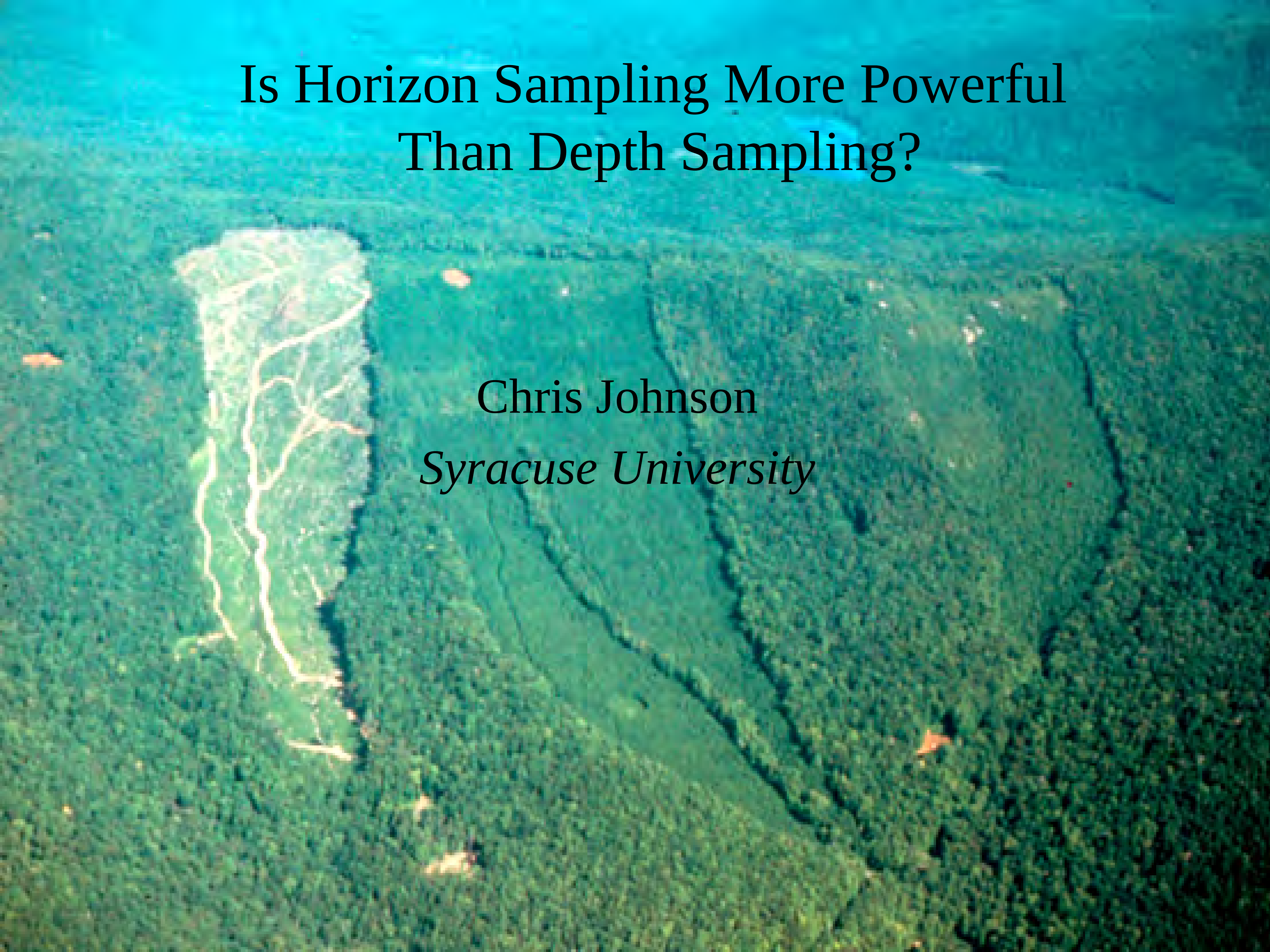
Is Horizon Sampling More Powerful Than Depth Sampling?



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The ‘Quantitative Pit’ Method

The Method

The Method

The Method

Advantages of Depth Sampling Generally

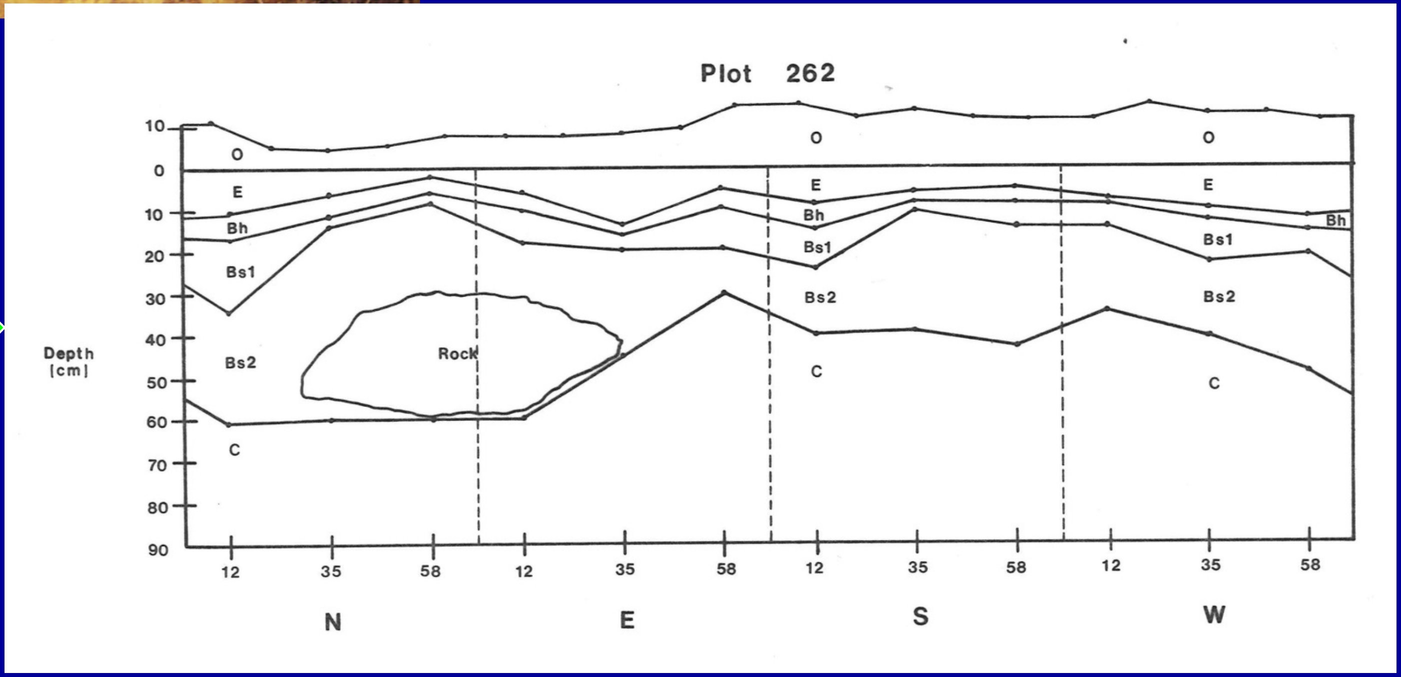
- Reproducible: No need for ‘expert’ horizon delineation.
- Easy (if not using ‘quantitative’ technique).
- Statistically efficient: not all profiles will have all horizons.

Advantages of the Quantitative Pit Method Specifically

- Sample integrates all soil in the layer.
- Soil mass per unit area (Mg/ha) is measured directly.
  - No need for bulk density estimate.
- Bulk density and “coarse fragment” content can be estimated in stony soils.

Horizon Sampling

Horizon Sampling



Advantages of Horizon Sampling

- Ease of interpretation: Horizonation reflects soil processes.
- Statistically efficient:
  - Horizons are differentiated by chemistry, texture, organic matter.
  - Chemical properties should be relatively consistent for a given horizon.
  - Depth layers incorporate multiple horizons.
  - Presence/absence of horizons varies in the landscape.
  - Data derived from horizon sampling should be less variable than data derived from depth layers.

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Is this true?

Hubbard Brook Watershed 5 Experiment

- 60 quantitative pits, sampled by depth increment: 0-10 cm, 10-20 cm, 20 cm-C/R
- In 1983 (before cutting), 30 pits were also sampled by horizon.

- Whole-tree clear-cut in winter 1983-84
- Resampled in 1986, 1991, 1997.
  - 60 quantitative pits each year
  - Horizon sampling carried out:
    - 48 pits (1986)
    - 59 pits (1991)
    - 60 pits (1998)

Matching Horizons to Depths

1983 (Pre-Harvesting) Data:

Horizon	Average Thickness Where Present (cm)
E	3.5
Bh	4.3
Bs1	4.9
Bs2	39.6

Compare to 0-10 cm layer

Compare to 10-20 cm layer

Compare to 20+ cm layer

Johnson et al., *SSSAJ* (1991)

Example: Soil Nitrogen

1983 (Pre-Harvesting) Data:

Horizon	Mean N ($g\ kg^{-1}$)	Std. Dev. ($g\ kg^{-1}$)	CV (%)
E	1.24	0.86	**69**
Bh	3.36	1.02	**30**
Bs1	2.81	0.64	**23**
Bs2	1.44	0.51	**35**

Layer	Mean N ($g\ kg^{-1}$)	Std. Dev. ($g\ kg^{-1}$)	CV (%)
0-10 cm	3.60	1.90	**53**
10-20 cm	2.48	1.31	**53**
20+ cm	1.57	0.73	**46**

Example: Soil Nitrogen

F-Test for Equality of Variances

Test Statistic: $F = \frac{S_1^2}{S_2^2}$, where $S_1^2 > S_2^2$

Compare to critical value of F-Distribution, with k_1, k_2 d.f.:

$$k_1 = N_1 - 1; k_2 = N_2 - 1$$

Total Nitrogen Data:

Horizon / Layer	Var_{Hor}	Var_{Layer}	F	$F_{critical}$	$Var_{Hor} < Var_{Layer}$?
E vs. 0-10	.740	3.61	4.88	1.95	**Yes**
Bh vs. 0-10	1.04	3.61	3.47	1.87	**Yes**
Bs1 vs. 10-20	.410	1.72	4.20	1.93	**Yes**
Bs2 vs. 20+	.260	.533	2.05	1.88	**Yes**

Example: Soil Nitrogen

Are these differences “important”?

<u>Power Calculation:</u>

Set: $N = 60$ $\alpha = 0.05$ $\beta = 0.75$ = Power

Horizon	Mean N (g kg^{-1})	Detectable Difference (g kg^{-1})	± %
E	1.24	0.42	± 34%
Bh	3.36	0.49	± 15%
Bs1	2.81	0.31	± 11%
Bs2	1.44	0.25	± 17%

Layer	Mean N (g kg^{-1})	Detectable Difference (g kg^{-1})	± %
0-10 cm	3.60	0.92	± 26%
10-20 cm	2.48	0.64	± 26%
20+ cm	1.57	0.35	± 22%

A change of 20%, for example, would be detected using horizons, but not layers.

Exchangeable Calcium

F-Test for Equality of Variances:

Horizon / Layer	Var_{Hor}	Var_{Layer}	F	$F_{critical}$	$Var_{Hor} < Var_{Layer}$?
E vs. 0-10	0.103	0.172	1.67	1.92	**No**
Bh vs. 0-10	0.0918	0.172	1.87	1.83	**Yes**
Bs1 vs. 10-20	0.0296	0.0670	2.26	1.90	**Yes**
Bs2 vs. 20+	0.0256	0.0313	1.22	1.84	**No**

Exchangeable Calcium

Power Calculation:

$N = 60$ $\alpha = 0.05$ $\beta = 0.75 =$ Power

Horizon	Mean Ex. Ca ($cmol_c\ kg^{-1}$)	Detectable Difference ($cmol_c\ kg^{-1}$)	± %
E	0.41	0.156	± 38%
Bh	0.63	0.147	± 23%
Bs1	0.35	0.083	± 24%
Bs2	0.17	0.078	± 46%

Layer	Mean Ex. Ca ($cmol_c\ kg^{-1}$)	Detectable Difference ($cmol_c\ kg^{-1}$)	± %
0-10 cm	0.79	0.201	± 25%
10-20 cm	0.36	0.126	± 35%
20+ cm	0.19	0.086	± 45%

Conclusions

1. For total N and exchangeable Ca, the variance of the layer data was always greater than the variance of the horizon data. In 6/8 cases, the difference was statistically significant.

2. Power calculations suggest that sampling by horizon can reduce the detectable difference in concentration by more than 50%.

3. However, estimating chemical pools using horizon data is difficult in stony soils (maybe next year…)