Soil Quality Attributes Ten Years After The Establishment of Alberta Soil Quality Benchmark Sites

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Canada

Introduction

- Predictive models have been used to assess probable soil quality change in Canada.
- The Soil Quality Benchmark Sites were established in an attempt to evaluate the predictions.
- Twenty three sites were established across Canada.
- After 5 and again 10 years the soils were re-sampled to monitor changes in dynamic soil properties.

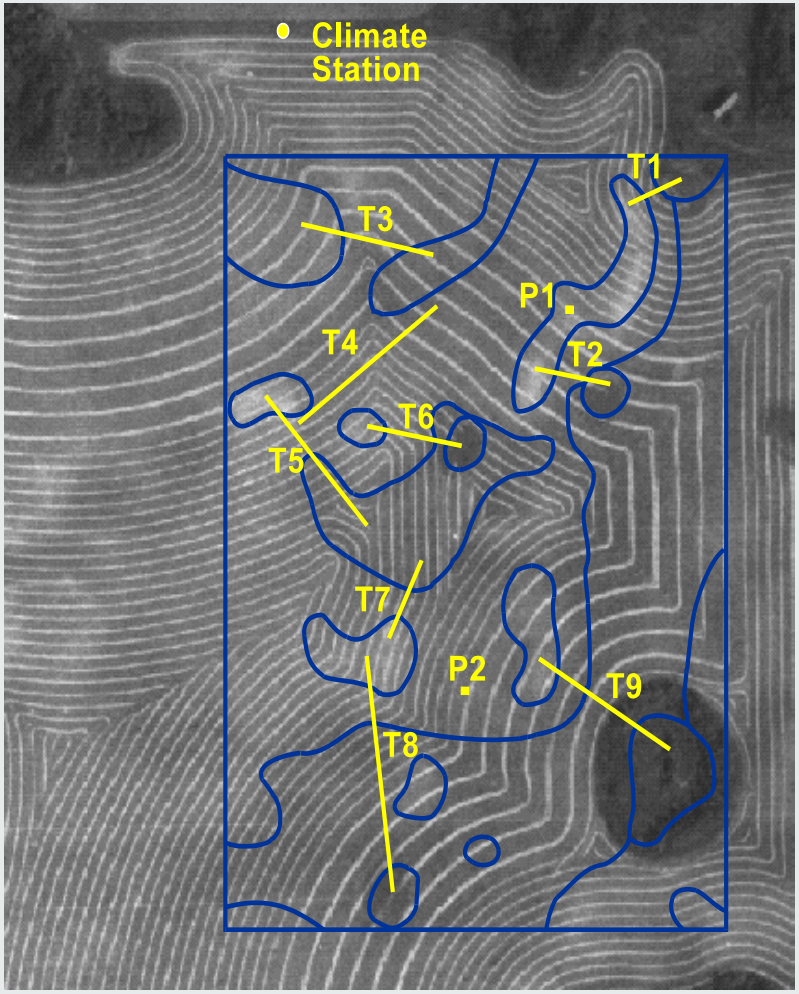
Benchmark Sites for Monitoring Soil Health in Canada

Objective

To compare soil quality attributes measured in 1991 - 92 with those measured in 2001 - 02 at four Alberta locations under soil management typical of the area where the study sites are located.

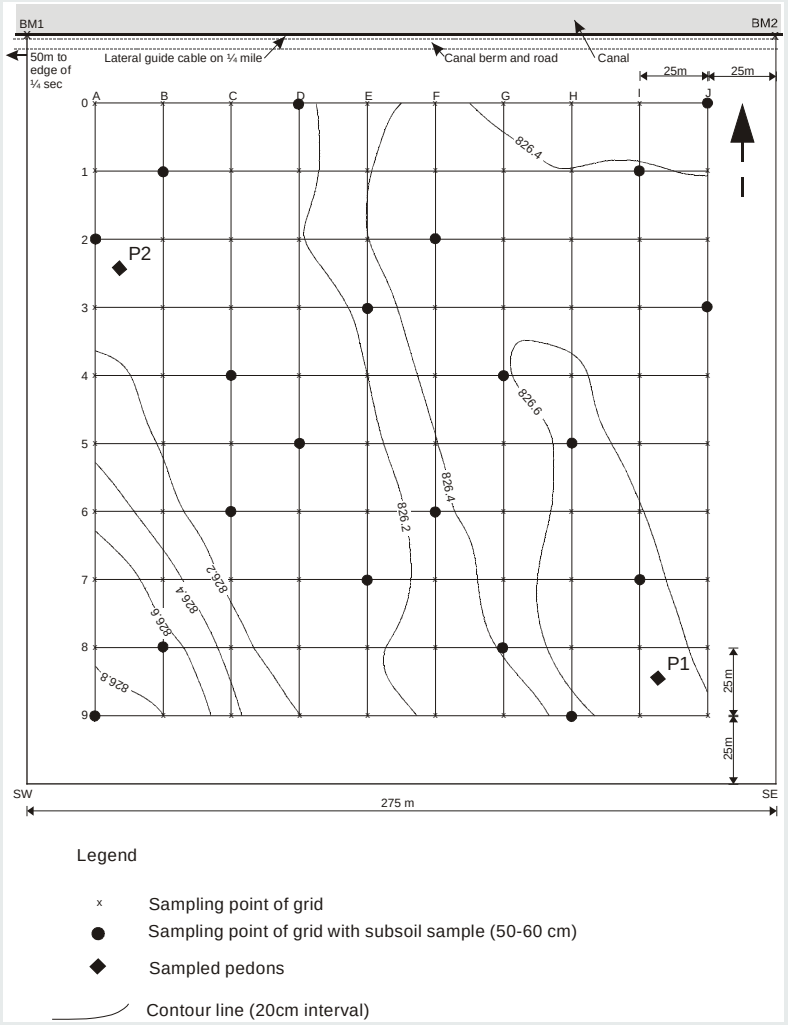
Materials and Methods

- **For low relief, hummocky morainal landscapes** a transect sampling design was used – suited to terrain with relief as in other studies on soils in toposequences (Arnold and Wilding 1991).



Materials and Methods (cont.)

- **For level landscapes** a 10 by 10 grid was used at 25 m spacings.



Materials and Methods (cont.)

- **Comparative analysis** – paired Student's t-test (parametric) or Sign test (non-parametric) ($P \leq 0.05$).
- **Laboratory analyses:** (Sheldrick 1984) on topsoil (Ap horizon) samples.
  - pH ($CaCl_2$) – measured by pH meter in a 1:2 soil to $CaCl_2$ solution.
  - Available Potassium (K) – by the pH7, 1M, NH_4OAc extraction method and for non-calcareous samples - cold, 0.05M, H_2SO_4 extraction.

Materials and Methods (cont.)

- **Laboratory analyses (cont.):**
  - Organic Carbon – total C (LECO induction furnace) minus inorganic C (manometric method).
  - Carbon-Light Fraction - M. R. Carter (Ed.) 1993. Soil sampling and methods of analysis. p 399 sect. 39.3. Expressed as % of Fine Earth.
  - Total Nitrogen – samples were digested using a semi-micro version of the Kjeldahl- Wilforth-Gunning method (AOAC 1955).

Results

- Only three sites are presented, the fourth is similar.
- Only the 10 year re-sampling data is compared to the baseline data. The five year data does not change the picture much, but does suggest that the significant differences found may not be as clear as they appear in the 10 year comparison.

Bow Island Soil Attributes: Whole Field

	Baseline (1991)		Repeat (2001)		Change over 10 yrs
	Mean	SdDev[+]	Mean	SdDev[+]	
pH_{CaCl_2}	7.2	0.4	7.2	0.3	0.0
Organic Carbon (%)[++]	1.16	0.08	1.34	0.07	0.18*
Carbon Light Fraction[++]	0.138	0.93	0.108	0.07	- 0.030*
Total Nitrogen (%)[++]	0.133	0.008	0.147	0.007	0.014*
C:N Ratio	8.7	0.4	9.1	0.4	0.4*
Available K (ug g^{-1})	484	117	423	99	- 61*

[+] Number of paired observations = 66

[++] Weight percent of fine earth fraction

* Significant difference by t-test: Paired Two Sample for Means (<0.05)

Falher Soil Attributes: Whole Field

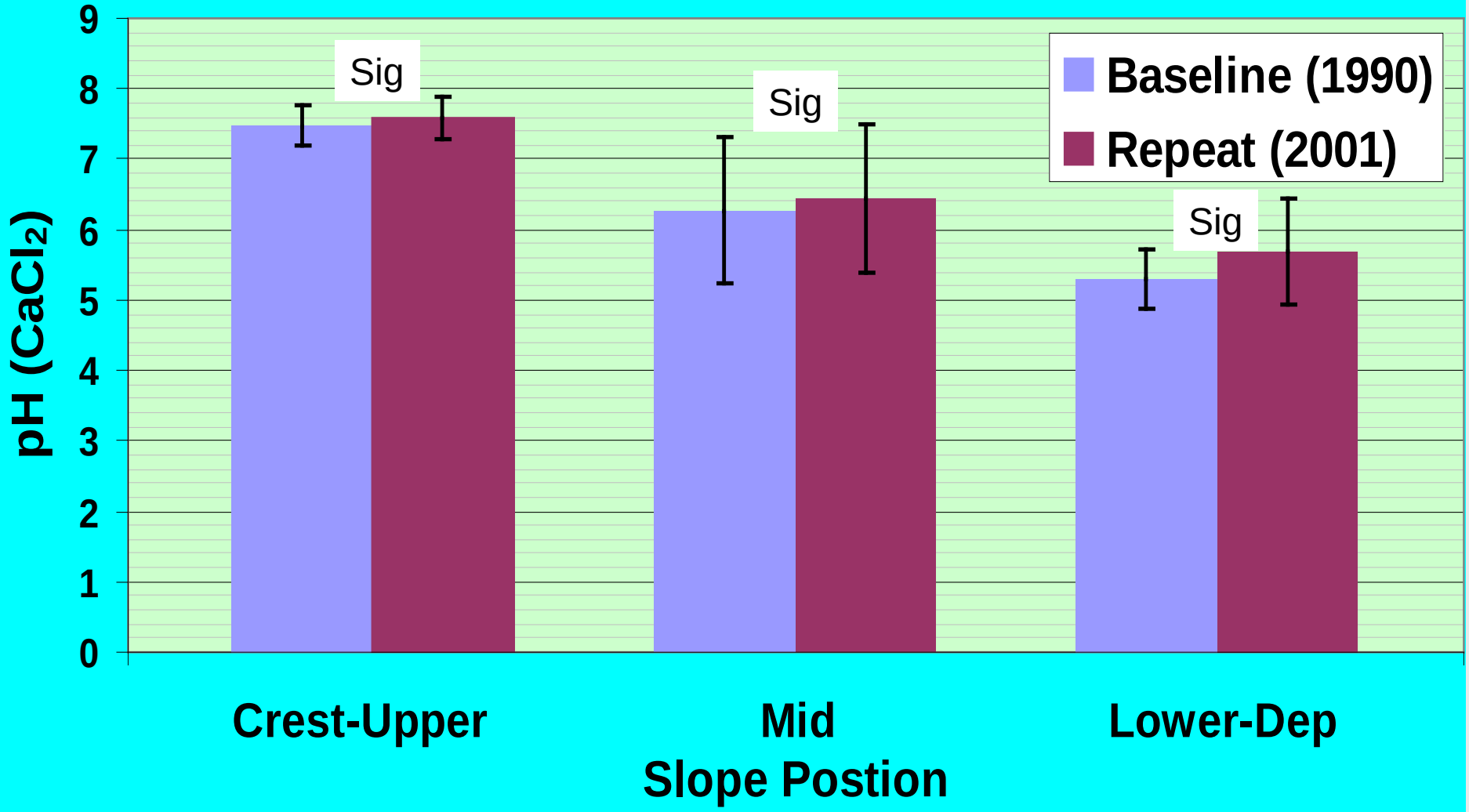
	Baseline (1991)		Repeat (2002)		Change over 10 yrs
	Mean	SdDev[+]	Mean	SdDev[+]	
pH_{CaCl_2}	5.2	0.1	5.2	0.1	0.0
Organic Carbon (%)[++]	3.16	0.32	3.23	0.31	0.07*
Carbon Light Fraction[++]	0.234	0.057	0.261	0.056	0.027*
Total Nitrogen (%)[++]	0.323	0.029	0.325	0.026	0.002
C:N Ratio	9.8	0.30	9.9	0.32	0.1*
Available K (ug g^{-1})	261	39	273	38	12

[+] Number of paired observations = 52

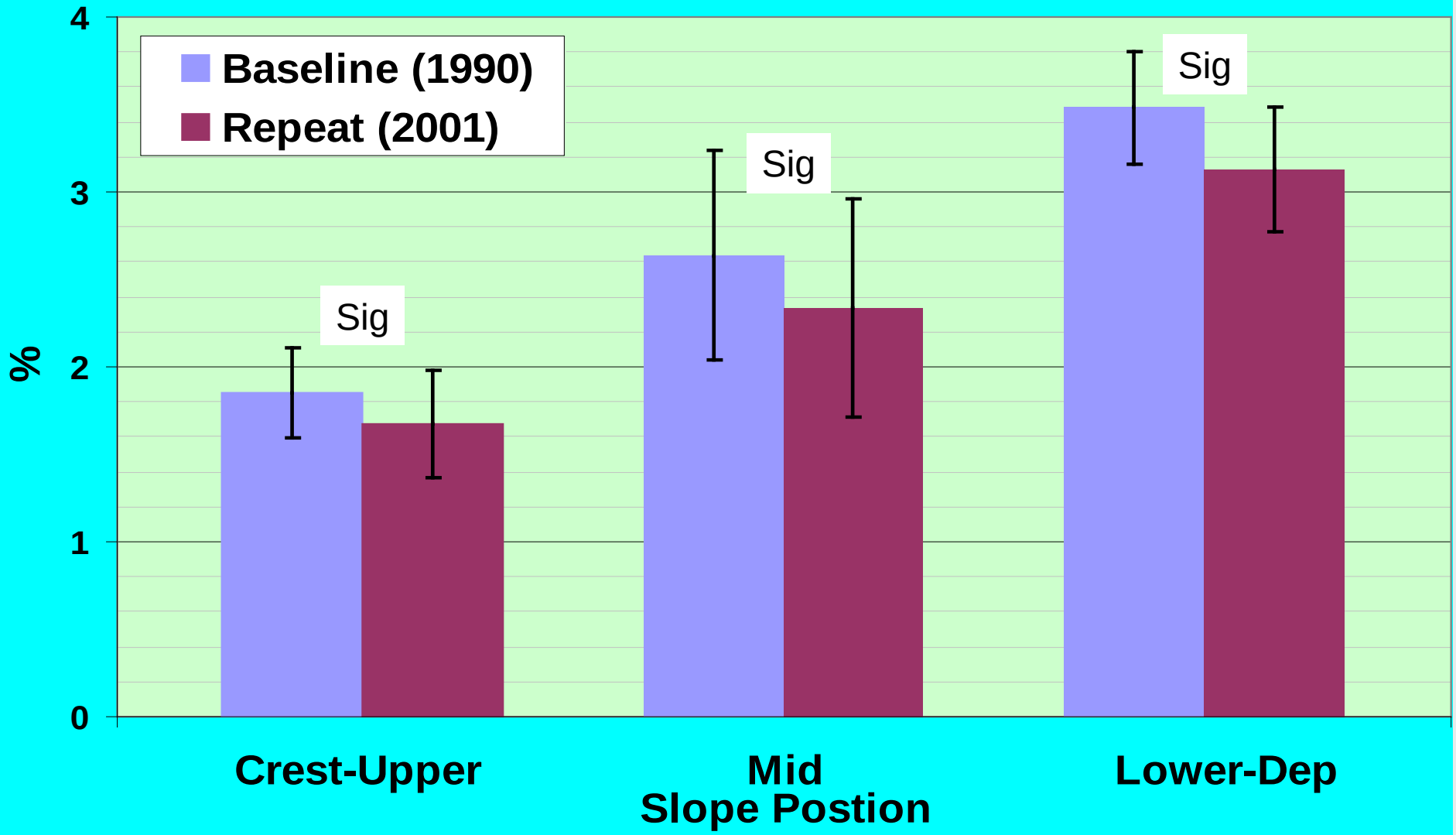
[++] Weight percent of fine earth fraction

* Significant difference by t-test: Paired Two Sample for Means (<0.05)

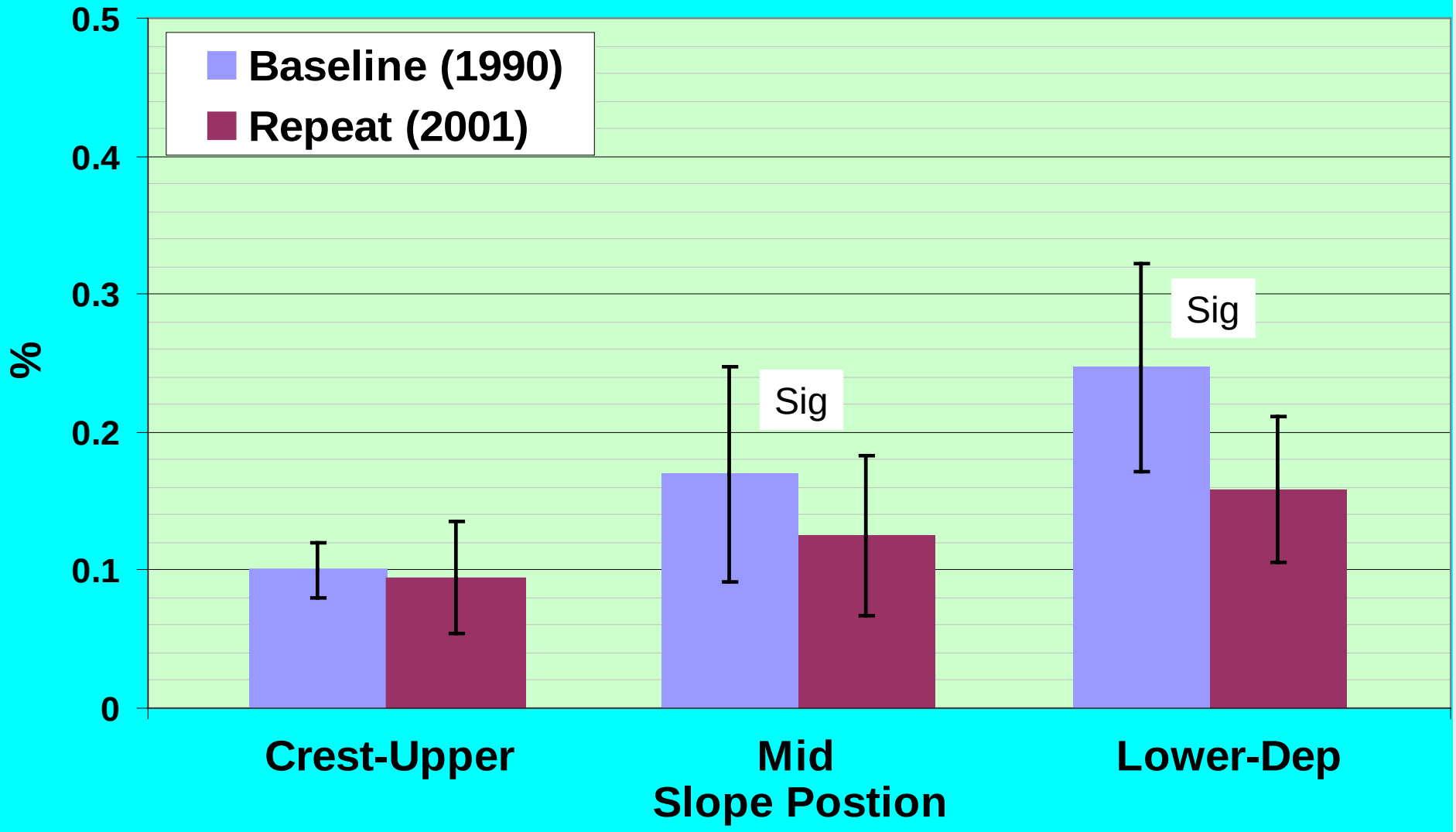
Provost Soil Quality Benchmark Site
pH



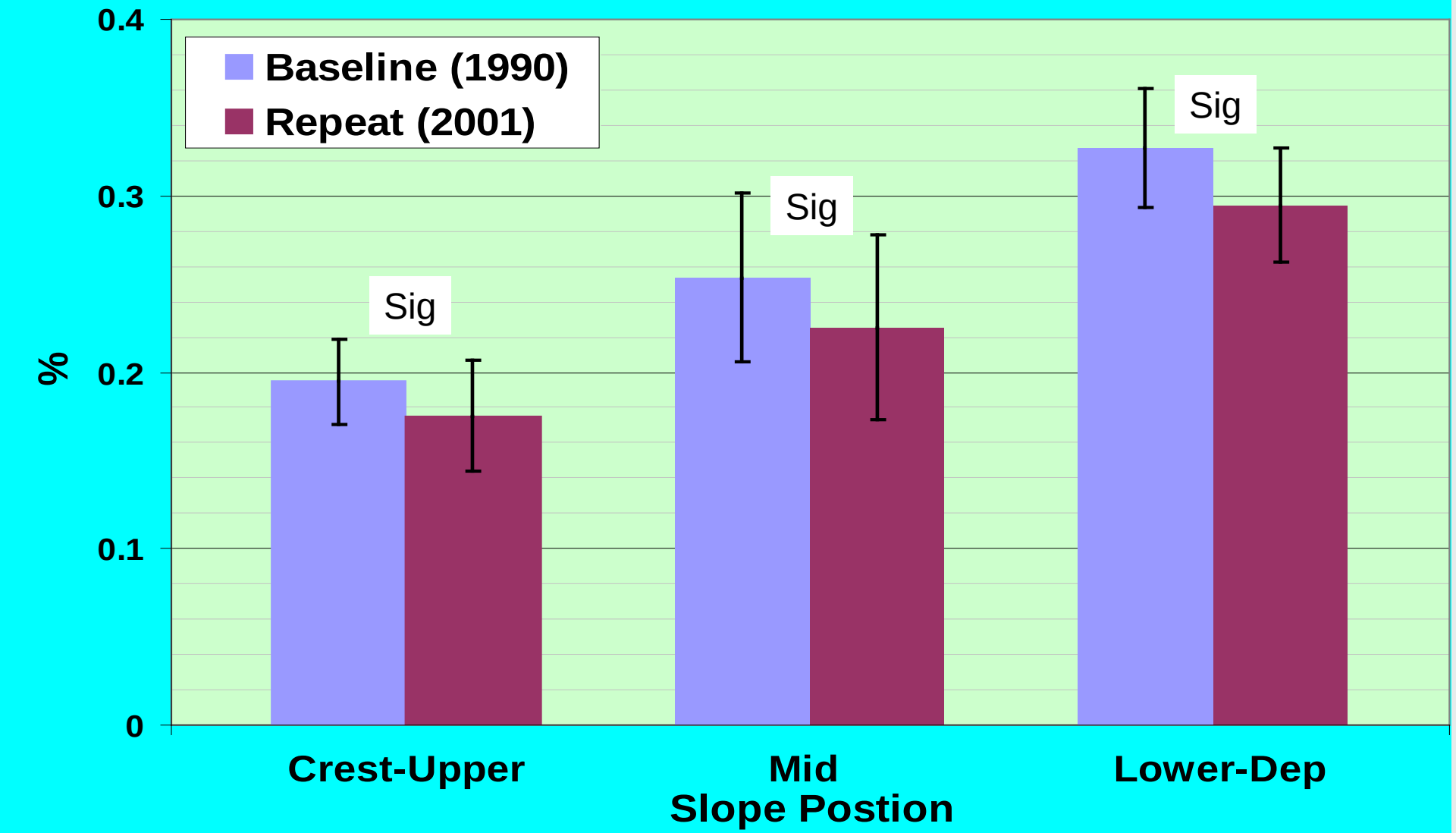
Provost Soil Quality Benchmark Site
Organic Carbon



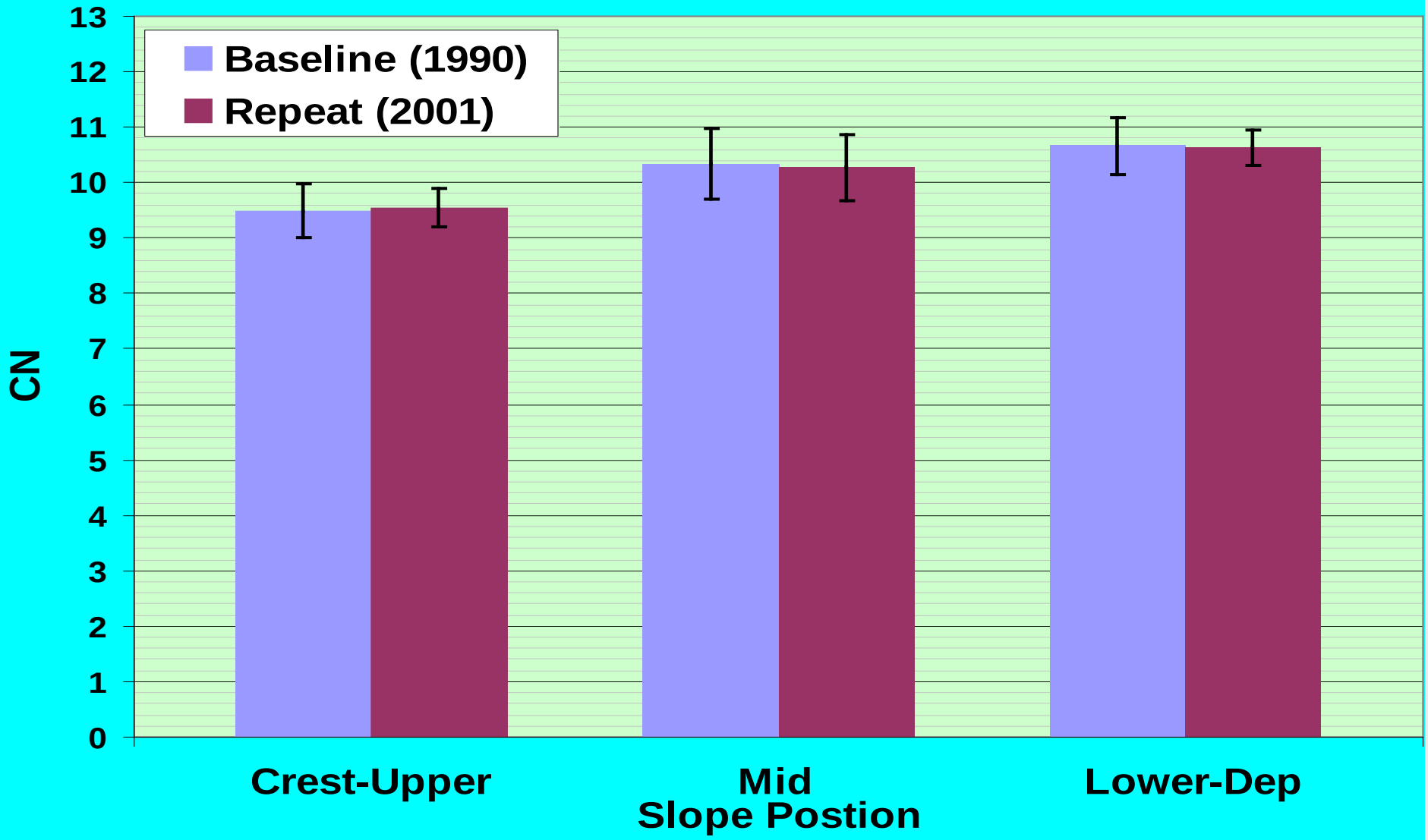
Provost Soil Quality Benchmark Site
Organic Carbon-Light Fraction



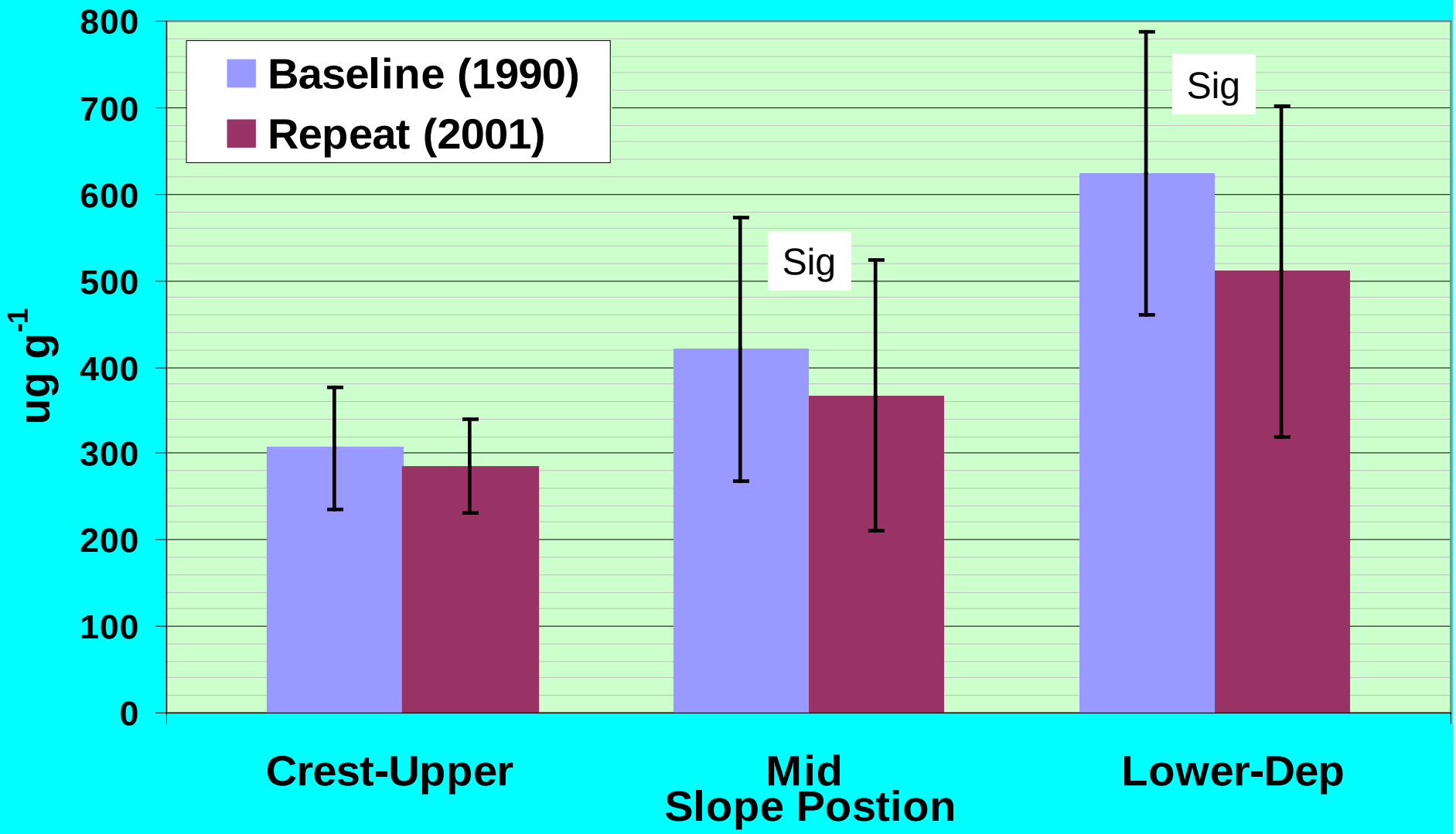
Provost Soil Quality Benchmark Site
Total Nitrogen



Provost Soil Quality Benchmark Site
CN



Provost Soil Quality Benchmark Site
Available Potassium



Results (cont.)

Bow Island - Irrigated Site, Brown Lacustrine Landscape

- Soft Wheat / Canola / Dry Beans
  - pH – No change
  - Organic Carbon – Increasing
  - C light Fraction – Decreasing
  - Available Potassium – Decreasing

Results (cont.)

Falher –Dark Gray Chernozemic, Lacustrine Landscape

- Wheat / Canola (Red Clover)
  - pH – No change
  - Organic Carbon – Increasing
  - C light Fraction – Increasing
  - Available Potassium – No change

Results (cont.)

Provost – Dark Brown Morainal Landscape

- Wheat / Canola /fallow
  - Upper Slope
    - pH – Increase
    - Organic Carbon – Decreasing
    - C light Fraction – No Change
    - Available Potassium – No change

Results (cont.)

Provost (cont.)

- Mid Slope
  - pH – Increasing
  - Organic Carbon – Decreasing
  - C light Fraction – Decreasing
  - Available Potassium – Decreasing

Results (cont.)

Provost (cont.)

- Lower Slope
  - pH – Increase
  - Organic Carbon – Decreasing
  - C light Fraction – Decreasing
  - Available Potassium – Decreasing

Conclusions

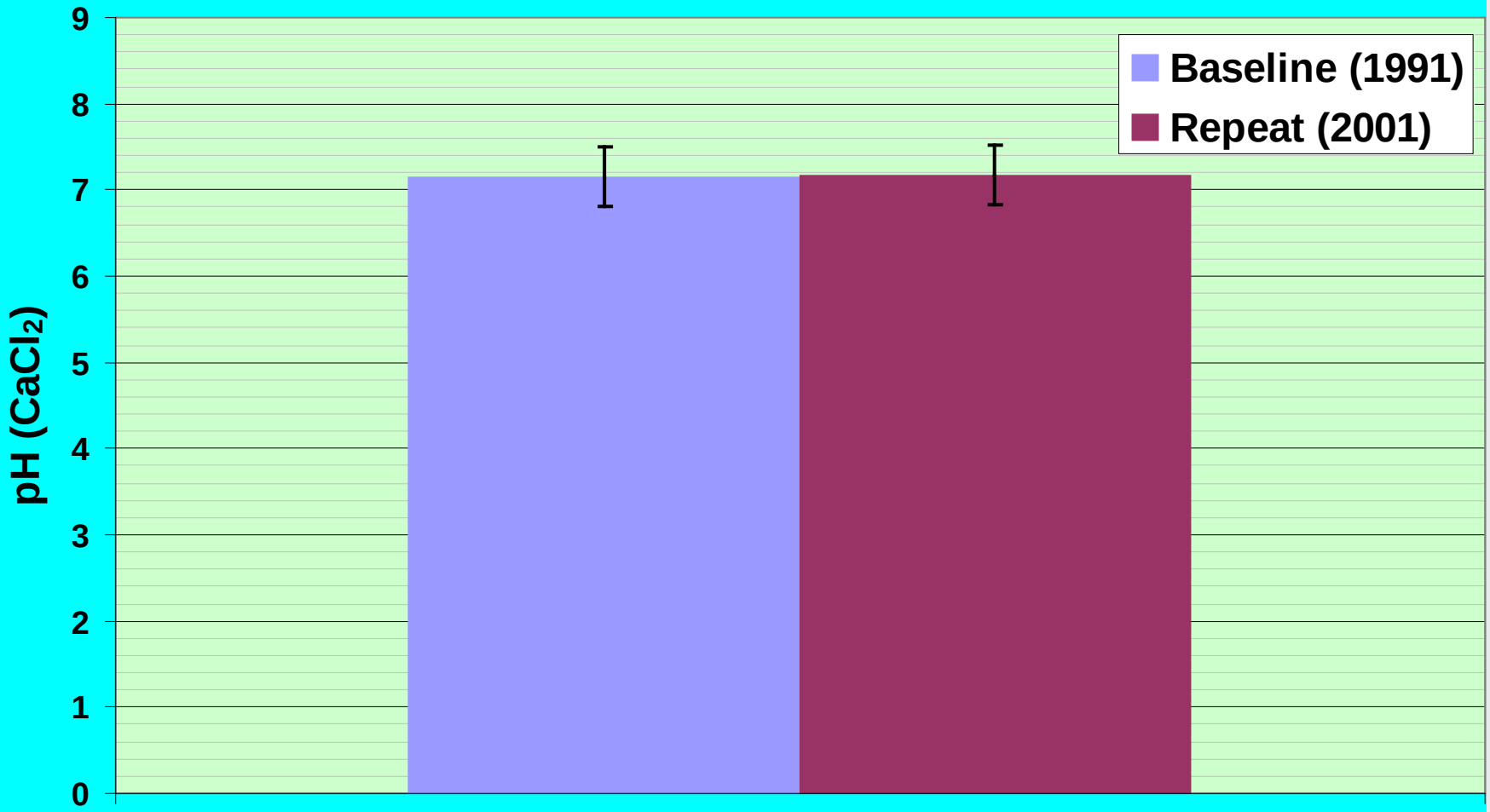
- There has been relatively minor changes in the soil characteristics that we have observed at four sites in Alberta
- Organic Carbon has increased slightly on the level sites and if the trend continues it could be considered relevant to carbon sequestering.
- Organic carbon has decreased slightly at all landscape positions on the morainal site.
- The fact that soil quality is changing even slowly may be relevant in a generation or century.

Acknowledgements

- **For landowner cooperation and field operations**
  D. Carter, T. Crooymans, P. Houde, R. Pitre and Parkland Conservation Farm (K. Montgomery).
- **For field and data management support**
  W. C. McKean, N. J. Sweetland, L. M. Datchkoff and seasonal staff.

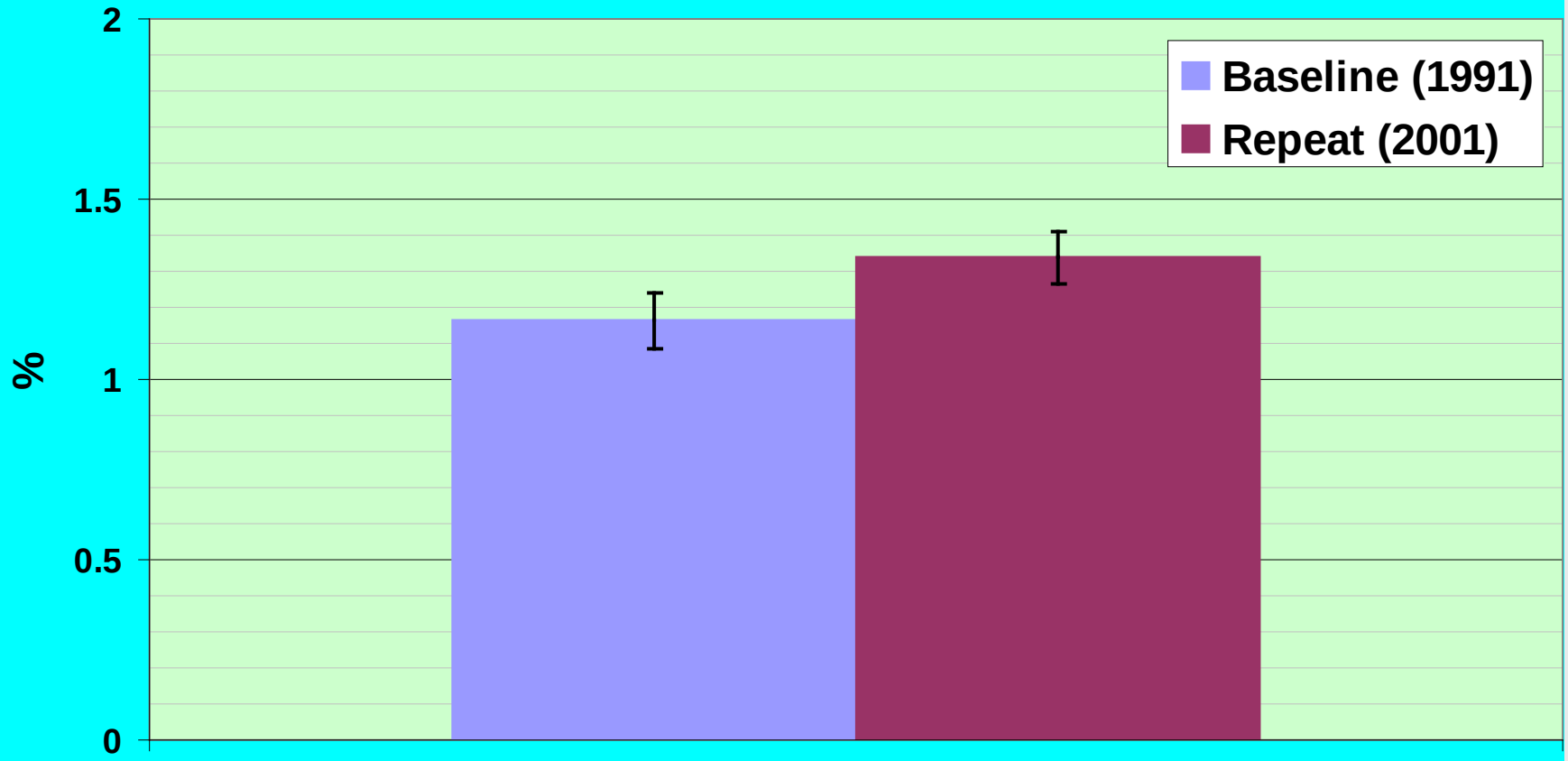
THE END

Bow Island Soil Quality Benchmark Site
pH



No Significant difference by t-test: Paired Two Sample for Means (<0.05)

Bow Island Soil Quality Benchmark Site
Organic Carbon



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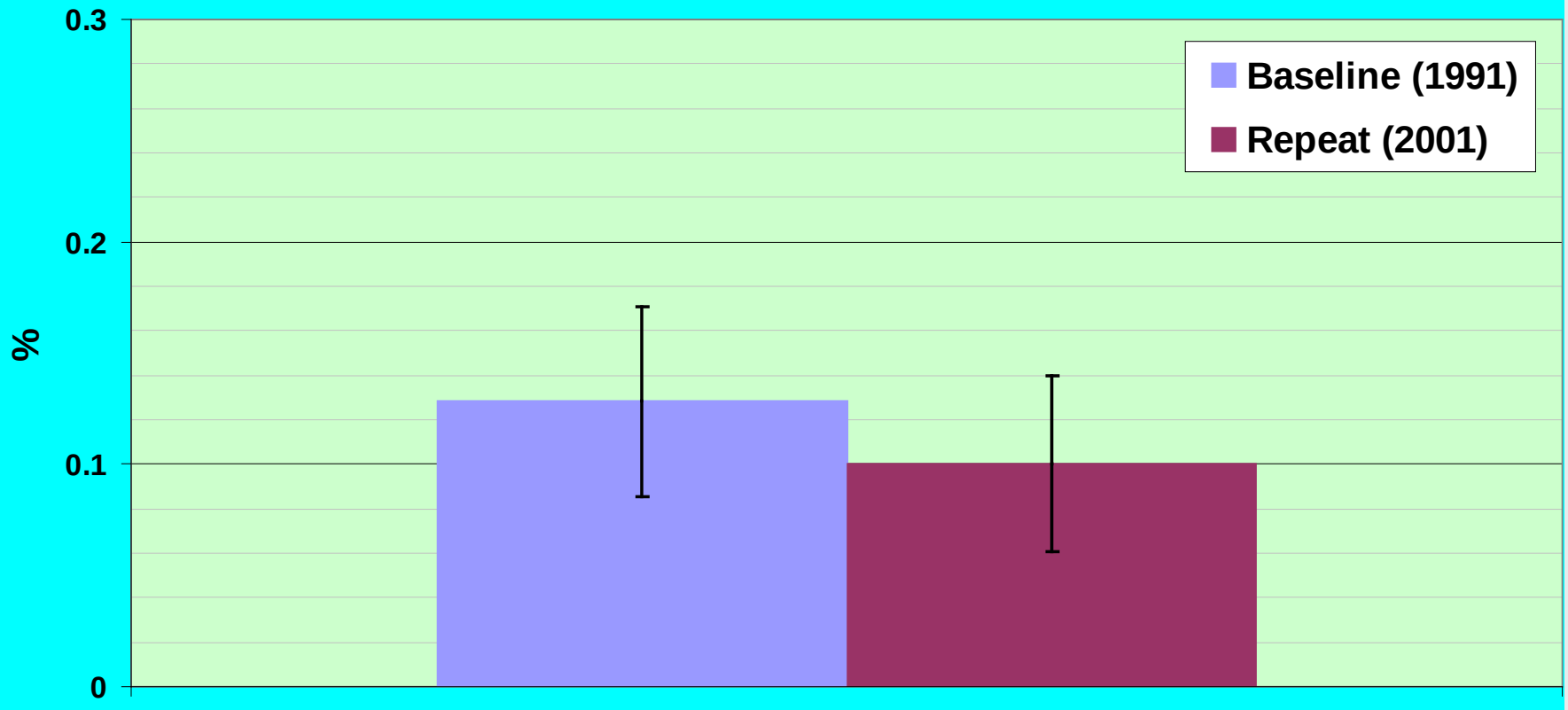
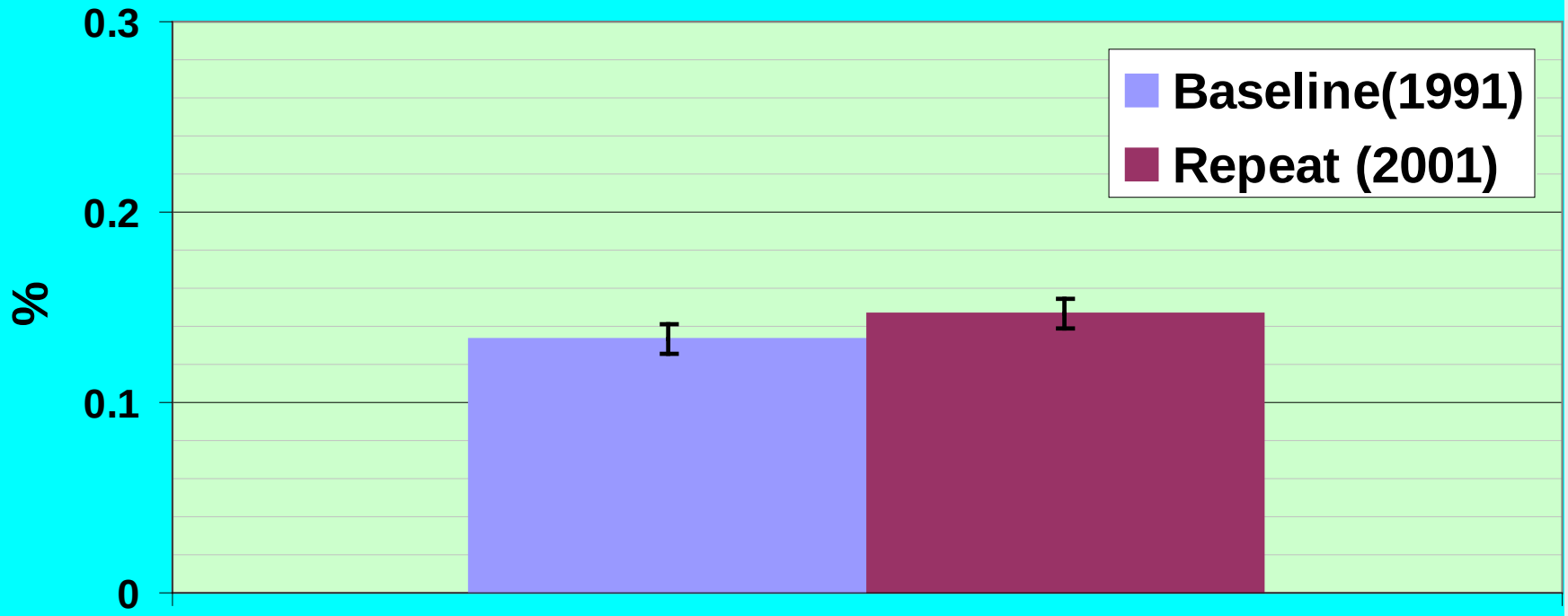
Bow Island Soil Quality Benchmark Site
Organic Carbon-Light Fraction



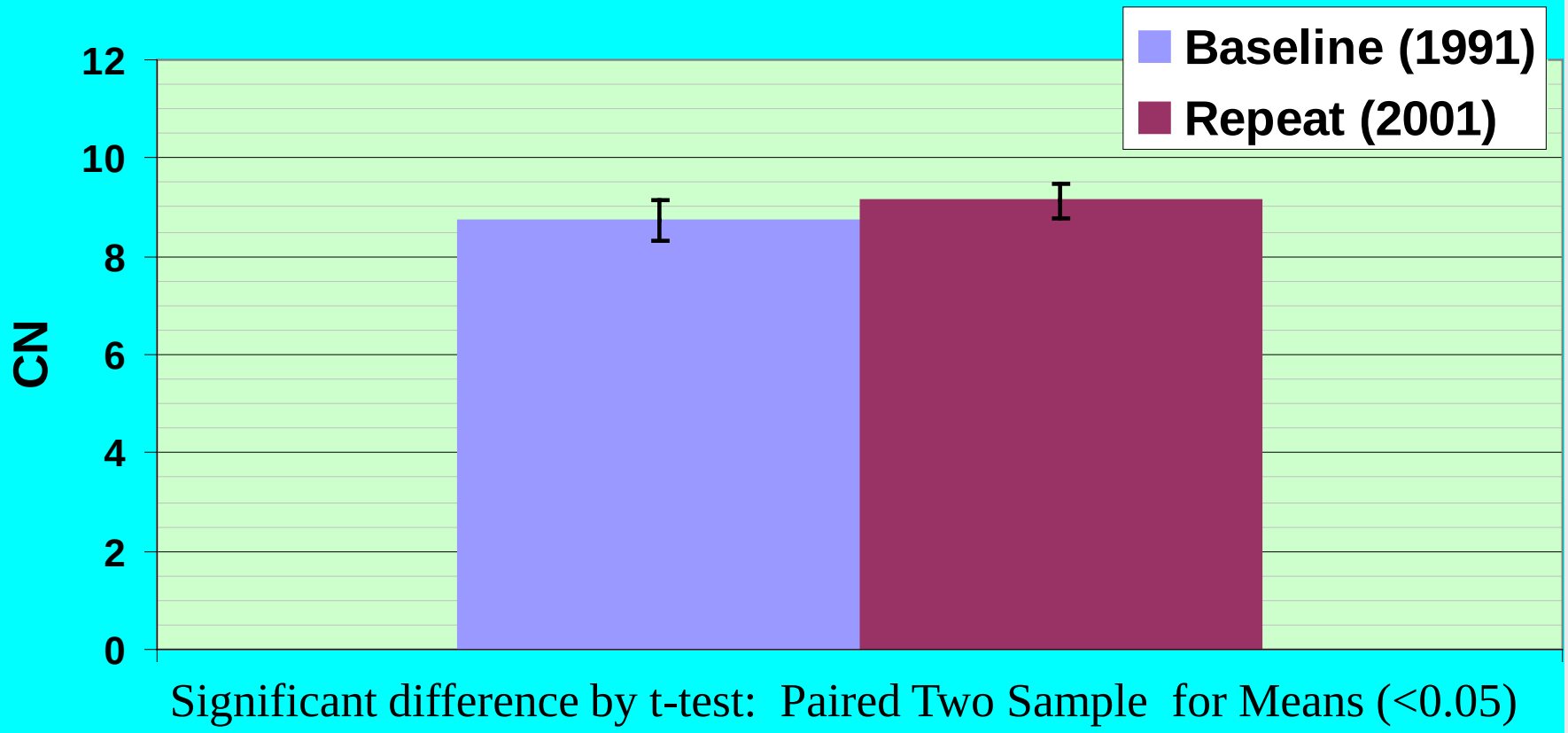
Significant difference by t-test: Paired Two Sample for Means (<0.05)

Bow Island Soil Quality Benchmark Site
Total Nitrogen



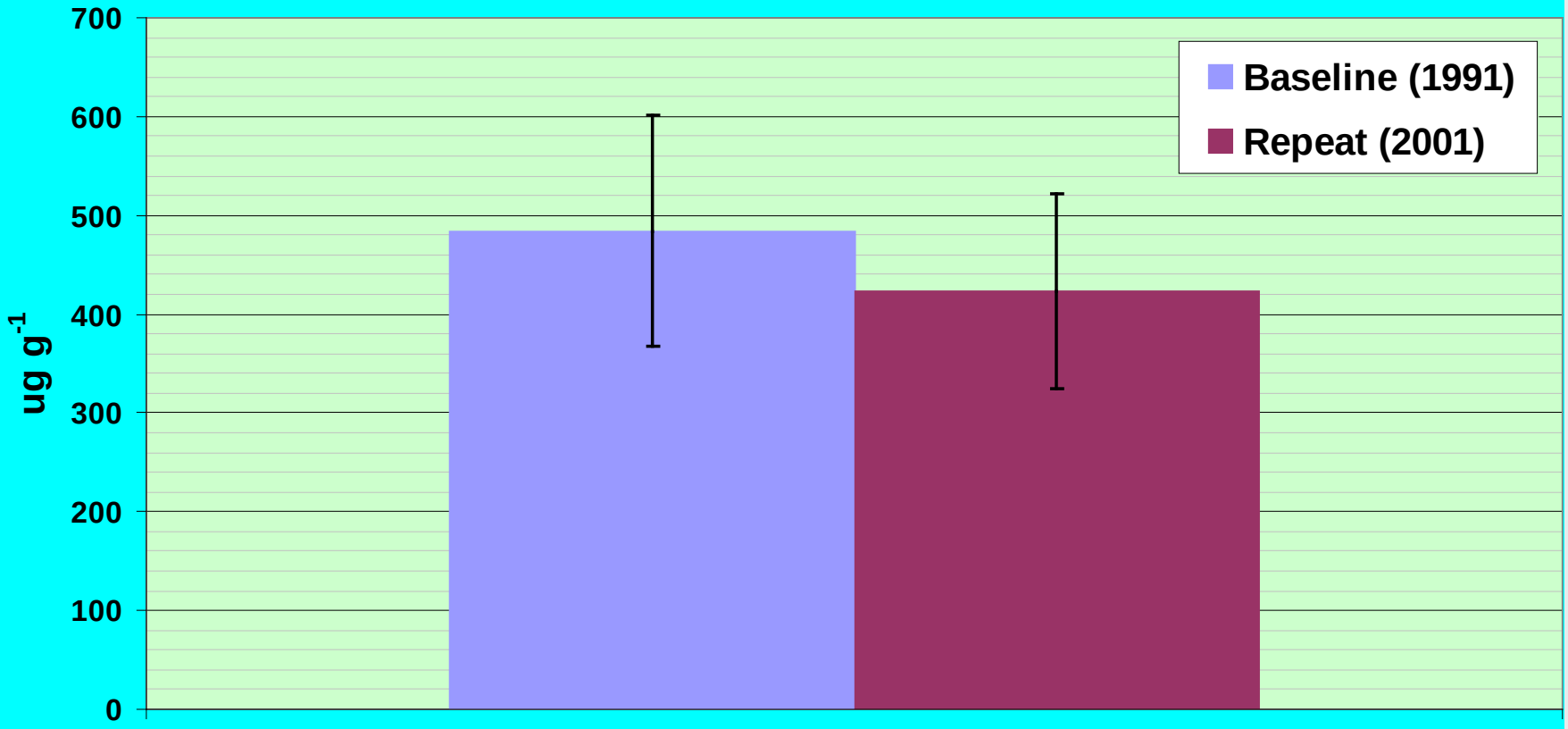
Significant difference by t-test: Paired Two Sample for Means (<0.05)

Bow Island Soil Quality Benchmark Site
CN Ratio



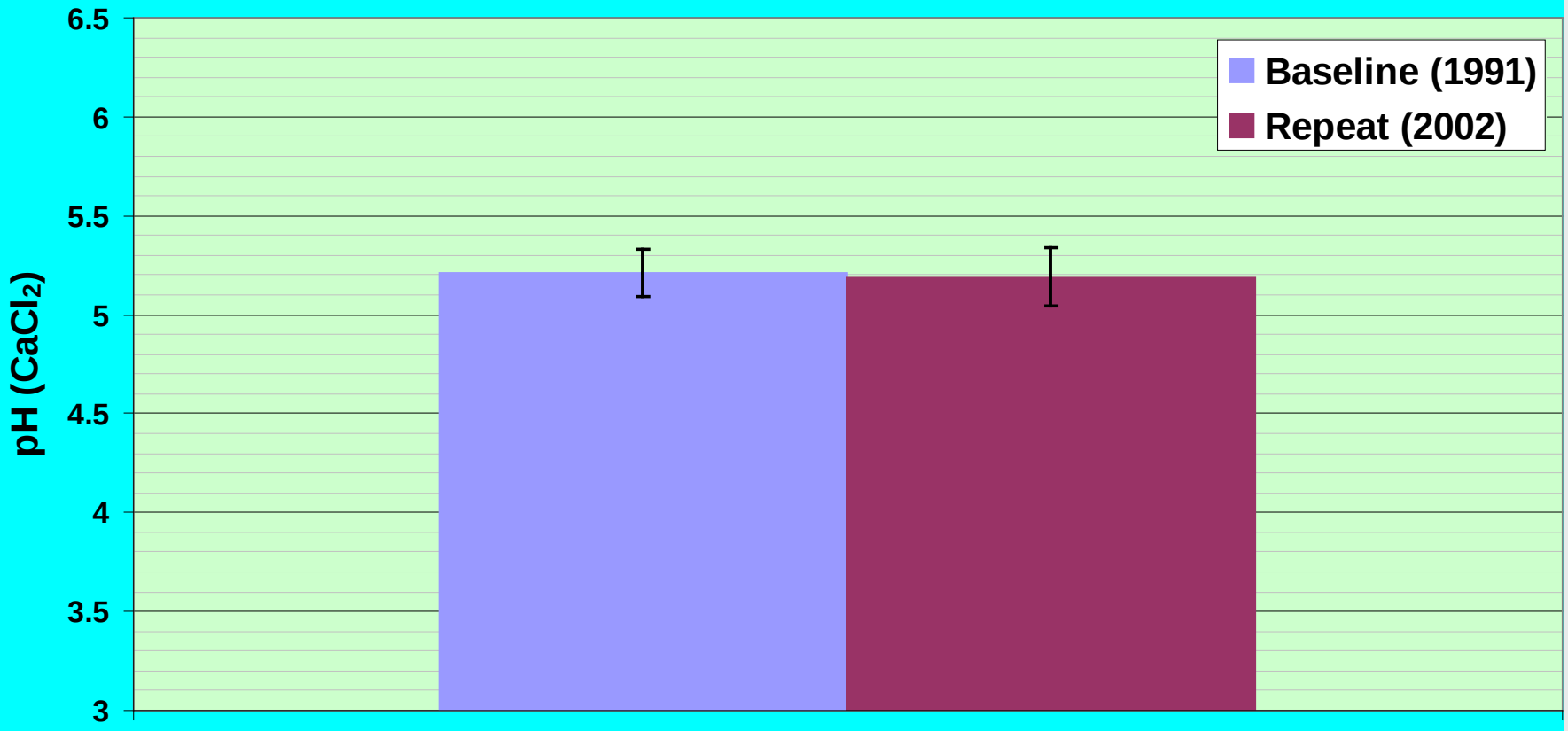
Significant difference by t-test: Paired Two Sample for Means (<0.05)

Bow Island Soil Quality Benchmark Site
Available Potassium



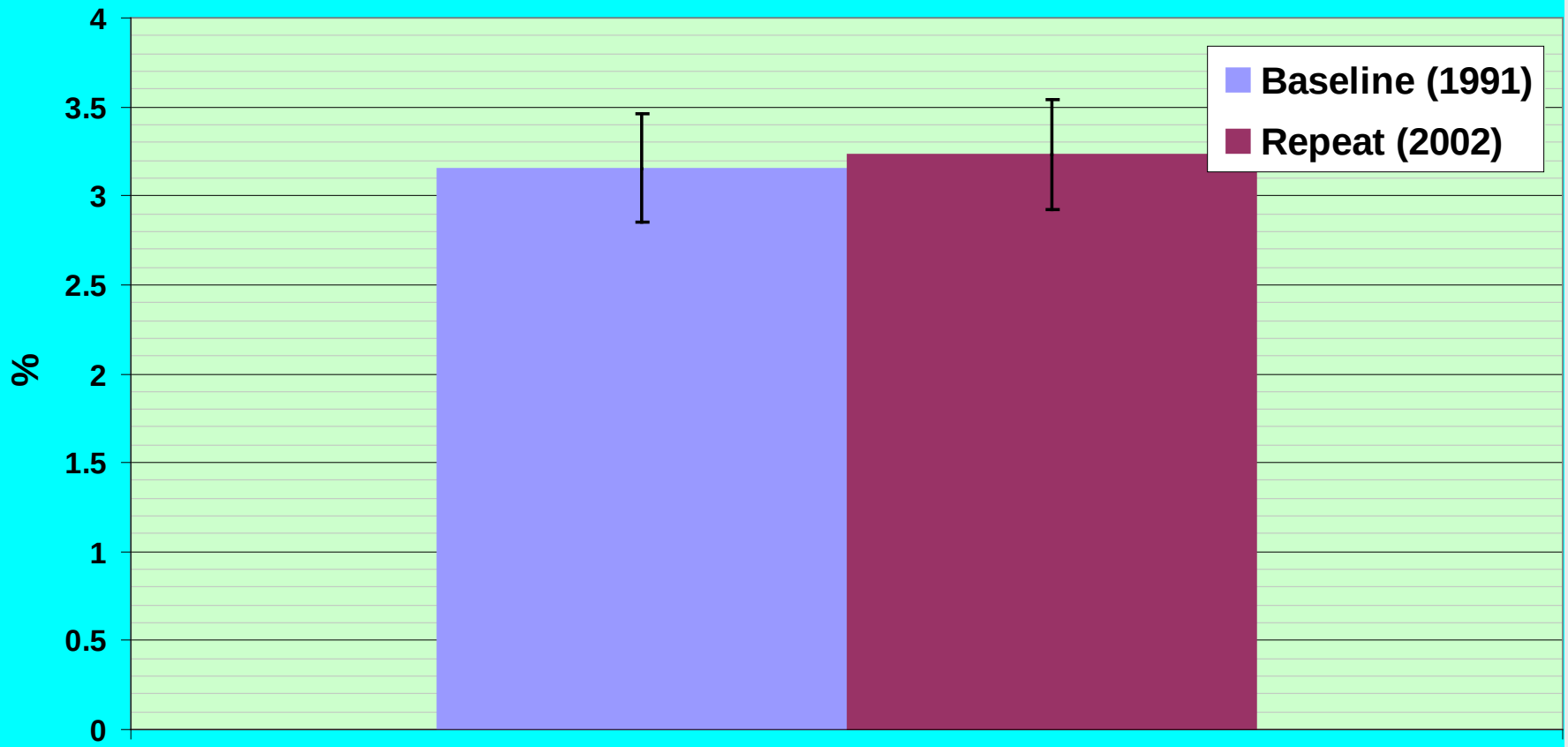
Significant difference by t-test: Paired Two Sample for Means (<0.05)

Falher Soil Quality Benchmark Site
pH



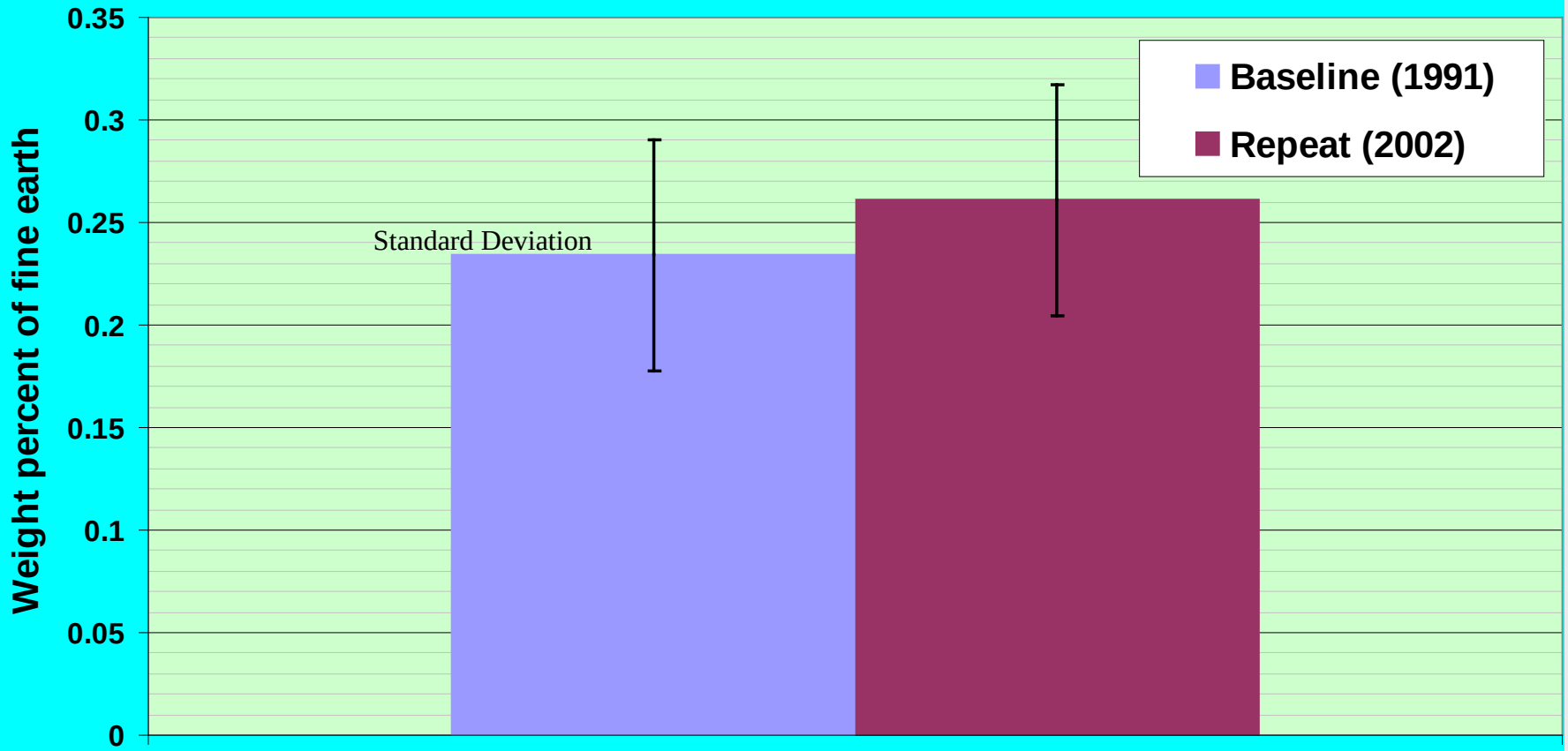
No Significant difference by t-test: Paired Two Sample for Means (<0.05)

Falher Soil Quality Benchmark Site
Organic Carbon



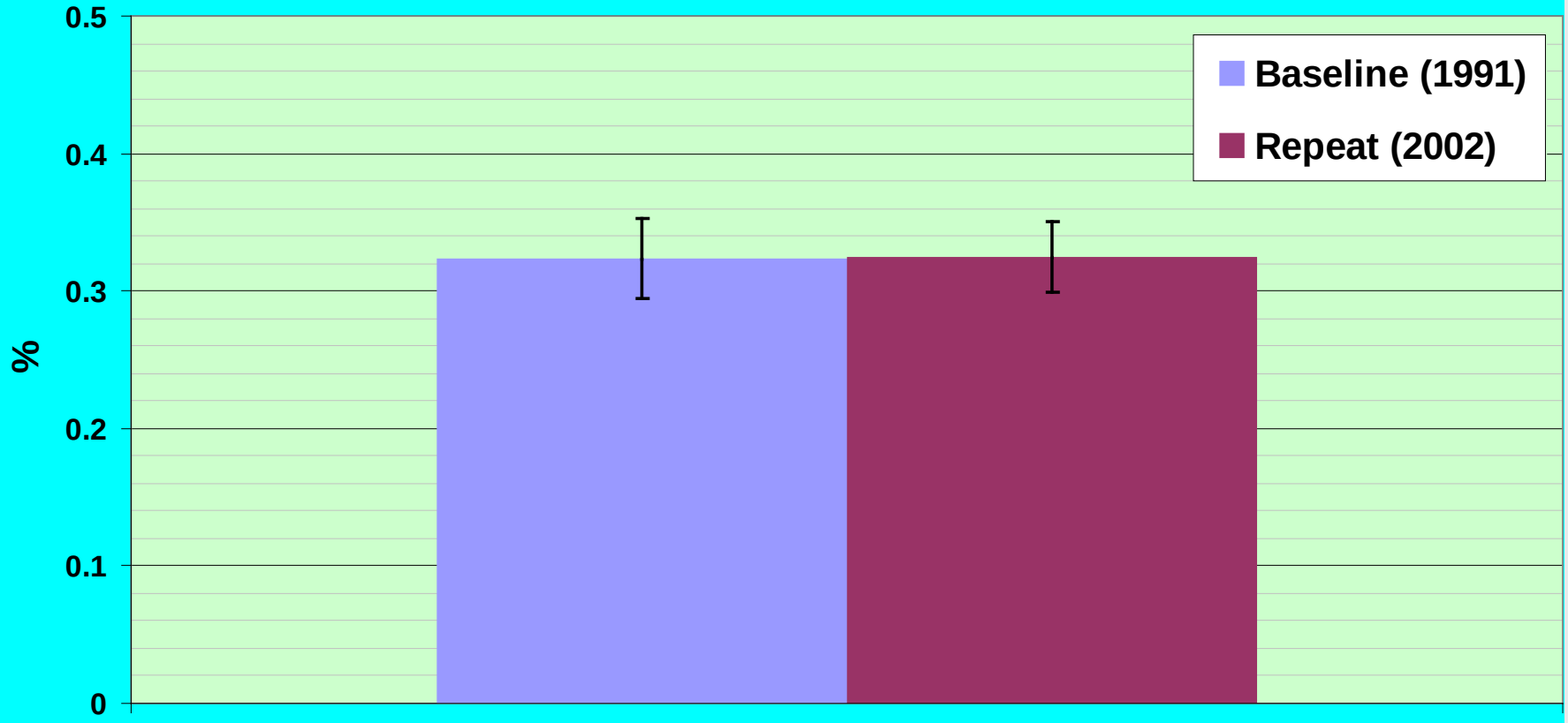
Significant difference by t-test: Paired Two Sample for Means (<0.05)

Falher Soil Quality Benchmark Site
Organic Carbon-Light Fraction



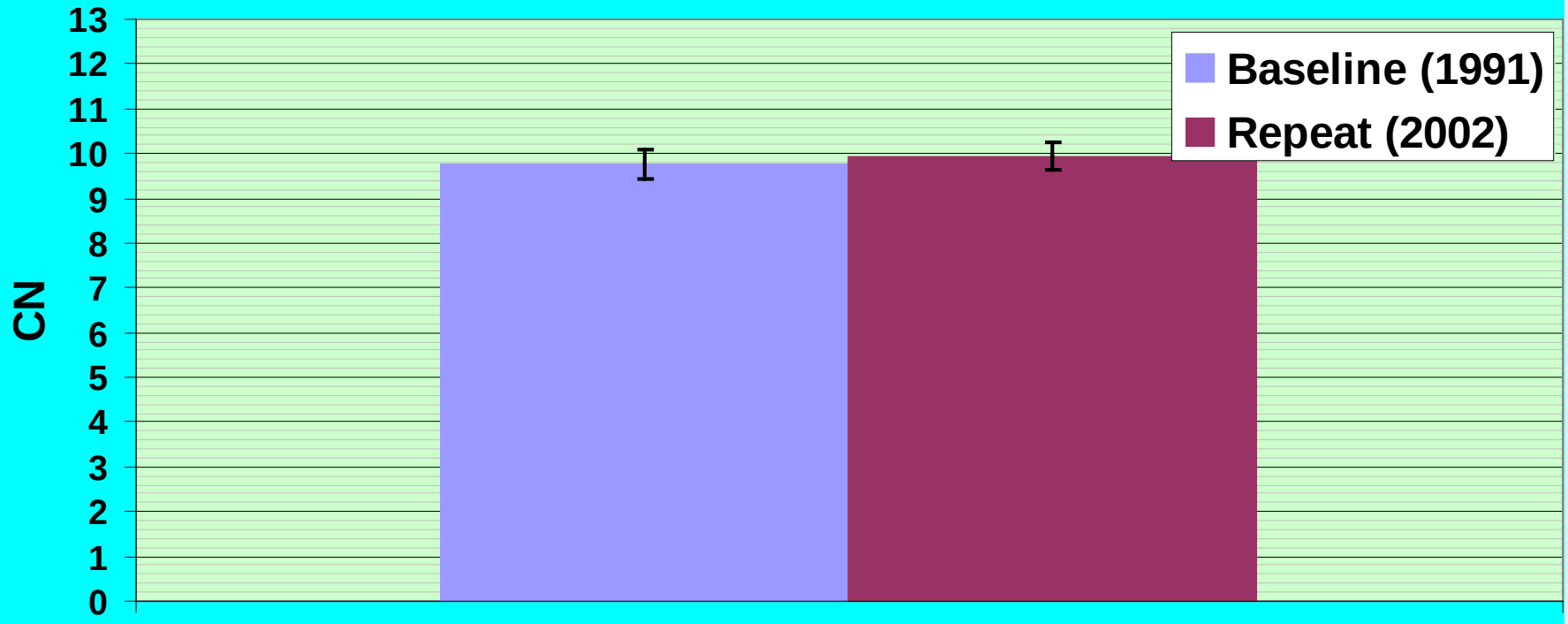
Significant difference by t-test: Paired Two Sample for Means (<0.05)

Falher Soil Quality Benchmark Site
Total Nitrogen



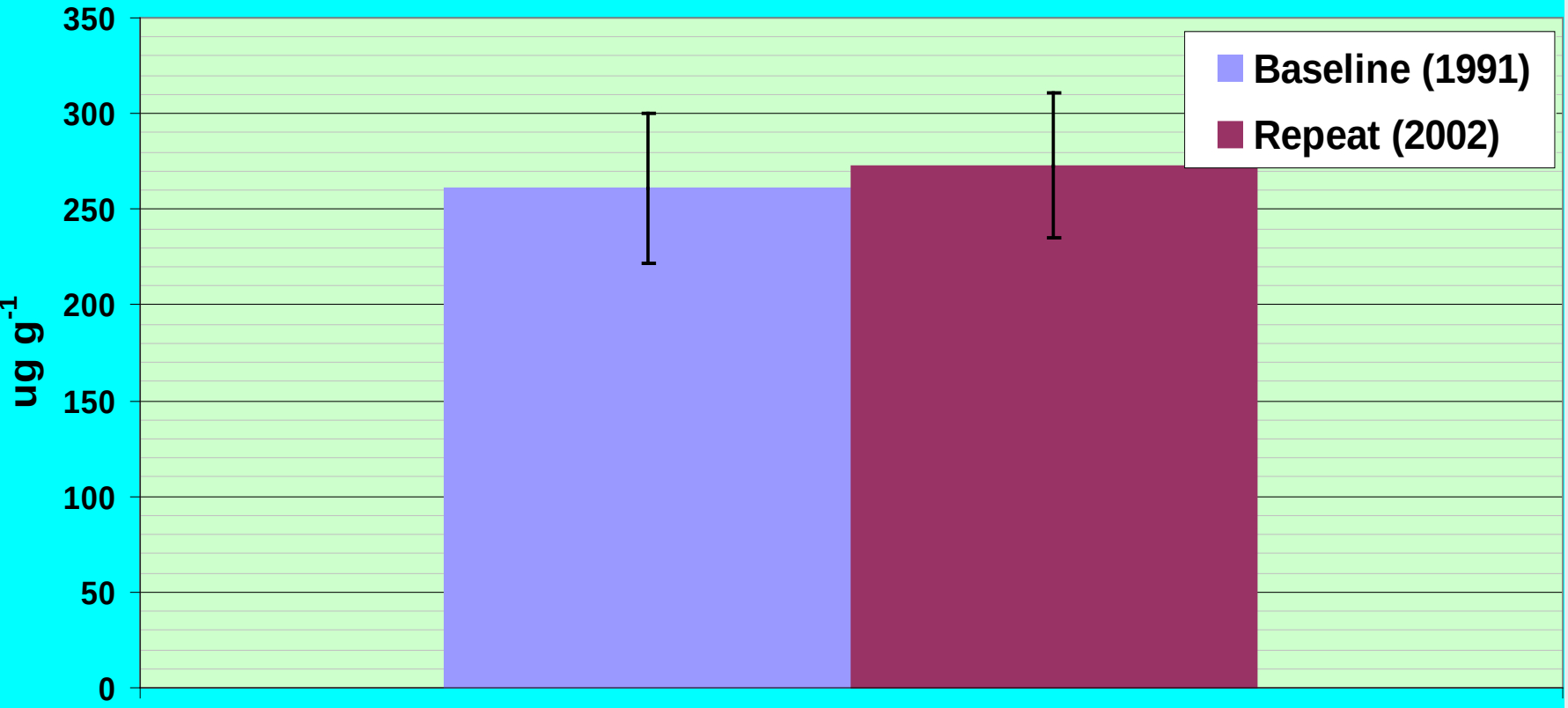
No Significant difference by t-test: Paired Two Sample for Means (<0.05)

Falher Soil Quality Benchmark Site
CN Ratio



Significant difference by t-test: Paired Two Sample for Means (<0.05)

Falher Soil Quality Benchmark Site
Available K



No Significant difference by t-test: Paired Two Sample for Means (<0.05)

Provost Soil Attributes: Upper Slope & Crest

	Baseline (1991)		Repeat (2001)		Change
	Mean	SdDev[+]	Mean	SdDev[+]	over 10 yrs
pH_{CaCl_2}	7.5	0.29	7.6	0.29	0.1*
Organic Carbon (%)[++]	1.85	0.26	1.67	0.30	- 0.18*
Carbon Light Fraction[++]	0.100	0.020	0.094	0.040	- 0.006
Total Nitrogen (%)[++]	0.195	0.024	0.175	0.031	- 0.020**
C:N Ratio	9.5	0.5	9.5	0.6	0.0
Available K (ug g^{-1})	306	71	285	54	21

[+] Number of paired observations = 15

[++] Weight percent of fine earth fraction

* Significant difference by t-test: Paired Two Sample for Means (<0.05)

** Significant difference by non parametric sign-test (m < 0.05)

Provost Soil Attributes: Mid Slope

	Baseline (1991)		Repeat (2001)		Change
	Mean	SdDev[+]	Mean	SdDev[+]	over 10 yrs
pH_{CaCl_2}	6.3	1.0	6.4	1.1	0.1*
Organic Carbon (%)[++]	2.64	0.60	2.34	0.63	- 0.30*
Carbon Light Fraction[++]	0.170	0.078	0.125	0.058	- 0.045*
Total Nitrogen (%)[++]	0.254	0.048	0.225	0.052	- 0.029*
C:N Ratio	10.3	0.63	10.3	0.59	0.0
Available K (ug g^{-1})	421	152	367	156	- 54*

[+] Number of paired observations = 24

[++] Weight percent of fine earth fraction

* Significant difference by t-test: Paired Two Sample for Means (<0.05)

** Significant difference by non parametric sign-test (m < 0.05)

Provost Soil Attributes: Lower Slope & Depression

	Baseline (1991)		Repeat (2001)		Change
	Mean	SdDev[+]	Mean	SdDev[+]	over 10 yrs
$pHCaCl_2$	5.3	0.4	5.7	0.8	0.4**
Organic Carbon (%)[++]	3.48	0.32	3.13	0.38	- 0.35*
Carbon Light Fraction[++]	0.247	0.075	0.159	0.053	- 0.088**
Total Nitrogen (%)[++]	0.327	0.034	0.294	0.324	- 0.033*
C:N Ratio	10.7	0.52	10.6	0.32	- 0.1
Available K (ug g^{-1})	625	164 (28)	511	192 (28)	- 114*

[+] Number of paired observations, $pHCaCl_2$ & Available K = 28; Organic Carbon, Carbon Light Fraction, Total Nitrogen & C:N Ratio = 25

[++] Weight percent of fine earth fraction

* Significant difference by t-test: Paired Two Sample for Means (<0.05)

** Significant difference by non parametric sign-test (m < 0.05)