Choosing soil health measurements for large-scale adoption

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BC ACARN Data Protocols Workshop

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Goal

Decision

Goal

Practices

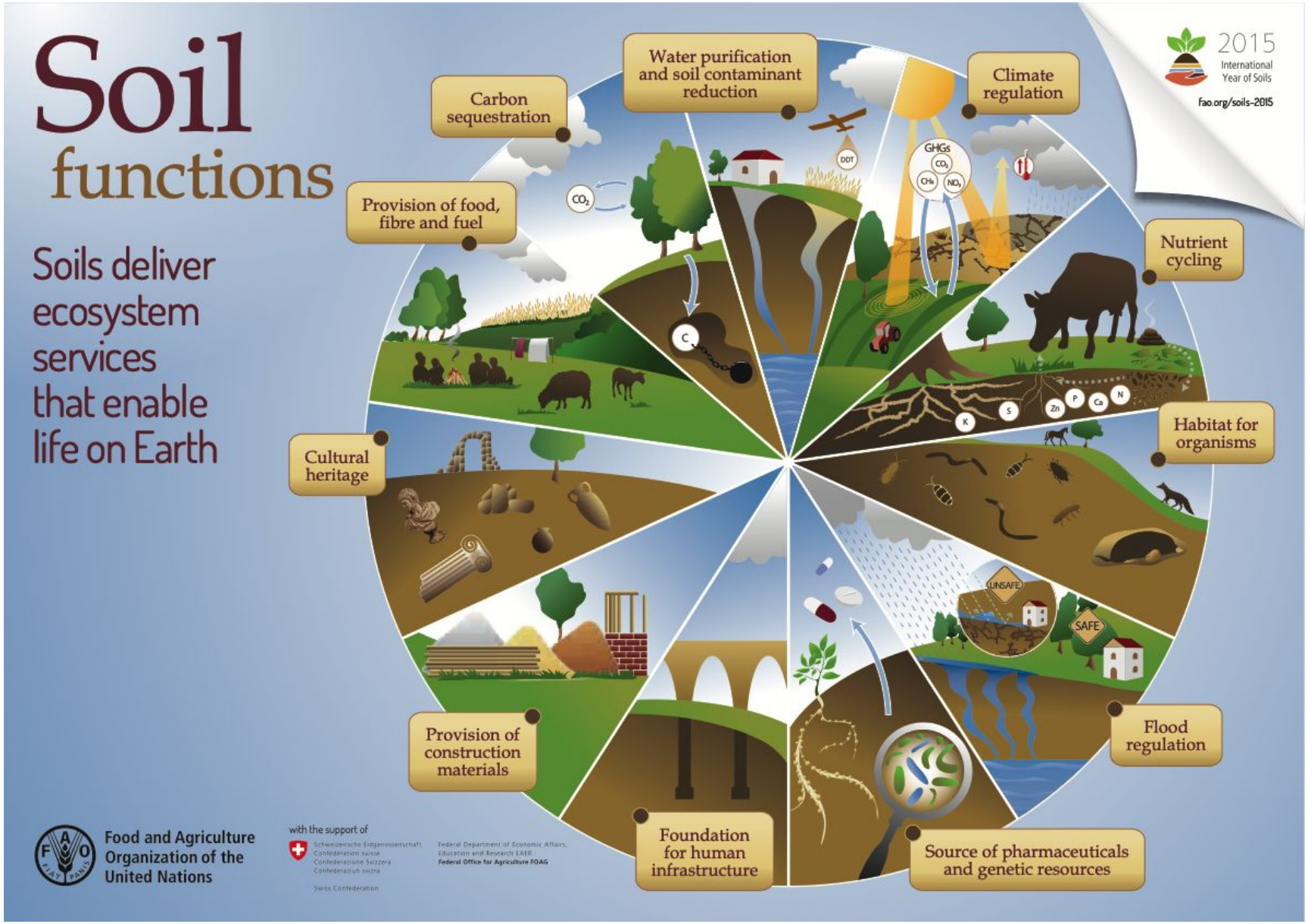
Tools

Practices


FOR BIGGER and BETTER CROPS
SAVE MONEY ON FERTILIZER
GET BIGGER CROPS
EASY TO USE—JUST COMPARE COLORS
NO KNOWLEDGE OF CHEMISTRY NEEDED
POTASH
NITROGEN
PHOSPHORUS
LIME OR ACIDITY (ph)
FIND OUT WHAT'S WRONG WITH YOUR SOIL!
TEST YOUR SOIL THE NEW SIMPLIFIED SUDBURY WAY
TELLS THE TRUE CONDITION OF SOIL AND HOW TO CORRECT IT
This Sudbury Soil Test Kit will assist you in determining the kind and amount of fertilizer your soil needs for maximum crop production—whether the crop is wheat, corn, oats, fruit trees, lawn grass, flowers, or just a backyard garden. In any case, your soil must contain Nitrogen, Phosphorus, and Potash in about the right proportions—and, it should not be too sweet or too sour (Acid or Alkaline) for the particular crop you want to grow.
Low cost refills make this Kit a permanent piece of equipment.
COMPLETE INSTRUCTIONS INCLUDED
SUDBURY SOIL TEST KIT
SUDBURY LABORATORY, INC.
SUDBURY, MASS., U.S.A.
LARGEST MANUFACTURERS OF SOIL TESTING EQUIPMENT IN THE WORLD

soil health

The capacity of a soil to function as a vital living ecosystem that sustains plants, animals, and humans.


Soil functions
Soils deliver ecosystem services that enable life on Earth
2015 International Year of Soils
fao.org/soils-2015
Water purification and soil contaminant reduction
Climate regulation
Carbon sequestration
Provision of food, fibre and fuel
Nutrient cycling
Cultural heritage
Habitat for organisms
Provision of construction materials
Flood regulation
Foundation for human infrastructure
Source of pharmaceuticals and genetic resources
Food and Agriculture Organization of the United Nations
with the support of

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Agronomy Journal

FORUM

Introducing the North American project to evaluate soil health measurements

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Abstract

The North American Project to Evaluate Soil Health Measurements was initiated with the objective to identify widely applicable soil health measurements for evaluation

North American Project to Evaluate Soil Health Measurements

Objective – a large-scale broad assessment of soil health indicators, both old and new, across a wide range of soils, climates, and management systems

- to identify the sensitivity of widely applicable soil measures to changes in soil condition from soil health management practices

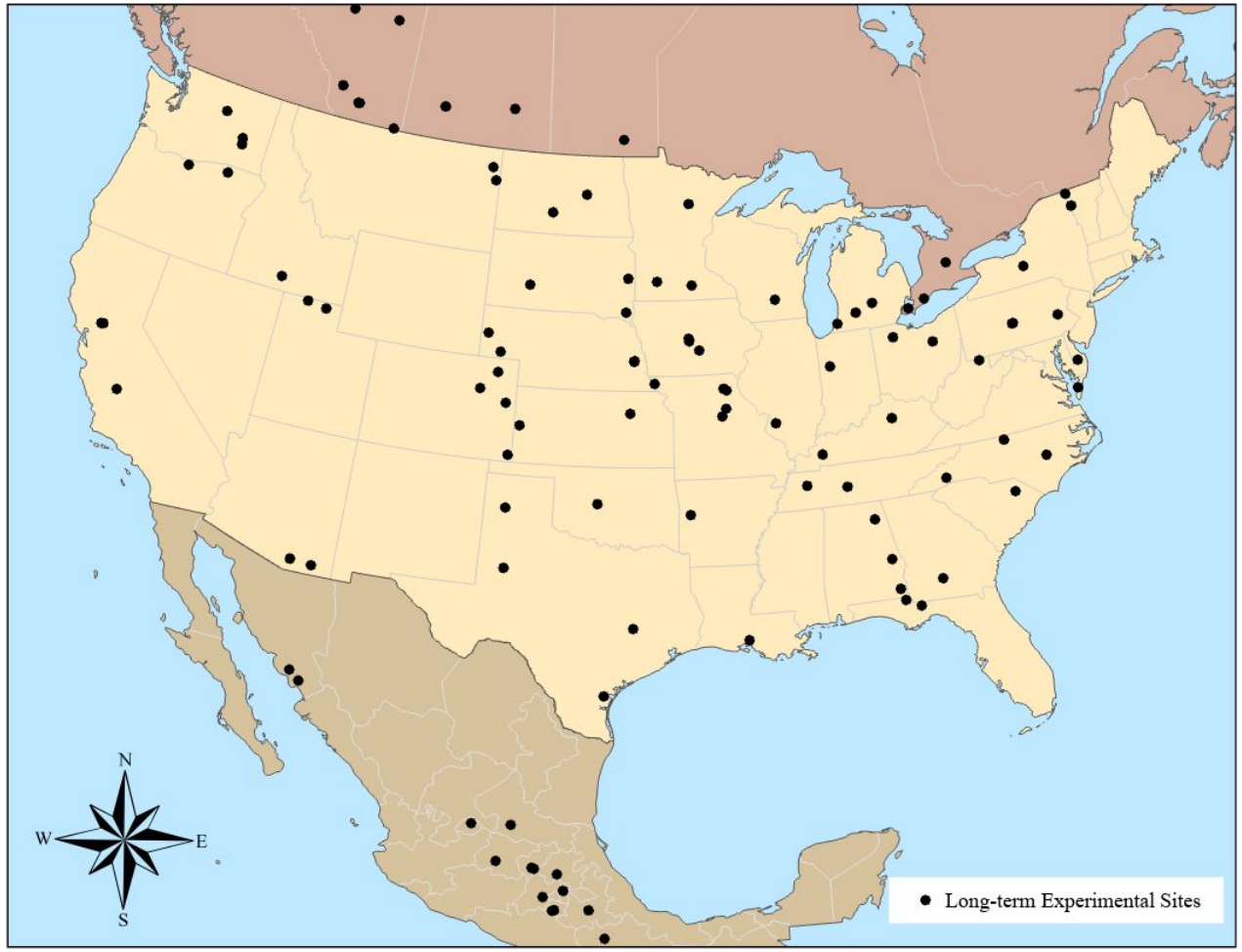
NAPESHM - Measurements

Properties	Indicators	Method	Reference
Soil physical	Soil texture	Pipette method with three size classes (2000-50, 50-2, and <2 µm)	Gee and Bauder, 1986
	Bulk density	Core method of 7.6 cm diameter and 7.6 cm depth	Blake and Hartge, 1986
	Aggregate stability	Wet sieve procedure with weight measurement	Kemper and Roseneau, 1986
	Water content	Ceramic plate method measured at -33 kPa on intact cores and -1500 kPa on repacked soils	Klute, 1986
	Soil stability index	Combination of wet and dry sieving at multiple sieve sizes	Franzluebbers et al., 2000
	Water infiltration rate K_{fs}	Two-ponding head method	Reynolds and Elrick, 1990
Soil chemical	Soil pH	1:2 soil:water	Thomas, 1996
	Soil electrical conductivity	1:2 soil:water	Rhoades, 1996
	Extractable phosphorus	Mehlich-3 extractant for all and Olsen extractant when soil pH≥7.2	Olsen and Sommers, 1982 or Sikora and Moore, 2014
	Extractable K, Ca, Mg, Na	Mehlich-3 extractant for all and ammonium acetate extraction when soil pH≥7.2	Knudsen et al., 1982 or Sikora and Moore, 2014
	Extractable Fe, Zn, Cu, Mn	Mehlich-3 extractant for all and DTPA when soil pH≥7.2	Lindsay and Norvell, 1978 or Sikora and Moore, 2014
	Cation exchange capacity	Sum of cations from Mehlich-3 extrant for all and ammonium acetate when soil pH≥7.2	Olsen and Sommers, 1982 or Sikora and Moore, 2014
	Base saturation	Calculation of cations from Mehlich-3 extractant for all and ammonium acetate when soil pH≥7.2	Olsen and Sommers, 1982 or Sikora and Moore, 2014
	Sodium adsorption ratio	Saturated paste extract followed by inductively coupled plasma spectroscopy	Miller et al., 2013
Soil biological	Soil organic carbon	Dry combustion, corrected for inorganic carbon, if present, using pressure-calcimeter	Nelson and Sommers, 1996 or Sherrod et al., 2002
	Active carbon	Permanganate oxidizable carbon (POXC) digestion followed by colorimetric measurement	Weil et al., 2003
	Short-term carbon mineralization	4-day incubation followed by CO_2-C evolution and capture at 50 % water-filled pore space	Zibilske, 1994
	Total nitrogen	Dry combustion	Nelson and Sommers, 1996
	Nitrogen mineralization rate	Short-term anaerobic incubation with ammonium and nitrate measured colorimetrically	Bundy and Meisinger, 1984
	Soil protein index	Autoclaved citrate extractable	Schindelbeck, 2016
	β-glucosidase	Assay incubation followed by colorimetric measurement	Tabatabai et al., 1994
	β-glucosaminidase	Assay incubation followed by colorimetric measurement	Deng and Popova, 2011
	Phosphatase	For soil pH≥7.2, alkaline phosphatase, otherwise acid phosphatase. Assay incubation followed by colorimetric measurement	Acosta-Martinez and Tabatabai, 2011
	Arylsulfatase	Assay incubation followed by colorimetric measurement	Klose et al., 2011
	Phospholipid Fatty Acid	Bligh-Dyer extractant, solid phase extraction, transesterification, and gas chromatography	Buyer and Sasser, 2012
	Genomics	16S rRNA, ITS, and shotgun metagenomics	Thompson et al., 2017 and Quince et al., 2017
Other	Reflectance	vis/NIR diffuse reflectance spectroscopy	Veum et al., 2015
	Crop yield	Obtained from historical plot yield	

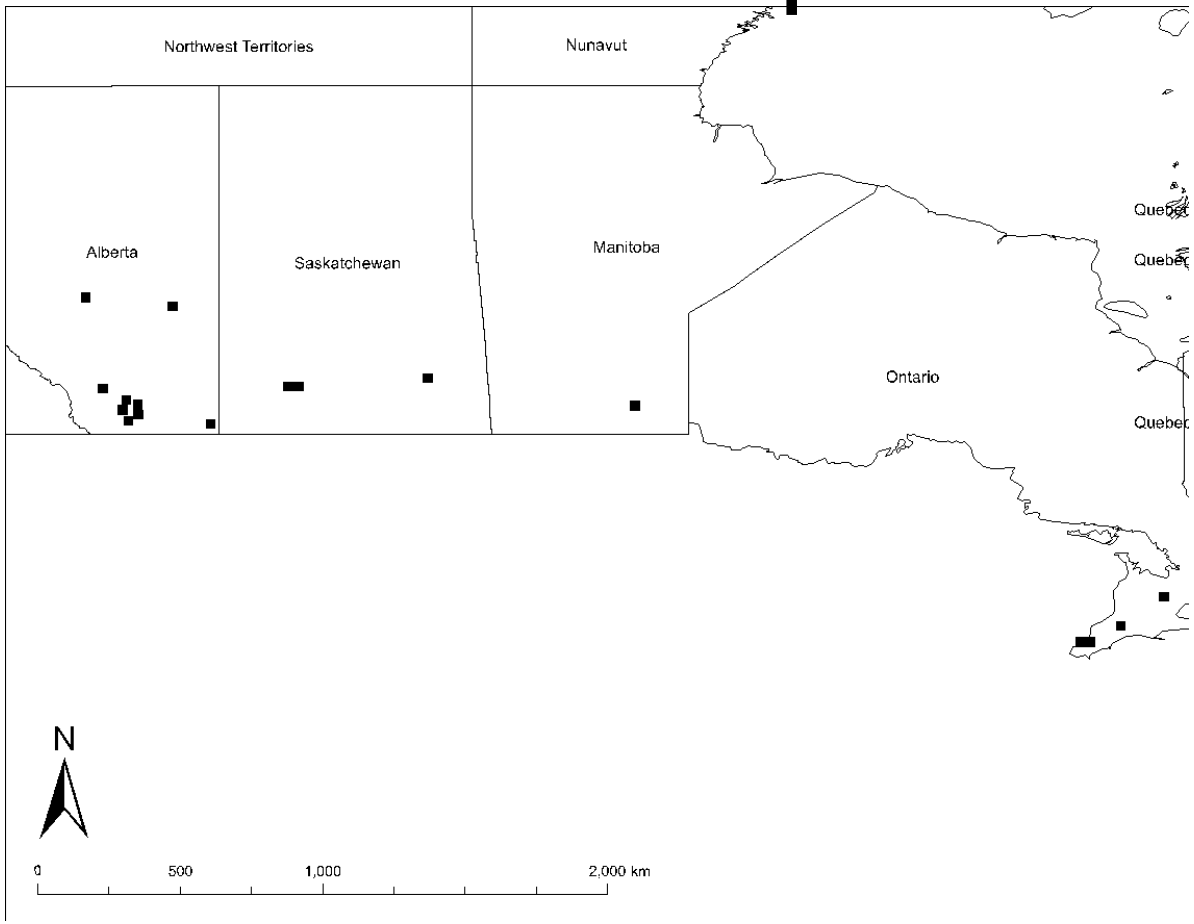
North American Project to Evaluate Soil Health Measurements (NAPESHM)

- 2029 samples
- 120 sites
- >10 yr old
- 1 of 5 criteria
  1. Physical disturbance
  2. Cover crops
  3. Crop diversity
  4. Nutrient management
  5. Water management

  and Location



Canadian component



- April – June 2019
- 10 sites across Canada
- 16 long-term experimental trials
- 103 treatments
- 333 plots (EUs)
    - 5 subsamples/plot

Norris et al. 2023. The story of long-term research sites and soil health in Canadian agriculture. Can. J. Soil Sci.

Physical measurements

- Particle size analysis -

  pipette method

- Water at field capacity -

  intact cores (-33 KPa with tension table)

- Aggregates -

  Cornell wet aggregate stability test

  wet aggregate stability test

  water stable aggregate mean weight diameter

  image recognition using smartphone SLAKES app

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SOIL PHYSICS & HYDROLOGY
Soil Science Society of America Journal

Carbon-sensitive pedotransfer functions for plant available water

Dianna K. Bagnall[1] | Cristine L. S. Morgan[1] | Michael Cope[1] | Gregory M. Bean[1] | Shannon Cappellazzi[1] | Kelsey Greub[1] | Daniel Liptzin[1] | Charlotte L. Norris[1]

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SOIL PHYSICS & HYDROLOGY
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Selecting soil hydraulic properties as indicators of soil health: Measurement response to management and site characteristics

Dianna K. Bagnall[1] | Cristine L. S. Morgan[1] | G. Mac Bean[1] | Daniel Liptzin[1] | Shannon B. Cappellazzi[1] | Michael Cope[1] | Kelsey L. H. Greub[1]

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Evaluation of aggregate stability methods for soil health

Elizabeth L. Rieke[a,*], Dianna K. Bagnall[a], Cristine L.S. Morgan[a], Kade D. Flynn[b], Julie A. Howe[c], Kelsey L.H. Greub[a], G. Mac Bean[a], Shannon B. Cappellazzi[a], Michael Cope[a], Daniel Liptzin[a], Charlotte E. Norris[a], Paul W. Tracy[a], Ezra Aberle[d], Amanda Ashworth[e],

Chemical measurements

Carbon -

- soil organic carbon
- permanganate oxidizable carbon
- potential carbon mineralization
- B-glucosidase enzyme activity
- water extractable organic carbon

Nitrogen -

- soil nitrogen
- nitrogen mineralization rate
- B-glucosaminidase
- water extractable nitrogen
- water extractable ammonium and nitrate

Soil Biology and Biochemistry 172 (2022) 108708

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Soil Biology and Biochemistry

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An evaluation of carbon indicators of soil health in long-term agricultural experiments

Daniel Liptzin [a,*], Charlotte E. Norris [a], Shannon B. Cappellazzi [a], G. Mac Bean [a], Michael Cope [a], Kelsey L.H. Greub [a], Elizabeth L. Rieke [a], Paul W. Tracy [a], Ezra Aberle [b], Amanda Ashworth [c], Oscar Bañuelos Tavarez [d], Andy I. Bary [e], R.L. Baumhardt [f], Alberto Borbón Gracia [g], Daniel C. Brainard [h], Jameson R. Brennan [i], Dolores Briones Reyes [g], Darren Bruhjell [j], Cameron N. Carlyle [k], James J.W. Crawford [l], Cody F. Creech [m], Steve W. Culman [n], Bill Deen [o], Curtis J. Dell [p], Justin D. Derner [q], Thomas F. Ducey [r], Sjoerd W. Duiker [s], Miles F. Dyck [t],

Biological measurements

PLFA – identified differences with management practices

Genomics – 16S rRNA identified differences with reduced tillage

Applied Soil Ecology 185 (2023) 104793

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Applied Soil Ecology

journal homepage: www.elsevier.com/locate/apsoil

Use of phospholipid fatty acid analysis as phenotypic biomarkers for soil health and the influence of management practices

Charlotte E. Norris [a,b,*], Mathew J.B. Swallow [c], Daniel Liptzin [a], Michael Cope [a], G. Mac Bean [a], Shannon B. Cappellazzi [a], Kelsey L.H. Greub [a], Elizabeth L. Rieke [a], Paul W. Tracy [a], Cristine L.S. Morgan [a], C. Wayne Honeycutt [a]

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Soil Biology and Biochemistry

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Linking soil microbial community structure to potential carbon mineralization: A continental scale assessment of reduced tillage

Elizabeth L. Rieke [a,*], Shannon B. Cappellazzi [a], Michael Cope [a], Daniel Liptzin [a], G. Mac Bean [a], Kelsey L.H. Greub [a], Charlotte E. Norris [a], Paul W. Tracy [a], Ezra Aberle [b], Amanda Ashworth [c], Oscar Bañuelos Tavarez [d], Andy I. Bary [e], R.L. Baumhardt [f], Alberto Borbón Gracia [g], Daniel C. Brainard [h], Jameson R. Brennan [i], Dolores Briones Reyes [g], Darren Bruhjell [j], Cameron N. Carlyle [k], James J.W. Crawford [l], Cody F. Creech [m], Steve W. Culman [n], Bill Deen [o],

3 minimum measurements

- Total organic carbon
- Aggregate stability
- 24-hour carbon mineralization

Soil Security 10 (2023) 100084

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Soil Security

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A minimum suite of soil health indicators for North American agriculture

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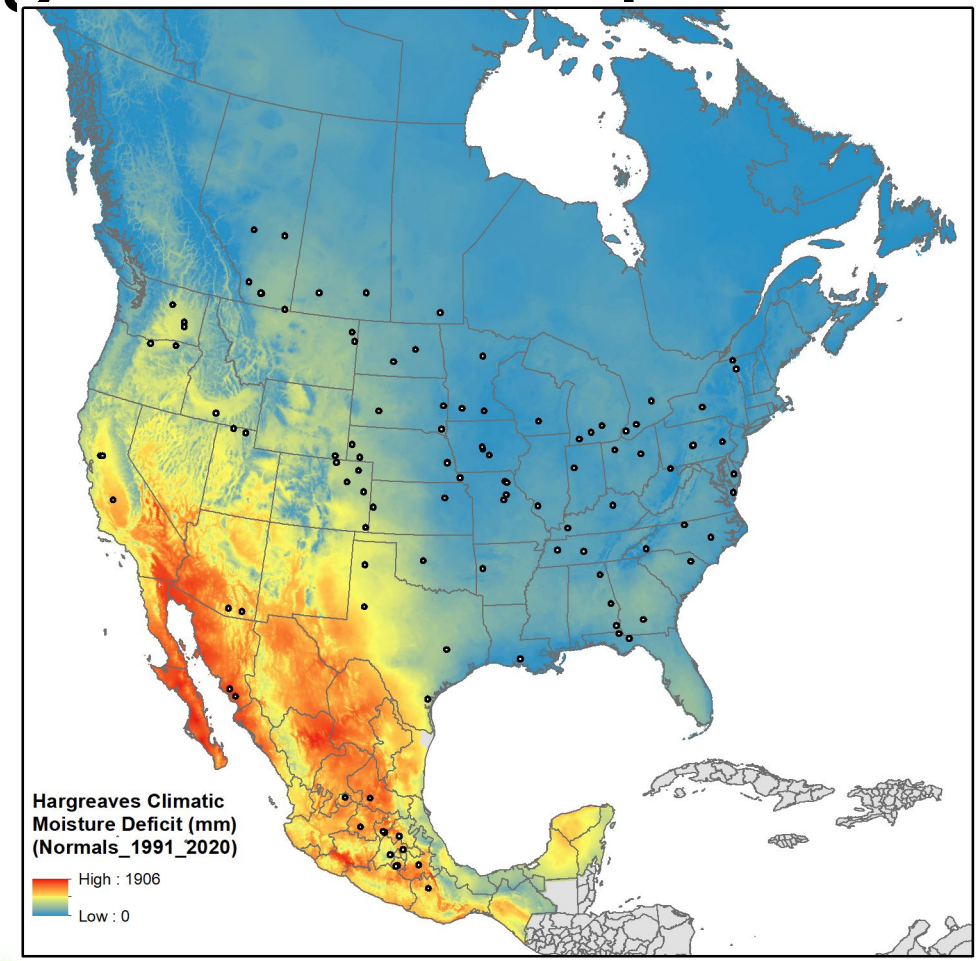
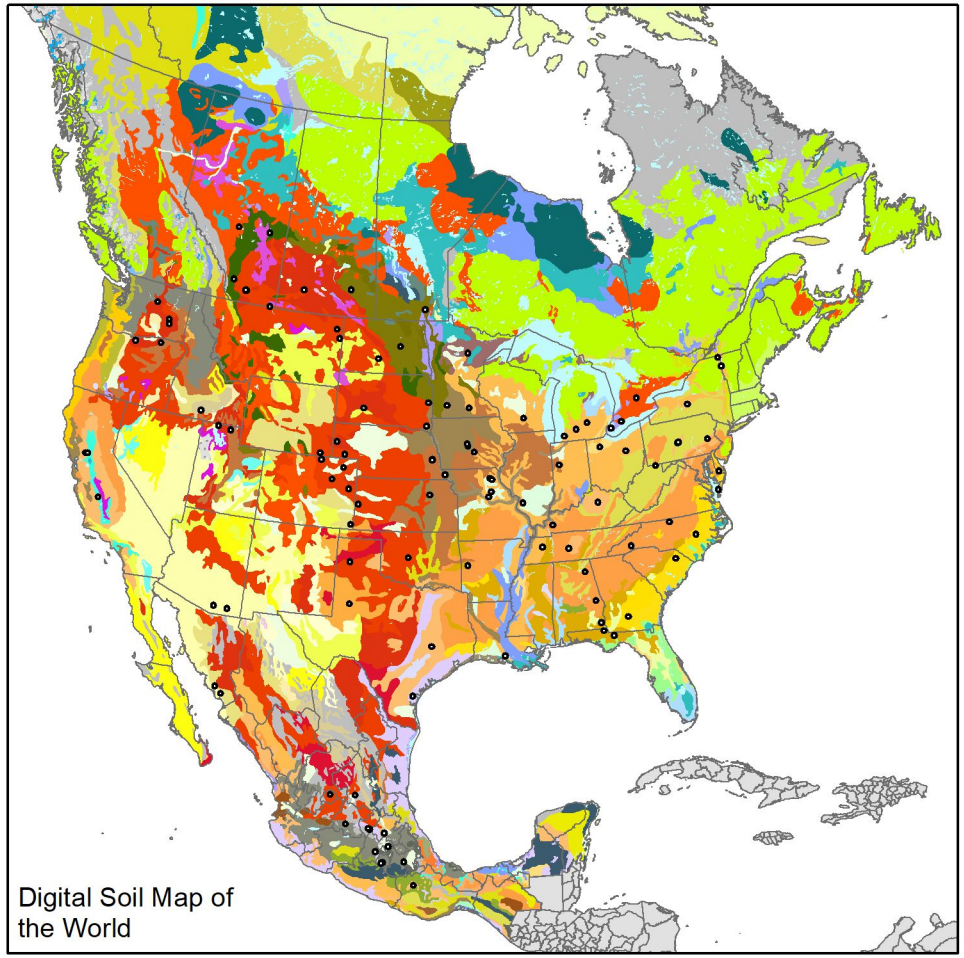
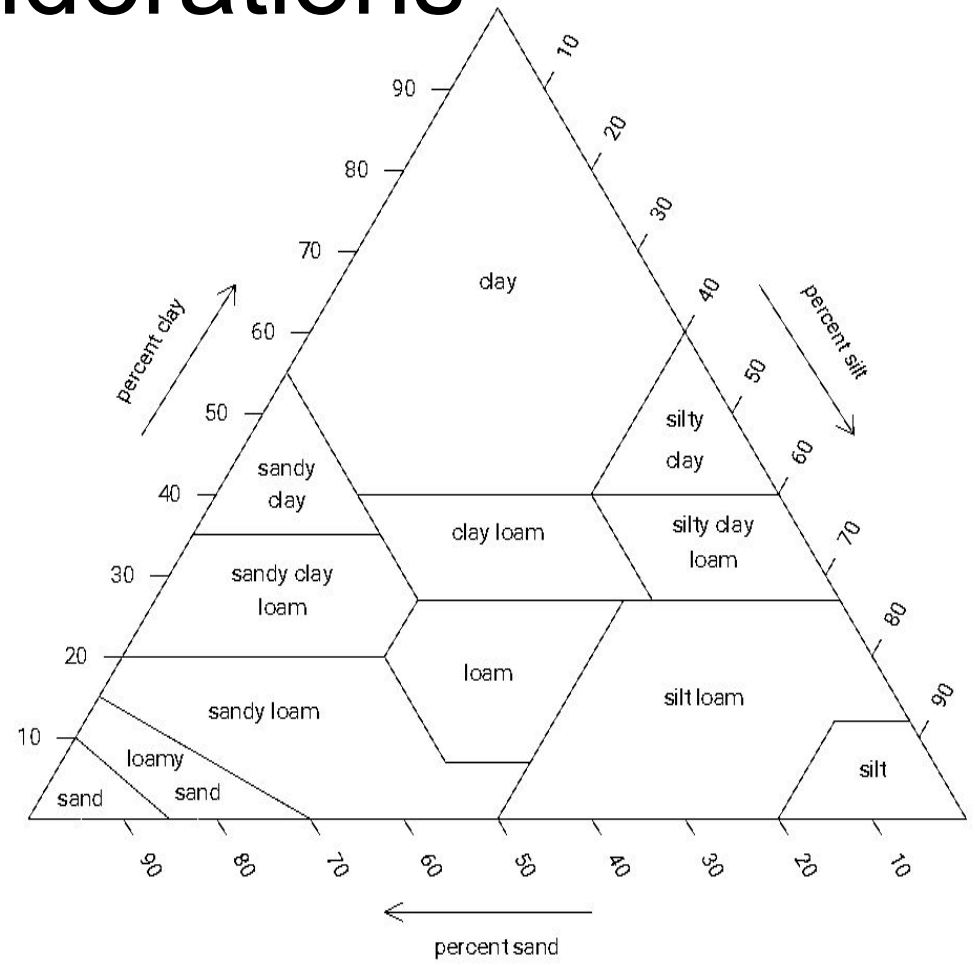
Choosing soil health measurements for large-scale adoption - considerations





Choosing soil health measurements for large-scale adoption - considerations

- Methodology -
  - the same method & lab
    - e.g., pH in water vs $CaCl_2$
- Data availability -
  - breadth and depth
  - consistent format and available
    - e.g., FAIR
- Laboratory capacity -
  - beyond research but also for managers, practitioners, and the public



Thank you!

Questions?

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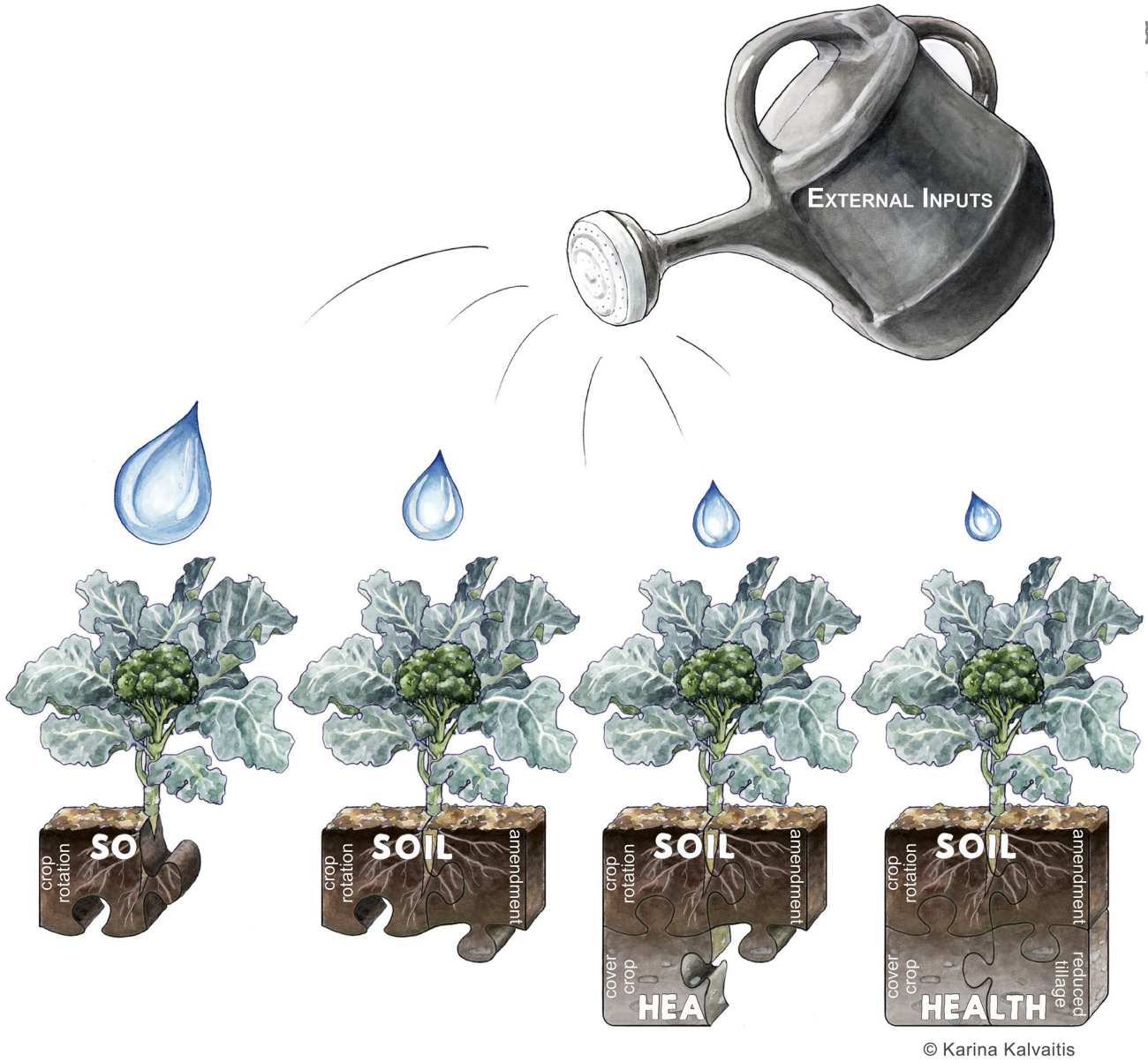
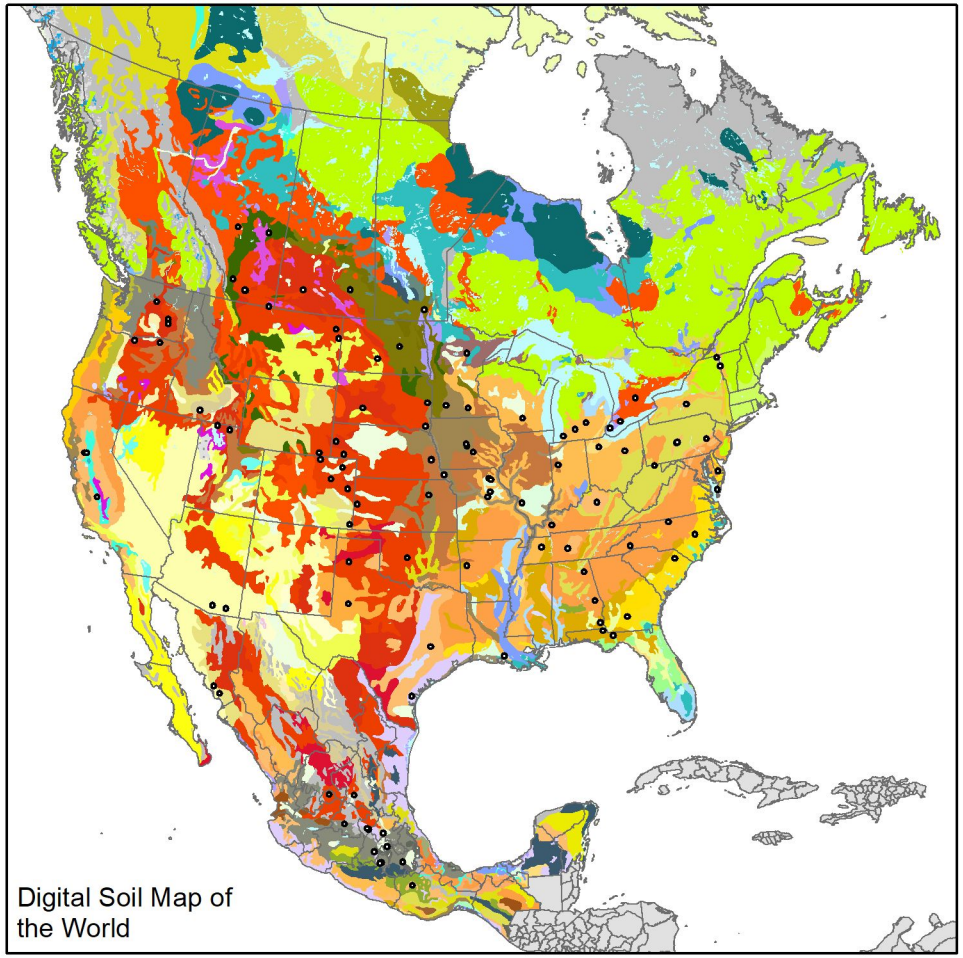


Digital Soil Map of the World

- Af-Ferric Acrisols
- Ag-Gleyic Acrisols
- Ah-Humic Acrisols
- Ao- Orthic Acrisols
- Ap-Plinthis Acrisols
- Bc- Chromic Cambisols
- Bd- Dystric Cambisols
- Be- Eutric Cambisols
- Bh- Humic Cambisols
- Bk- Calcic Cambisols
- Bv- Vertic Cambisols
- Bx- Gelic Cambisols
- E- RENDZINAS
- Ch- Haplic Chernozems
- Ck- Calcic Chernozems
- Cl- Luvic Chernozems
- De- Eutric Podzoluvisols
- Gc- Calcaric Gleysols
- Gd- Dystric Gleysols
- Ge- Eutric Gleysols
- Gh- Humic Gleysols
- Gm- Mollic Gleysols
- Hg- Gleyic Phaeozems
- Hh- Haplic Phaeozems
- Hl- Luvic Phaeozems
- I- Lithosols
- Jc- Calcaric Fluvisols
- Jd- Dystric Fluvisols
- Je - Eutric Fluvisols
- Kh- Haplic Kastanozems
- Kk- Calcic Kastanozems
- Kl- Luvic Kastanozems
- La- Albic Luvisols
- Lc- Chromic Luvisols
- Lf- Ferric Luvisols
- Lg- Gleyic Luvisols
- Lk- Calcic Luvisols
- Lo- Orthic Luvisols
- Lv - Vertic Luvisols
- Mo- Orthic Greyzems
- Ne- Eutric Nitosols
- O- HISTOSOLS
- Od- Dystric Histosols
- Oe- Eutric Histosols
- Ox- Gelic Histosols
- Pg- Gleyic Podzols
- Pl- Leptic Podzols
- Po- Orthic Podzols
- Rc- Calcaric Regosols
- Rd- Dystric Regosols
- Re- Eutric Regosols
- Rx- Gelic Regosols
- Sm- Mollic Solonetz
- So- Orthic Solonetz
- Th- Humic Andosols
- Tm- Mollic Andosols
- To-Ochric Andosols
- Tv- Vitric Andosols
- Vc- Chromic Vertisols
- Vp- Pellic Vertisols
- We- Eutric Planosols
- Ws- Solodic Planosols
- Xh- Haplic Xerosols
- Xk- Calcic Xerosols
- Xl- Luvic Xerosols
- Y-YERMOSOLS
- Yh- Haplic Yermosols
- Yk- Calcic Yermosols
- Yl- Luvic Yermosols
- Zo- Orthic Solonchaks
- Water bodies (WA)
- Glaciers (GL)
- Salt flats (ST)



Digital Soil Map of the World