Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Canadian Soil Data

Glenn Lelyk
Agriculture and Agri-Food Canada

GlobalSoilMap and Soil Survey Uncertainty Workshop
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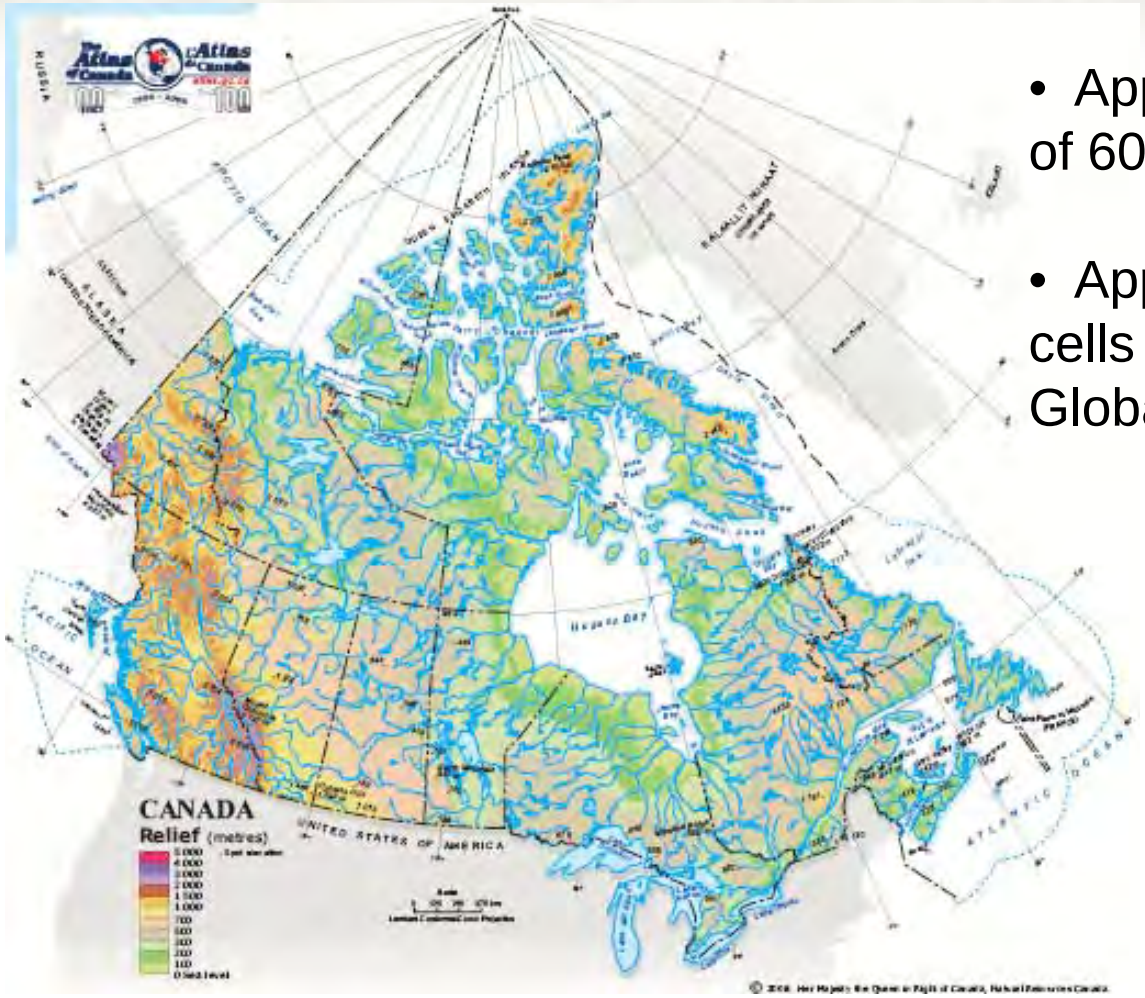
Canada

Canada's Land Area



- 9,093,507km^2 (6.1% of the world land area).
- Approx. 40% of Canada is north of 60^{0}N (the SRTM limit)
- Approx. 1 billion 90m by 90m grid cells in Canadian portion of the Global Soil Map

Soil Landscapes of Canada

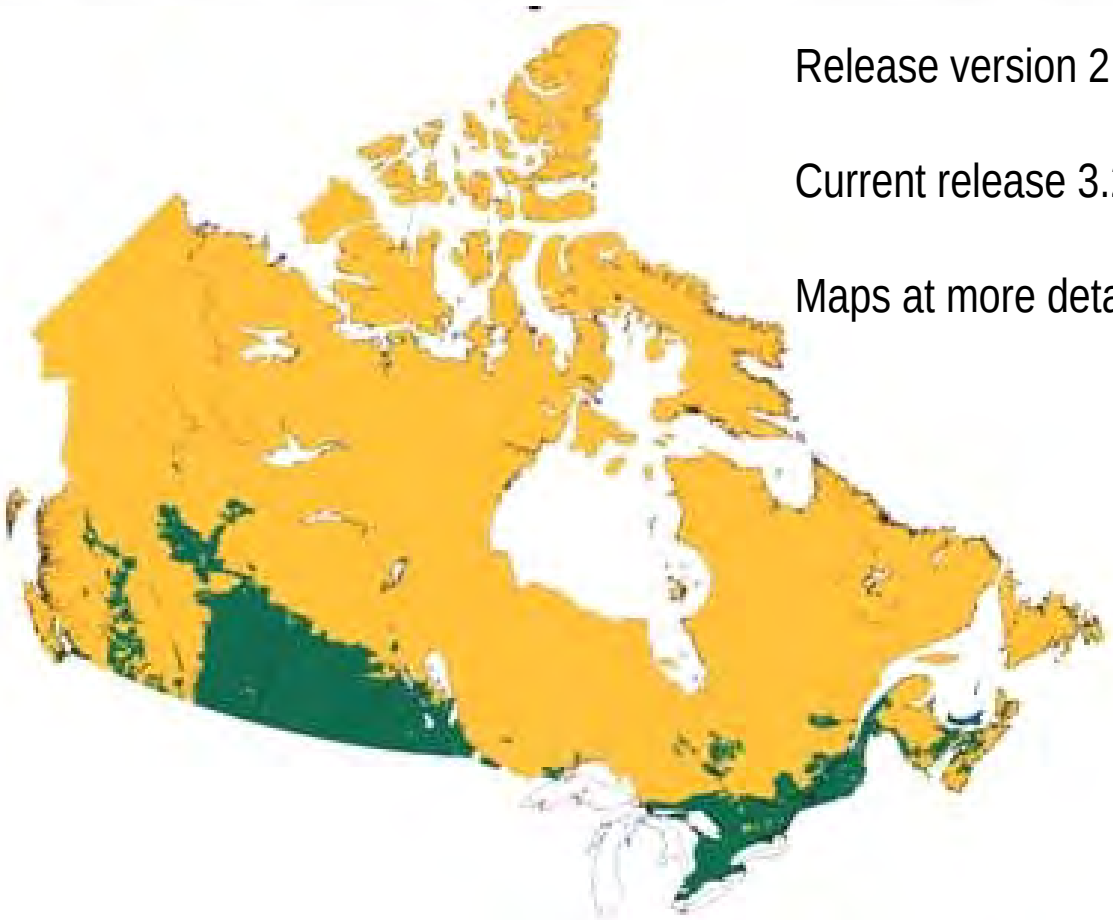
Uniform national soil map and database

Compiled at 1:1 M scale

Release version 2.2 covers whole nation

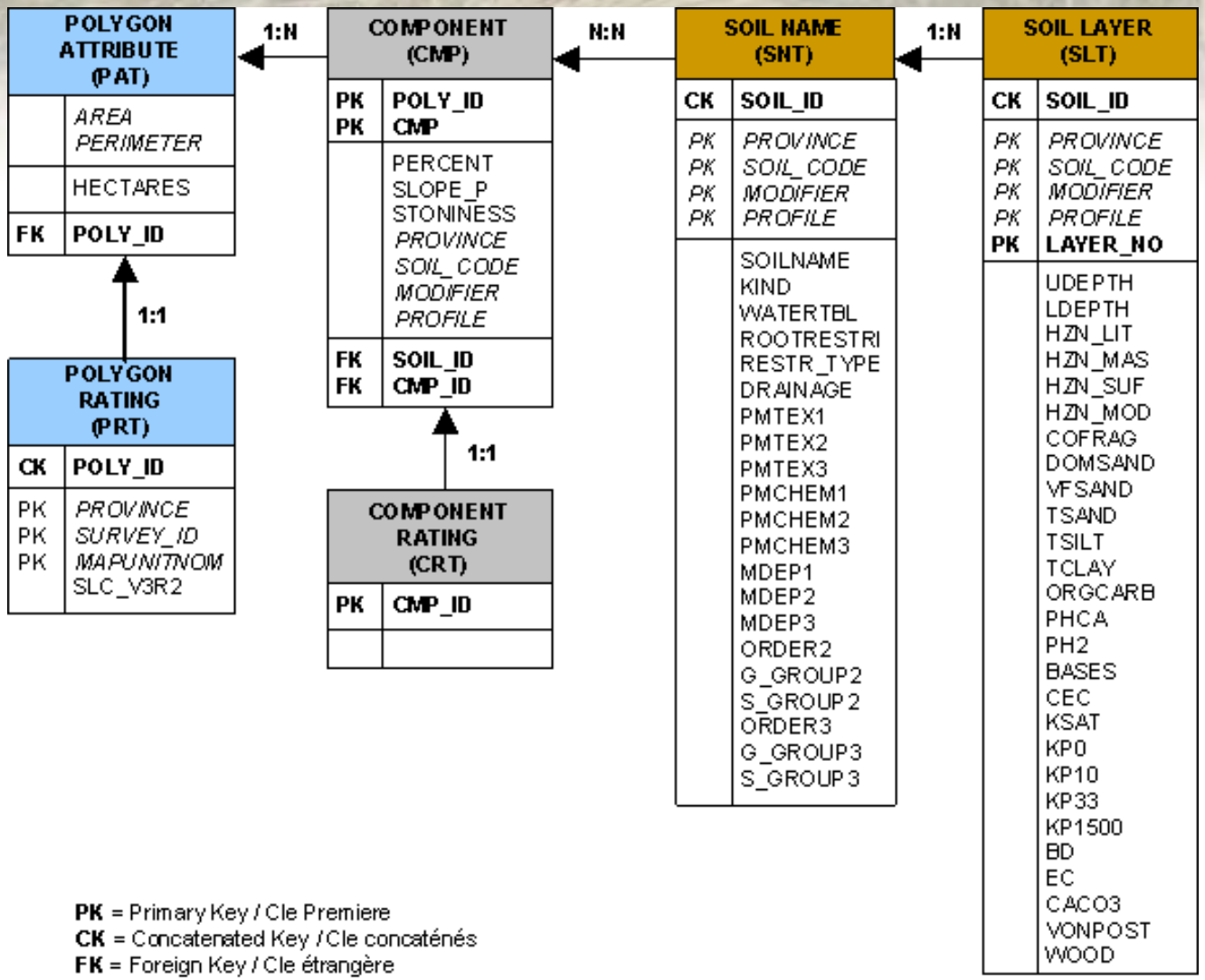
Current release 3.2 covers agriculture extent in Canada

Maps at more detailed scales are piecemeal and inconsistent.



45.5 million ha of improved cropland
80% in the Prairie provinces
45% in Saskatchewan alone

Soil Entity Relationship Diagram



PK = Primary Key / Cle Premiere
CK = Concatenated Key / Cle concaténés
FK = Foreign Key / Cle étrangère

Component Table (CMP)

Field	Name	Type	Width	Description
1	POLY_ID	integer	68	Polygon Identifier
2	CMP	integer	2	Component Number
3	PERCENT	integer	3	Percent of polygon occupied by the component
4	SLOPE_P	integer	3	Slope Steepness
5	STONINESS	string	1	Surface Stoniness Class
6	PROVINCE	string	2	Province Code
7	SOIL_CODE	string	3	Soil Code
8	MODIFIER	string	5	Soil Code Modifier
9	PROFILE	string	1	Type of soil profile
10	SOIL_ID	string	11	Soil Name Identifier
11	CMP_ID	string	70	Polygon Component Identifier

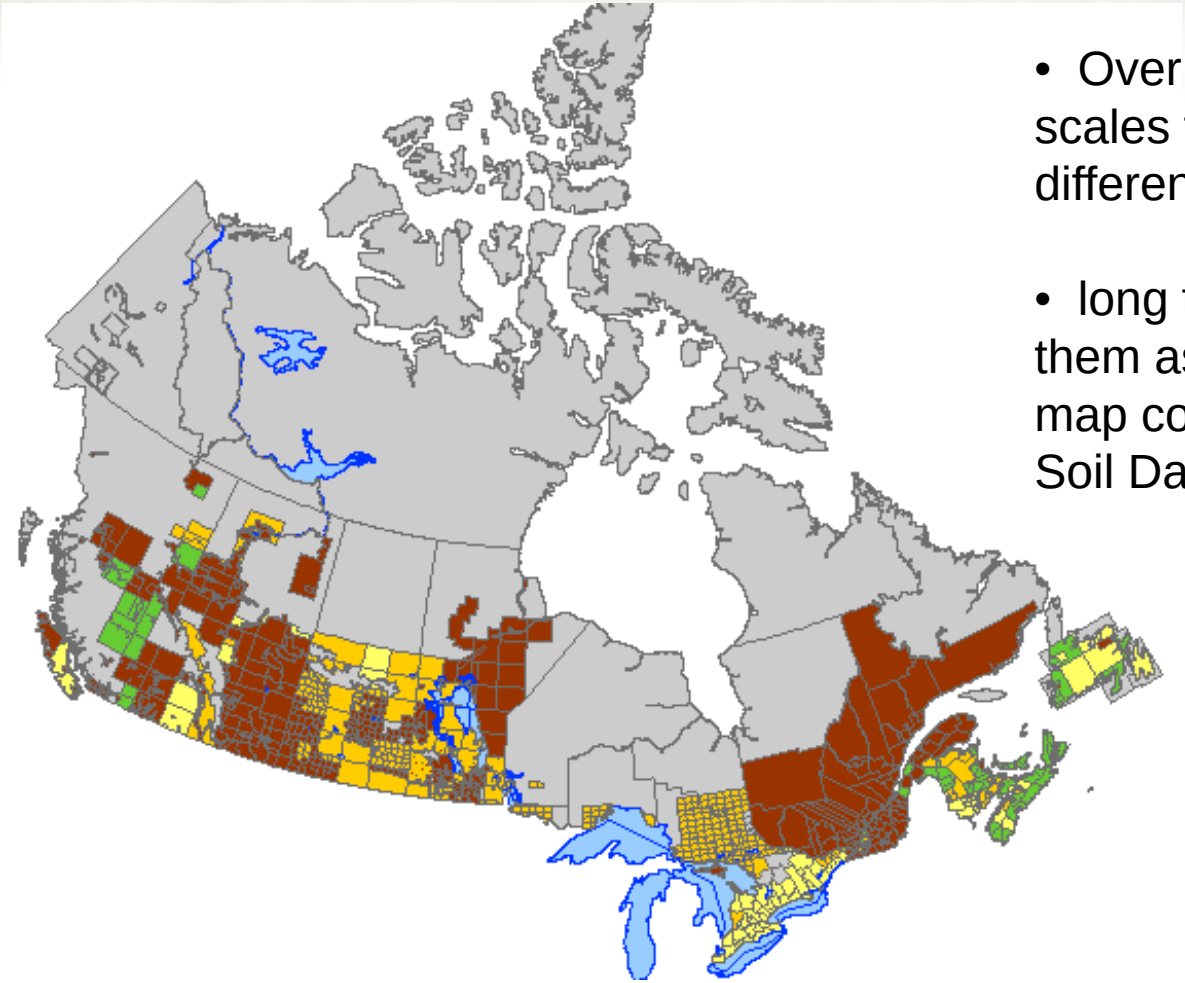
Soil Name Table (SNT)

Field	Name	Type	Width	Description
1	SOIL_ID	string	11	Soil Name Identifier
2	PROVINCE	string	2	Province Code
3	SOIL_CODE	string	3	Soil Code
4	MODIFIER	string	5	Soil Code Modifier
5	PROFILE	string	1	Type of soil profile
6	SOILNAME	string	24	Soil Name
7	KIND	string	1	Kind of Surface Material
8	WATERTBL	string	2	Watertable Characteristics
9	ROOTRESTRI	string	1	Soil layer that restricts root growth
10	RESTR_TYPE	string	2	type of root restricting layer
11	DRAINAGE	string	2	Soil Drainage Class
12	PMTEX1	string	2	Parent material texture - firstÂ (uppermost)
13	PMTEX2	string	2	Parent material texture - second
14	PMTEX3	string	2	Parent material texture - third
15	PMCHEM1	string	2	Parent material chemical property - firstÂ (uppermost)
16	PMCHEM2	string	2	Parent material chemical property-secondÂ
17	PMCHEM3	string	2	Parent material chemical property-thirdÂ
18	MDEP1	string	4	mode of deposition - first (uppermost)
19	MDEP2	string	4	mode of deposition - second
20	MDEP3	string	4	mode of deposition - third
21	ORDER2	string	2	Soil Order (2nd edition)
22	G_GROUP2	string	3	Soil Great GroupÂ (2nd edition)
23	S_GROUP2	string	4	Soil SubgroupÂ (2nd edition)
24	ORDER3	string	2	Soil Order (3rd edition)
25	G_GROUP3	string	3	Soil Great Group (3rd edition)
26	S_GROUP3	string	5	Soil Subgroup (3rd edition)

Soil Layer Table (SLT)

Field	Name	Type	Width	Description
1	PROVINCE	string	2	Province Code
2	SOIL_CODE	string	3	Soil Code
3	MODIFIER	string	3	Soil Code Modifier
4	LU	string	1	Land Use flag
5	LAYER_NO	string	1	Layer Number
6	UDEPTH	string	3	Upper Depth
7	LDEPTH	string	3	Lower Depth
8	HZN_LIT	string	1	Horizon Lithological Discontinuity
9	HZN_MAS	string	3	Horizon Master Code
10	HZN_SUF	string	7	Horizon Suffix
11	HZN_MOD	string	1	Horizon Modifier
12	COFRAG	string	3	Coarse Fragments
13	DOMSAND	string	2	Dominant Sand Fraction
14	VFSAND	string	3	Very Fine Sand
15	TSAND	string	3	Total Sand
16	TSILT	string	3	Total Silt
17	TCLAY	string	3	Total Clay
18	ORGCARB	float	5	Organic Carbon
19	PHCA	float	4	pH in calcium chloride
20	PH2	float	4	pH as per project report
21	BASE	string	3	Base Saturation
22	CEC	string	3	Cation Exchange Capacity
23	KSAT	float	7	Saturated Hydraulic Conductivity
24	KP0	string	3	Water Retention at 0 kP
25	KP10	string	3	Water Retention at 10 kP
26	KP33	string	3	Water Retention at 33 kP
27	KP1500	string	3	Water Retention at 1500 kP
28	BD	float	5	Bulk Density
29	EC	string	3	Electrical Conductivity
30	CACO3	string	2	Calcium Carbonate Equivalent
31	VONPOST	string	2	Von Post
32	WOOD	string	2	Woody Material
33	SOILKEY	string	9	Soil Name Identifier

Detailed Canadian Soil Maps



Approximately 20% of Canada (mainly in agricultural areas).

- Over 3,000 separate maps, at scales from1:20,000 to 1:250,000, in different historical formats.

- long term national plan to compile them as consistent provincial GIS soil map coverages within the National Soil Data Base.

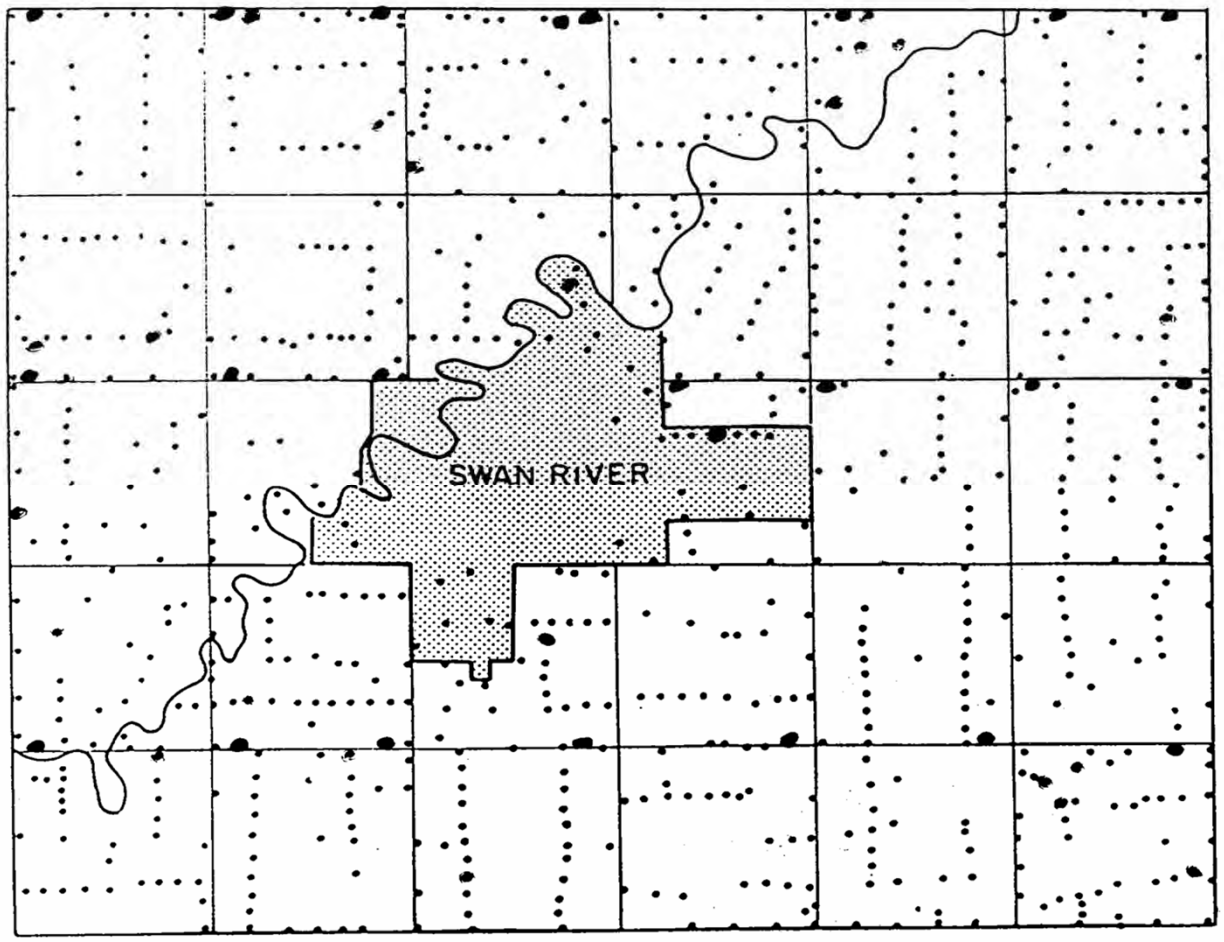
- Standard core file structure and content
- Different scales, different legends, differing base maps
- Inconsistent use of soil series and associations over time
- Usually organized by county, rural municipality or national topographic series mapsheet
- Some value-added, e.g. digitized tile drainage, drape on DTM

- Now moving to single coverage by province through data harmonization and a process often called *conflation*

Inspection Densities from Canadian Soil Maps

SIL	Scale	Province	Hectares represented by 1 inspection	Inspections per cm^2 on the map
2	20 000	Manitoba	10 – 20	0.4 – 0.2
	20 000	British Columbia	7	0.57
	20 000	Newfoundland	26	0.15
	20 000	Ontario	24 – 45	0.26 – 0.14
3	40 000	Manitoba	32	0.5
	50 000	Newfoundland	165	0.15
	125 000	Alberta	70	2.2
4	125 000	Manitoba	120	1.3
	50 000	British Columbia	500	0.05
5	125 000	Manitoba	18 000	0.009
	125 000	British Columbia	8 300	0.08
	250 000	Alberta	4 600	0.14

Field Inspection Sites



SECTIONS 7-36 TP. 36 RGE. 27W

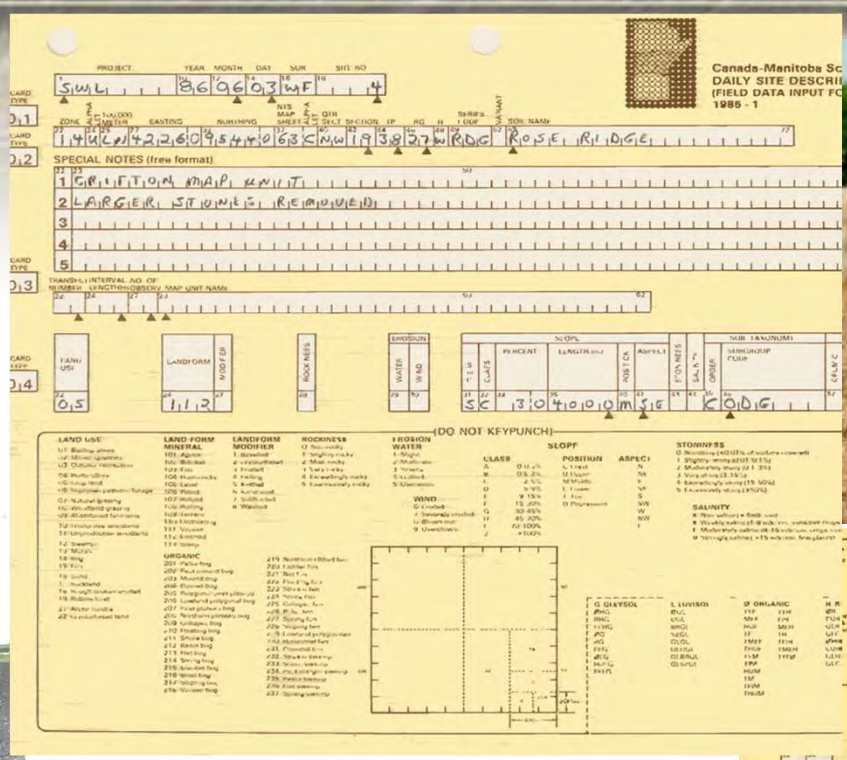
- 1:20,000 scale (SIL2)
- Typically 25 to 30 sites per section
- Soil surveys also include Detailed profile sites, drill logs, well sites, and soil temperature sites

Soil Inspections

Standardized Field Sheet

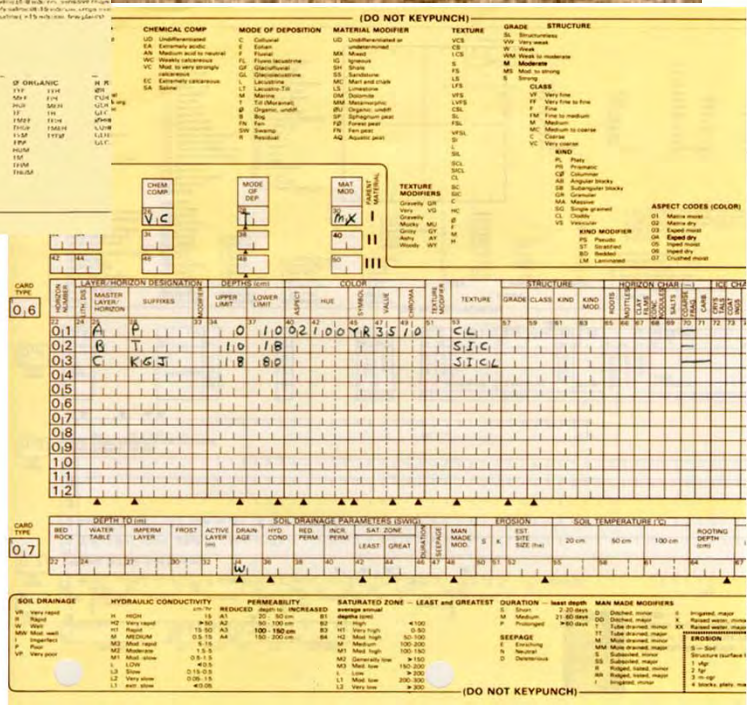
- "Yellow Form" (side 1)

- site information



- "Yellow Form" (side 2)

- Soil profile information



- Any type of ground observation which the Pedologist can use to verify the differentiating characteristics of a map unit

Manitoba Soil Layer File

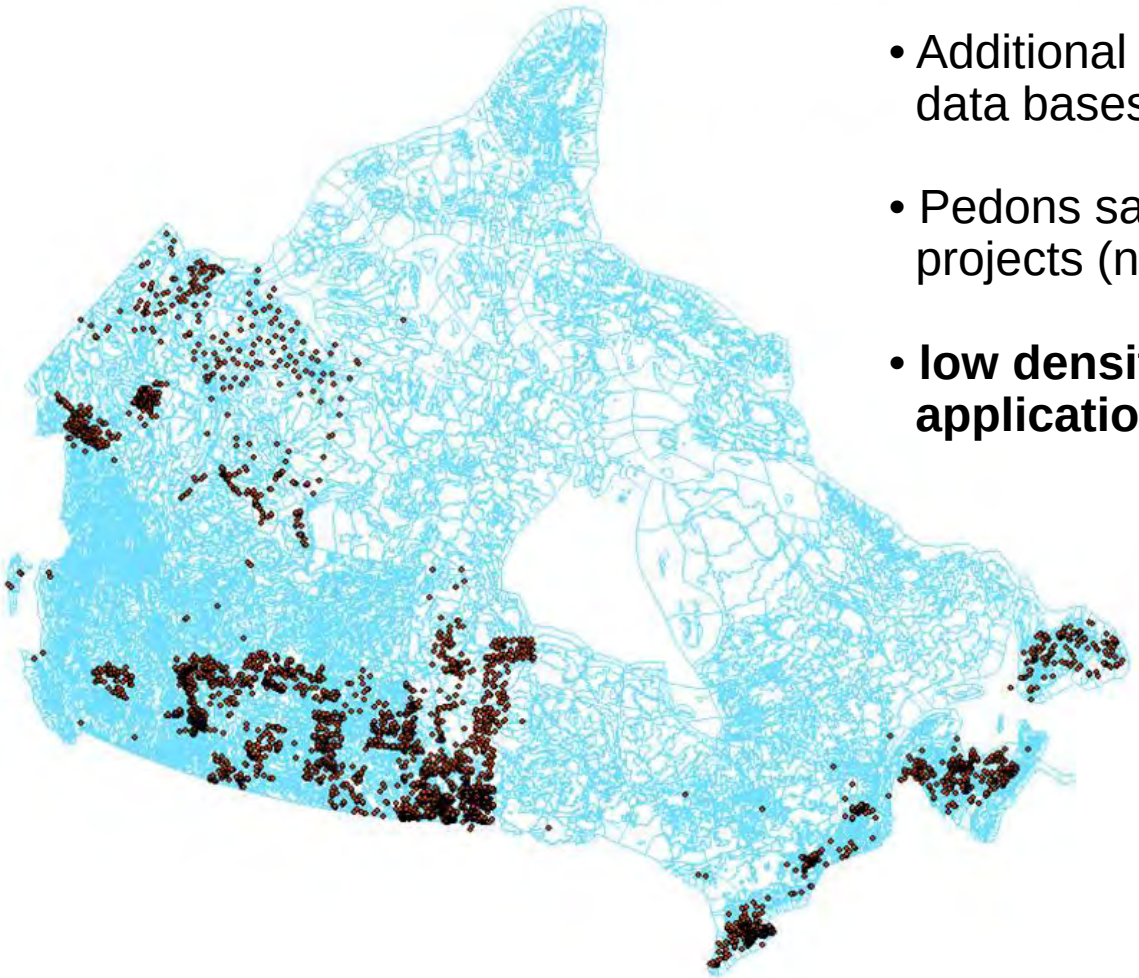
- A data base model of each Manitoba soil series
- Over 2000 soils, and 10,000 soil layer records
- Data source for GIS soil interpretations
- Based on best available information (updated regularly)

SOIL CODE: GOL MODIFIER: LU: A FILE: MBSLFMAS RECORDS: 3244/4 PROVINCE: MB UPDATED: 1993.06.25

#	HORIZON	UP	LO	CF%	CF#	DS	VFS%	VFS#	S%	S#	Si%	Si#	C%	C#	OC%	OC#	PHCA	PHCA#	PH2	PH2#
1	A p	0	25	0	0	F	0	0	24	1	45	1	31	1	3.4	1	6.7	1	7.2	0
2	B tgj	25	40	0	0	F	0	0	10	1	43	1	47	1	1.7	1	7.6	1	7.9	0
3	BC	40	60	0	0	F	0	0	12	1	43	1	45	1	0.9	1	8.3	1	8.6	0
4	C kgs	60	100	0	0	F	0	0	10	1	56	1	34	1	0.0	0	8.5	1	8.8	0

#	BASES	BASES#	CEC	CEC#	KSAT	KSAT#	KP0	KP0#	KP10	KP10#	KP33	KP33#	KP1500	KP1500#	BD	BD#	EC	EC#	CACO3	CACO3#	VP	VP#	WOOD	WOOD#
1	100	1	27	1	3.000	0	49	0	41	0	33	0	16	0	1.30	0	1	1	0	0	-9	0	-9	0
2	100	1	27	1	3.000	0	48	0	39	0	31	0	15	0	1.35	0	1	1	0	0	-9	0	-9	0
3	100	1	28	1	3.000	0	44	0	38	0	30	0	14	0	1.45	0	3	1	8	1	-9	0	-9	0
4	100	1	19	1	3.000	0	43	0	38	0	30	0	14	0	1.51	0	8	1	26	1	-9	0	-9	0

Pedon Samples in the National Soil Data Base



- Approx. 6500 pedons in the NSDB (1 pedon /1400 km^2).
- Additional soil inspection data in provincial data bases (approx. 12,000)
- Pedons sampled during soil inventory projects (non random).
- **low density limits use for DSM applications.**

Versioning of Gridded Raster Soil Attribute Property Maps for Canada

- To develop raster products following GlobalSoilMap.net specifications
  - Weighted mean
  - Spline

- Raster product from Soil Landscapes of Canada version 3.22 components
- Evaluate the ver. 0.1 products and data for future versions

- Raster product from Provincial Detail Soil components
- Evaluate the ver. 0.5 products and data for future versions

- Utilize the NSDB Soil Layer and Soil Names tables

Process

- Create raster in ArcGIS from the SLC and available Provincial coverages
  - The data is not continuous, still controlled by soil components and grouped by polygons

- Process data through created algorithm
  - Weighted Mean
    - Calculate an average value for each attribute in each depth increment
    - Summarize above values by the percent occupied for each component
  - Spline
    - Extract value for each attribute in each depth increment
    - Summarize above values by the percent occupied for each component

Data Manipulation

- Populate GSM attribute table by fixed depths
  - 0-5
  - 5-15
  - 15-30
  - 30-60
  - 60-100
  - 100-200
- Attributes
  - Organic Carbon
  - pH
  - Clay
  - Sand
  - Silt
  - Coarse Fragments
  - Electrical Conductivity
  - Bulk Density
  - Available Water Holding Capacity
- Remove surface LFH layers for calculation
- Layer table data in the NSDB for the most part goes to a depth of 100 cm.
  - Records exist that exceed this depth
- Created a new horizon that duplicates the last horizon to a depth of 200 cm.
- Develop routine to convert spline data to data table

Soil Layer Table

Soil_id	Province	Soil_code	Modifier	Profile	Layer_no	Udepth	Ldepth	Hzn_lit	Hzn_mas	Hzn_suf	Hzn_mod	Cofrag	Domsand	Vfsand	Tsand	Tsilt	Tclay	Orgcarb	Phca	Ph2	Bases	Cec	Ksat	Kp0	Kp10	Kp33	Kp1500	Bd	Ec	Caco3
MBGYV~~~~~~A	ZZ	GYV	~~~~~~	A	5	100	200	2	C	dup		0	-	0	6	45	49	0.3	8.0	8.3	100	39	0.100	51	44	42	22	1.30	1	22
MBHAL~~1~~A	MB	HAL	~~1~~	A	1	0	20		A	p		0	F	19	80	9	11	1.0	5.0	5.5	45	16	3.000	37	24	14	6	1.31	0	0
MBHAL~~1~~A	MB	HAL	~~1~~	A	2	20	35		B	m		0	F	16	85	6	9	0.8	6.0	6.5	67	10	11.200	26	18	10	5	1.53	0	0
MBHAL~~1~~A	MB	HAL	~~1~~	A	3	35	50		BC			0	F	24	91	2	7	0.3	6.3	6.8	75	6	25.000	28	12	9	3	1.57	0	0
MBHAL~~1~~A	MB	HAL	~~1~~	A	4	50	65		C			0	F	15	84	8	8	0.1	6.4	7.0	75	6	30.000	28	12	9	3	1.69	0	0
MBHAL~~1~~A	MB	HAL	~~1~~	A	5	65	80	2	C	k	1	0	VF	15	21	53	26	0.6	7.4	7.8	100	14	3.000	46	40	22	10	1.53	0	12
MBHAL~~1~~A	MB	HAL	~~1~~	A	6	80	110	2	C	k	2	0	VF	9	13	52	35	0.4	7.4	7.8	100	24	2.000	52	45	26	12	1.41	0	21
MBHAL~~1~~A	ZZ	HAL	~~1~~	A	7	110	200	2	C	dup	2	0	VF	9	13	52	35	0.4	7.4	7.8	100	24	2.000	52	45	26	12	1.41	0	21
MBHAL~~2~~A	MB	HAL	~~2~~	A	1	0	20		A	p		0	F	16	85	6	9	0.8	6.0	6.5	67	10	10.000	26	18	10	5	1.40	0	0
MBHAL~~2~~A	MB	HAL	~~2~~	A	2	20	35		BC			0	F	24	91	2	7	0.3	6.3	6.8	75	6	25.000	28	12	9	3	1.57	0	0
MBHAL~~2~~A	MB	HAL	~~2~~	A	3	35	50		C			0	F	15	84	8	8	0.1	6.4	7.0	75	6	30.000	28	12	9	3	1.69	0	0
MBHAL~~2~~A	MB	HAL	~~2~~	A	4	50	65	2	C	k	1	0	VF	15	21	53	26	0.6	7.4	7.8	100	14	3.000	46	40	22	10	1.53	0	12
MBHAL~~2~~A	MB	HAL	~~2~~	A	5	65	100	2	C	k	2	0	VF	9	13	52	35	0.4	7.4	7.8	100	24	2.000	52	45	26	12	1.41	0	21
MBHAL~~2~~A	ZZ	HAL	~~2~~	A	6	100	200	2	C	dup	2	0	VF	9	13	52	35	0.4	7.4	7.8	100	24	2.000	52	45	26	12	1.41	0	21
MBHAL~~3~~A	MB	HAL	~~3~~	A	1	0	20		A	p		0	F	24	91	2	7	0.3	6.3	6.8	75	6	25.000	28	12	9	3	1.40	0	0
MBHAL~~3~~A	MB	HAL	~~3~~	A	2	20	40		C			0	F	15	84	8	8	0.1	6.4	7.0	75	6	30.000	28	12	9	3	1.69	0	0
MBHAL~~3~~A	MB	HAL	~~3~~	A	3	40	55	2	C	k	1	0	VF	15	21	53	26	0.6	7.4	7.8	100	14	3.000	46	40	22	10	1.53	0	12
MBHAL~~3~~A	MB	HAL	~~3~~	A	4	55	100	2	C	k	2	0	VF	9	13	52	35	0.4	7.4	7.8	100	24	2.000	52	45	26	12	1.41	0	21
MBHAL~~3~~A	ZZ	HAL	~~3~~	A	5	100	200	2	C	dup	2	0	VF	9	13	52	35	0.4	7.4	7.8	100	24	2.000	52	45	26	12	1.41	0	21
MBHAL~~o~~A	MB	HAL	~~o~~	A	1	0	15		A	p		0	F	15	90	5	5	0.8	6.5	7.0	50	10	15.000	25	17	10	4	1.40	0	0
MBHAL~~o~~A	MB	HAL	~~o~~	A	2	15	40		A	pb		0	F	19	80	9	11	1.8	5.4	5.9	65	16	3.000	37	24	14	6	1.31	0	0
MBHAL~~o~~A	MB	HAL	~~o~~	A	3	40	55		B	m		0	F	16	85	6	9	0.8	6.0	6.5	67	10	11.200	26	18	10	5	1.53	0	0
MBHAL~~o~~A	MB	HAL	~~o~~	A	4	55	70		BC			0	F	24	91	2	7	0.3	6.3	6.8	75	6	25.000	28	12	9	3	1.57	0	0
MBHAL~~o~~A	MB	HAL	~~o~~	A	5	70	85		C			0	F	15	84	8	8	0.1	6.4	7.0	75	6	30.000	28	12	9	3	1.69	0	0
MBHAL~~o~~A	MB	HAL	~~o~~	A	6	85	100	2	C	k	1	0	VF	15	21	53	26	0.6	7.4	7.8	100	14	1.390	46	40	22	10	1.53	0	12
MBHAL~~o~~A	MB	HAL	~~o~~	A	7	100	130	2	C	k	2	0	VF	9	13	52	35	0.4	7.4	7.8	100	24	2.000	52	45	26	12	1.41	0	21
MBHAL~~o~~A	ZZ	HAL	~~o~~	A	8	130	200	2	C	dup	2	0	VF	9	13	52	35	0.4	7.4	7.8	100	24	2.000	52	45	26	12	1.41	0	21

NSDB Soil Layer table has 73,571 records

Correlates to 13196 unique soils

Soil Landscapes of Canada used in this version test has 3248 soils

Soil Layer Rating Table

Soil_id	PE	Oc5	Oc15	Oc30	Oc60	Oc100	Oc200	Ph5	Ph15	Ph30	Ph60	Ph100	Ph200	Clay5	Clay15	Clay30	Clay60	Clay100	Clay200	Silt5	Silt15	Silt30	Silt60	Silt100	Silt200
MBGYSt~~~~~A		3	1	1	0	0	0	7.4	7.6	7.6	7.8	7.8	7.8	10	20	20	10	3	3	9	20	20	13	2	2
MBGYSu~~~~~A		3	1	1	0	0	0	7.4	7.6	7.6	7.8	7.8	7.8	10	20	20	10	3	3	9	20	20	13	2	2
MBGYSv~~~~~N		3	1	1	0	0	0	7.4	7.6	7.6	7.8	7.8	7.8	10	20	20	10	3	3	9	20	20	13	2	2
MBGYS~~~~~~A		3	1	1	0	0	0	7.4	7.6	7.6	7.8	7.8	7.8	10	20	20	10	3	3	9	20	20	13	2	2
MBGYS~~~~~~N		3	1	1	0	0	0	7.4	7.6	7.6	7.8	7.8	7.8	10	20	20	10	3	3	9	20	20	13	2	2
MBGYVs~~~~~A		4	4	2	1	0	0	7.8	7.8	7.9	7.8	8.0	8.0	39	39	32	24	49	49	55	55	64	73	45	45
MBGYV~~~~~~A		4	4	2	1	0	0	7.8	7.8	7.9	7.8	8.0	8.0	39	39	32	24	49	49	55	55	64	73	45	45
MBHAL~~1~~A		1	1	1	0	0	0	5.0	5.0	5.7	6.3	7.3	7.4	11	11	10	8	28	35	9	9	7	5	47	52
MBHAL~~2~~A		1	1	0	0	0	0	6.0	6.0	6.2	6.7	7.4	7.4	9	9	8	14	34	35	6	6	3	22	52	52
MBHAL~~3~~A		0	0	0	0	0	0	6.3	6.3	6.4	7.1	7.4	7.4	7	7	8	22	35	35	2	2	6	38	52	52
MBHAL~~o~~A		1	1	2	1	0	0	6.5	6.5	5.4	5.9	6.8	7.4	5	5	11	9	15	35	5	5	9	6	23	52
MBHAL~~~~~~A		2	2	1	1	0	0	5.5	5.5	5.8	6.2	7.0	7.4	11	11	10	8	22	35	9	9	7	4	36	52
MBHAT~~1~~A		1	1	1	0	0	0	7.1	7.1	7.2	7.3	7.6	7.5	12	12	13	14	11	10	19	19	19	20	25	26
MBHAT~~2~~A		1	1	1	0	0	0	7.2	7.2	7.2	7.3	7.5	7.5	12	12	13	14	12	10	19	19	19	20	24	26
MBHAT~~3~~A		0	0	0	0	0	0	7.5	7.5	7.6	7.6	7.5	7.5	13	13	11	11	10	10	22	22	25	25	26	26
MBHAT~~o~~A		2	2	2	1	0	0	7.0	7.0	6.6	7.0	7.3	7.5	12	12	13	13	14	10	23	23	26	21	20	26
MBHAT~~~~~A		2	2	1	0	0	0	6.4	6.4	7.1	7.2	7.5	7.5	14	14	12	13	12	10	28	28	19	19	23	26
MBHAT~~~~~N		2	2	1	0	0	0	7.1	7.1	7.1	7.2	7.5	7.5	12	12	12	13	12	10	19	19	19	19	23	26
MBHAU~~~~~~N		52	52	53	54	56	12	7.3	7.3	7.2	7.0	6.9	7.4	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
MBHAY~~~~~~A		7	7	1	1	0	0	6.2	6.2	7.3	7.3	7.5	7.5	27	27	16	21	1	1	49	49	33	38	3	3
MBHAY~~~~~~N		3	3	1	1	0	0	6.3	6.3	7.3	7.3	7.5	7.5	27	27	16	21	1	1	49	49	33	38	3	3
MBHBB~~~~~~N		2	1	0	0	0	0	5.7	7.3	7.0	7.0	7.0	7.0	39	35	21	18	4	3	35	26	43	35	23	24

Each soil from the Soil Layer Table has a corresponding record that contains the GSM attributes and their associated fixed depth increments

Data Issues

- Coverage limited to areas with polygonal soil information
- GSM Specifications changed during processing
  - Units for Clay, Sand, Silt has alternated between g/Kg to % weight
  - Units for Coarse fragments has alternated between g/Kg to % volume
- Rock layers at depth in component attributes skewing weighted average
  - Alternative set of SLC products showing percent rock occupying polygon
- Spline routine changed to new version
- Spline data contains negative values

Soil Layer Table – Comparison Input

SLT

Soil_code	Modifier	Profile	Layer_no	Udepth	Ldepth	Awhc	Bd	Tclay	Tsand	Tsilt	Ec	Orgcarb	Phca	Cofrag	Hzn_lit	Hzn_mas	Hzn_suf
PGE	p~~~~~	N	2	0	10	26	1.14	67	3	30	0	3.2	7.3	0		A	hkg
PGE	p~~~~~	N	3	10	30	22	1.32	59	25	16	0	0.1	7.4	0		AC	
PGE	p~~~~~	N	4	30	70	22	1.32	53	22	25	0	0.0	7.7	0		C	kg
PGE	p~~~~~	N	5	70	100	10	1.65	32	22	46	0	0.0	7.9	15	2	C	kg
PGE	p~~~~~	N	6	100	200	10	1.65	32	22	46	0	0.0	7.9	15	2	C	dup
PGE	~~~~~~	A	1	0	20	24	1.14	67	3	30	1	3.2	7.3	0		A	p
PGE	~~~~~~	A	2	20	30	22	1.32	59	25	16	0	0.5	7.4	0		AC	
PGE	~~~~~~	A	3	30	70	23	1.32	53	22	25	0	0.3	7.8	0		C	kg
PGE	~~~~~~	A	4	70	100	10	1.80	32	22	46	0	0.0	7.9	15	2	C	kg
PGE	~~~~~~	A	5	100	200	10	1.80	32	22	46	0	0.0	7.9	15	2	C	dup
PGU	~~~~~~	A	1	0	15	24	1.10	51	5	44	0	2.6	6.5	0		A	p
PGU	~~~~~~	A	2	15	40	25	1.30	62	23	15	0	2.1	6.9	0		B	tgj
PGU	~~~~~~	A	3	40	100	12	1.70	23	30	47	1	0.0	8.0	14	2	C	kgj
PGU	~~~~~~	A	4	100	200	12	1.70	23	30	47	1	0.0	8.0	14	2	C	dup

SLT Weighted Average – Spline Comparison

Weighted Average

Soil_id	Depth	Awhc	Bd	Clay	Sand	Silt	Ec	OrgC	Phca	Cofrag
MBPGEp~~~~~N	0-5	13	1.1	67	3	30	0	3	7.3	0
	5-15	22	1.3	59	25	16	0	0	7.4	0
	15-30	33	1.3	59	25	16	0	0	7.4	0
	30-60	66	1.3	53	22	25	0	0	7.7	0
	60-100	52	1.6	37	22	41	0	0	7.9	11
	100-200	100	1.7	32	22	46	0	0	7.9	15
MBPGE~~~~~~A	0-5	12	1.1	67	3	30	1.0	3	7.3	0
	5-15	24	1.1	67	3	30	1.0	3	7.3	0
	15-30	34	1.3	62	18	21	0.3	1	7.4	0
	30-60	39	1.3	53	22	25	0	0	7.8	0
	60-100	53	1.7	37	22	41	0	0	7.9	11
	100-200	100	1.8	32	22	46	0	0	7.9	15
MBPGU~~~~~~A	0-5	12	1.1	51	5	44	0	3	6.5	0
	5-15	24	1.1	51	5	44	0	3	6.5	0
	15-30	38	1.3	62	23	15	0	2	6.9	0
	30-60	49	1.6	36	28	36	0.7	1	7.6	9
	60-100	48	1.7	23	30	47	1.0	0	8.0	14
	100-200	120	1.7	23	30	47	1.0	0	8.0	14

Spline

Soil_id	Province	Soil_code	Modifier	Profile	Udepth	Ldepth	Awhc	Bd	Clay	Sand	Silt	Ec	Orgcarb	Phca	Cofrag
MBPGEp~~~~~N	MB	PGE	p~~~~~	N	0	5	26.36	1.12	68	1	31	0.00	3.5	7.3	0
MBPGEp~~~~~N	MB	PGE	p~~~~~	N	5	15	24.53	1.20	64	10	25	0.00	2.2	7.3	0
MBPGEp~~~~~N	MB	PGE	p~~~~~	N	15	30	21.95	1.33	59	26	15	0.00	-0.1	7.4	0
MBPGEp~~~~~N	MB	PGE	p~~~~~	N	30	60	22.82	1.30	55	23	22	0.00	-0.1	7.7	-1
MBPGEp~~~~~N	MB	PGE	p~~~~~	N	60	100	12.41	1.58	36	22	43	0.00	0.0	7.9	12
MBPGEp~~~~~N	MB	PGE	p~~~~~	N	100	200	9.96	1.65	32	22	46	0.00	0.0	7.9	15
MBPGE~~~~~~A	MB	PGE	~~~~~~	A	0	5	24.57	1.09	69	-2	34	1.25	3.9	7.3	0
MBPGE~~~~~~A	MB	PGE	~~~~~~	A	5	15	24.08	1.13	67	2	30	1.03	3.3	7.3	0
MBPGE~~~~~~A	MB	PGE	~~~~~~	A	15	30	22.51	1.28	61	20	19	0.25	1.2	7.4	0
MBPGE~~~~~~A	MB	PGE	~~~~~~	A	30	60	23.78	1.29	55	23	22	-0.01	0.3	7.7	-1
MBPGE~~~~~~A	MB	PGE	~~~~~~	A	60	100	12.66	1.70	36	22	42	0.01	0.1	7.9	12
MBPGE~~~~~~A	MB	PGE	~~~~~~	A	100	200	9.95	1.80	32	22	46	0.00	0.0	7.9	15
MBPGU~~~~~~A	MB	PGU	~~~~~~	A	0	5	23.61	1.08	49	3	49	0.02	2.6	6.5	0
MBPGU~~~~~~A	MB	PGU	~~~~~~	A	5	15	24.24	1.11	52	6	41	-0.01	2.6	6.5	0
MBPGU~~~~~~A	MB	PGU	~~~~~~	A	15	30	25.58	1.24	62	19	19	-0.06	2.3	6.8	-1
MBPGU~~~~~~A	MB	PGU	~~~~~~	A	30	60	19.35	1.50	46	28	25	0.44	1.1	7.4	6
MBPGU~~~~~~A	MB	PGU	~~~~~~	A	60	100	9.90	1.75	16	30	53	1.16	-0.3	8.2	16
MBPGU~~~~~~A	MB	PGU	~~~~~~	A	100	200	11.94	1.70	23	30	47	1.00	0.0	8.0	14

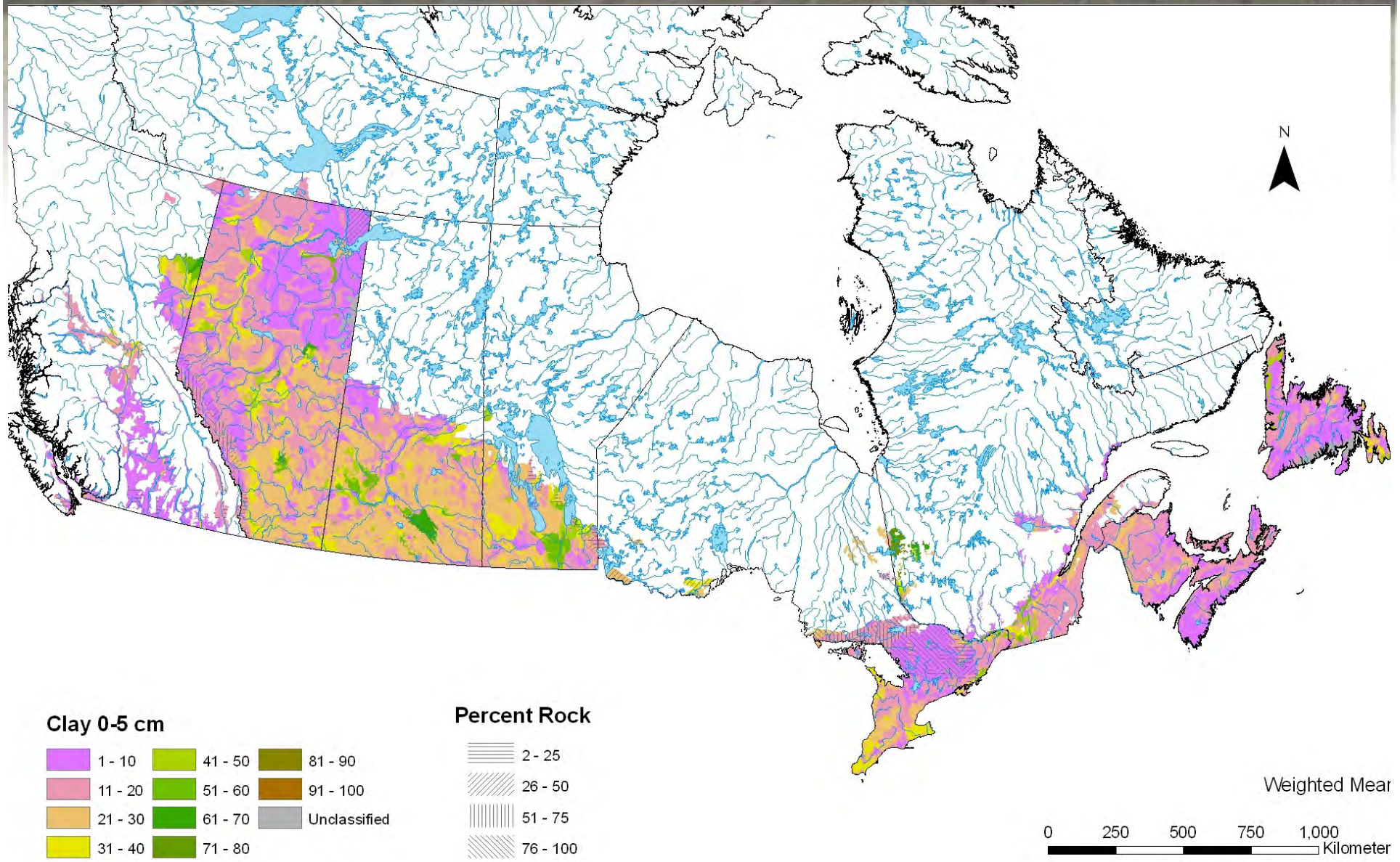
Negative values

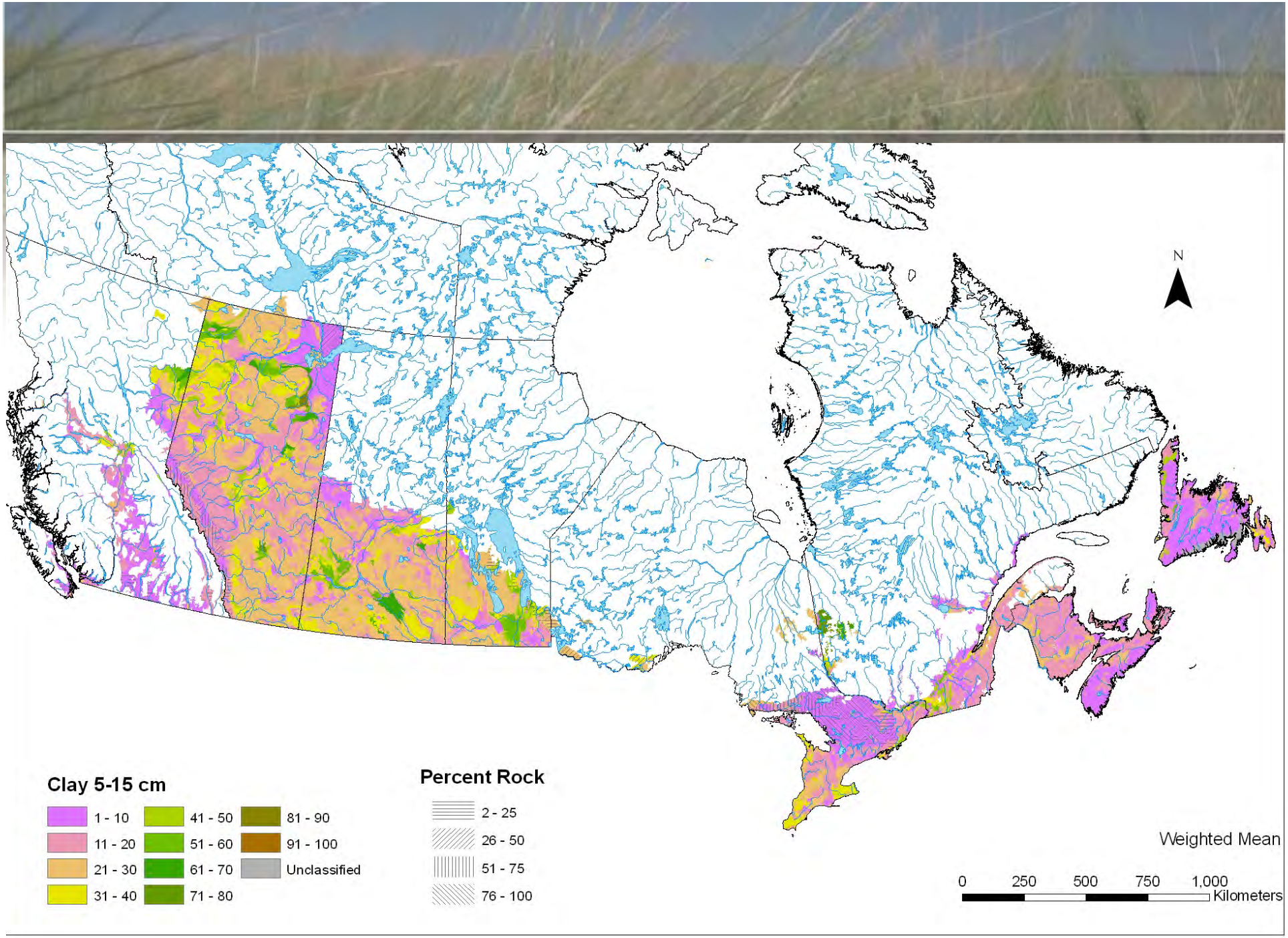
Negative values in the spline data

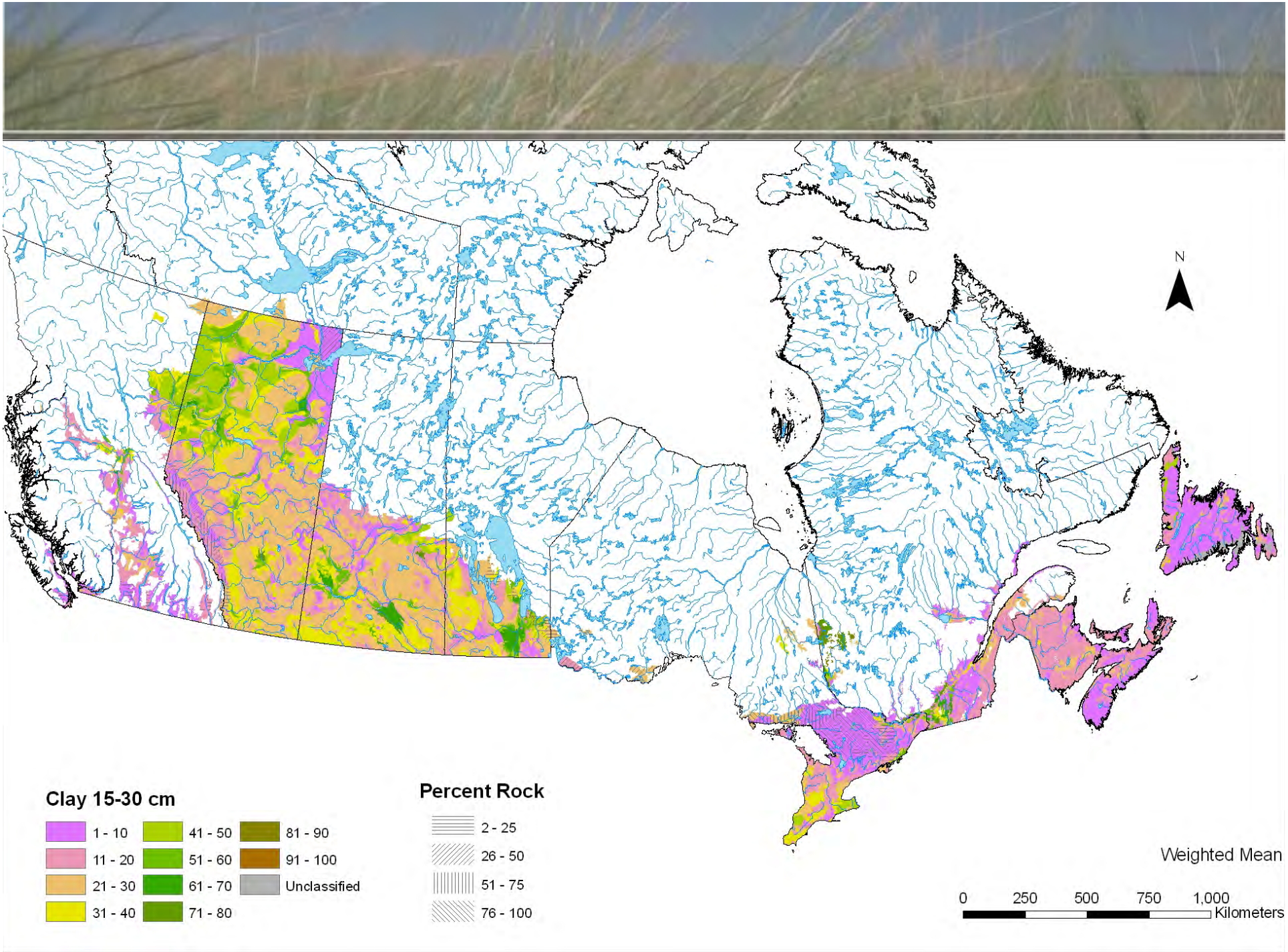
Bd < 0	78 records (horizons)
Bd < 0.5	817 records
pHca < 0	78 records
pHca < 2	509
Sand < 0	183
Silt < 0	186
Clay < 0	156
Cofrag < 0	216
OrgC< 0	356

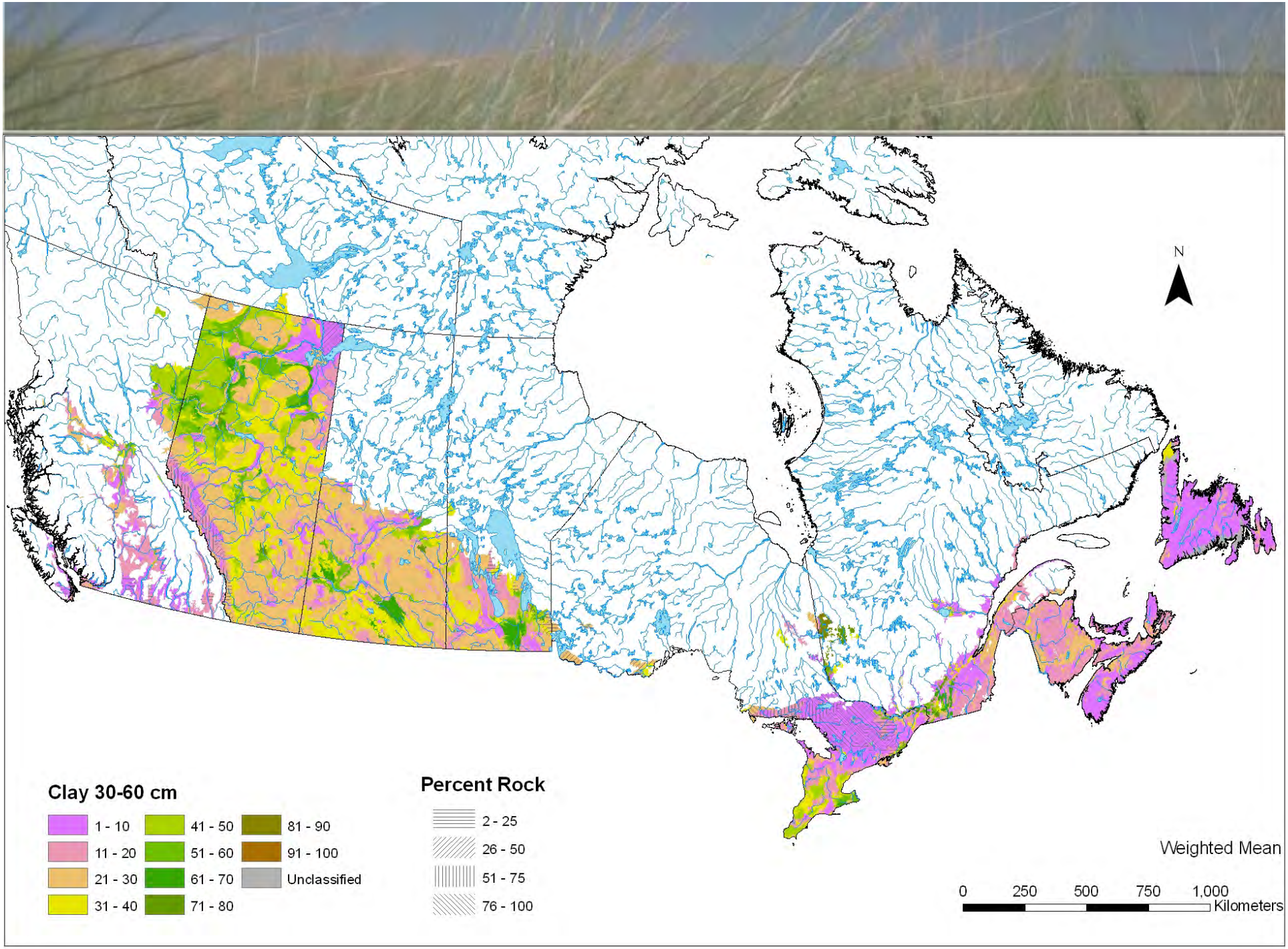
Negative values are identified by the spline authors and
a solution exits that would require modifying the input in 1 cm increments
around those horizons that exhibit problems

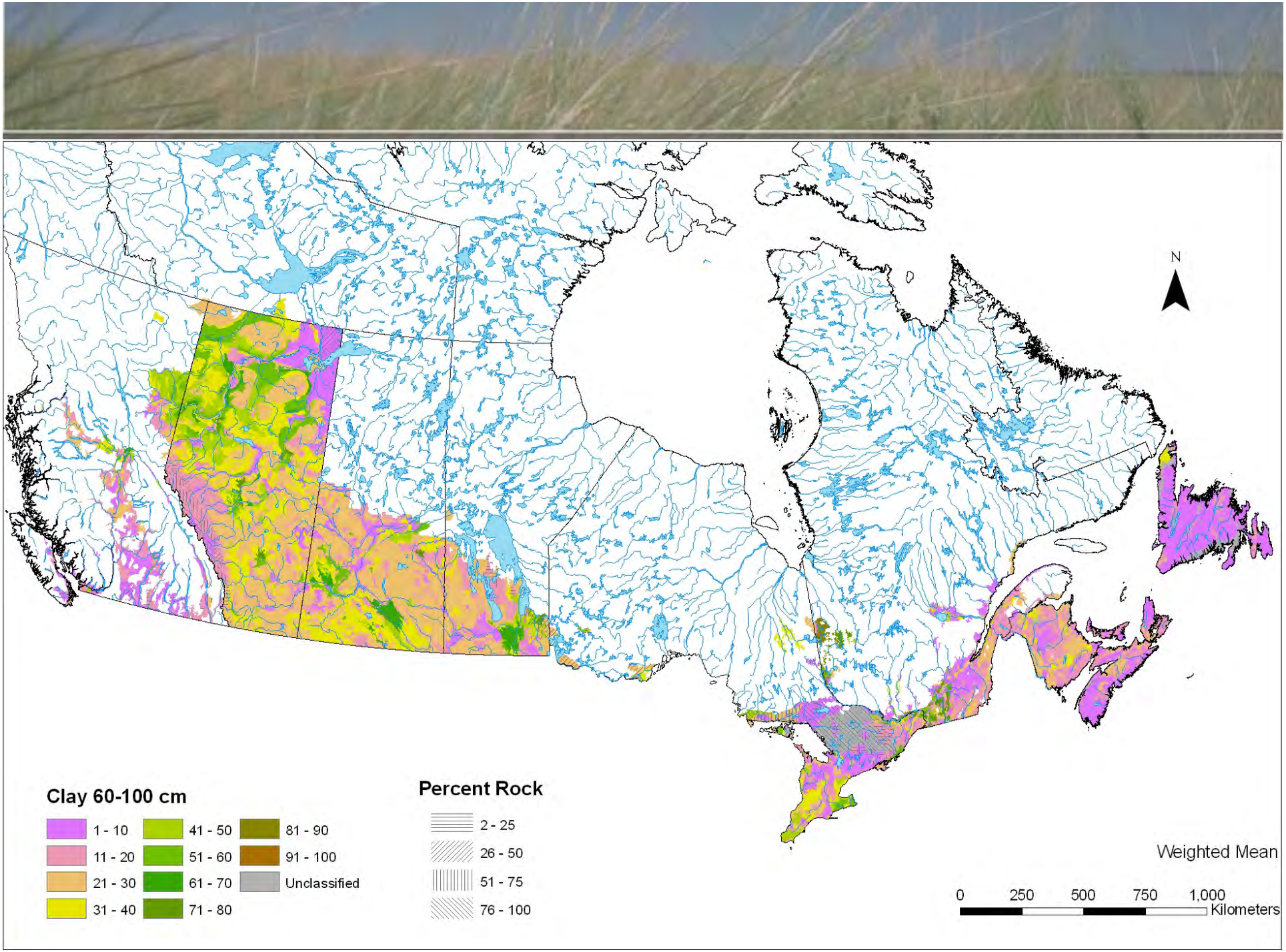
Soil Landscapes of Canada- Weighted Average Example

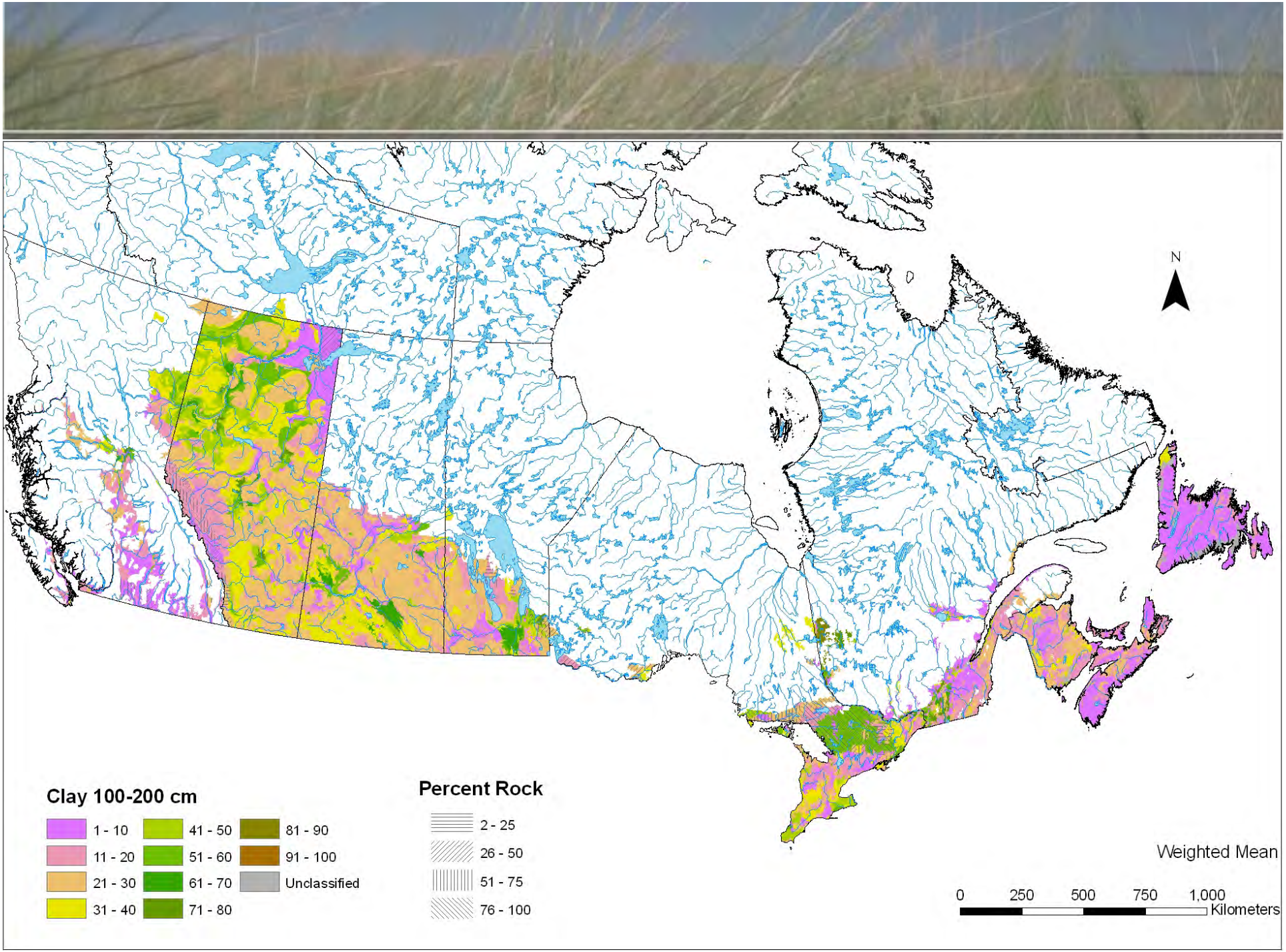



N
Clay 5-15 cm
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
Unclassified
Percent Rock
2 - 25
26 - 50
51 - 75
76 - 100
Weighted Mean
0
250
500
750
1,000
Kilometers

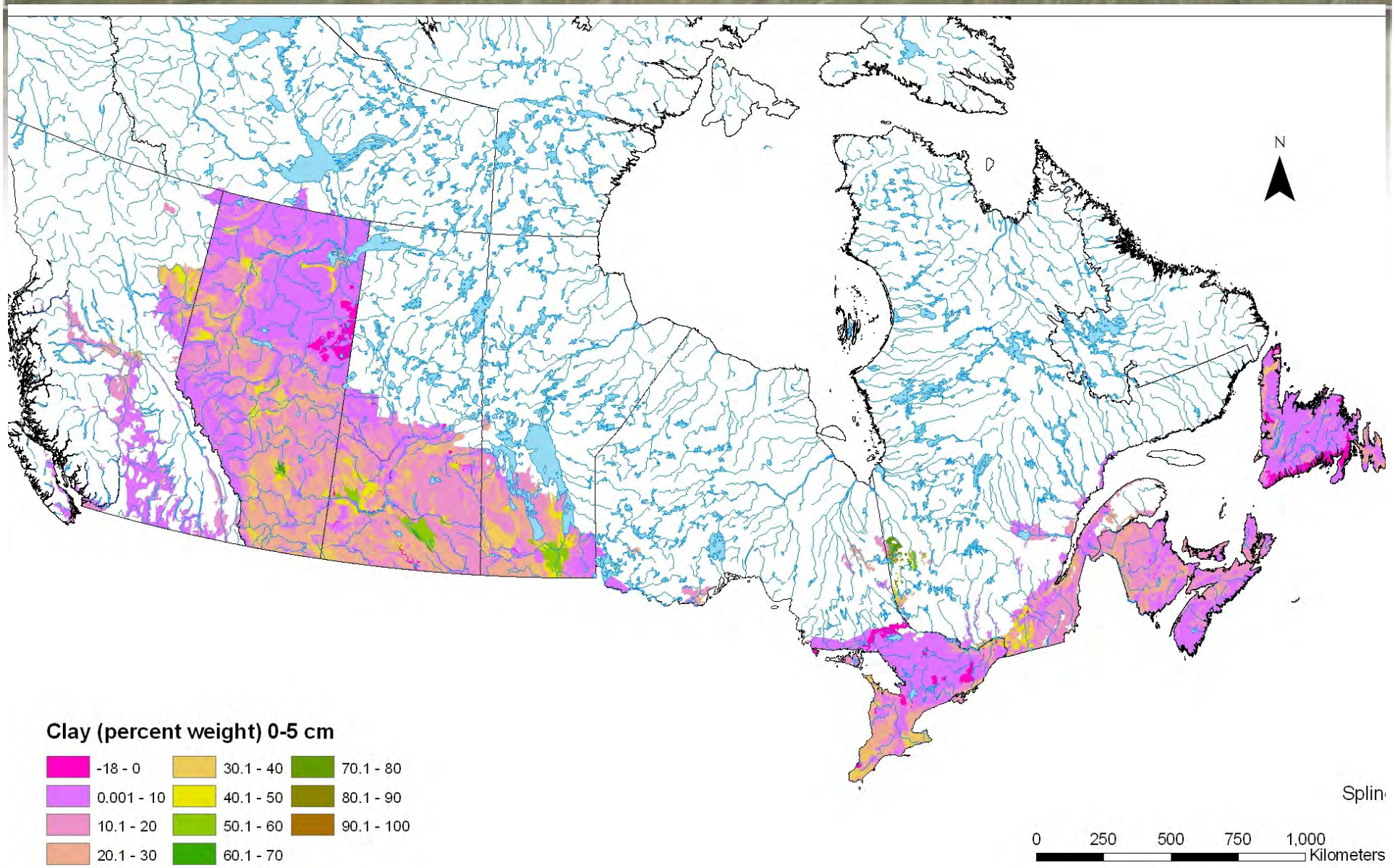

N
Clay 15-30 cm
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
Unclassified
Percent Rock
2 - 25
26 - 50
51 - 75
76 - 100
Weighted Mean
0
250
500
750
1,000
Kilometers

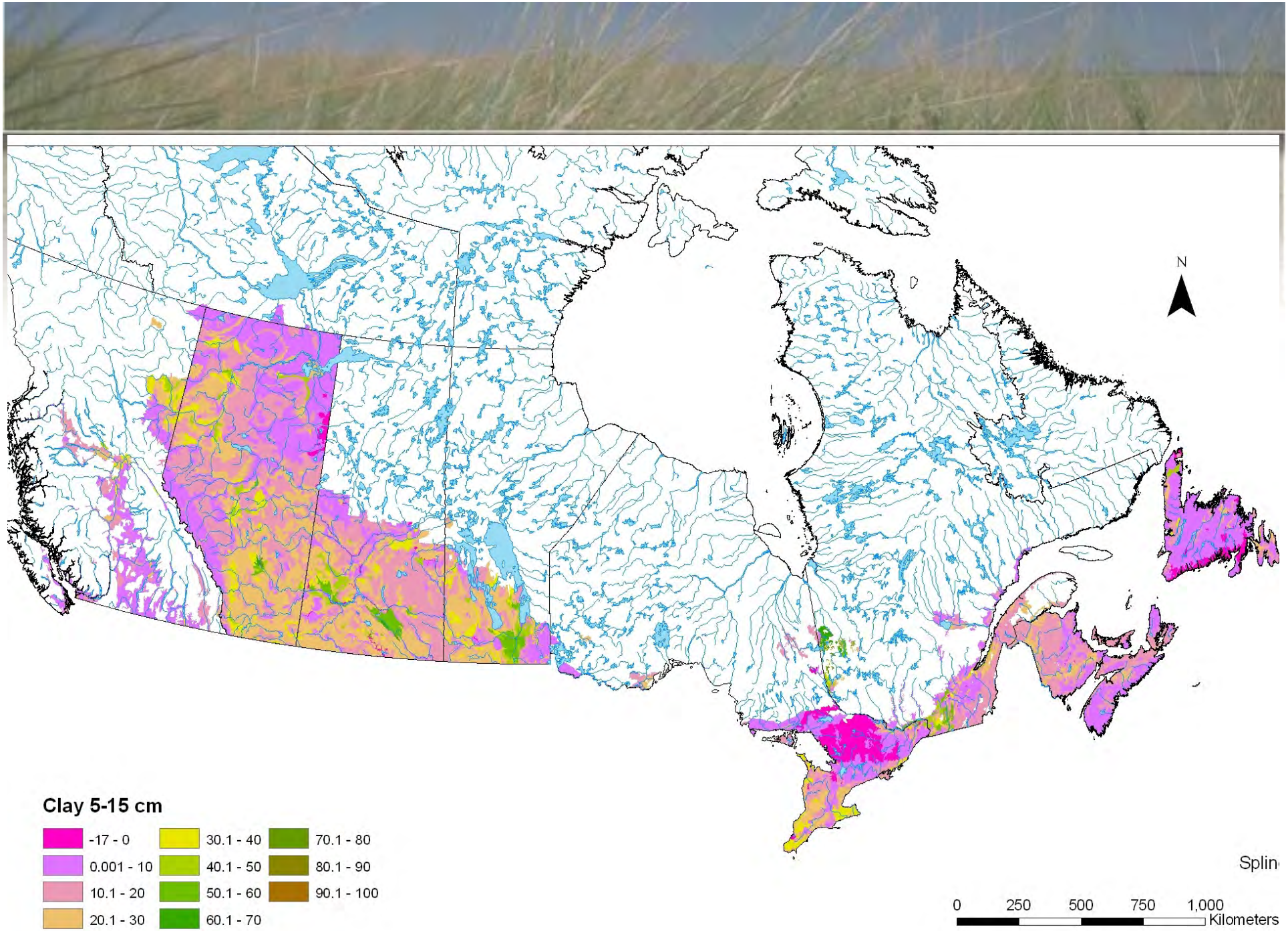

N
Clay 30-60 cm
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
Unclassified
Percent Rock
2 - 25
26 - 50
51 - 75
76 - 100
Weighted Mean
0
250
500
750
1,000
Kilometers

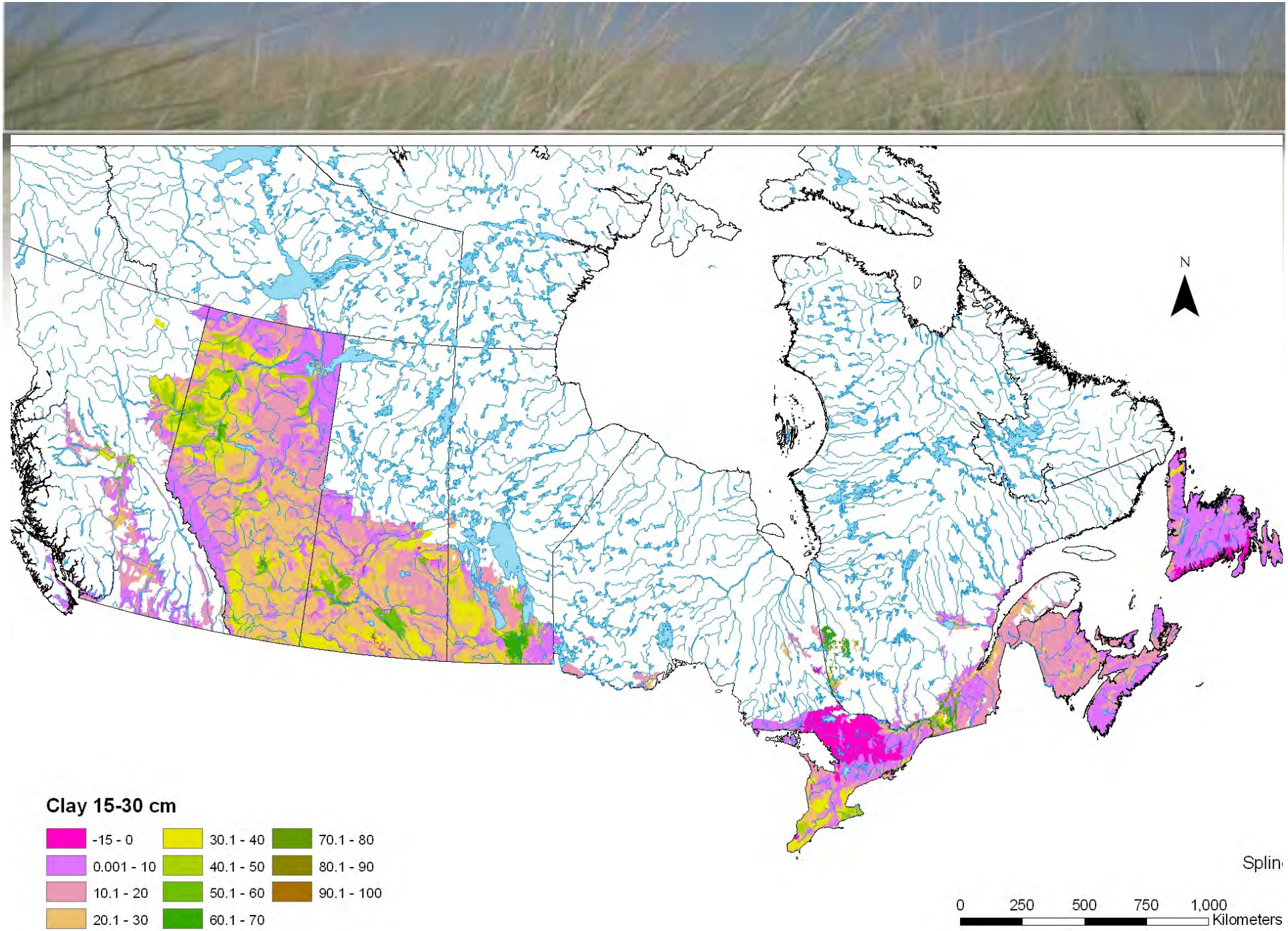

N
Clay 60-100 cm
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
Unclassified
Percent Rock
2 - 25
26 - 50
51 - 75
76 - 100
Weighted Mean
0
250
500
750
1,000
Kilometers

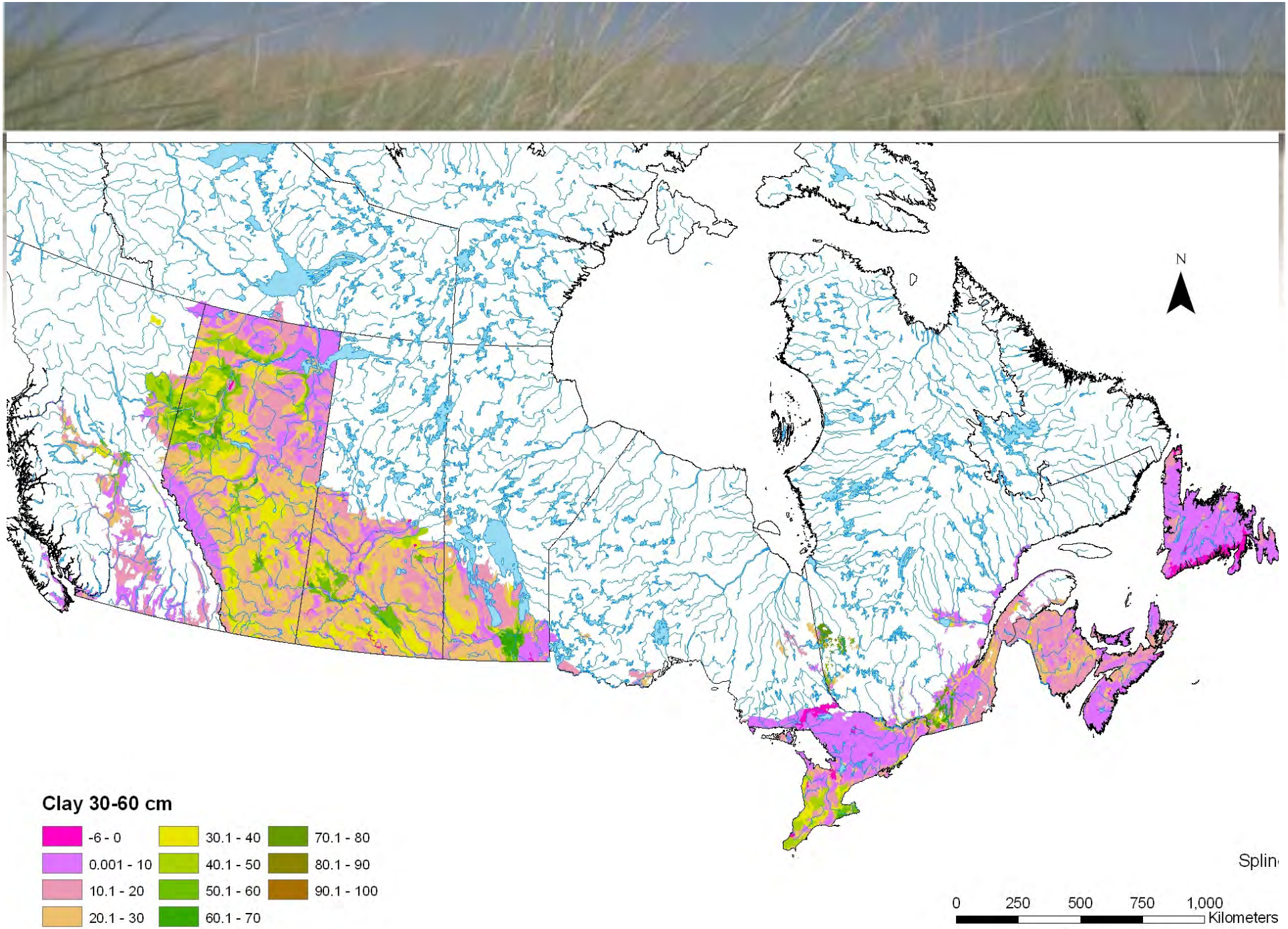

N
Clay 100-200 cm
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
Unclassified
Percent Rock
2 - 25
26 - 50
51 - 75
76 - 100
Weighted Mean
0
250
500
750
1,000
Kilometers

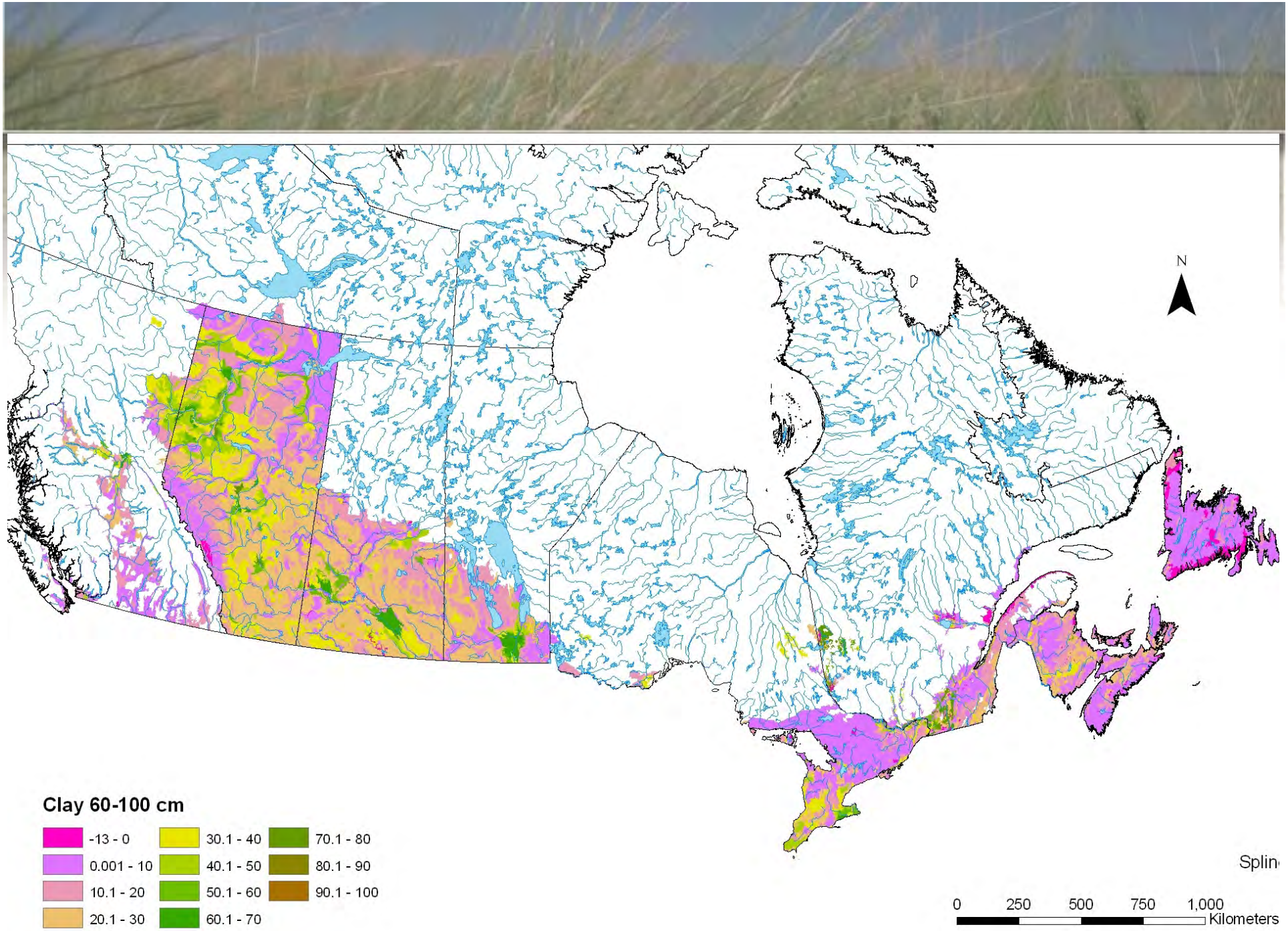
Soil Landscapes of Canada - Spline Example

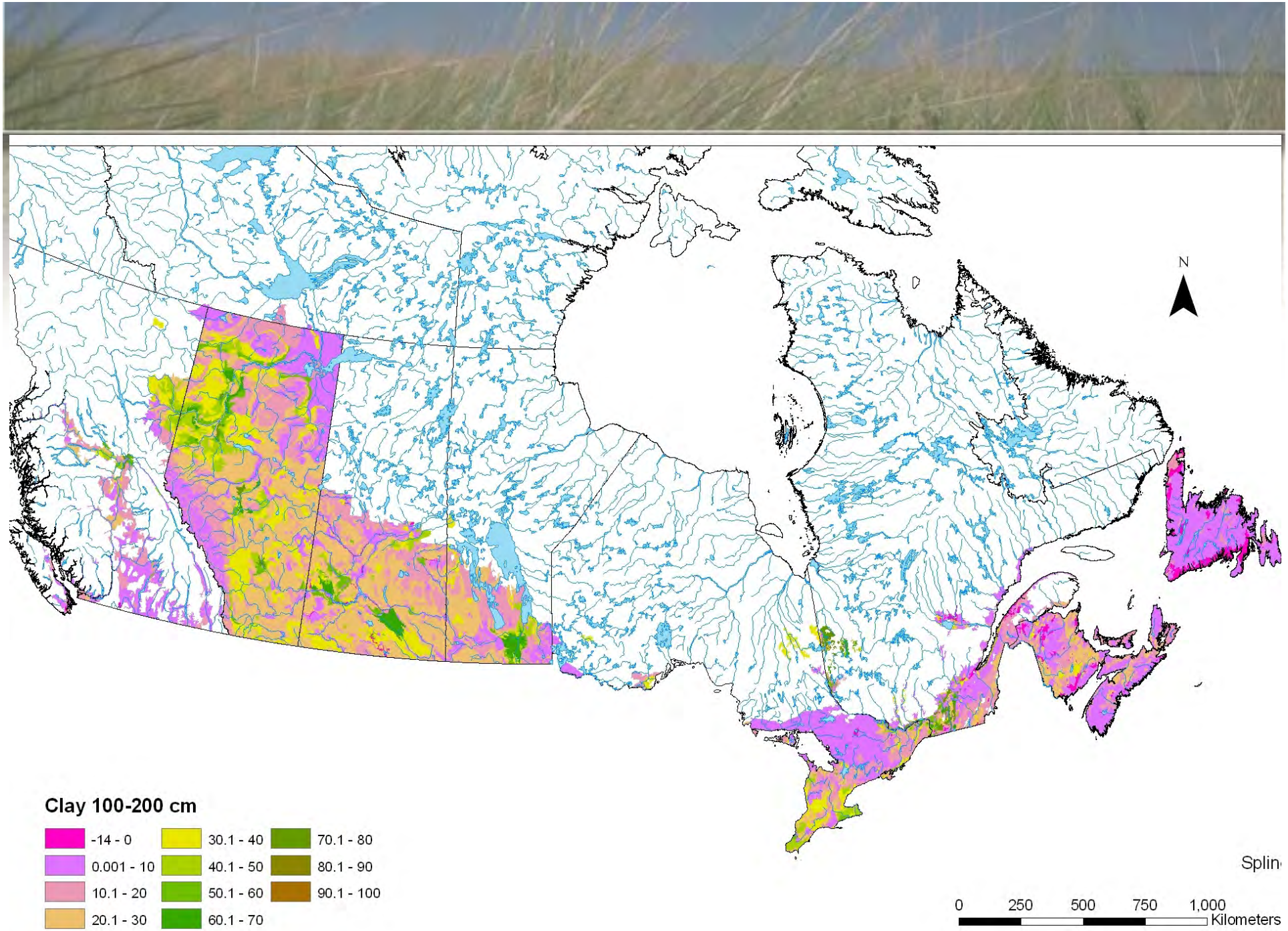


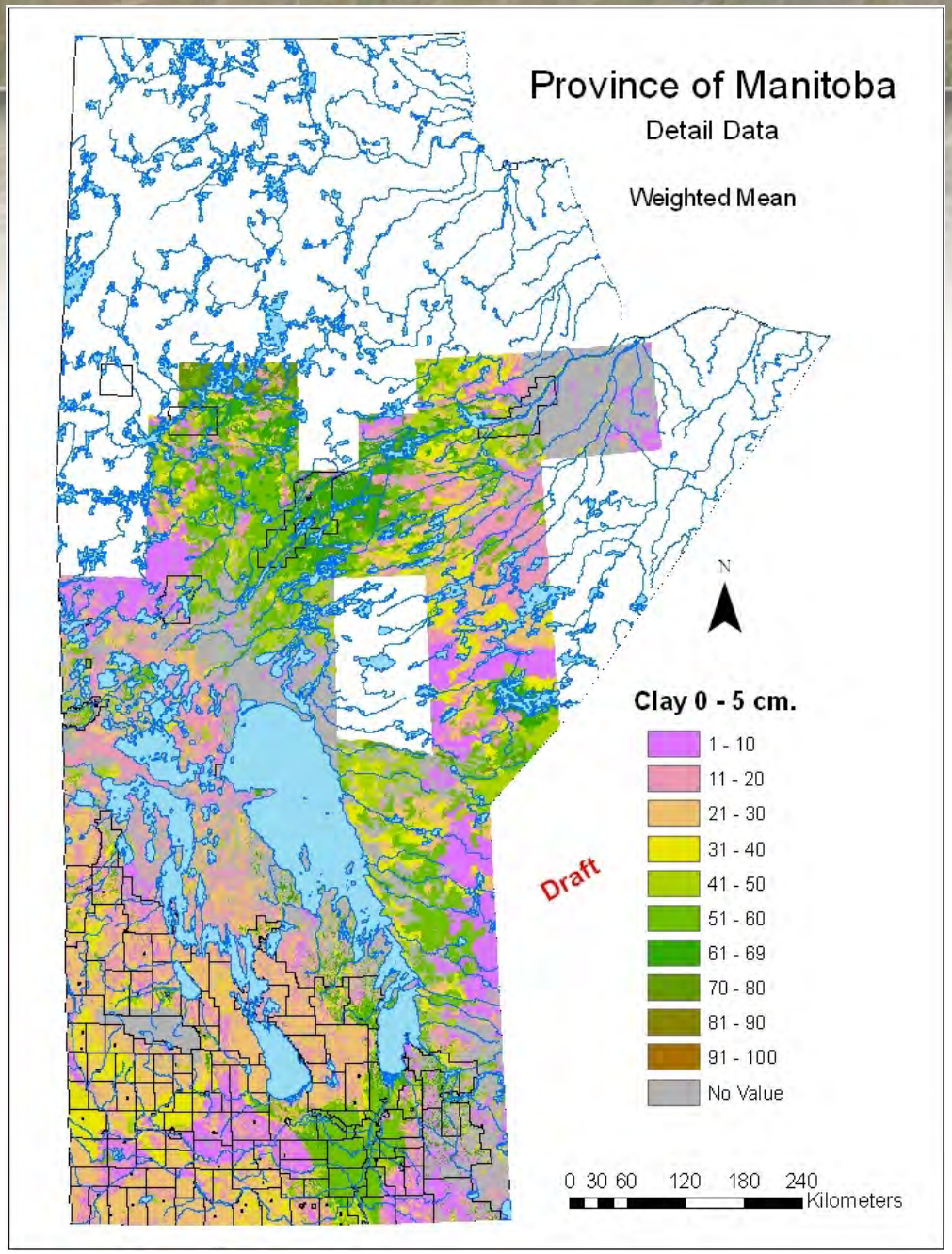

N
Clay 5-15 cm
-17 - 0
0.001 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
Splin
0
250
500
750
1,000
Kilometers

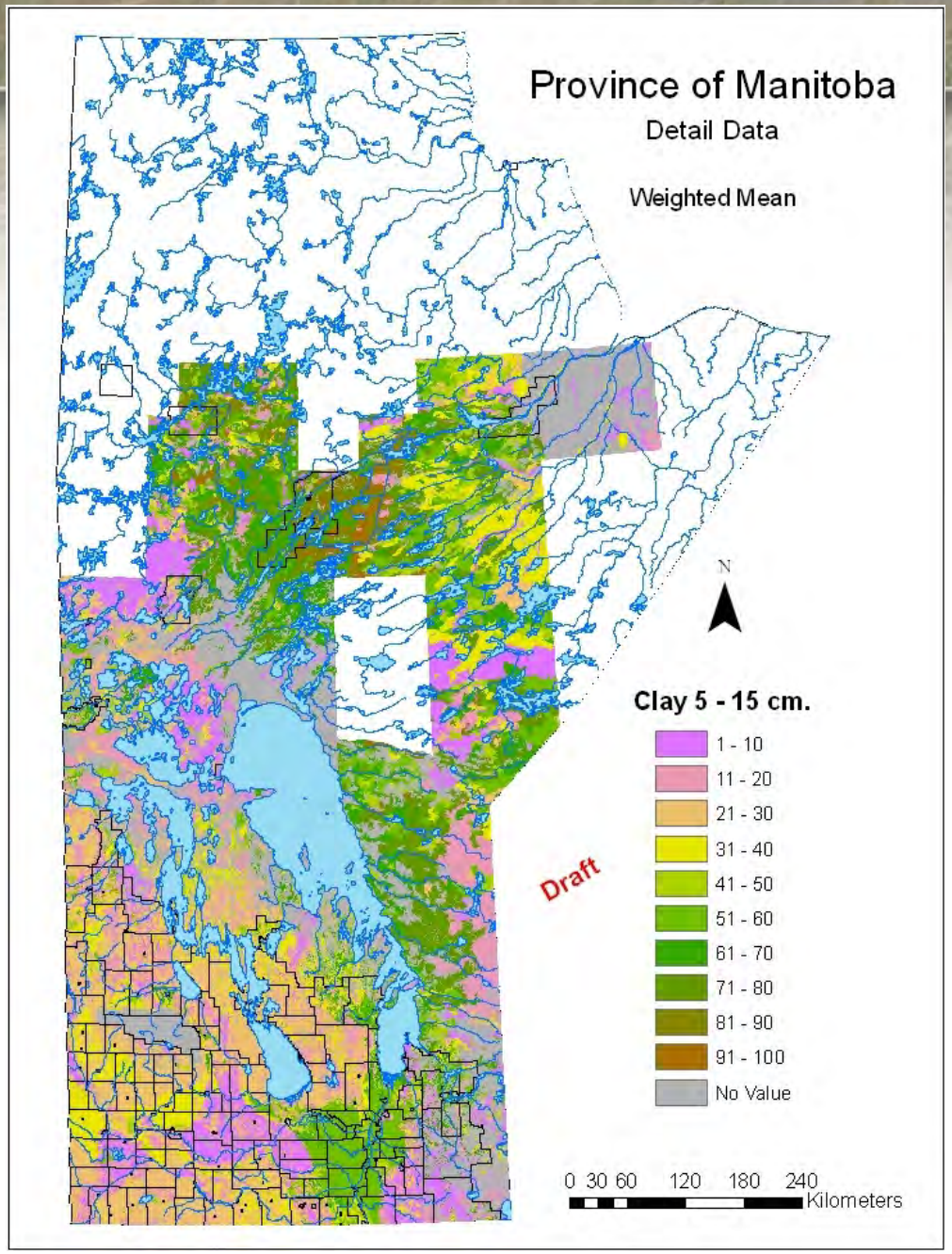

N
Clay 15-30 cm
-15 - 0
0.001 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
Splin
0
250
500
750
1,000
Kilometers


N
Clay 30-60 cm
-6 - 0
0.001 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
Splin
0
250
500
750
1,000
Kilometers


N
Clay 60-100 cm
-13 - 0
0.001 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
Splin
0
250
500
750
1,000
Kilometers


N
Clay 100-200 cm
-14 - 0
0.001 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
Splin
0
250
500
750
1,000
Kilometers


Province of Manitoba
Detail Data
Weighted Mean
N
Clay 0 - 5 cm.
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 69
70 - 80
81 - 90
91 - 100
No Value
Draft
0 30 60 120 180 240
Kilometers

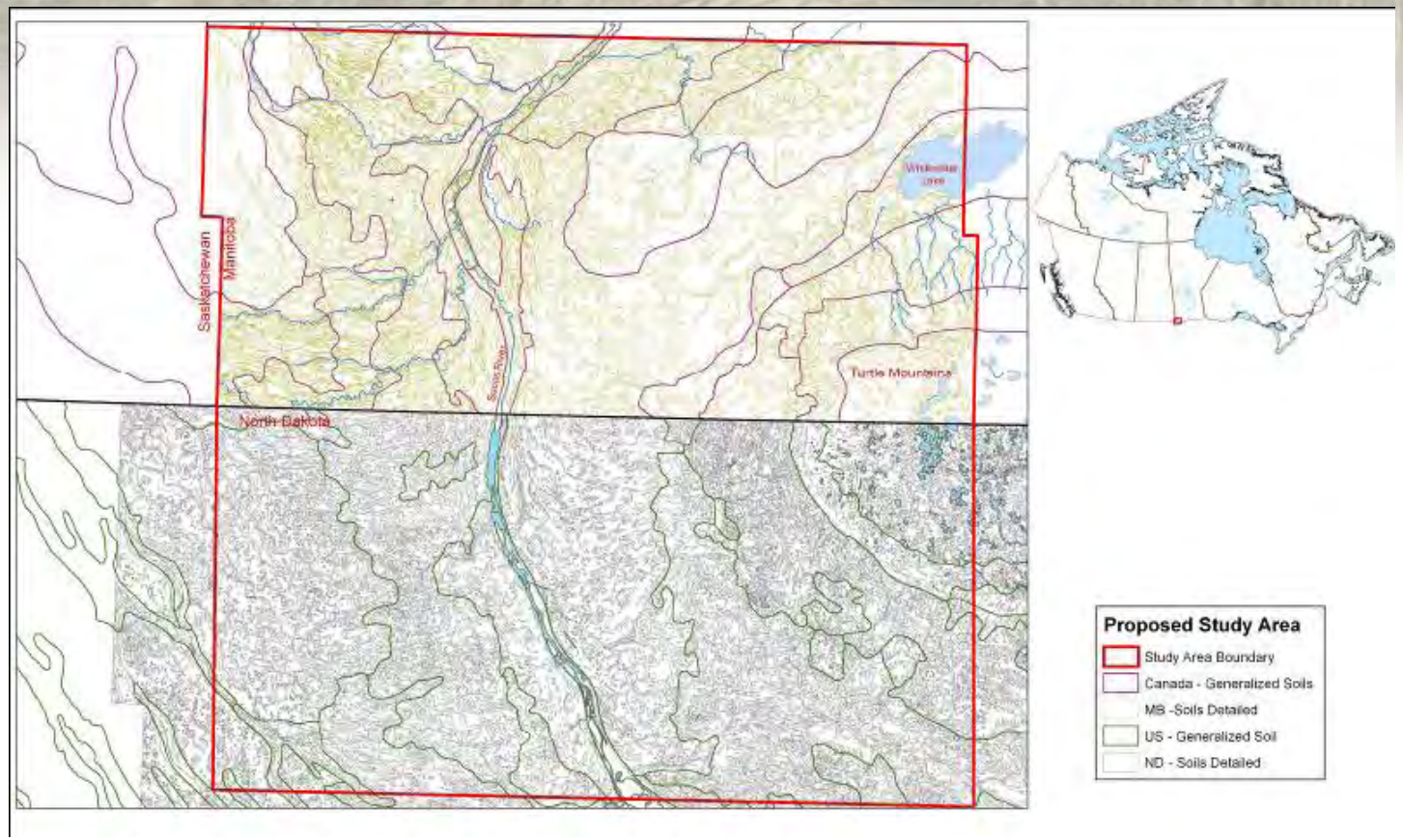

Province of Manitoba
Detail Data
Weighted Mean
N
Clay 5 - 15 cm.
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
No Value
Draft
0 30 60 120 180 240
Kilometers

GSM v0.1 and v0.5 Summary

- Currently do not completely meet GSM specifications
  - lack uncertainty attribute
  - methods
- Issues with the spatial extent of attributed legacy maps
  - (i.e. SLC v3.x) to facilitate GSM project
  - Several northern regions undergoing or planned to undergo upgrading
- Relatively quick and easy method of providing functional soil property maps and data from existing legacy information.
- Will be used in the development of integrated soil and landscape models, data and map products

Canada Pilot Area Disaggregation

Pilot Study Area



Only examined area within Canada in the Rural Municipalities of Arthur, Brenda Edward and Winchester of the Province of Manitoba

Process

- LandMapR Classification applied to 90 metre grid cells created using SRTM DEM
  - 15 default fuzzy landform classes
- Define Map zones
  - Similar polygons with similar soils
- Identify which soil is most likely to occupy landform class in each map zone
- Create a database of soil property values at specified depths for all listed soils
- Calculate a weighted average for all soil property values at all depths at every grid cell in the current map zone
- Create and evaluate map product

Names and attributes of the 15 default LandMapR fuzzy landform classes

LM3crule default 15 LSM classes			Slope Curvature		Slope		Generalized 3-4 classes		
ID No.	**Code**	**Name**	**Profile**	**Plan**	**Gradient**	**Other**	**ID No.**	**Code**	**Description**
1	LCR	Level crest	Planar	Planar	Low	Near Peak/Div	1	UP	Upper Slopes
2	DSH	Divergent Shoulder	Convex	Convex	Any	Low WI	1		
3	UDE	Upper Depression	Concave	Concave	Low	High WI	1		
4	BSL	Back slope	Planar	Planar	High	Near Half/Mid	2	MID	Mid Slopes
5	DBS	Divergent Back slope	Planar	Convex	High	Near Half/Mid	2		
6	CBS	Convergent Back slope	Planar	Concave	High	Near Half/Mid	2		
7	TER	Terrace	Planar	Planar	Low	Near Half/Mid	2		
8	SAD	Saddle	Concave	Convex	Any	Near Half/Mid	2		
9	MDE	Mid Slope Depression	Concave	Concave	Low	Near Half/Mid	2		
10	FSL	Foot slope	Concave	Concave	High	Near Chan/Pit	3	LOW	Lower Slopes
11	TSL	Toe slope	Planar	Planar	High	Near Chan/Pit	3		
12	FAN	Fan	Planar	Convex	High	Near Chan/Pit	3		
13	LSM	Lower Slope Mound	Convex	Convex	Any	Near Chan/Pit	3		
14	LLS	Level Lower Slope	Planar	Planar	Low	Near Chan/Pit	4	DEP	Depression
15	DEP	Lower Depression	Concave	Concave	Low	Near Chan/Pit	4		

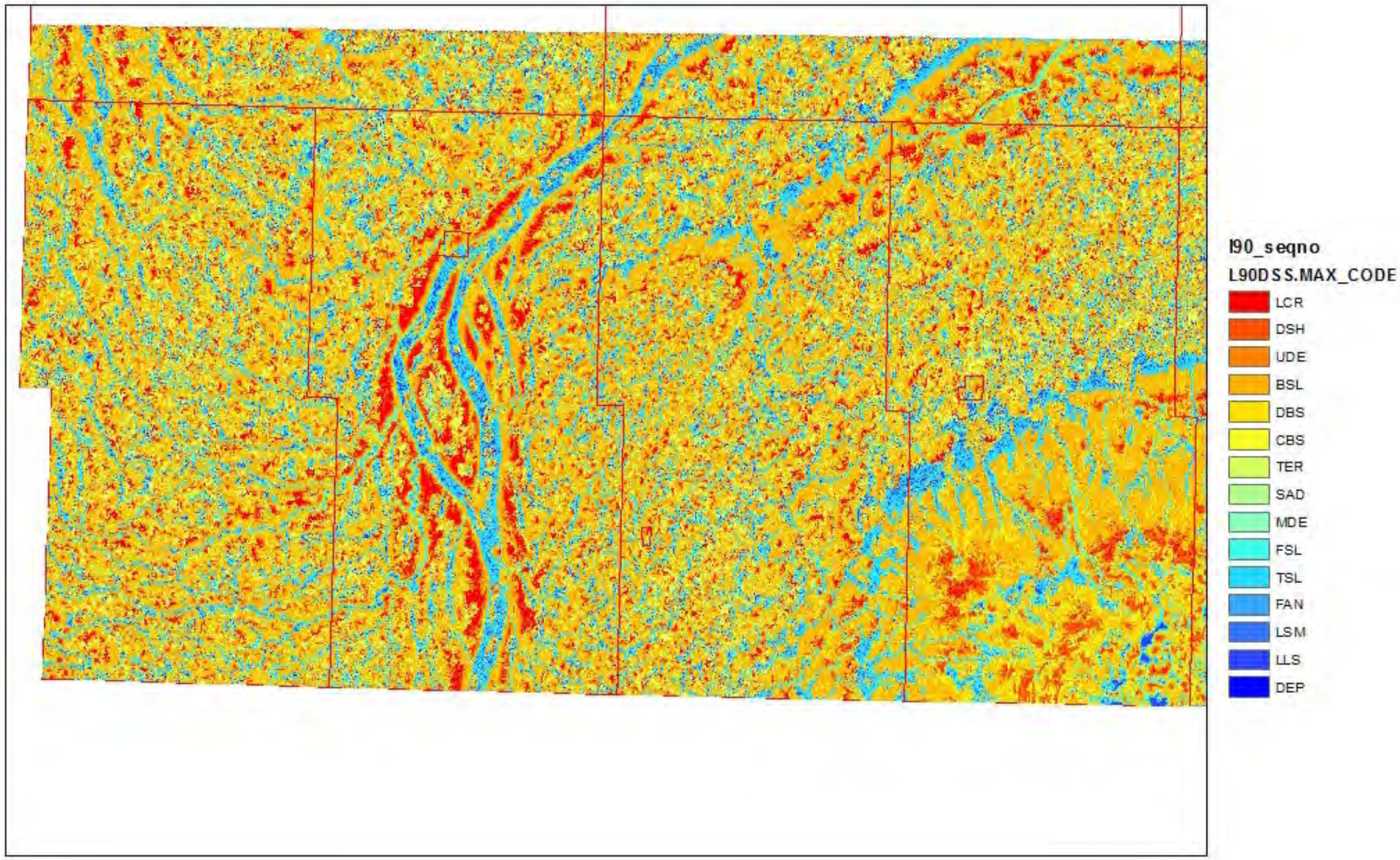
Example link table

Each landform position (Fuz_class) in each map zone is associated with a single most likely soil

Map_zone	Fuz_class	Fuz_code	Soil_no	Soil_code
2000	LCR	1	2	DRY
2000	DSH	2	2	DRY
2000	UDE	3	3	MOIST
2000	BSL	4	1	NOR
2000	DBS	5	2	DRY
2000	CBS	6	3	MOIST
2000	TER	7	1	NOR
2000	SAD	8	2	DRY
2000	MDE	9	3	MOIST
2000	FSL	10	5	DEEP
2000	TSL	11	5	DEEP
2000	FAN	12	2	DRY
2000	LSM	13	2	DRY
2000	LLS	14	5	DEEP
2000	DEP	15	4	WET
600	LCR	1	1	NOR
600	DSH	2	2	DRY

LandMapR Classification

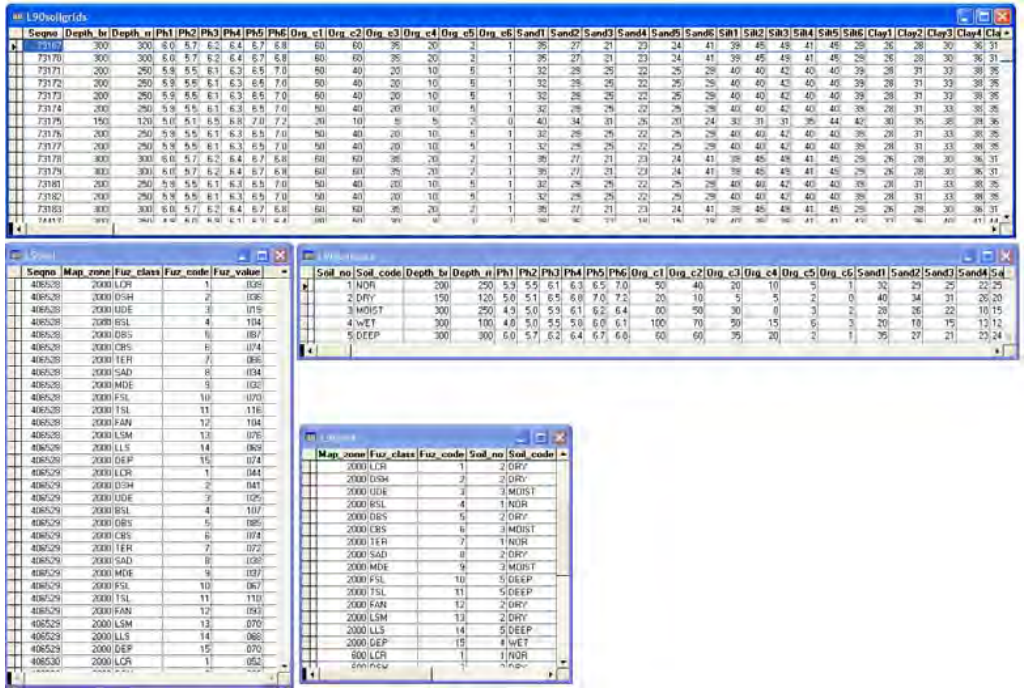
Rm's of Edward, Arthur, Brenda and Winchester



Soil Properties

- Identify which soil is most likely to occupy landform class in each map zone
  - 150 Soils described in the pilot study map area
  - 40 Unique associations identified for link tables
  - 8 associations had more than five soils requiring 20 additional link tables

- Create a database of soil property values at specified depths for all listed soils



L90soilgrids

Seqno	Depth_bt	Depth_tt	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	Org_c1	Org_c2	Org_c3	Org_c4	Org_c5	Org_c6	Sand1	Sand2	Sand3	Sand4	Sand5	Sand6	Silt1	Silt2	Silt3	Silt4	Silt5	Silt6	Clay1	Clay2	Clay3	Clay4	Cla
73167	300	300	6.0	5.7	6.2	6.4	6.7	6.8	60	60	35	20	2	1	35	27	21	23	24	41	39	45	49	41	45	29	26	28	30	36	31
73170	300	300	6.0	5.7	6.2	6.4	6.7	6.8	60	60	35	20	2	1	35	27	21	23	24	41	39	45	49	41	45	29	26	28	30	36	31
73171	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25	29	40	40	42	40	40	39	28	31	33	38	35
73172	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25	29	40	40	42	40	40	39	28	31	33	38	35
73173	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25	29	40	40	42	40	40	39	28	31	33	38	35
73174	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25	29	40	40	42	40	40	39	28	31	33	38	35
73175	150	120	5.0	5.1	6.5	6.8	7.0	7.2	20	10	5	5	2	0	40	34	31	26	20	24	33	31	31	35	44	42	30	35	38	39	36
73176	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25	29	40	40	42	40	40	39	28	31	33	38	35
73177	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25	29	40	40	42	40	40	39	28	31	33	38	35
73178	300	300	6.0	5.7	6.2	6.4	6.7	6.8	60	60	35	20	2	1	35	27	21	23	24	41	39	45	49	41	45	29	26	28	30	36	31
73179	300	300	6.0	5.7	6.2	6.4	6.7	6.8	60	60	35	20	2	1	35	27	21	23	24	41	39	45	49	41	45	29	26	28	30	36	31
73181	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25	29	40	40	42	40	40	39	28	31	33	38	35
73182	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25	29	40	40	42	40	40	39	28	31	33	38	35
73183	300	300	6.0	5.7	6.2	6.4	6.7	6.8	60	60	35	20	2	1	35	27	21	23	24	41	39	45	49	41	45	29	26	28	30	36	31

L90soil

Seqno	Map_zone	Fuz_class	Fuz_code	Fuz_value
406528	2000	LCR	1	035
406528	2000	DSH	2	036
406528	2000	UDE	3	015
406528	2000	BSL	4	104
406528	2000	DBS	5	087
406528	2000	CBS	6	074
406528	2000	TER	7	086
406528	2000	SAD	8	034
406528	2000	MDE	9	032
406528	2000	FSL	10	070
406528	2000	TSL	11	116
406528	2000	FAN	12	104
406528	2000	LSM	13	076
406528	2000	LLS	14	068
406528	2000	DEP	15	074
406529	2000	LCR	1	044
406529	2000	DSH	2	041
406529	2000	UDE	3	025
406529	2000	BSL	4	107
406529	2000	DBS	5	085
406529	2000	CBS	6	074
406529	2000	TER	7	072
406529	2000	SAD	8	030
406529	2000	MDE	9	027
406529	2000	FSL	10	067
406529	2000	TSL	11	110
406529	2000	FAN	12	093
406529	2000	LSM	13	070
406529	2000	LLS	14	066
406529	2000	DEP	15	070
406530	2000	LCR	1	052

L90soilcode

Soil_no	Soil_code	Depth_bt	Depth_tt	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	Org_c1	Org_c2	Org_c3	Org_c4	Org_c5	Org_c6	Sand1	Sand2	Sand3	Sand4	Sa
1	NOR	200	250	5.9	5.5	6.1	6.3	6.5	7.0	50	40	20	10	5	1	32	25	25	22	25
2	DRY	150	120	5.0	5.1	6.5	6.8	7.0	7.2	20	10	5	5	2	0	40	34	31	26	20
3	MOIST	300	250	4.9	5.0	5.9	6.1	6.2	6.4	60	50	30	0	3	2	28	26	22	10	15
4	WET	300	100	4.8	5.0	5.5	5.8	6.0	6.1	100	70	50	15	6	3	20	18	15	12	12
5	DEEP	300	300	6.0	5.7	6.2	6.4	6.7	6.8	60	60	35	20	2	1	35	27	21	23	24

L90soilcode

Map_zone	Fuz_class	Fuz_code	Soil_no	Soil_code
2000	LCR	1	2	DRY
2000	DSH	2	2	DRY
2000	UDE	3	3	MOIST
2000	BSL	4	1	NOR
2000	DBS	5	2	DRY
2000	CBS	6	3	MOIST
2000	TER	7	1	NOR
2000	SAD	8	2	DRY
2000	MDE	9	3	MOIST
2000	FSL	10	5	DEEP
2000	TSL	11	5	DEEP
2000	FAN	12	2	DRY
2000	LSM	13	2	DRY
2000	LLS	14	5	DEEP
2000	DEP	15	4	WET
600	LCR	1	1	NOR

Calculation

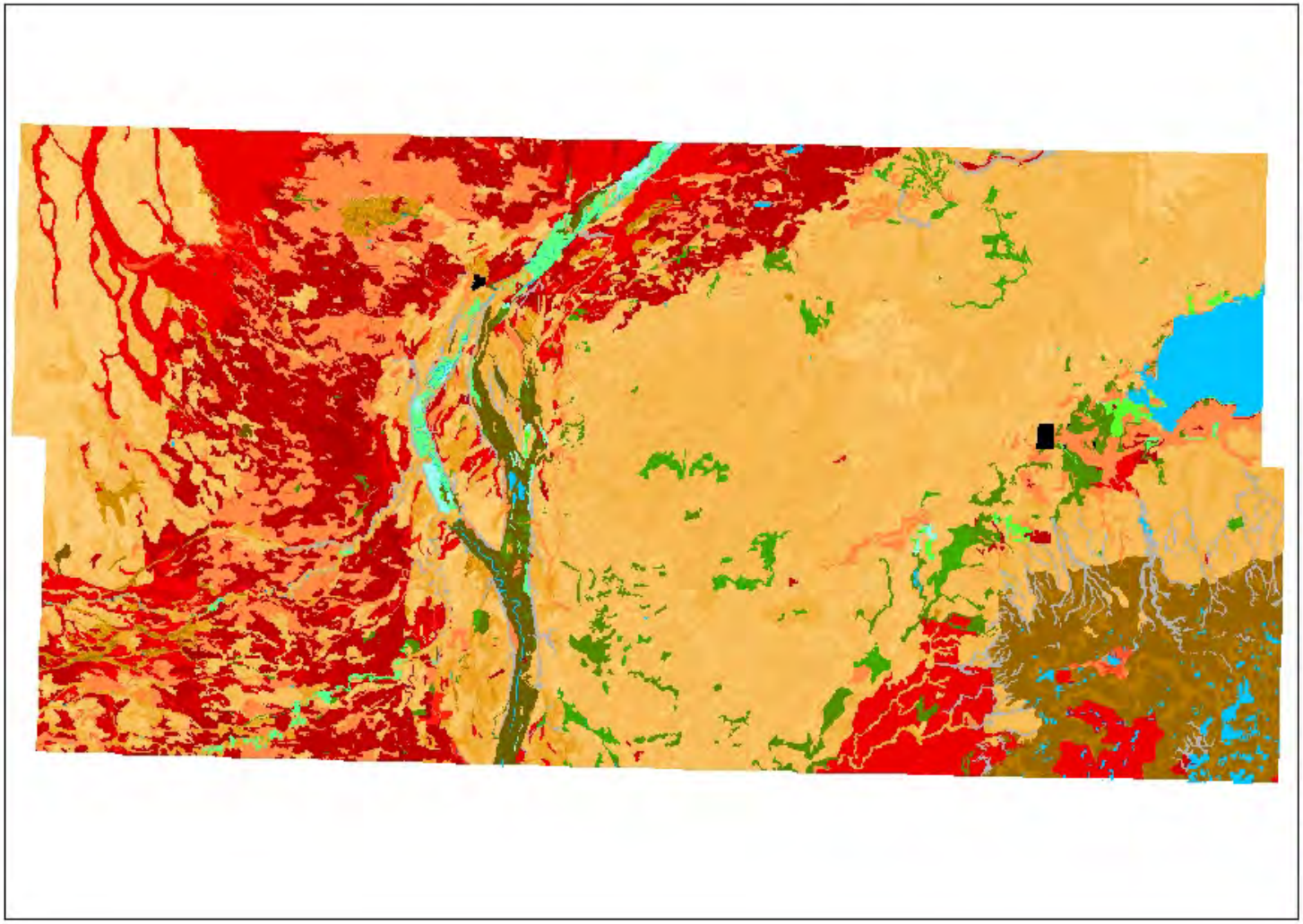
For any grid cell, we can identify the likelihood value for each defined landform position and the soil most likely to occupy that landform position.

To compute a weighted average for any soil property at any depth, we obtain the value for that soil property at that depth for the soil that has been identified as occupying a given landform position.

We then multiply the likelihood value of the landform position occurring at that grid location times the soil property value for the given depth for the soil assigned to that landform position in that zone.

We continue this calculation until all (or a specified number) of landform classes have been considered for that grid cell. The result is a weighted average estimate of the soil property value for that soil property and depth at that grid cell.

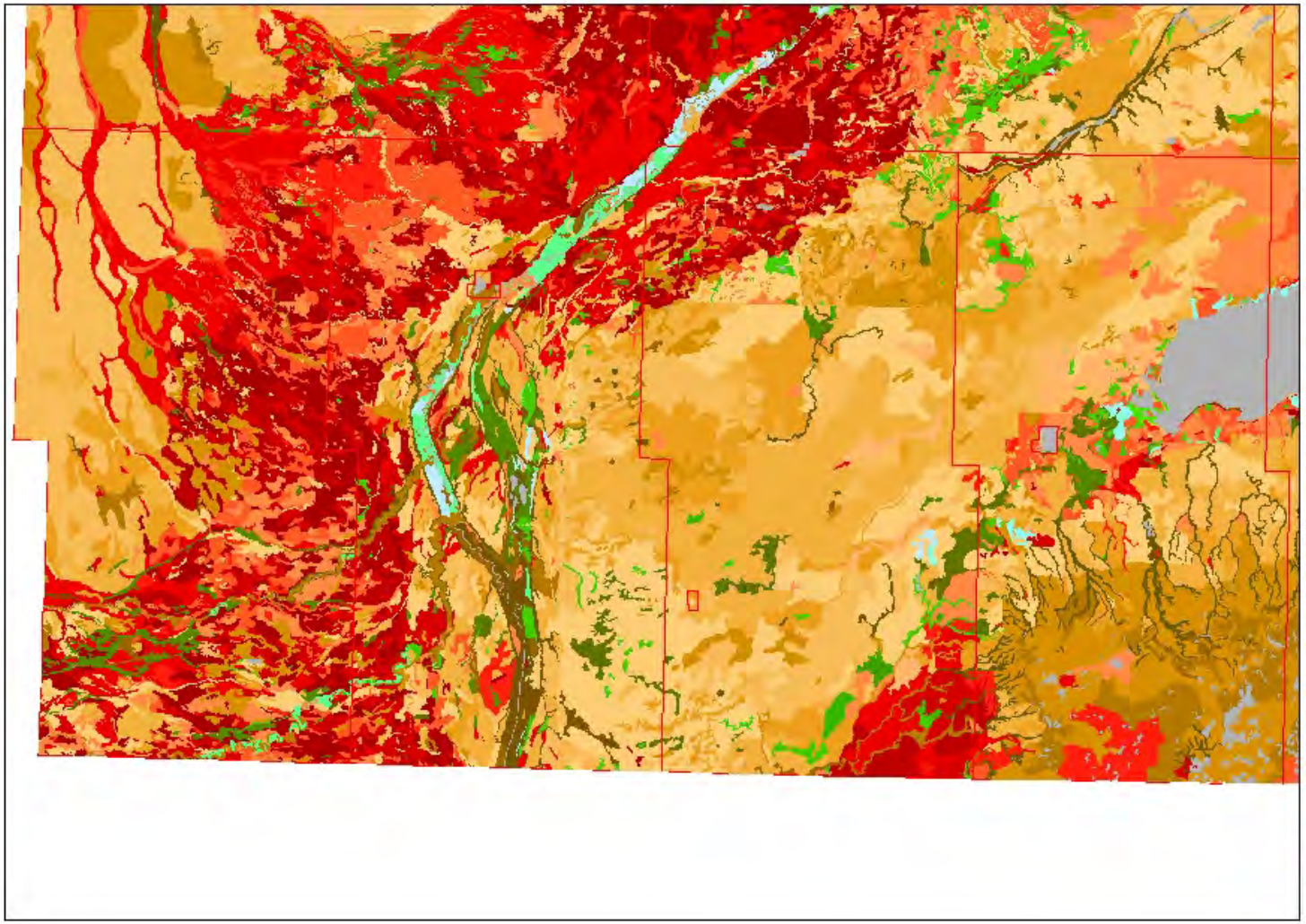
Soil Property Map of Clay (0-5 cm.)
for
Rm's of Edward, Arthur, Brenda and Winchester



l90_seqno
L90soilgrids15.CLAY1

- -9
- -8.999999999 - -7
- -6.999999999 - -6
- -5.999999999 - 0
- 0 - 8
- 8.000000001 - 10
- 10.00000001 - 12
- 12.00000001 - 14
- 14.00000001 - 16
- 16.00000001 - 18
- 18.00000001 - 20
- 20.00000001 - 21
- 21.00000001 - 22
- 22.00000001 - 23
- 23.00000001 - 24
- 24.00000001 - 25
- 25.00000001 - 26
- 26.00000001 - 27
- 27.00000001 - 28
- 28.00000001 - 29
- 29.00000001 - 30
- 30.00000001 - 32
- 32.00000001 - 34
- 34.00000001 - 36
- 36.00000001 - 38
- 38.00000001 - 40
- 40.00000001 - 42
- 42.00000001 - 44
- 44.00000001 - 46
- 46.00000001 - 48
- 48.00000001 - 50
- 50.00000001 - 52

Detail Version 0.5
for
Rm's of Edward, Arthur, Brenda and Winchester



dtl
dtl_polywmv_per.CLAY5

- 0
- 0.001 - 1
- 1.001 - 2
- 2.001 - 3
- 3.001 - 8
- 8.001 - 10
- 10.001 - 12
- 12.001 - 14
- 14.001 - 16
- 16.001 - 18
- 18.001 - 20
- 20.001 - 21
- 21.001 - 22
- 22.001 - 23
- 23.001 - 24
- 24.001 - 25
- 25.001 - 26
- 26.001 - 27
- 27.001 - 28
- 28.001 - 29
- 29.001 - 30
- 30.001 - 32
- 32.001 - 34
- 34.001 - 36
- 36.001 - 38
- 38.001 - 40
- 40.001 - 42
- 42.001 - 44
- 44.001 - 46
- 46.001 - 48
- 48.001 - 50
- 50.001 - 52

Next steps

- Pilot Area
  - Field trip this September to evaluate soils, landscapes and how they represent the Detail (0.5) and LandMapR disaggregation

- Data
  - Re-allocate soils and landform positions
  - Calculate using only dominant landscape
  - Calculate using four dominant landform groups
  - Integrate detail soil components directly with landform classes

- Presentations
  - Canadian Land Resource Network and Canadian Society of Soil Science DSM meetings, June 3 to 6 in Quebec City
  - SSSA DSM symposium in Cincinnati (October)