The Prairie Landscape Inventory: A wall-to-wall native prairie model for Saskatchewan

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The Prairie Landscape Inventory (PLI) is a wall-to-wall landcover classification that maps the distribution of native grassland and tame pasture in the Prairie Ecozone in Saskatchewan. The classification was developed in stages by ecoregion, with the Mixed Grassland completed first in 2019 and the Cypress Upland completed most recently in 2023. The landcover classification models were developed using 10-meter resolution Sentinel satellite imagery and over 8,750 ground-truth field points, collected with the help of many collaborators. The highest accuracy was achieved using machine learning algorithms, and big data issues were resolved by using the Google Earth Engine (GEE) platform.

The PLI is a publicly available data product that fills a key gap in the available information on the distribution of native prairie grasslands in Saskatchewan. This information will support improvements to programs, policy and decision-making to drive strategic conservation and restoration initiatives across the Saskatchewan prairie.

Prairie Ecozone Summary

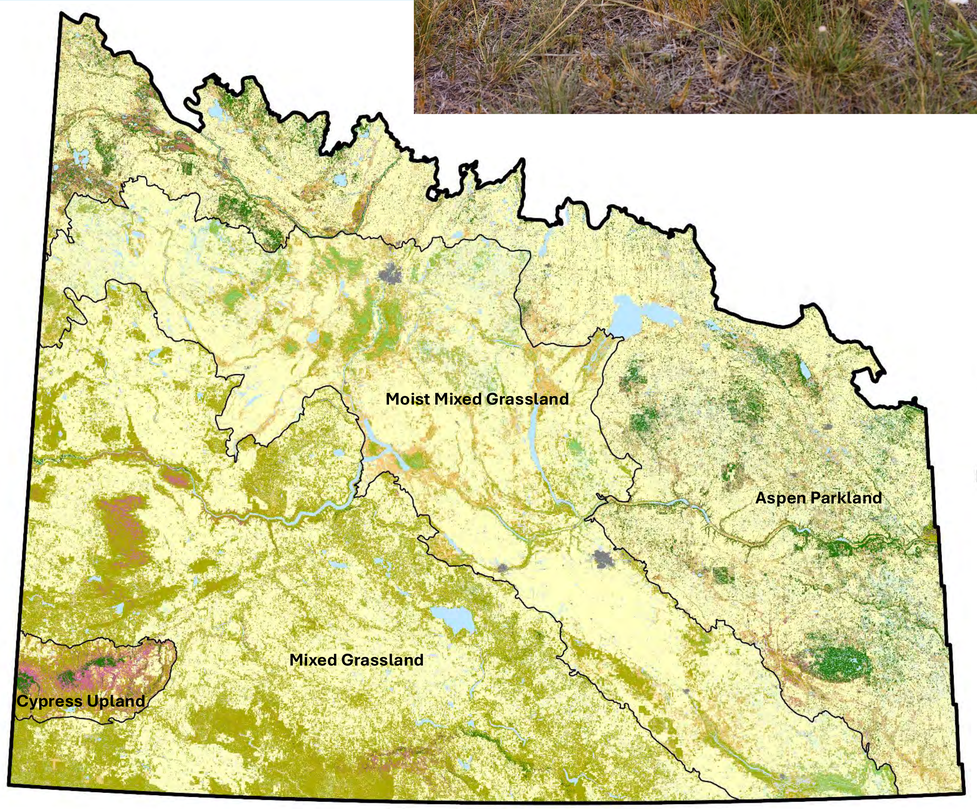
240,000 square km
Approximate area of the Prairie Ecozone

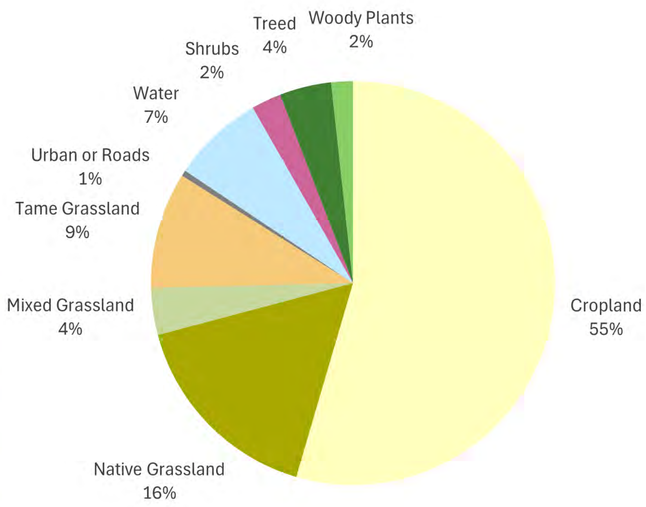
16% (39,000 square km)
Estimated area of **native grassland**

13% (31,400 square km)
Estimated area of **altered or tame grassland**

55% (131,000 square km)
Estimated area of **cropland**

Class	Definition
Native Grass	Composed of at least 75% native grass and forb species.
Tame Grass	Composed of at least 75% seeded or planted species with introduced grasses and forb species.
Mixed Grass	A heterogenic grassland with a mix of less than 75% native grass species or less than 75% tame species.
Cropland	All cultivated areas with crop commodities such as corn, pulse, soybeans, canola, grains, summer-fallow.
Shrub	Dominated by shrubs (generally < 2m height) with typically > 20% canopy cover.
Tree	Dominated by trees with typically >20% canopy cover.
Woody Plants	Merged shrubs and trees (Moist Mixed Grassland only).
Water	Permanent water sources such as lakes and rivers.





Ecoregion Models: Methods and Results Summary

Mixed Grassland (2019)

34% Native Grassland
6% Tame or Altered Grassland
52% Cropland

Overall Model Accuracy: 90%
Native Grassland Accuracy:
- 98% user's accuracy
- 88% producer's accuracy

- Field surveys between 2016 and 2019 collected 2,385 ground truth points.
- Radar and optical variables from Sentinel-1 and Sentinel-2 images from 2017 to 2019 (June 15 to August 15); PCA used to reduce the number of variables.
- Landcover classification completed with a Random Forest model using ArcGIS Pro 2.6 Forest-based classification and regression tool.
- "Shrub" and "tree" classes were masked from the 2019 Agriculture and Agri-Food Canada (AAFC) Annual Crop Inventory.

Moist Mixed Grassland (2021)

9% Native Grassland
15% Tame or Altered Grassland
61% Cropland

Overall Model Accuracy: 70%
Native Grassland Accuracy:
- 78% user's accuracy
- 62% producer's accuracy

- Field surveys in 2020 and 2021 collected 2,539 ground truth points, with additional points for "water" from photo interpretation.
- Radar and optical variables from Sentinel-1 (June) and Sentinel-2 (June and July) images from 2020 and 2021.
- Landcover classification completed with a Random Forest model using Google Earth Engine (GEE); shrubs and trees were combined into "woody plants" class.
- Urban and developed areas were masked from the 2020 AAFC Annual Crop Inventory.

Aspen Parkland (2022)

3% Native Grassland
18% Tame or Altered Grassland
54% Cropland

Overall Model Accuracy: 73%
Native Grassland Accuracy:
- 75% user's accuracy
- 73% producer's accuracy

- Field surveys in 2020, 2021 and 2022 collected 3,606 ground truth points, with additional points for "water" from photo interpretation.
- Radar and optical variables from Sentinel-1 (July and September) and Sentinel-2 (Spring: Apr. 15 – June 14; Summer: June 15 to July 31; Fall: Aug. 1 to Oct. 1) images from 2022.
- Landcover classification completed with a Random Forest model using GEE.
- Urban and developed areas were masked from the 2021 AAFC Annual Crop Inventory.

Cypress Upland (2023)

35% Native Grassland
15% Tame or Altered Grassland
17% Cropland

Overall Model Accuracy: 92%
Native Grassland Accuracy:
- 90% user's accuracy
- 93% producer's accuracy

- Field surveys in 2023 collected 468 ground truth points, with additional points for "water", "shrubs", "trees", and "cropland" from photo interpretation and the 2022 Annual Cropland Inventory.
- Radar and optical variables from Sentinel-1 (July and September) and Sentinel-2 (Spring: Apr. 15 – June 14; Summer: June 15 to July 31; Fall: Aug. 1 to Oct. 1) images from 2023.
- Landcover classification completed with a Random Forest model using GEE; "mixed" class was not modelled.
- Urban and developed areas were masked from the 2022 AAFC Annual Crop Inventory.

Download all layers by scanning this QR code!

The Prairie Landscape Inventory was developed by the Saskatchewan Ministry of Environment, in collaboration with the University of Saskatchewan. Funding was provided by: Plains and Prairie Pothole Landscape Conservation Cooperative, Prairie Habitat Joint Venture, Canadian Forage and Grassland Association, and Environment and Climate Change Canada. Current funding is provided by Environment and Climate Change Canada. The landcover classification maps are available for download.

Prairie Landscape Inventory

What is the Prairie Landscape Inventory (PLI)?

The Prairie Landscape Inventory is a wall-to-wall landcover classification that maps the distribution of native grassland in the Prairie Ecozone in Saskatchewan.

It is a publicly available data product that fills a key gap in the available information on the distribution of native prairie grasslands in Saskatchewan.

This information will support improvements to programs, policy and decision-making to drive strategic conservation and restoration initiatives across the Saskatchewan prairie.

How was the PLI developed?

The classification was developed in stages by ecoregion, with the Mixed Grassland completed first in 2019 and the Cypress Upland completed most recently in 2023.

The landcover classification models were developed using 10-meter resolution satellite imagery and over 8,750 ground-truth field points, primarily collected through roadside surveys.

What does the PLI tell us about Saskatchewan's native prairie grasslands?

The Prairie Ecozone is approximately 240,000 sq. km. Our mapping estimates that about **16 per cent** of the area remains as native grassland, compared to **55 per cent** of the area as cropland and **13 per cent** as altered or tame grassland.

The Mixed Grassland Ecoregion and the Cypress Upland Ecoregion are the areas with the highest percentage of native grassland (**~35 per cent** each) and the Moist Mixed Grassland and Aspen Parkland Ecoregions have the lowest (**9 per cent** and **3 per cent** respectively).

Native grasslands in the PLI are defined as areas with at least 75% cover of native species, such as grasses, forbs and moss or lichen.

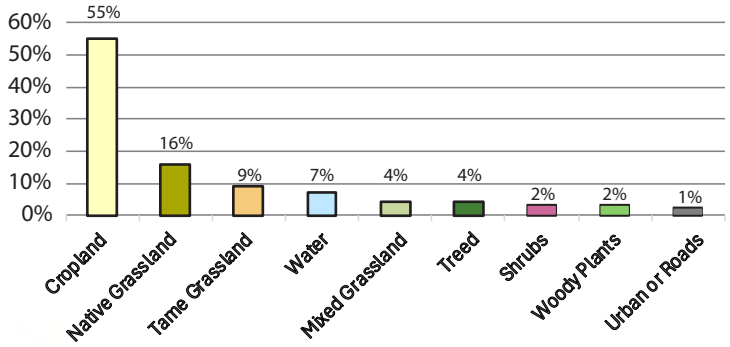
Where can I access the maps and data?

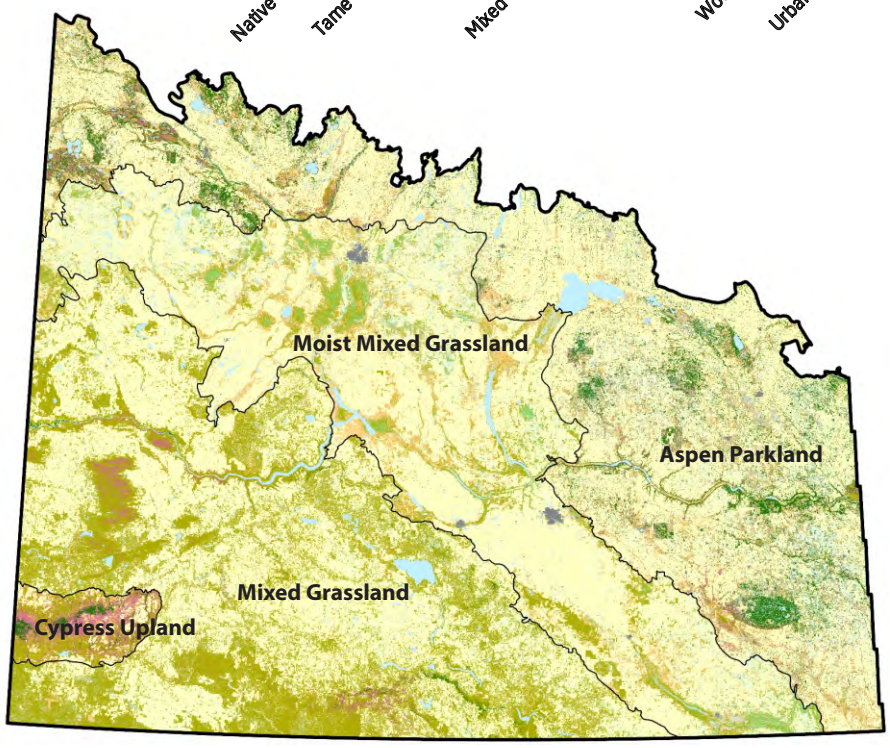
The PLI is available to view in HABISask.

The data for each ecoregion can be downloaded from the Government of Saskatchewan GeoHub.

Please contact members of the PLI team bea.prieto@gov.sk.ca or amy.nixon@gov.sk.ca – with comments or questions about the data or project.

Prairie Ecozone





The Prairie Landscape Inventory was developed by the Saskatchewan Ministry of Environment, in collaboration with the University of Saskatchewan. Funding through the development of this project was provided by: Plains and Prairie Pothole Landscape Conservation Cooperative, Prairie Habitat Joint Venture, Canadian Forage and Grassland Association, and through the last stage of the project by Environment and Climate Change Canada.

Saskatchewan Prairie Landscape Inventory Technical Summary

Overview

The Prairie Landscape Inventory (PLI) is a wall-to-wall landcover classification that maps the distribution of native grassland in the Prairie Ecozone in Saskatchewan. It is a publicly available data product that fills a key gap in the available information on the distribution of native grasslands in Saskatchewan. This information will support improvements to programs, policy, and decision-making to drive strategic conservation and restoration initiatives across the Saskatchewan prairie.

The Prairie Ecozone is approximately 240,000 sq. km. Our mapping estimates that about 16 per cent of the area remains as native grassland, compared to 55 per cent of the area as cropland and 13 per cent as altered or tame grassland. The Mixed Grass Ecoregion and the Cypress Upland Ecoregion are the areas with the highest percentage of native grassland (~35 per cent each) and the Moist Mixed Grass and Aspen Parkland Ecoregions have the lowest (9 per cent and 3 per cent respectively). Native grasslands in the PLI are defined as areas with at least 75 per cent cover of native species, such as grasses, forbs and moss or lichen. The full definitions of the landcover classes included in the PLI are provided in Table 1.

The PLI is available to view in HABISask. The data for each ecoregion can be downloaded from the Government of Saskatchewan GeoHub.

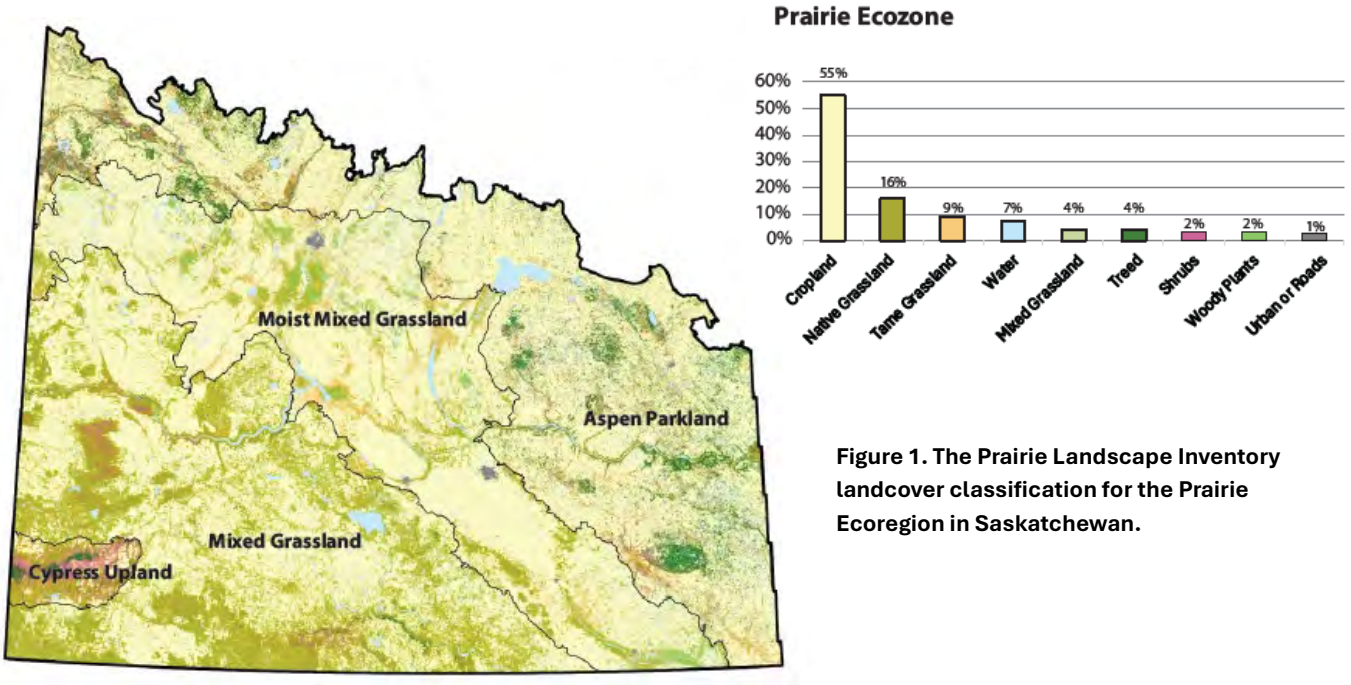


Figure 1. The Prairie Landscape Inventory landcover classification for the Prairie Ecoregion in Saskatchewan.

Table 1. Definitions of landcover classes included in the Prairie Landscape Inventory.

Class	Definition
Native	Composed of at least 75 per cent native grass and forb species; unbroken grassland that is invaded by species like Kentucky bluegrass, crested wheatgrass, or smooth brome, such that native cover is less than 75 per cent, is not considered native.
Tame	Composed of at least 75 per cent seeded or planted species with introduced grasses and forb species.
Mixed	A heterogenic grassland with a mix of less than 75 per cent native grass species or less than 75 per cent tame species.
Cropland	All cultivated areas with crop commodities such as corn, pulse, soybeans, canola, grains, summer-fallow.
Shrub*	Dominated by shrubs (generally less than 2m height) with typically greater than 20 per cent canopy cover.
Tree*	Dominated by trees with typically greater than 20 per cent canopy cover.
Water	Permanent water sources such as lakes and rivers.

**In the Moist Mixed Grassland classification, the Shrub and Tree classes were combined into a "Woody Plants" class.*

History

The Prairie Landscape Inventory started in 2013 by assessing the feasibility of developing a Grassland Vegetation Inventory (after the Alberta model) for Saskatchewan. That approach was very time-consuming and extremely expensive, although the product provided detailed information on land cover and land use, including features like individual trees. Several remote-sensing approaches were tested as an alternative, including using LiDAR and satellite imagery. The method that achieved the highest accuracy at the lowest cost used machine learning to model land cover classes from freely available Sentinel satellite imagery at a resolution of 10-meters. This approach formed the basis of the PLI.

Approach

The landcover classification models in the PLI were developed using 10-meter resolution satellite imagery and over 8,750 ground-truth field points, primarily collected through roadside surveys.

Over 8,750 ground truth field points inform the PLI landcover classification models.

The PLI classification was developed in stages by ecoregion, with the Mixed Grassland completed first in 2019 and the Cypress Upland completed most recently in 2023. The models for each ecoregion differ in the imagery and modelling approaches used. Most notably, the project adopted Google Earth Engine in 2021 to take advantage of the imagery storage and modeling algorithms available on that platform. The details of the models for each ecoregion are summarized below.

Mixed Grass Ecoregion – Completed in 2019

Field surveys were completed in 2019. A total of 2,385 ground truth points from the PLI field surveys and historical field surveys (2016-2019) informed the classification model. Of these ground truth points, 1,658 were in native grassland, 254 were in tame grassland, and 146 were in mixed grassland. Sentinel-1 (radar) and Sentinel-2 (optical) images from 2017 to 2019 were used to develop the classification.

Imagery was acquired using the "getspatialdata" package in the R statistical computing environment and preprocessed with Sentinel Application Platform (SNAP) software. Sentinel-1 preprocessing followed Filipponi's Workflow. Sentinel-2 Level-1C images were corrected with Sen2Cor. Final mosaic data sets were created with PCI Geomatica.

Key temporal windows for distinguishing native grassland from tame grassland were determined using the Normalized Difference Vegetation Index in MODIS time series data. The full modelling data set, which included 78 radar and optical bands and indices from Sentinel-1, Sentinel-2, and a digital elevation model, was further reduced through Principal Component Analysis. This data reduction approach identified key temporal windows and influential variables to streamline modeling and improve classification accuracy.

The landcover classification model was developed using the ArcGIS Pro 2.6 Forest-based Classification and Regression tool, which is a supervised machine learning algorithm. The final model included a combination of radar and optical variables for the June 15 to August 15 period (Appendix A). Shrub and tree classes were masked from the 2019 Agriculture and Agrifood Canada (AAFC) Annual Cropland Inventory. To assess model accuracy, the data were split into 30 per cent training and 70 per cent testing data sets.

The Mixed Grassland Ecoregion includes 34 per cent native grassland, 6 per cent tame or altered grassland and 52 per cent cropland (Figure 2). The overall accuracy of the landcover classification for the Mixed Grass Ecoregion is 90 per cent. Class-level accuracy is presented in Table 2.

Table 2. Summary of the class-level accuracy for the Mixed Grassland Ecoregion.

Class	User's accuracy* (%)	Producer's accuracy** (%)	F1 score*** (%)
Cropland	98	97	98
Native grassland	98	88	93
Mixed grassland	46	83	59
Tame grassland	81	94	87
Water	91	95	93

User's accuracy: whether the classification of a pixel represents that category on the ground. **Producer's accuracy: how accurately the reference ground data are classified.* F1 score: combines user's and producer's accuracy in a single metric.*

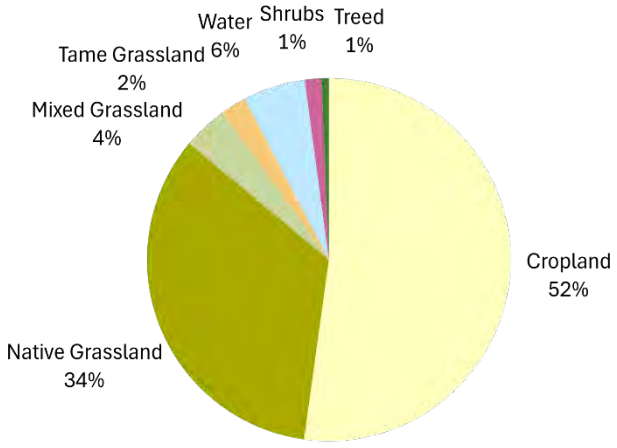


Figure 2. Summary of the PLI landcover in the Mixed Grass Ecoregion.

Moist Mixed Grass Ecoregion – Completed in 2021

Field surveys were completed in the summer of 2020 and 2021. In total, 2,539 ground truth points collected, with 775 points in native grassland, 799 points in tame grassland, and 381points in mixed grassland. Ground truth points for the water class were selected from high resolution aerial imagery. Sentinel-1 (radar) images from April to September, 2020 and 2021, and Sentinel-2 (optical) images from June 15 to July 31, 2020, and 2021, were used to develop the classification.

Pre-processed Sentinel-1 and Sentinel-2 data were acquired in the Google Earth Engine (GEE) cloud computing platform. Additional pre-processing, including angle correction and speckle filtering was completed on the Sentinel-1 imagery.

A variety of machine learning algorithms were tested in the development of the landcover classification model. In addition, several different combinations of temporal windows and variable combinations were examined for the Sentinel-1 radar variables and the Sentinel-2 optical bands and indices. All modelling was performed in the GEE platform. Model selection was conducted by evaluating accuracy metrics. To assess model accuracy, the data set was split into 70 per cent training and 30 per cent testing data sets. The highest accuracy model was a Random Forest model that included both radar and optical variables from the summer (June to July) of 2021 and 2022 (Appendix A).

The Moist Mixed Grassland Ecoregion includes 9 per cent native grassland, 15 per cent tame or altered grassland and 61 per cent cropland (Figure 3). The overall accuracy of the landcover classification for the Mixed Grass Ecoregion is 70 per cent. Class-level accuracy is presented in Table 3.

Table 3. Summary of the class-level accuracy for the Moist Mixed Grassland Ecoregion.

Class	User's accuracy* (%)	Producer's accuracy** (%)	F1 score*** (%)
Cropland	87	75	81
Native grassland	78	62	69
Mixed grassland	26	58	36
Tame grassland	70	67	68
Water	84	96	90
Woody Plants	73	81	77

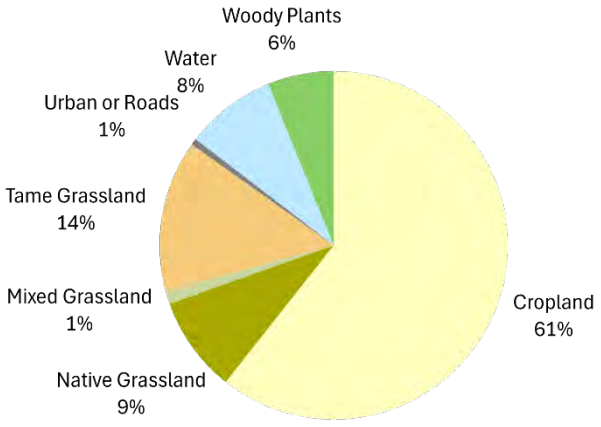


Figure 3. Summary of the PLI landcover in the Moist Mixed Grass Ecoregion.

Aspen Parkland Ecoregion – Completed in 2022

Field surveys were completed in the summer of 2020, 2021, and 2022, with most of the observations collected in 2022. In total, 3,606 ground truth points were collected, including 663 in native grassland, 673 in tame grassland and 594 in mixed grassland. Ground truth points for the water class were selected from high resolution aerial imagery. Sentinel-1 (radar) images from July to September, 2022 and Sentinel-2 (optical) images for three time periods in 2022 (April 15 to June 14; June 15 to July 31; and August 1to October 1) were used to develop the classification.

Pre-processed Sentinel-1 and Sentinel-2 data were acquired in the Google Earth Engine (GEE) cloud computing platform. Additional pre-processing, including angle correction and speckle filtering was completed on the Sentinel-1 imagery.

The Random Forest machine learning algorithm in the GEE platform was used to develop the model. Several different combinations of temporal windows and variable combinations were examined for the Sentinel-1 radar variables and the Sentinel-2 optical bands and indices. Model selection was conducted by evaluating accuracy metrics. To assess model accuracy, the data set was split into 70 per cent training and 30 per cent testing data sets. The highest accuracy model included radar variables from the summer (July) and fall (September) periods and optical variables from the spring (April to mid-June), summer (mid-June to July), and fall (Aug to October) periods (Appendix A). Urban and developed areas from the 2021 AAFC Annual Cropland Inventory were added as a mask in the final classification.

The Aspen Parkland Ecoregion includes 3 per cent native grassland, 18 per cent tame or altered grassland and 54 per cent cropland (Figure 4). The overall accuracy of the landcover classification for the Aspen Parkland Ecoregion is 73 per cent. Class-level accuracy is presented in Table 4.

Table 4. Summary of the class-level accuracy for the Aspen Parkland Ecoregion.

Class	User's accuracy (%)	Producer's accuracy (%)	F1 score (%)
Cropland	90	97	93
Native grassland	75	73	74
Mixed grassland	43	41	42
Tame grassland	66	73	69
Water	95	91	93
Shrubs	63	52	57
Trees	91	94	92

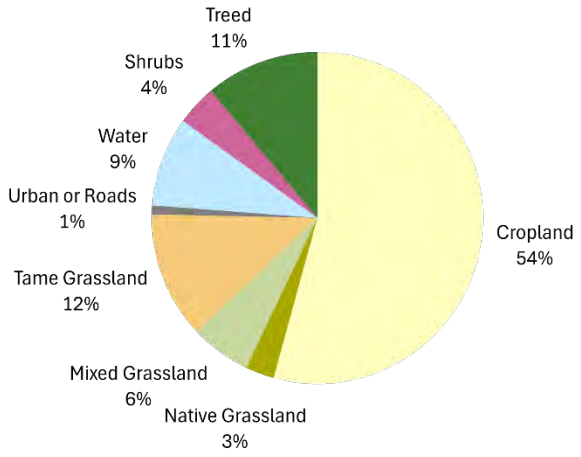


Figure 4. Summary of the PLI landcover in the Aspen Parkland Ecoregion.

Cypress Uplands Ecoregion – Completed in 2023

Field surveys were completed in 2023, with a total of 468 ground truth points collected in the Cypress Upland Ecoregion, including 117 native grassland, 107 tame grassland and 48 mixed grassland points. The ground truth points for the water, shrubs, trees, and cropland classes were supplemented with points collected through photo interpretation and the 2022 AAFC Annual Cropland Inventory. The full modelling data set included 833 points. Sentinel-1 (radar) images from July to September, 2023 and Sentinel-2 (optical) images for three time periods in 2023 (April 15 to June 14; June 15 to July 31; and August 1to October 1) were used to develop the classification.

Pre-processed Sentinel-1 and Sentinel-2 data were acquired in the Google Earth Engine (GEE) cloud computing platform. Additional pre-processing, including angle correction and speckle filtering was completed on the Sentinel-1 imagery.

The Random Forest machine learning algorithm in the GEE platform was used to develop the model. Several different combinations of temporal windows and variable combinations were examined for the Sentinel-1 radar variables and the Sentinel-2 optical bands and indices. Model selection was conducted by evaluating accuracy metrics. To assess model accuracy, the data set was split into 70 per cent training and 30 per cent testing data sets. The highest accuracy model included radar variables from the summer (July) and fall (September) periods and optical variables from the spring (April to mid-June), summer (mid-June to July), and fall (Aug to October) periods (Appendix A). The final model omitted the mixed grassland class due to an insufficient sample size. Urban and developed areas from the 2022 AAFC Annual Cropland Inventory were added as a mask in the final classification.

The Cypress Upland Ecoregion includes 35 per cent native grassland, 15 per cent tame or altered grassland and 17 per cent cropland (Figure 5). The overall accuracy of the landcover classification for Cypress Upland Ecoregion is 92 per cent. Class-level accuracy is presented in Table 5.

Table 5. Summary of the class-level accuracy for the Cypress Upland Ecoregion.

Class	User's accuracy (%)	Producer's accuracy (%)	F1 score (%)
Cropland	96	100	98
Native grassland	90	93	92
Mixed grassland	-	-	-
Tame grassland	93	71	82
Water	100	100	100
Shrubs	77	88	83
Trees	96	96	96

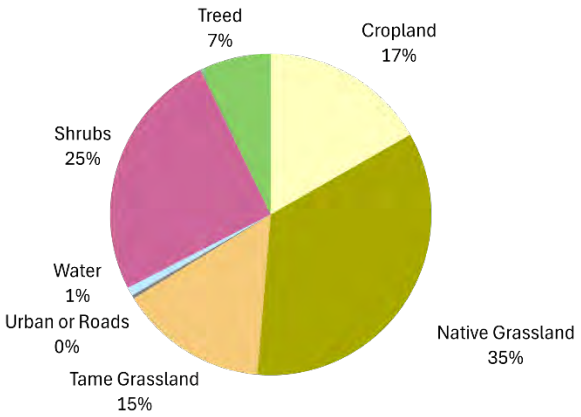


Figure 5. Summary of the PLI landcover in the Aspen Parkland Ecoregion.

Acknowledgements

The Prairie Landscape Inventory was developed by the Saskatchewan Ministry of Environment, in collaboration with the University of Saskatchewan. Funding was provided by: Plains and Prairie Pothole Landscape Conservation Cooperative, Prairie Habitat Joint Venture, Canadian Forage and Grassland Association, and Environment and Climate Change Canada.

Many individuals and organizations collaborated to collect ground truth points through field surveys. Thank you to all who contributed their time and energy to the project!

Appendix A – Model Details

The tables below provide the detailed list of the model variables used in the PLI landcover classification models for each ecoregion. Model complexity increased as the evolution of cloud computing on the Google Earth Engine platform allowed for consideration of a larger, more diverse modelling data set.

Table A.1. Variables used in the PLI landcover classification model for the Mixed Grass Ecoregion.

Source	Variable/Index	Data Acquisition Window
Digital Elevation Model	Topographic Wetness Index (TWI)	NA
Sentinel-1	VV/VH	15 June to 15 August, 2019
	VH/VV	
	VV-VH	
	VV	
	VH	
Sentinel-2	Normalized Difference Salinity Index (NDSI)	
	Chlorophyll Red-Edge (Chlred-edge)	
	Atmospherically Resistant Vegetation Index (ARVI)	
	Band 12 / Band 2	

Table A.2. Variables used in the PLI landcover classification model for the Moist Mixed Grass Ecoregion.

Source	Variable/Index	Data Acquisition Window
Sentinel-1	VV	June, 2020 & 2021
	VH	
	Radar Vegetation Index (RVI)	
Sentinel-2	Normalized Difference Vegetation Index (NDVI)	15 June to 31 July, 2020 & 2021
	Normalized Difference Senescent Vegetation Index (NDSVI)	
	Tasseled Cap Wetness (TCW)	
	Sentinel-2 Water Index (SWI)	
	Anthocyanin Reflectance Index (ARI)	
	Structure Insensitive Pigment Index (SIPI)	
	Modified Chlorophyll Absorption Ratio Index (MCARI/OSAVI)	
	Red Edge Position (REP)	

Table A.3. Variables used in the PLI landcover classification model for the Aspen Parkland Ecoregion.

Source	Variable/Index		Data Acquisition Window
Saskatchewan Rangeland Ecosystems (Thorpe 2014)[1]	Range Ecosites		NA
Digital Elevation Model	Google Earth Engine Terrain Derivatives	elevation, slope, aspect, hillslope, northness, eastness, vertical curvature, horizontal curvature, mean curvature, gaussian curvature, minimal curvature, maximal curvature, shape index	NA
	Topographic Wetness Index (TWI)		
Sentinel-1	Dual-band cross-polarization (monthly average)	VV	July 2022, September 2022
		VH	
	Radar Indices (monthly average)	Radar Vegetation Index (RVI)	
		VV/VH	
		Normalized Difference Radar Index (NDRI)	
Sentinel-2	Optical Bands (average)	B2, B3, B4, B8, B11, B12	15 April to 14 June, 15 June to 31 July, 1 August to 1 October, 2022
	Optical Bands (standard deviation)	B2, B3, B4, B8, B11, B12	
	Optical Indices (average)	Normalized Difference Vegetation Index (NDVI)	
		Soil Adjusted Total Vegetation Index (SATVI)	
		Sentinel-2 Water Index (SWI)	
		Plant Senescence Reflectance Index (PSRI)	
		Normalized Difference Infrared Index (NDII)	
		Moisture Stress Index (MSI)	
		Anthocyanin Reflectance Index (ARI)	
		Modified Chlorophyll Absorption in Reflectance Index (MCARI)	
		Red Edge Position Index (REP)	
	NDVI Texture	NDVI Angular Second Moment	
		NDVI Contrast	
		NDVI Correlation	
		NDVI Variance	
		NDVI Inverse Difference Moment	
		NDVI Entropy	
		NDVI Dissimilarity	
		NDVI Cluster Shade	
	Spectral Fractions	Green Vegetation Fraction (GV)	
		Shade Fraction	
		Non-Photosynthetic Vegetation Fraction	
		Soil Fraction	
		Cloud Fraction	

[1]Thorpe, J. 2014. Saskatchewan Rangeland Ecosystems, Publication 1: Ecoregions and Ecosites, Version 2. Saskatchewan Prairie Conservation Action Plan. Saskatchewan Research Council Pub. No. 11881-1E14.

Table A.4. Variables used in the PLI landcover classification model for the Cypress Upland Ecoregion.

Cypress Upland (2023)			
Source	**Variable/Index**		**Data Acquisition Window**
Saskatchewan Rangeland Ecosystems (Thorpe 2014)[1]	Range Ecosites		NA
Digital Elevation Model	Google Earth Engine Terrain Derivatives	elevation, slope, aspect, hillslope, northness, eastness, vertical curvature, horizontal curvature, mean curvature, gaussian curvature, minimal curvature, maximal curvature, shape index	NA
	Topographic Wetness Index (TWI)		
Sentinel-1	Dual-band cross-polarization (monthly average)	VV	July 2023, September 2023
		VH	
	Radar Indices (monthly average)	Radar Vegetation Index (RVI)	
		VV/VH	
		Normalized Difference Radar Index (NDRI)	
Sentinel-2	Optical Bands (average)	B2, B3, B4, B8, B11, B12	15 April to 14 June, 15 June to 31 July, 1 August to 1 October, 2023
	Optical Bands (standard deviation)	B2, B3, B4, B8, B11, B12	
	Optical Indices (average)	Normalized Difference Vegetation Index (NDVI)	
		Soil Adjusted Total Vegetation Index (SATVI)	
		Sentinel-2 Water Index (SWI)	
		Plant Senescence Reflectance Index (PSRI)	
		Normalized Difference Infrared Index (NDII)	
		Moisture Stress Index (MSI)	
		Anthocyanin Reflectance Index (ARI)	
		Modified Chlorophyll Absorption in Reflectance Index (MCARI)	
		Red Edge Position Index (REP)	
	NDVI Texture Indices	NDVI Angular Second Moment	
		NDVI Contrast	
		NDVI Correlation	
		NDVI Variance	
		NDVI Inverse Difference Moment	
		NDVI Entropy	
		NDVI Dissimilarity	
		NDVI Cluster Shade	
	Spectral Fraction Indices	Green Vegetation Fraction (GV)	
		Shade Fraction	
		Non-Photosynthetic Vegetation Fraction	
		Soil Fraction	
		Cloud Fraction	

[1]Thorpe, J. 2014. Saskatchewan Rangeland Ecosystems, Publication 1: Ecoregions and Ecosites, Version 2. Saskatchewan Prairie Conservation Action Plan. Saskatchewan Research Council Pub. No. 11881-1E14