AGGP-Agroforestry

CONIFEROUS SHELTERBELT LAND SUITABILITY FOR MAXIMIZED ECOSYSTEM CARBON STOCKS

No. SASK-42

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Coniferous shelterbelts are a vital component of Canadian farms; however, guidelines are lacking to help land managers locate suitable areas for planting new shelterbelts on their landbases. Therefore, to address this knowledge gap, we created a land suitability map for coniferous shelterbelt establishment across a wide range of climatic regions and soil zones of Saskatchewan. The land suitability map delineates and ranks the land across large landscapes in regards to maximized ecosystem carbon stocks in coniferous shelterbelts. The resulting suitability map is one of several important components built into the Shelterbelt Management Support Toolbox.

MAPPING CONIFEROUS SHELTERBELT LAND SUITABILITY IN SASKATCHEWAN

Maps of coniferous shelterbelt carbon data and 50 predictor variables were analyzed using multivariate principal component analysis (PCA), principal component regression (PCR), fuzzy logic analysis, and GIS mapping techniques. Statistically significant positive correlation between mapped coniferous shelterbelt suitability levels and observed mean shelterbelt carbon stocks were used to evaluate the resulting suitability map (1.96 million hectares (Mha) study area; $p<0.001$, $R2= 0.77$). The map delineated land of higher suitability for coniferous shelterbelts in the northern agricultural regions of Saskatchewan (Fig.1).

There are approximately 1.96 million hectares of agricultural land on which shelterbelts of various lengths and designs were established using coniferous species. In general, across all soil zones and suitability map levels, the agricultural land with planted shelterbelts represented only 9% of the total agricultural landbase in Saskatchewan. In terms of availability of above-average or high level of suitability land for coniferous shelterbelt establishment, additional 7.90 Mha were mapped across five soil zones, 64% of which were above-average suitability, and 36% were high suitability. The majority of these additional land areas were located in the Black (62%), Dark Gray (20%), and Dark Brown (11%) soil zones; the land availability in the other soil zones was <6% (Fig. 1).

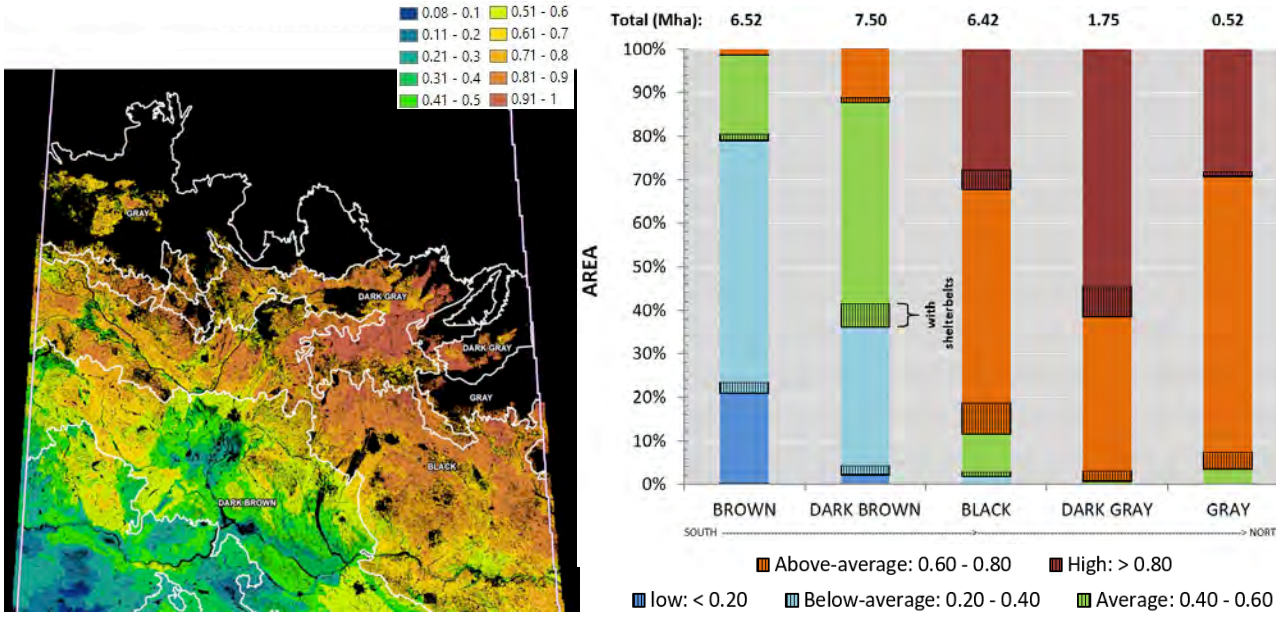

Figure 1. Coniferous shelterbelt suitability map (e.g., pine, spruce) for Saskatchewan. Summaries of land areas (million ha (Mha) and % units) with and without shelterbelts are estimated for five land suitability classes (low, below-average, average, above-average, high) within five soil zones and shown in the bar graph.

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FACTORS AFFECTING CONIFEROUS SHELTERBELT C STOCKS

- **Factor interactions**: Coniferous shelterbelt C stocks and distribution are largely affected by (two-way) climate (temperature) and anthropogenic criteria interactions, as well as (two-way) soils and anthropogenic criteria interactions.
- **High ranks**: The top three highest-ranking variables were mean annual temperature, maximum annual temperature, and annual growing degree-days, all describing the temperature regime of an area.
- Coniferous shelterbelts were negatively correlated with the top three ranking variables, meaning that shelterbelts are mainly distributed in agricultural areas with cooler temperatures and lower annual growing degree-days.
- **Recommendations**: Future shelterbelts in the Brown soil zone should be planted using deciduous or shrub species.
- Most future shelterbelts in the Dark Brown soil zone should be planted using deciduous or shrub species, while the use of coniferous species be relatively more limited.
- Most future shelterbelts in the **Black** soil zone should be coniferous, with relatively limited use of deciduous or shrub species.
- Most future shelterbelts in the **Dark Gray** and **Gray** soil zones should be planted using coniferous species only.

Criteria Group	50 Variables	Units	Range (min; max)	Loading/Rank +/- load.	C
Clim	Mean annual Temp	°C	(0.4; 4.9)	(-) 6.01	1
Clim	Max annual Temp	°C	(6.2; 11.7)	(-) 5.86	2
Clim	Growing Degree-Days annual	°C·day	(2191.7; 2965.9)	(-) 5.85	3
Clim	Min annual Temp	°C	(-5.7; -1.8)	(-) 5.75	4
Clim	GDD JanJul	°C·day	(1162.3; 1592.4)	(-) 5.58	5
Clim	Max July Temp	°C	(20.7; 25.7)	(-) 5.3	6
Clim	Lowest Min Temp	°C	(-44.4; -35.6)	(-) 4.64	7
Clim	Solar radiation in July	MJ/m²	(513.7; 644.2)	(-) 4.49	8
Clim	Vapour pressure deficit	kPa	(0.2; 0.4)	(-) 4.49	9
Clim	Frost days	day	(192.6; 212.7)	(+) 4.04	10
Clim	Mean July Temp	°C	(15.3; 19.5)	(-) 3.7	11
Mgmt	Hardiness zone	-	(2; 7)	(-) 3.48	12
Mgmt	Hybrid poplar suitab. index	-	(0.3; 0.6)	(+) 3.44	13
Mgmt	Fertilizer in-farm	%	(1.1; 88.9)	(+) 3.36	14
Mgmt	Herbicides in-farm	%	(1.1; 90)	(+) 3.35	15
Clim	Solar radiation	MJ/m²	(4376.7; 4986.8)	(-) 3.21	16
Soils	Agric. land capability class	-	(1; 6)	(-) 2.87	17
Soils	Buk density (0-5 cm depth)	Mg/m3	(0.9; 1.4)	(-) 2.4	18
Clim	Wind speed	km/h	(11.9; 18.3)	(-) 2.08	19
Clim	Rain days	day	(36.3; 64)	(+) 2.04	20
Mgmt	Env. Indic. GHG farm emiss.	kg CO2-eq./ha	(-328.3; 582.5)	(+) 1.68	21
Soils	Agric. land erosion class	-	(1; 5)	(-) 1.6	22
Topo	Elevation	m	(339.3; 1015.4)	(-) 1.55	23
Soils	Sand (0-5 cm depth)	mass %	(7.9; 72.1)	(-) 1.44	24
Soils	AWHC (0-30 cm)	mm	(13.2; 35)	(+) 1.41	25
Soils	Soil organic C (0-25 cm)	Mg/ha	(34.1; 98)	(+) 1.31	26
Clim	Growing season days	day	(122.1; 153.4)	(-) 1.13	27
Soils	Soil depth (plant-exploit.)	cm	(99.8; 200)	(+) 1	28
Soils	Agricultural land texture cl.	-	(1; 4)	(-) 1	29
Clim	Aridity Index	-	(0.5; 1)	(+) 0.89	30
Mgmt	Fertilizer farms-in-CCS	%	(1.4; 91.1)	(+) 0.86	31
Mgmt	Herbicides farms-in-CCS	%	(1.4; 93.5)	(+) 0.75	32
Mgmt	Env. Indic. wind erosion	Mg/ha/yr	(0.2; 3.6)	(-) 0.59	33
Soils	Clay (0-5 cm depth)	mass %	(9.4; 61.2)	(+) 0.57	34
Mgmt	Crop type class	-	(34; 220)	(+) 0.52	35
Topo	Distance to water	m	(103; 980.9)	(+) 0.39	36
Soils	Agric. land drainage class	-	(3; 5)	(-) 0.35	37
Clim	Min July Temp	°C	(9.9; 13.6)	(-) 0.26	38
Soils	pH (0-5 cm)	-	(5.5; 7.4)	(-) 0.15	39
Mgmt	Irrigation farms-in-CCS	%	(0; 46.3)	(-) 0.14	40
Soils	Silt (0-5 cm depth)	mass %	(16; 45.9)	(+) 0.13	41
Soils	Coarse fragments (0-5 cm)	vol. %	(0; 7.7)	(-) 0.1	42
Mgmt	Tillage farms-in-CCS	%	(0.7; 36.4)	(+) 0.07	43
Mgmt	Tillage in-farm	%	(0; 27.6)	(+) 0.05	44
Clim	Mean annual precipitation	mm	(218.2; 399.3)	(+) 0.04	45
Clim	Wind speed in Feb	km/h	(10.1; 17.5)	(-) 0.03	46
Mgmt	Irrigation in-farm	%	(0; 18)	(-) 0.02	47
Clim	Rain for July	mm	(98.6; 180.1)	(+) 0.02	48
Clim	Wind speed in July	km/h	(10.4; 17.2)	(+) 0.02	49
Soils	Elec. conductivity (0-5 cm)	mS/m	(0; 1.7)	(+) 0	50

➔ **Table 1.** Ranking of 50 variables from four criteria groups (Clim = climate; Mgmt = land management; Soils = soil characteristics; Topo = topography) affecting agricultural land suitability for maximized shelterbelt ecosystem C stocks in Saskatchewan for coniferous shelterbelt species, such as pine, spruce (C= coniferous). Ranks (1=highest; 50=lowest), top-third shown in bold and bottom-third as underlined values, are based on principal component analysis (i.e., variable loadings) and principal component regression (see fact sheet SASK-40). ➔

This study is the first to indicate the high importance of land management techniques on the distribution of shelterbelts, second only to climate factors, and therefore, should be given high consideration in all shelterbelt planning and management activities. We highly recommend using the coniferous shelterbelt suitability map accessible through the Saskatchewan Shelterbelt Carbon Tool.

FURTHER READING: Fact sheets SASK-40, SASK-41, SASK-43

CONTACT FOR MORE INFORMATION: SASKAGROFORESTRY.CA/

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