Supplementary Materials

Contents

Section 1. The number of First Nations in Saskatchewan, Canada

Indigenous Services Canada (ISC) lists 70 First Nations in Saskatchewan (*Table S1*), each with a band number and at least one reserve in the province (Aboriginal Affairs and Northern Development Canada, 2011). However, other sources report 74 (*FSIN Executive*, 2024) or 75 (Joseph, 2023) First Nations. The five First Nations missing from the ISC dataset are:

- Big Bear

- Chakastaypasin

- Peter Chapman

- Chacachas

- Stoney Knoll (Young Chippewayan, also spelled Chipeewayan)

This study only includes data from publicly available sources, most of which come from federal government records.

Section 2. Details of the land cover classification

Methodology

The reference data used for the supervised image classification were derived from FlySask2, high-resolution imagery in Google Earth Pro, and the AAFC Annual Crop Inventory product, all of which were visually interpreted. To ensure temporal consistency, the selected data points were tested using the Continuous Change Detection and Classification (CCDC) algorithm, confirming no abrupt changes within the five-year windows used for image composition(Arévalo et al., 2020). 715 reference points for the Pre-Land Claims era and 723 for the Post-Land Claims era were used for supervised classification. Of these, 80% were allocated for classifier training, while the remaining 20% was reserved for accuracy validation. Figure S3 shows the land cover classification results for Pre- and Post- Land Claims periods.

Five quality metrics were explored to evaluate the accuracy of the land use classification: 1) the overall accuracy (OA), 2) the kappa coefficient (K), 3) the user's accuracy (UA), 4) the producer's accuracy (PA), and 5) the F score (F_1) (Becker et al., 2021).

$$OA = \frac{Number\ of\ correctly\ classified\ samples}{Number\ of\ all\ samples} * 100\%$$

Equation 1

$$K = \frac{OA - Estimated\ chance\ agreement}{1 - Estimated\ chance\ agreement}$$

Equation 2

$$UA = \frac{Number\ of\ correctly\ classfied\ samples\ in\ each\ class}{Number\ of\ samples\ to\ that\ class} * 100\%$$

Equation 3

$$PA = \frac{Number\ of\ correctly\ classfied\ samples\ in\ each\ class}{Number\ of\ samples\ from\ reference\ data\ in\ each\ class} * 100\%$$

<div align="right">Equation 4</div>

$$F_1 = \frac{2 * UA * PA}{UA + PA}$$

<div align="right">Equation 5</div>

Overall Accuracy (*OA*) and Cohen's Kappa (*K*) are critical indicators for assessing land use classification accuracy. *K*, also known as Cohen's Kappa coefficient, measures inter-rater reliability for categorical items (Zhao et al., 2024). User's Accuracy (*UA*) indicates the probability that a pixel was correctly classified within a given class. At the same time, the Producer's Accuracy (*PA*) reflects the likelihood that a pixel classified in a given map class represents that class on the ground. The F_1-score, the harmonic mean of Producer's and User's accuracies, evaluates accuracy at the class level (Nasiri et al., 2022). These metrics were assessed to ensure the land use map generated before the Land Claims period was accurate enough to explore land use diversity within and outside the First Nations Reserves.

Results

The land cover classification accuracy assessment was conducted for both the Pre-Land Claims (1988–1992) and Post-Land Claims (2020–2024) periods to evaluate classification performance (Table S4 and Table S5). The overall accuracy (OA) reached 86.9% for the Pre-Land Claims classification, with a Cohen's Kappa coefficient of 81.7%, indicating substantial agreement. The F1-scores varied across different land cover types, with cropland achieving the highest accuracy (92.7%) and grassland showing lower accuracy (77.4%). The UA and PA metrics similarly reflected high classification reliability for most land cover categories (Table S4). For the Post-Land Claims classification, the OA was slightly lower at 85.5%, with a Cohen's Kappa of 81.5%.

The cropland category maintained high classification performance (92.0% F1-score), while grassland and wetland exhibited relatively lower accuracy (76.9% and 72.0% F1-scores, respectively). The decrease in classification accuracy for specific land cover types may be attributed to increased landscape heterogeneity in the Post-Land Claims period (Table S5).

Section 3. Determination of the dominant AC from CLI

The corresponding percentages were used to calculate the dominant soil agricultural capability AC for polygons containing multiple classes in the AC rating.

$$AC = \begin{cases} \sum_{i=A}^{D} Class_i * Percent_i, & (if\ any\ class\ labled\ as\ 'Organic\ Soils'\ has\ the\ Percent < 50\%) \\ 0, & (if\ any\ class\ labled\ as\ 'Organic\ Soils'\ has\ the\ Percent \geq 50\%) \end{cases}$$

Equation 6

A 50% threshold was applied to each polygon in the Canada Land Inventory (CLI) product to filter out fields with a higher percentage of organic soil. For polygons with less than 50% Organic soil composition, Equation 6 was used to calculate the AC score. Subsequently, the CLI product and the land use map were overlaid to conduct zonal statistics, analyzing AC under different land covers (*Figure S2*).

Tables:

Table S1 List of all the First Nations provided by the ISC (70); the 58 Nations within the study region are in **_bold Italics_**.

Count	Band NO.	Band Name	Main Reserve	Treaty	Tribal Council
1	*406*	*Ahtahkakoop Cree Nation*	*Ahtahkakoop 104*	*6*	*Battlefords Agency Tribal Chiefs*
2	*369*	*Beardy's and Okemasis*	*Beardy's 96 & 97*	*6*	*Independent*
3	*399*	*Big Island Lake Cree Nation*	*Big Island Lake 124*	*6*	*Meadow Lake Tribal Council*
4	*404*	*Big River First Nation*	*Big River 118A*	*6*	*Agency Chiefs Tribal Council*
5	403	Birch Narrows First Nation	Churchill Lake 193A	10	Meadow Lake Tribal Council
6	359	Black Lake Denesuline Nation	Black Lake 221	8/10	Prince Albert Grand Council
7	398	Buffalo River Dene Nation	Buffalo River Dene 193	10	Meadow Lake Tribal Council
8	394	Canoe Lake Cree First Nation	Canoe Lake 165	10	Meadow Lake Tribal Council
9	*378*	*Carry The Kettle Nakoda Nation*	*Carry The Kettle 76*	*4*	*File Hills Qu'Appelle Tribal Council*
10	401	Clearwater River Dene Nation	Clearwater River 222	8	Meadow Lake Tribal Council
11	*366*	*Cote First Nation*	*Cote 366*	*4*	*Yorkton Tribal Council*
12	*361*	*Cowessess First Nation*	*Cowessess 73*	*4*	*File Hills Qu'Appelle Tribal Council*
13	350	Cumberland House Cree Nation	Cumberland House 20	5	Prince Albert Grand Council
14	*389*	*Day Star First Nation*	*Day Star 87*	*4*	*File Hills Qu'Appelle Tribal Council*
15	400	English River First Nation	La Plonge 192	10	Prince Albert Grand Council
16	*390*	*Fishing Lake First Nation*	*Fishing Lake 89A*	*4*	*Yorkton Tribal Council*
17	*395*	*Flying Dust First Nation*	*Flying Dust 105*	*6*	*Meadow Lake Tribal Council*
18	351	Fond du Lac Denesuline Nation	Fond du Lac 227	8	Prince Albert Grand Council
19	*391*	*George Gordon First Nation*	*George Gordon 86*	*4*	*File Hills Qu'Appelle Tribal Council*
20	352	Hatchet Lake Denesuline Nation	Hatchet Lake 183	10	Prince Albert Grand Council
21	*370*	*James Smith Cree Nation*	*James Smith 100*	*6*	*Prince Albert Grand Council*
22	*362*	*Kahkewistahaw First Nation*	*Kahkewistahaw 72*	*4*	*Yorkton Tribal Council*

Count	Band NO.	Band Name	Main Reserve	Treaty	Tribal Council
23	*393*	*Kawacatoose First Nation*	*Kawacatoose 88*	*4*	*Touchwood Agency Tribal Council*
24	*367*	*Keeseekoose First Nation*	*Keeseekoose 66*	*4*	*Yorkton Tribal Council*
25	*377*	*Kinistin Saulteaux Nation*	*Kinistin 91*	*4*	*Saskatoon Tribal Council*
26	*353*	*Lac La Ronge Indian Band*	*Lac La Ronge 156*	*6*	*Prince Albert Grand Council*
27	*379*	*Little Black Bear First Nation*	*Little Black Bear 84*	*4*	*File Hills Qu'Appelle Tribal Council*
28	*340*	*Little Pine First Nation*	*Little Pine 116*	*6*	*Battlefords Tribal Council*
29	*341*	*Lucky Man Cree Nation*	*Lucky Man 72*	*6*	*Battlefords Tribal Council*
30	*396*	*Makwa Sahgaiehcan First Nation*	*Makwa Sahgaiehcan 129*	*6*	*Meadow Lake Tribal Council*
31	*397*	*Ministikwan Lake Cree Nation*	*Ministikwan 161*	*6*	*Meadow Lake Tribal Council*
32	*374*	*Mistawasis Nêhiyawak*	*Mistawasis 103*	*6*	*Saskatoon Tribal Council*
33	354	Montreal Lake Cree Nation	Montreal Lake 106	6	Prince Albert Grand Council
34	*342*	*Moosomin First Nation*	*Moosomin 112B*	*6*	*Battlefords Tribal Council*
35	*343*	*Mosquito, Grizzly Bear's Head, Lean Man*	*Mosquito 109*	*6*	*Battlefords Tribal Council*
36	*381*	*Muscowpetung Saulteaux Nation*	*Muscowpetung 80*	*4*	*File Hills Qu'Appelle Tribal Council*
37	*375*	*Muskeg Lake Cree Nation*	*Muskeg Lake 102*	*6*	*Saskatoon Tribal Council*
38	*371*	*Muskoday First Nation*	*Muskoday 99*	*6*	*Saskatoon Tribal Council*
39	*392*	*Muskowekwan First Nation*	*Muskowekwan 85*	*4*	*Touchwood Agency Tribal Council*
40	*380*	*Nekaneet First Nation*	*Nekaneet 160A*	*4*	*Independent*
41	*408*	*Ocean Man First Nation*	*Ocean Man 69*	*4*	*File Hills Qu'Appelle Tribal Council*
42	*363*	*Ochapowace Nation*	*Ochapowace 71*	*4*	*File Hills Qu'Appelle Tribal Council*
43	*382*	*Okanese First Nation*	*Okanese 82*	*4*	*File Hills Qu'Appelle Tribal Council*
44	*373*	*One Arrow First Nation*	*One Arrow 95*	*6*	*Saskatoon Tribal Council*
45	*344*	*Onion Lake Cree Nation*	*Onion Lake 119-1*	*6*	*Independent*
46	*383*	*Pasqua First Nation*	*Pasqua 79*	*4*	*File Hills Qu'Appelle Tribal Council*
47	*384*	*Peepeekisis Cree Nation*	*Peepeekisis 81*	*4*	*File Hills Qu'Appelle Tribal Council*
48	*405*	*Pelican Lake First Nation*	*Pelican Lake 191*	*6*	*Agency Chiefs Tribal Council*

Count	Band NO.	Band Name	Main Reserve	Treaty	Tribal Council
49	355	Peter Ballantyne Cree Nation	Amiskosakahikan 210	6/10	Prince Albert Grand Council
50	409	Pheasant Rump Nakota Nation	Pheasant Rump 68	4	Independent
51	385	Piapot First Nation	Piapot 75	4	File Hills Qu'Appelle Tribal Council
52	345	Poundmaker Cree Nation	Poundmaker 114	6	Battlefords Tribal Council
53	356	Red Earth Cree Nation	Red Earth 29	5	Prince Albert Grand Council
54	346	Red Pheasant First Nation	Red Pheasant 108	6	Battlefords Tribal Council
55	347	Saulteaux First Nation	Saulteaux 159	6	Battlefords Tribal Council
56	357	Shoal Lake Cree Nation	Shoal Lake 28A	5	Prince Albert Grand Council
57	386	Standing Buffalo Dakota Nation	Standing Buffalo 78	4	File Hills Qu'Appelle Tribal Council
58	387	Star Blanket Cree Nation	Star Blanket 83	4	File Hills Qu'Appelle Tribal Council
59	360	Sturgeon Lake First Nation	Sturgeon Lake 154	6	Prince Albert Grand Council
60	348	Sweetgrass First Nation	Sweetgrass 113	6	Battlefords Tribal Council
61	368	The Key First Nation	The Key 65	4	Yorkton Tribal Council
62	349	Thunderchild First Nation	Thunderchild 115B	6	Battlefords Tribal Council
63	358	Wahpeton Dakota Nation	Wahpeton 94A	6	Prince Albert Grand Council (non-signatory)
64	402	Waterhen Lake First Nation	Waterhen Lake 130	6	Meadow Lake Tribal Council
65	365	White Bear First Nations	White Bear 70	4	File Hills Qu'Appelle Tribal Council
66	372	Whitecap Dakota First Nation	Whitecap 94	6	Saskatoon Tribal Council
67	407	Witchekan Lake First Nation	Witchekan Lake 117	6	Battlefords Tribal Council
68	388	Wood Mountain First Nation	Wood Mountain 160	4	Independent
69	376	Yellow Quill First Nation	Yellowquill 90	4	Saskatoon Tribal Council
70	364	Zagime Anishinabek	Sakimay 74	4	File Hills Qu'Appelle Tribal Council

Table S2 Ecoregional Characteristics of the 58 First Nation Reserves in the study region.

Ecoregion Name	Number of First Nations	Area (km²)	Mean annual temperature (˚C)	Mean annual precipitation (mm)	Dominant soil type	Natural vegetative cover
Aspen Parkland	29	$8.17*10^4$	1.5	400-500	Black Chernozem, Gleysol	Trembling aspen, oak, mixed tall shrubs, intermittent fescue grasslands
Boreal Transition	21	$5.41*10^4$	1.0	450-550	Gray Luvisol, Dark Gray Chernozem	Deciduous forest and farmland
Cypress Upland	1	$4.86*10^3$	3	325-450	Chernozemic Black and Dark Brown	fescue and wheatgrass grasslands, mixed montane-type open forest and shrub
Mid_Boreal Lowland	2	$2.15*10^4$	-1	375-625	Eutric Brunisols and Mesisols	Tamarack, balsam fir, and black spruce
Mid_Boreal Uplands	3	$6.78*10^3$	0	100-550	Gray Luvisol	Mixed coniferous and deciduous forest
Mixed Grassland	1	$8.64*10^4$	2.5	250-350	Brown Chernozern, Solonetz	Spear grass, blue grama grass, wheat grass
Moist Mixed Grassland	1	$6.78*10^4$	2.5	350-400	Dark Brown Chernozem, Solonetz	Spear grass, wheat grass, and deciduous shrubs, including buckbrush, chokecherry, wolf willow, and Saskatoon berry

Table S3 Land capability classification for agriculture classes.

AC Class	Description	Category
1	Soils in this class have no significant limitations when used for crops.	**Prime or high-quality**
2	Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.	
3	Soils in this class have moderately severe limitations that restrict the range of crops or require particular conservation practices.	**Marginal, or less suitable for agriculture**
4	Soils in this class have severe limitations that restrict the range of crops or require particular conservation practices.	
5	Soils in this class had very severe limitations that restricted their capability to produce perennial forage crops, and improvement practices were feasible.	**Limited capacity for cropland, only for forage crops**
6	Soils in this class can only produce perennial forage crops, and improvement practices are not feasible.	
7	Soils in this class have no capacity for arable culture or permanent pasture.	**Unsuitable for Farming**
8		Unclassified (**UN**)
O	Organic Soils (not placed in capability classes).	**O**

Table S4 Accuracy assessment matrix for the land cover classification of the Pre-Land Claims era (1989-1992 composition)

		Validation Data								
	Class	*Settlement*	*Water*	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Other Land*	**Total**	**UA**
	Settlement	**8**	0	0	0	0	0	1	9	88.9%
Classification Results	*Water*	0	**9**	0	0	0	1	0	10	90.0%
	Forest	0	1	**18**	2	1	0	0	22	81.9%
	Cropland	1	0	1	**63**	3	0	0	68	92.7%
	Grassland	0	0	2	2	**15**	1	0	20	75.0%
	Wetland	0	2	0	1	0	**9**	0	12	75.0%
	Other Land	0	0	0	0	0	0	**3**	3	100.0%
	Total	9	12	21	68	19	11	4	**144**	
	PA	88.9%	75.0%	85.8%	92.7%	79.9%	81.7%	75%		
	OA	86.9%								
	F$_1$	88.9%	81.8%	83.8%	92.7%	77.4%	78.2%	85.7%		
	K	81.7%								

Table S5 Accuracy assessment matrix for the land cover classification of the Post-Land Claims era (2019-2023 composition)

		Validation Data								
	Class	*Settlement*	*Water*	*Forest*	*Cropland*	*Grassland*	*Wetland*	*Other Land*	**Total**	**UA**
	Settlement	**8**	0	0	0	0	0	1	9	88.9%
Classification Results	*Water*	0	**9**	0	0	0	1	0	10	90.0%
	Forest	1	1	**17**	1	1	1	0	22	77.3%
	Cropland	1	0	1	**63**	2	1	0	68	91.7%
	Grassland	1	0	1	3	**15**	1	0	21	71.4%
	Wetland	0	1	1	1	0	**9**	0	12	75.0%
	Other Land	0	0	0	0	0	0	**3**	3	100.0%
	Total	11	11	20	68	18	13	4	**145**	
	PA	72.7%	81.8%	85.0%	92.7%	83.3%	69.2%	75.0%		
	OA	85.5%								
	F$_1$	80.0%	85.7%	81.1%	92.0%	76.9%	72.0%	85.7%		
	K	81.5%								

Table S6 The land cover change matrix of the original Reserves between 1992 and 2024.

Original Reserves		Pre-Land Claims (**1992**)							
	Land cover types (%)	Settlement	Water	Forest	Cropland	Grassland	Wetland	Others	Subtotal
Post-Land Claims (2024)	**Settlement**	0.53	0.01	0.01	0.02	0.01	0.02	0.00	0.60
	Water	0.08	2.28	0.01	0.09	0.12	0.36	0.01	2.95
	Forest	0.12	0.55	31.85	7.78	0.79	1.01	0.00	42.10
	Cropland	0.87	0.21	0.22	27.28	1.07	0.54	0.00	30.19
	Grassland	0.92	0.02	2.43	2.27	8.54	1.08	0.00	15.26
	Wetland	0.00	0.40	3.10	0.30	0.02	5.08	0.00	8.90
	Others	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Subtotal	2.53	3.47	37.62	37.74	10.55	8.09	0.01	

Table S7 The land cover change matrix of the Additions between 1992 and 2024

Additions		Pre-Land Claims (**1992**)							
	Land cover types (%)	Settlement	Water	Forest	Cropland	Grassland	Wetland	Others	Subtotal
Post-Land Claims (2024)	**Settlement**	1.14	0.01	0.00	0.00	0.01	0.00	0.00	1.16
	Water	0.01	2.69	0.02	0.03	0.12	0.08	0.01	2.96
	Forest	0.01	1.61	22.73	8.42	0.82	0.36	0.00	33.95
	Cropland	0.09	0.14	0.08	34.68	0.26	1.85	0.00	37.10
	Grassland	0.06	0.51	0.58	4.07	10.09	4.28	0.00	19.59
	Wetland	0.05	0.33	0.08	0.28	0.02	4.50	0.00	5.24
	Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subtotal	1.36	5.29	23.49	47.48	11.32	11.06	0.01	

Table S8 Percentage of land cover types across soil agricultural capability scores (AC) in original Reserves (2024 Land Cover Classification).

Original Reserves	Land Cover Type						
	Settlement	**Water**	**Forest**	**Cropland**	**Grassland**	**Wetland**	**Others**
AC (%)							
1	1.92	1.29	7.10	83.91	0.80	4.99	0.00
2	2.23	3.14	15.31	71.66	2.47	5.19	0.00
3	1.94	3.74	25.28	48.06	6.08	14.90	0.00
4	2.18	7.71	43.38	29.08	5.46	12.18	0.01
5	2.29	9.52	49.57	15.74	11.69	11.18	0.01
6	1.62	3.14	46.89	21.36	13.44	13.53	0.02
7	1.16	37.67	28.76	8.99	3.74	19.68	0.00
8	0.01	0.13	92.96	0.00	0.00	6.90	0.00
O	1.00	13.87	67.12	5.75	1.52	10.72	0.01

Table S9 Percentage of land cover types across soil agricultural capability scores (AC) in Additions of the Reserves (2024 Land Cover Classification).

Additions	Land Cover Type						
	Settlement	**Water**	**Forest**	**Cropland**	**Grassland**	**Wetland**	**Others**
AC (%)							
1	1.73	1.16	2.72	90.89	0.60	2.90	0.00
2	1.85	2.30	9.66	80.61	2.49	3.08	0.00
3	1.43	2.98	11.66	76.84	1.34	5.75	0.00
4	1.21	2.71	34.28	52.16	4.15	5.49	0.00
5	1.08	5.23	30.24	28.84	26.09	8.52	0.01
6	1.64	1.78	37.87	23.45	28.40	6.83	0.02
7	1.29	23.26	20.23	5.19	22.98	17.57	9.48
8	1.10	0.46	92.20	0.27	0.03	5.93	0.01
O	0.88	4.86	78.47	2.58	1.30	11.81	0.10

Figures:
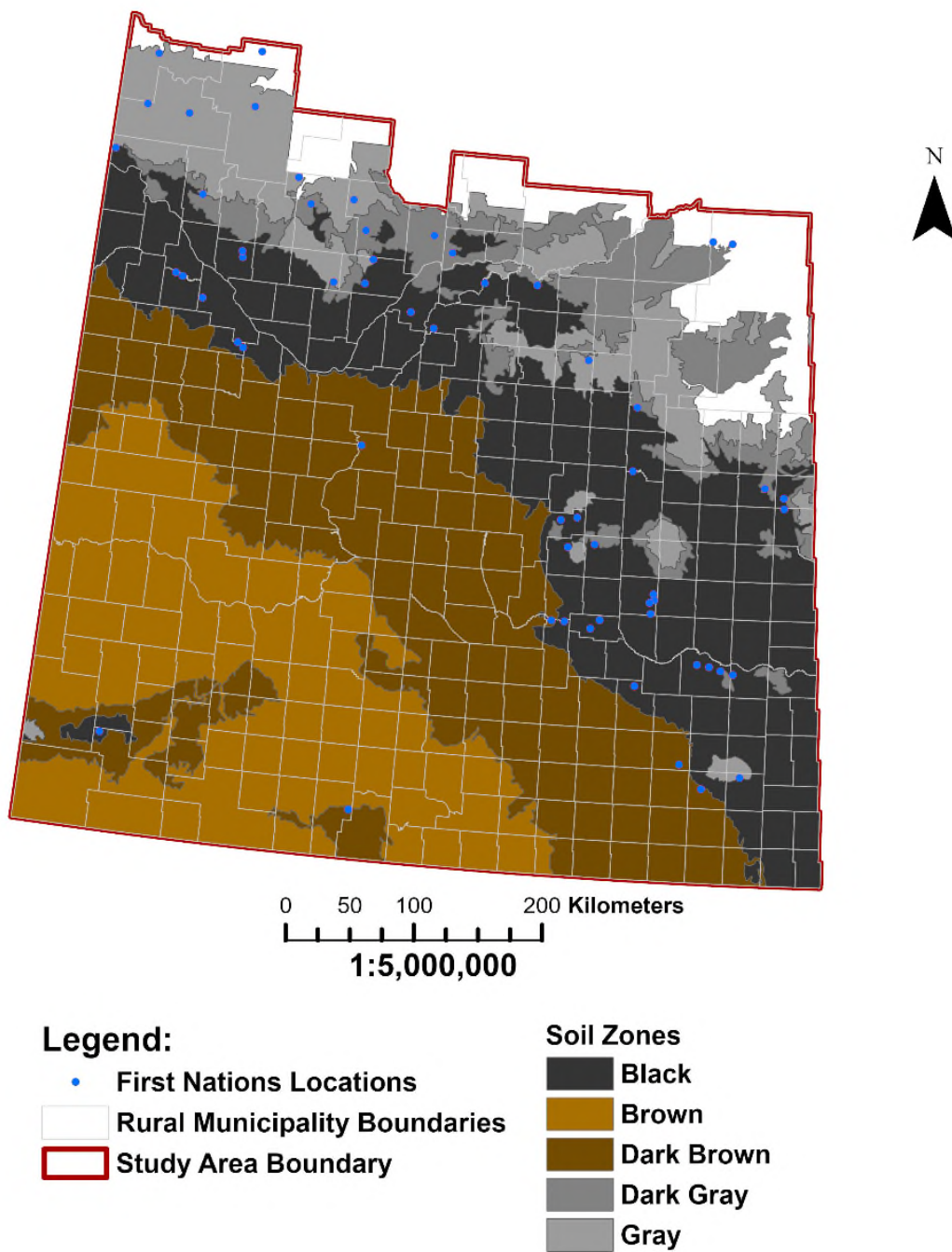
Figure S1 Soil Zones of Southern Saskatchewan in Relation to 58 First Nation Reserves
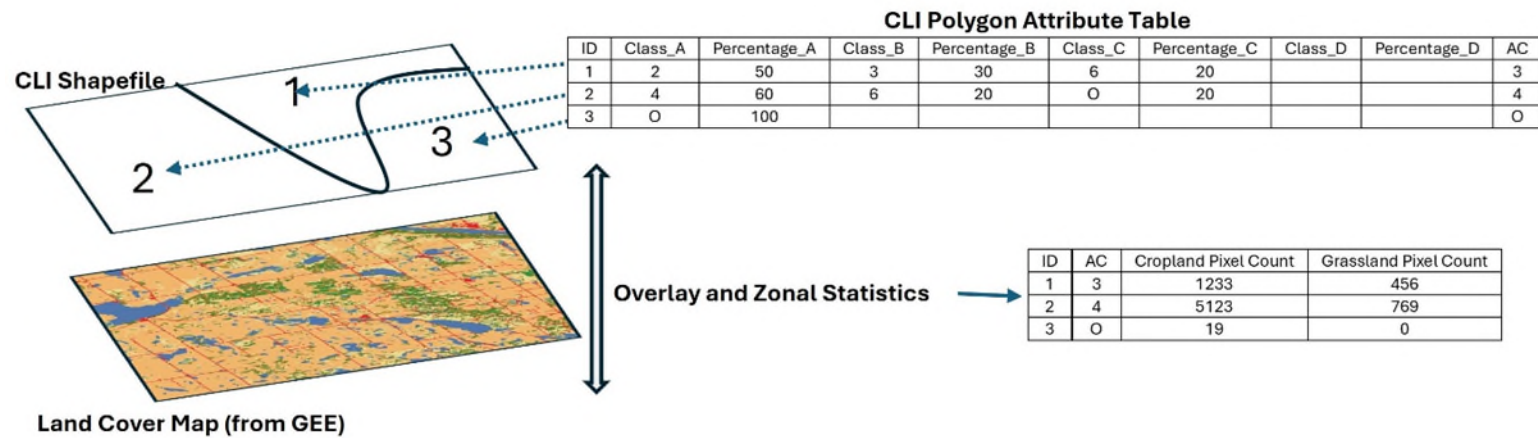
Locations.

CLI Polygon Attribute Table

ID	Class_A	Percentage_A	Class_B	Percentage_B	Class_C	Percentage_C	Class_D	Percentage_D	AC
1	2	50	3	30	6	20			3
2	4	60	6	20	O	20			4
3	O	100							O

CLI Shapefile

Overlay and Zonal Statistics

ID	AC	Cropland Pixel Count	Grassland Pixel Count
1	3	1233	456
2	4	5123	769
3	O	19	0

Land Cover Map (from GEE)

Figure S2 Illustration of the workflow for determining the dominant agricultural capability score for each CLI polygon (i.e., soil map unit) from the CLI product with the Land Cover Map.
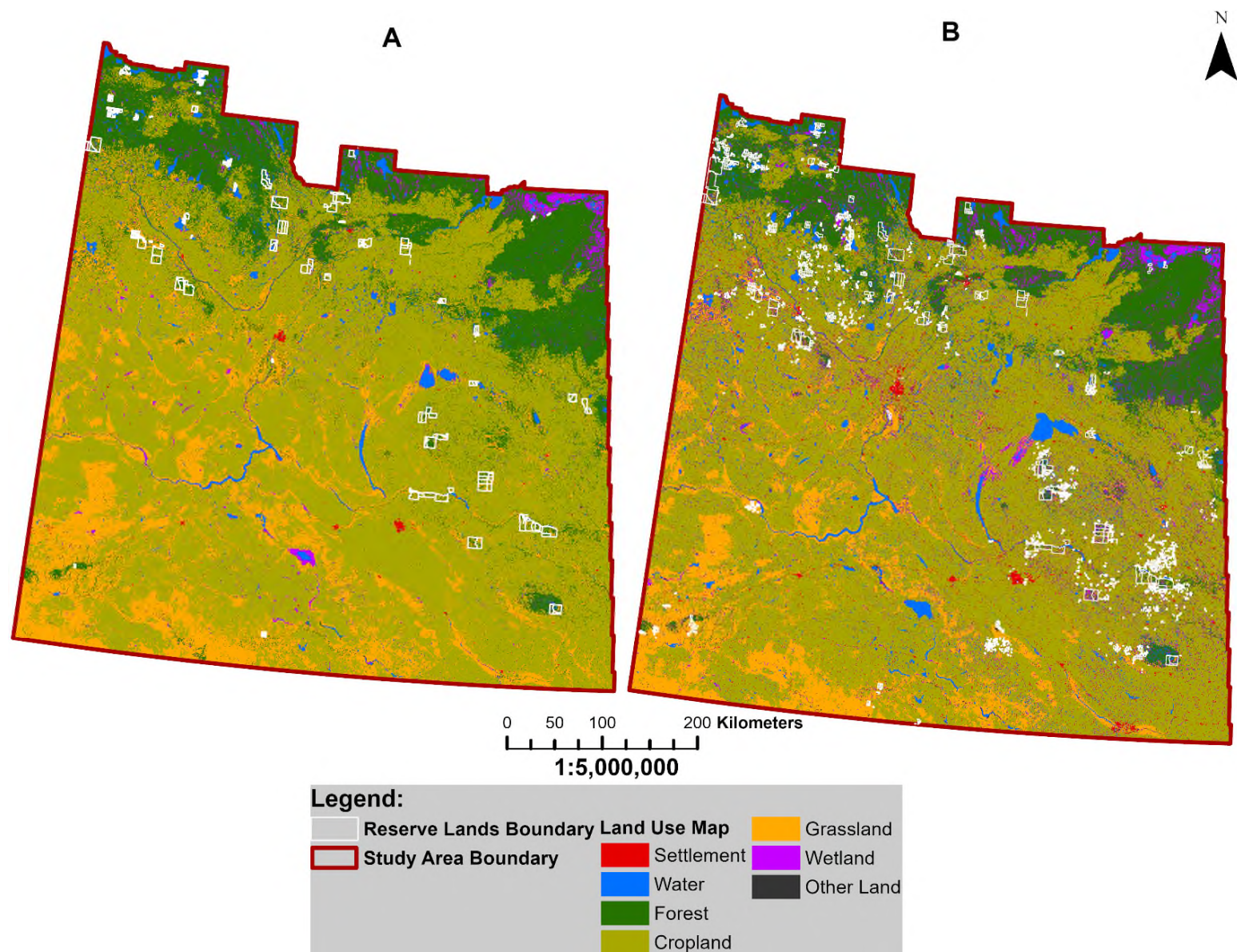
Figure S3 Land cover classification in the agricultural zone of Saskatchewan (A) Pre- and (B) Post-Land Claims.
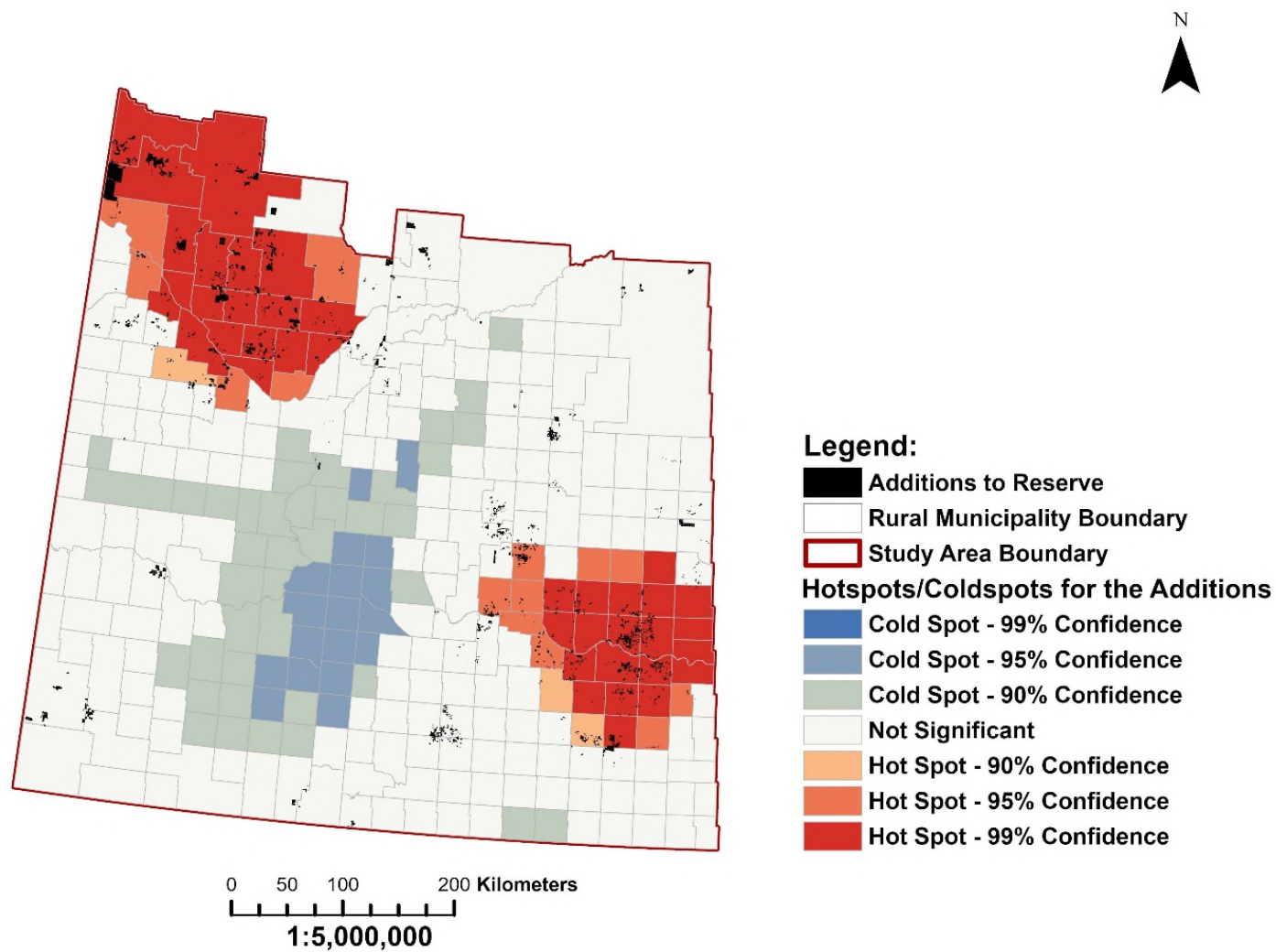
Figure S4 Hotspot analysis of the new reserve additions using the Getis-Ord Gi* statistic.

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