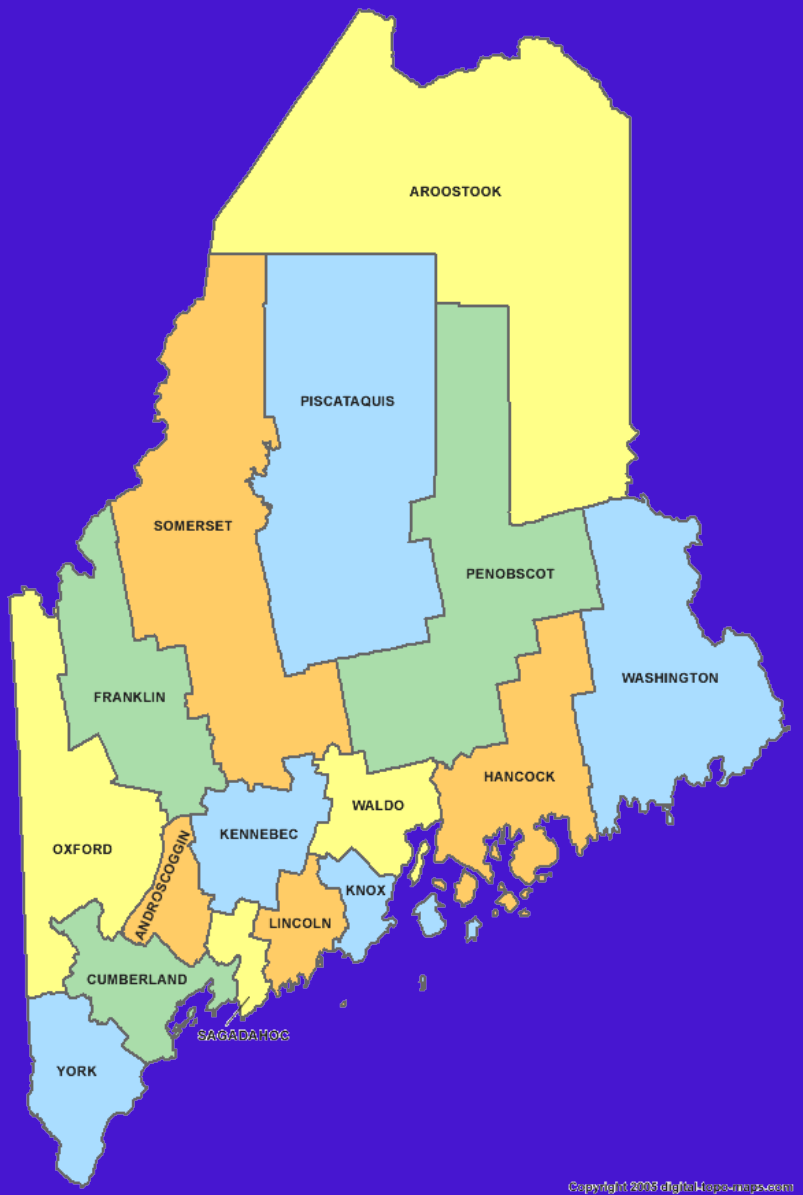
Aroostook County

Potato Capital of

America

2007

65,000 tons



Energy, fertilizer and irrigation costs continue to rise...

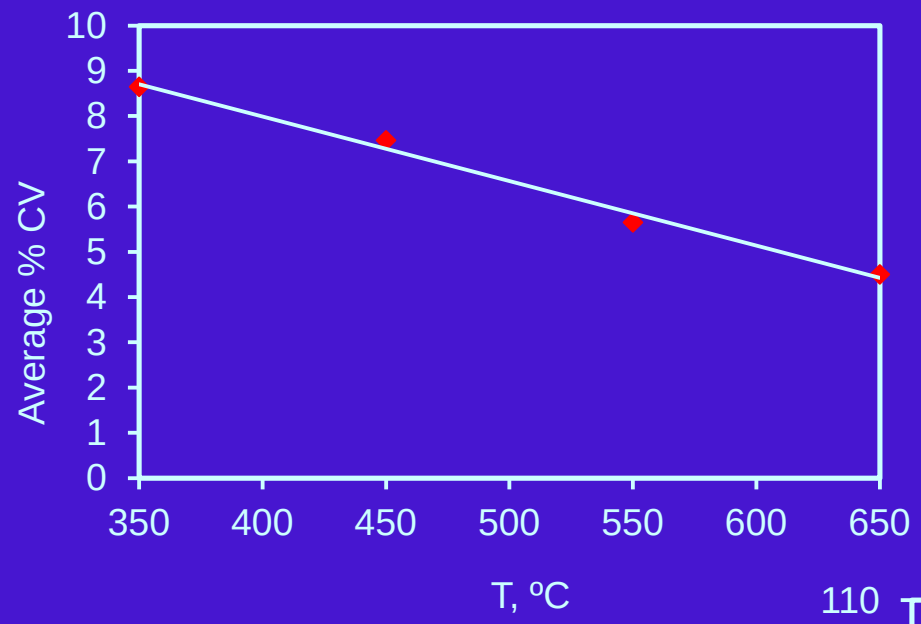
Forest *vs.* Field

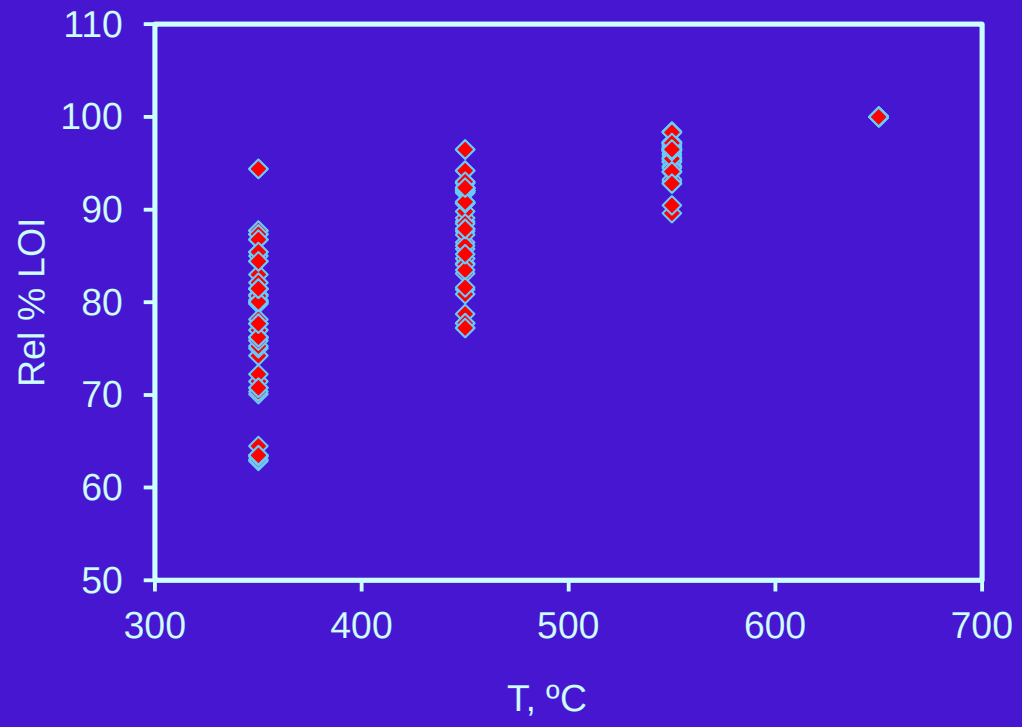
20
40

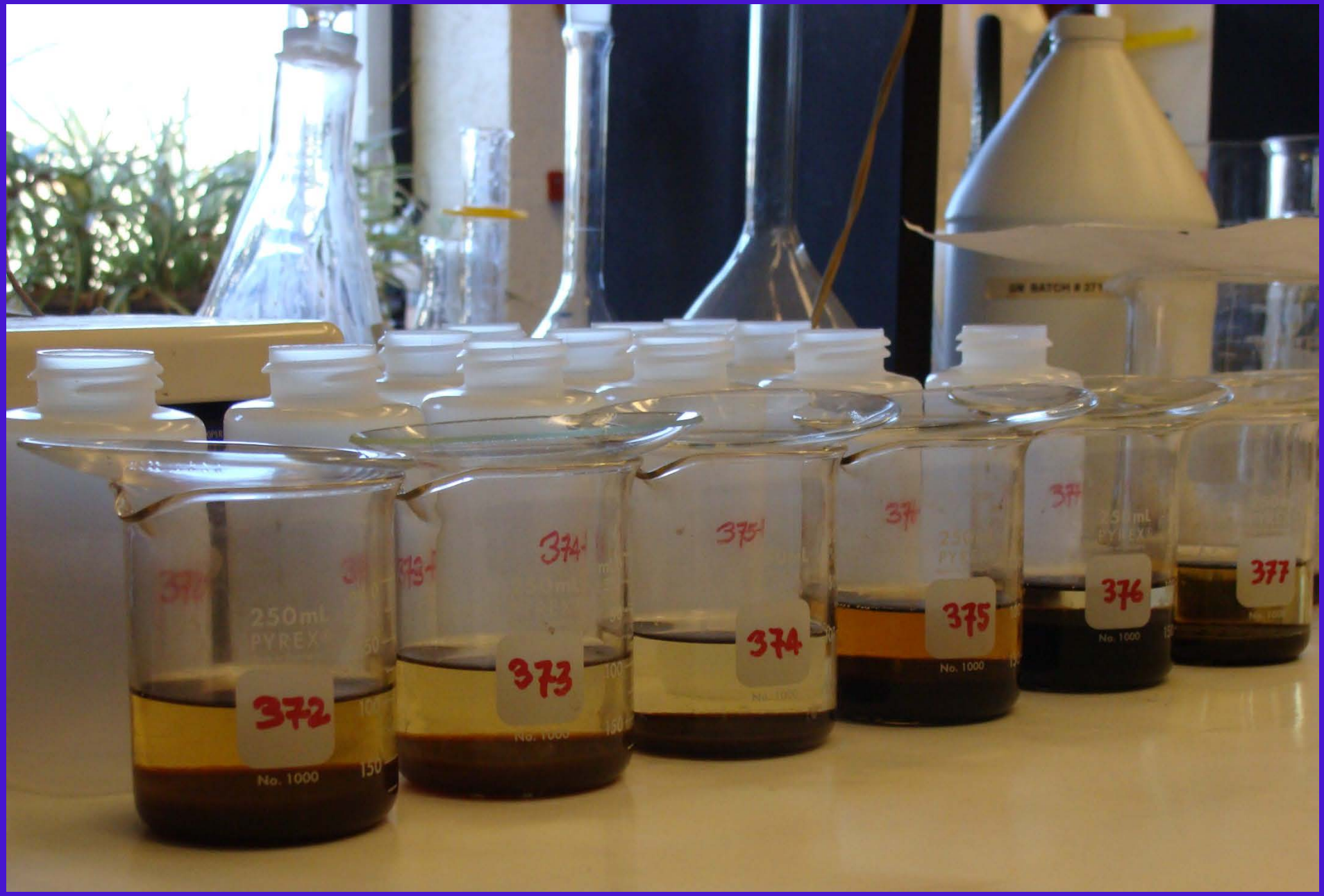
Soil series, KSSL sample identifications, and land use

Series	Sample ID	Land Use
Caribou	S11ME003030	Long-term tillage agriculture
Caribou	S11ME003012	Long-term tillage agriculture
Kinsman	S09ME021004	Forest (black spruce, balsam fir, white cedar, white birch)
Monadnock	S09ME021009	Forest (red spruce, balsam fir, yellow birch, red pine)
Wassookeag	S11ME003004	Long-term tillage agriculture
Wassookeag	S11ME003012	Forest (sugar maple, yellow birch, red maple, balsam fir)

LOI


Average % CV
10
9
8
7
6
5
4
3
2
1
0
350
400
450
500
550
600
650
T, ºC


Rel % LOI
110
100
90
80
70
60
50
300
400
500
600
700
T, ºC

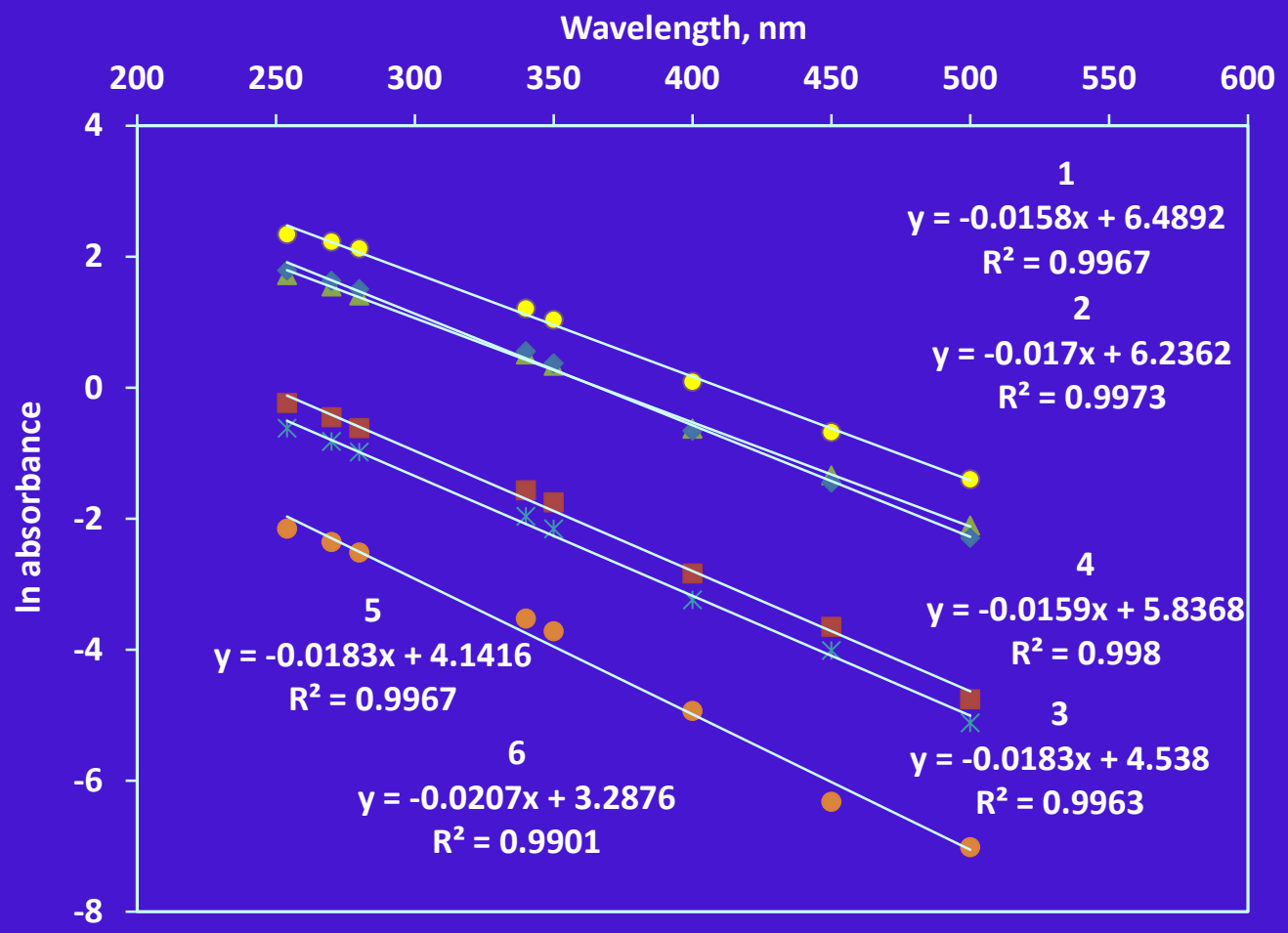

250mL
PYREX
No. 1000
372
373
374
375
376
377

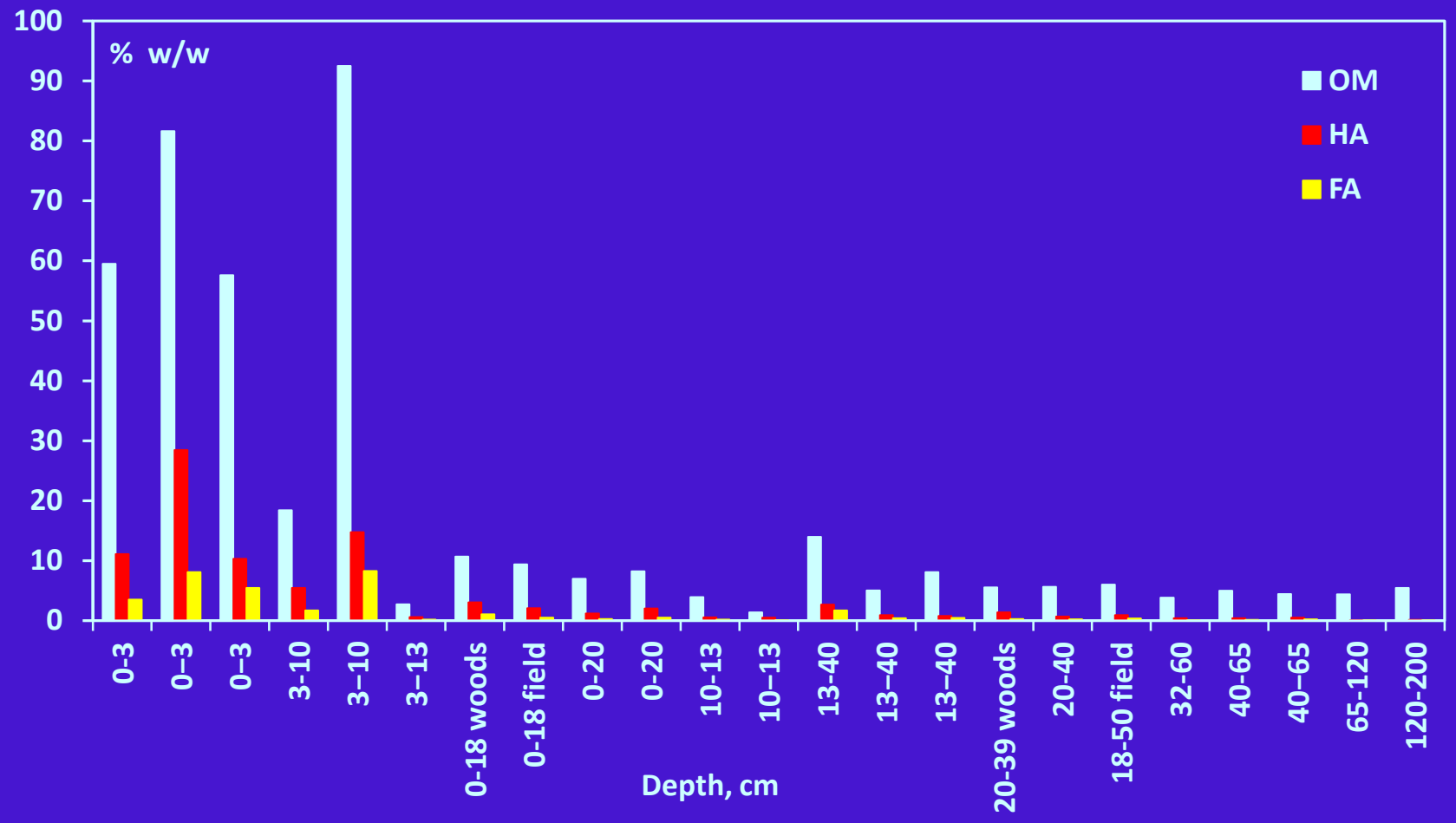
Reproducibility of HA and FA ME Samples (NSP 907-921)

Site	Depth	% HA (1)	% HA (2)	% FA (1)	% FA (2)	% LOI
Telos	0-3	11.9	10.4	3.6	3.4	59.5
	3-10	5.6	5.4	1.8	1.7	18.4
	10-13	0.6	0.5	0.2	0.2	4.0
	13-40	2.7	2.7	1.8	1.7	14.0
	40-65	0.4	0.4	0.1	0.2	5.0
	65-120	0.1	0.1	0.03	0.03	4.4
	120-200	0.1	0.2	0.01	0.02	5.5
Wassookeag	0-18 field	2.2	2.0	0.5	0.5	9.4
	0-18 woods	2.9	3.3	1.2	1.0	10.7
	20-39 woods	1.6	1.2	0.3	0.3	5.6
	18-50 field	1.0	0.9	0.4	0.4	6.0
Caribou	0-20	1.2	1.3	0.3	0.3	7.0
	0-20	2.2	2.0	0.5	0.5	8.2
	20-40	0.7	0.8	0.2	0.2	5.7
	32-60	0.4	0.4	0.1	0.1	3.8

Reproducibility of HA and FA ME Samples (NSP 907-921)

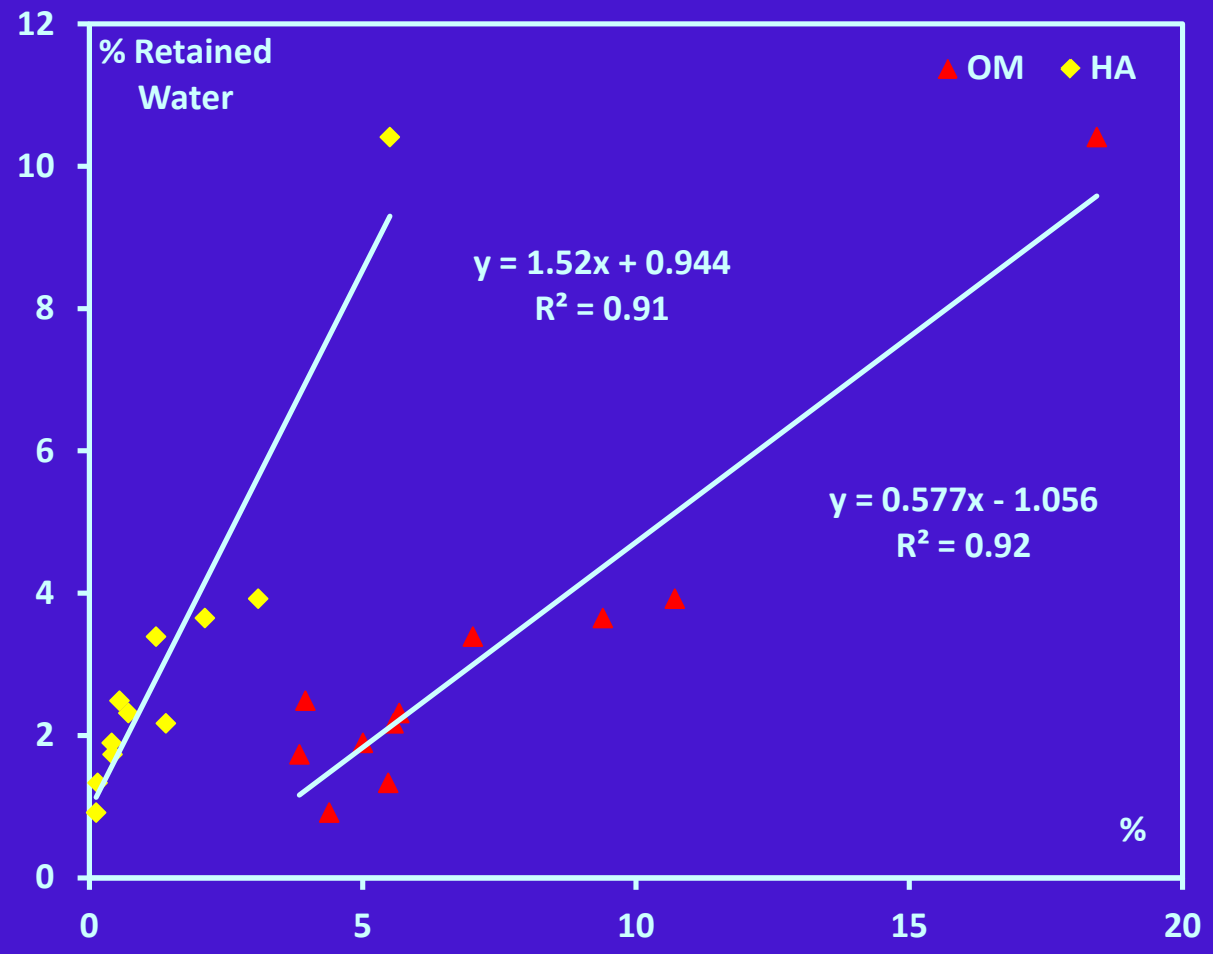
Site	Depth	% HA (1)	% HA (2)	% FA (1)	% FA (2)	% LOI
Telos	0-3	11.9	10.4	3.6	3.4	59.5
	3-10	5.6	5.4	1.8	1.7	18.4
	10-13	0.6	0.5	0.2	0.2	4.0
	13-40	2.7	2.7	1.8	1.7	14.0
	40-65	0.4	0.4	0.1	0.2	5.0
	65-120	0.1	0.1	0.03	0.03	4.4
	120-200	0.1	0.2	0.01	0.02	5.5
Wassookeag	0-18 field	2.2	2.0	0.5	0.5	9.4
	0-18 woods	2.9	3.3	1.2	1.0	10.7
	20-39 woods	1.6	1.2	0.3	0.3	5.6
	18-50 field	1.0	0.9	0.4	0.4	6.0
Caribou	0-20	1.2	1.3	0.3	0.3	7.0
	0-20	2.2	2.0	0.5	0.5	8.2
	20-40	0.7	0.8	0.2	0.2	5.7
	32-60	0.4	0.4	0.1	0.1	3.8


Wavelength, nm
200
250
300
350
400
450
500
550
600
4
2
0
-2
-4
-6
-8
ln absorbance
1
y = -0.0158x + 6.4892
R² = 0.9967
2
y = -0.017x + 6.2362
R² = 0.9973
4
y = -0.0159x + 5.8368
R² = 0.998
3
y = -0.0183x + 4.538
R² = 0.9963
5
y = -0.0183x + 4.1416
R² = 0.9967
6
y = -0.0207x + 3.2876
R² = 0.9901


% w/w
OM
HA
FA
100
90
80
70
60
50
40
30
20
10
0
0-3
0–3
0–3
3-10
3–10
3–13
0-18 woods
0-18 field
0-20
0-20
10-13
10–13
13-40
13–40
13–40
20-39 woods
20-40
18-50 field
32-60
40-65
40–65
65-120
120-200
Depth, cm

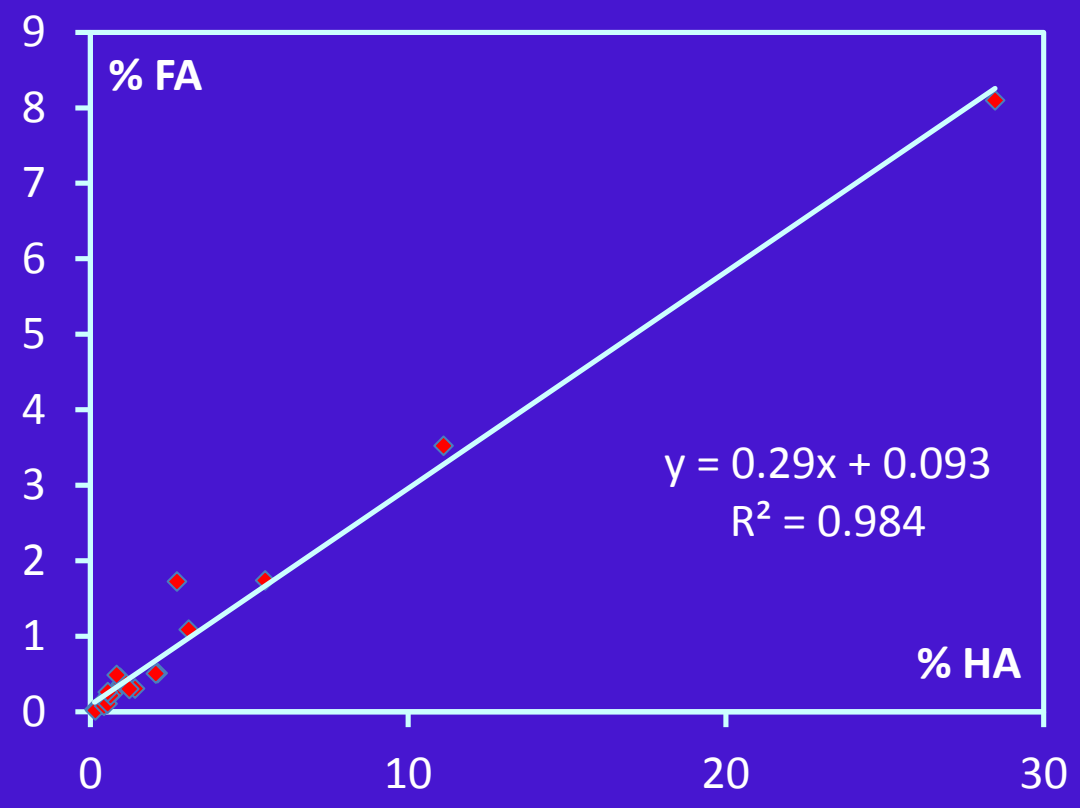
% Humification

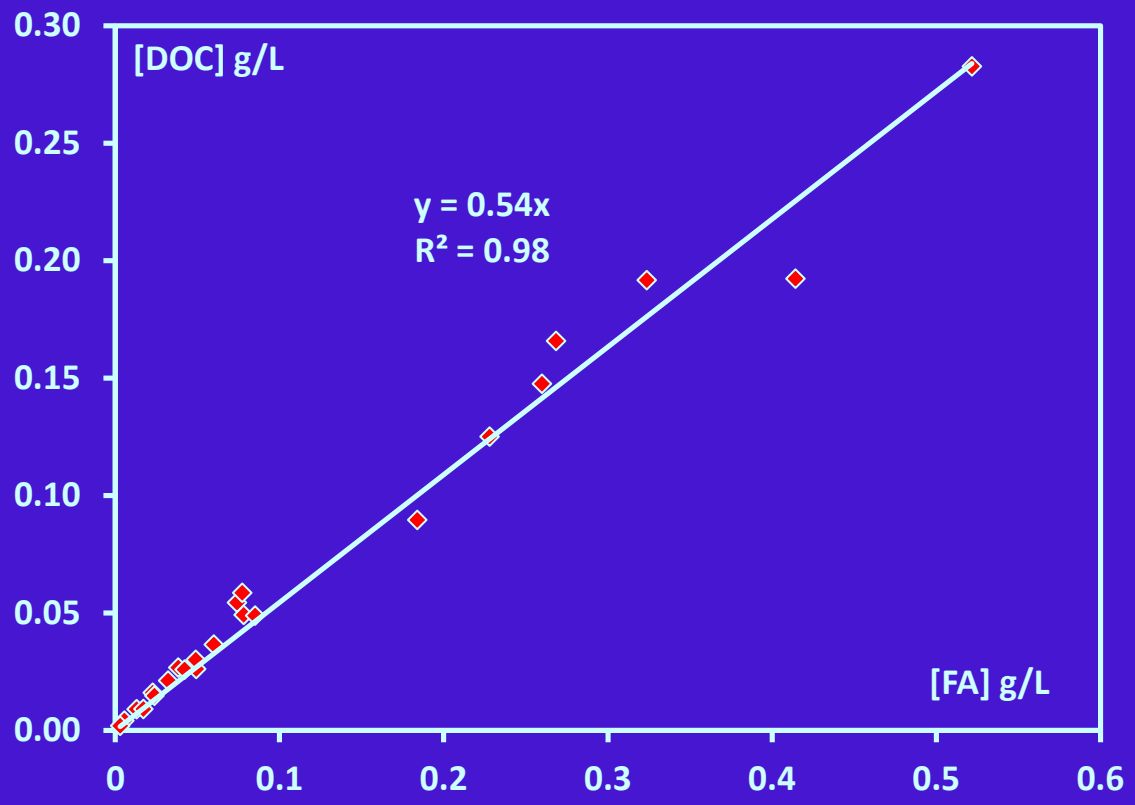
Depth, cm	Fields	Woods
0-20	24 ± 2	31
18-50	17	27
> 40	< 9	-

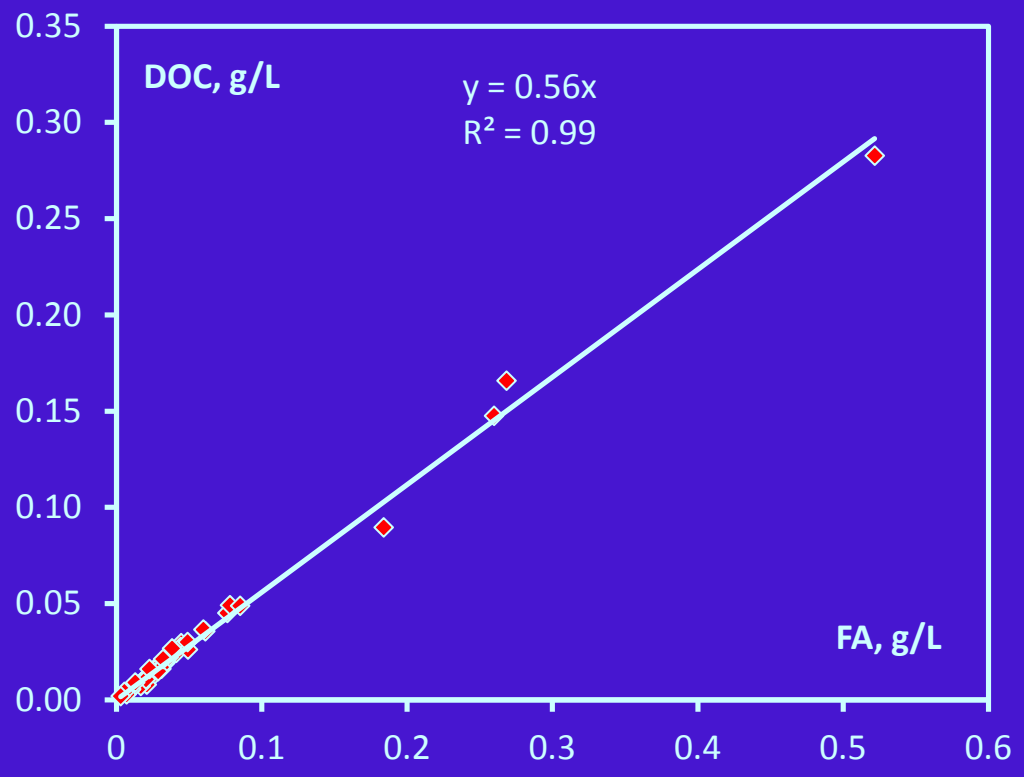

% Retained
Water
OM
HA
y = 1.52x + 0.944
R² = 0.91
y = 0.577x - 1.056
R² = 0.92
%
12
10
8
6
4
2
0
0
5
10
15
20

Steady State!

$$HA \bullet FA(s) \rightleftharpoons HA(s) + FA(aq) \qquad K_D = 0.29$$




[DOC] g/L
y = 0.54x
R² = 0.98
[FA] g/L
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
0.1
0.2
0.3
0.4
0.5
0.6


DOC, g/L
y = 0.56x
R² = 0.99
FA, g/L
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
0.1
0.2
0.3
0.4
0.5
0.6

Conclusions

- Humic acids definitely are water retainers
- HA and FA analysis is reproducible for different soils
- Humin detection is rare
- Humification starts at the soil surface
- HA and FA contents decrease sharply with soil depth below the A horizon
- The Maine soils are in a steady state, with a HA/FA ratio of about 3:1
- FA is about 55% carbon in the Maine and ALP samples
- HA, FA and HU analysis is feasible and reproducible
- Sequestered soil carbon can be measured and known

Acknowledgements

1000+ Donors from 50 US States

NSSL

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