

MGM Research Note #2019-1

Estimating site index using ecosite and edatope in Alberta and Saskatchewan

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Introduction

Site index is used as the primary estimator of potential productivity in the Mixedwood Growth Model (MGM) and in other models. Site index can be readily determined for stands where there are healthy top height trees close to reference age (50 years is widely used as the reference age in western Canada) for the species of interest. However, site index is difficult to determine when healthy top height trees are not present, and where estimates of site index are required for species not currently present in the stand. In addition, site index estimates can be unreliable when trees are less than 7 m tall or substantially older than reference age.

The use of ecological information, such as ecological site classification (Mah and Nigh 2003; BC Ministry of Forest and Range 2008) or ecological site factors (Wang and Klinka 1996; Ung et al. 2001) to estimate site index is being pursued in many areas.

Since height growth of post-harvest or regenerated stands differs from what site index values from mature stands would indicate (Huang et al. 2004), there is a need to find ways to estimate site index of post-harvest stands for use in growth models. Alberta ecosite guides (Beckingham and Archibald 1996; Beckingham et al. 1996) and Saskatchewan ecosite guides (McLaughlan et al. 2010) provide estimates of site index for major tree species found in each ecosite. However, the applicability of the estimates provided in the Alberta guides to regenerating stands is of concern due to: 1) the focus of ecosite sampling in mature and old-growth stands (ie. they did not include post-harvest or young stands); 2) sample sizes used in development of their estimates are generally small; 3) the broad ranges of climates included in the aggregation of natural subregions into Ecological Areas in Beckingham and Archibald (1996) (particularly aggregation of several Subregions into the “Boreal Mixedwoods” Area); and, 4) the use of unspecified Site Index equations which have been replaced by the Huang et al. (2009) equations since publication of the ecosite guides.

Methods

Data for this study came from field data collected from 347 sample plots for estimation of site index as a function of environmental variables (FRIP Project FFI-14-08) together with data from other similar projects previously conducted in Alberta (FRIAA Project WCG-017), and data from permanent sample plots in Alberta and Saskatchewan. Sampling was restricted to post-harvest and fire origin stands for aspen and pine, and post-harvest white spruce stands and was limited to stands between 25 and 70 years of age. Sample plots had a 50 m buffer from any disturbance to avoid edge effects on trees growth. When more than one plot was placed in the same block, neighboring plots were located in different site and soil conditions in order to minimize correlations due to adjacency and ensure independence of plots. The dataset includes natural, and post-harvest origin stands, and a range of treatments (mechanical site preparation, brushing and thinning) applied to post-harvest stands. Due to unbalanced sampling across ecosites and edatopes, only classes with sample size of 3 or more plots were retained in summarizing SI to ensure reliable estimates.

Field sampling within 300 m² circular sample plots involved top height tree measurements, ecological surveys (ecosite, ecosite phase, topography parameters, soil properties, and stand density), and georeferencing plot centers. Three top height trees were selected in each plot for determination of SI for

each target species. Measurements included species, crown class, pathology and damage notes, diameter at breast height (DBH) and total height. Increment cores were extracted at breast height of each top height tree for breast-height age determination. In each plot, a soil pit was excavated at plot centre to determine major edaphic properties (humus form, organic matter thickness, soil texture, coarse fragment content, seepage, mottles/gleying, drainage, soil moisture regime, and soil nutrient regime). Ecosite and soil characteristics were assessed following the corresponding ecological survey guide (Beckingham et al. 1996; Beckingham and Archibald 1996).

Site index (SI), defined as height at a reference age of 50 years age for all species, was estimated at plot level using species-specific top height sub-models (height-age curves) of the GYPSY (Growth and Yield Projection System) forest growth and yield model (Huang et al. 2009), which is currently in use in Alberta. SI was calculated for both breast height (1.3 m) age of 50 and total age of 50 since MGM requires SI calculated using breast height age 50. SI for Jack pine was calculated using GYPSY's Lodgepole pine height-age curves. Given that GYPSY requires total age, breast height age was corrected to total age following recommended procedures (Huang et al. 2009). Plots were deleted when either the range of ages of top height trees exceeded 20 years or the range in SI values exceeded 5m.

Results and Discussion

Mean values of SI (breast height age 50) for each species by natural subregion and ecosite are shown in Figure 1. Appendix 1 shows sample size, mean site index, and standard deviation around the mean for each species recorded in each ecosite. Mean values of SI (breast height age 50) by natural subregion and edatope (combinations of SMR and SNR) are shown in Figure 2 for each species and Appendix 2 shows sample size, mean site index, and standard deviation around the mean for each species recorded in each edatope.

While either ecosite or edatope can be used for estimating Site Index, use of edatope (Fig. 2) is preferred since edatopes cover a more restricted range of site conditions and since edatope determination may be more straightforward than ecosite determination in young stands. In the Central Mixedwoods NSR best white spruce and SI is indicated for the 4C edatope while the highest aspen SI is in the 7C edatope (Fig. 2) while in the Lower Foothills (LF) highest SI of aspen, lodgepole pine and white spruce are in edatope 5D.

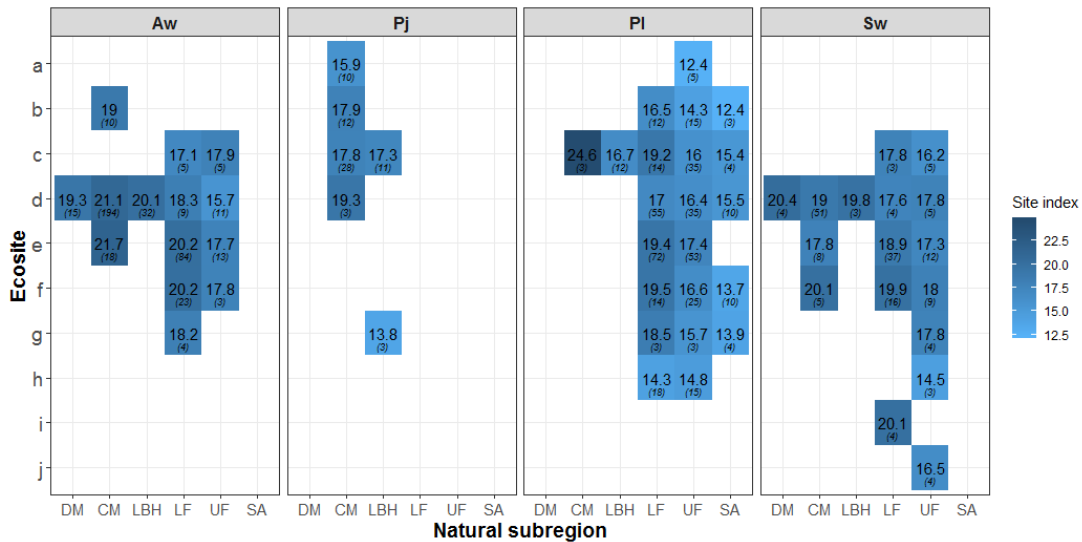


Figure 1. Mean site index (at age 50 breast height age) values by species, natural subregion, and ecosite (n≥3). Numbers in brackets are sample size. Natural Subregion: DM=Dry Mixedwood; CM=Central Mixedwoods; LBH=Lower Boreal Highlands; LF=Lower Foothills; UF=Upper Foothills; SA=Subalpine.

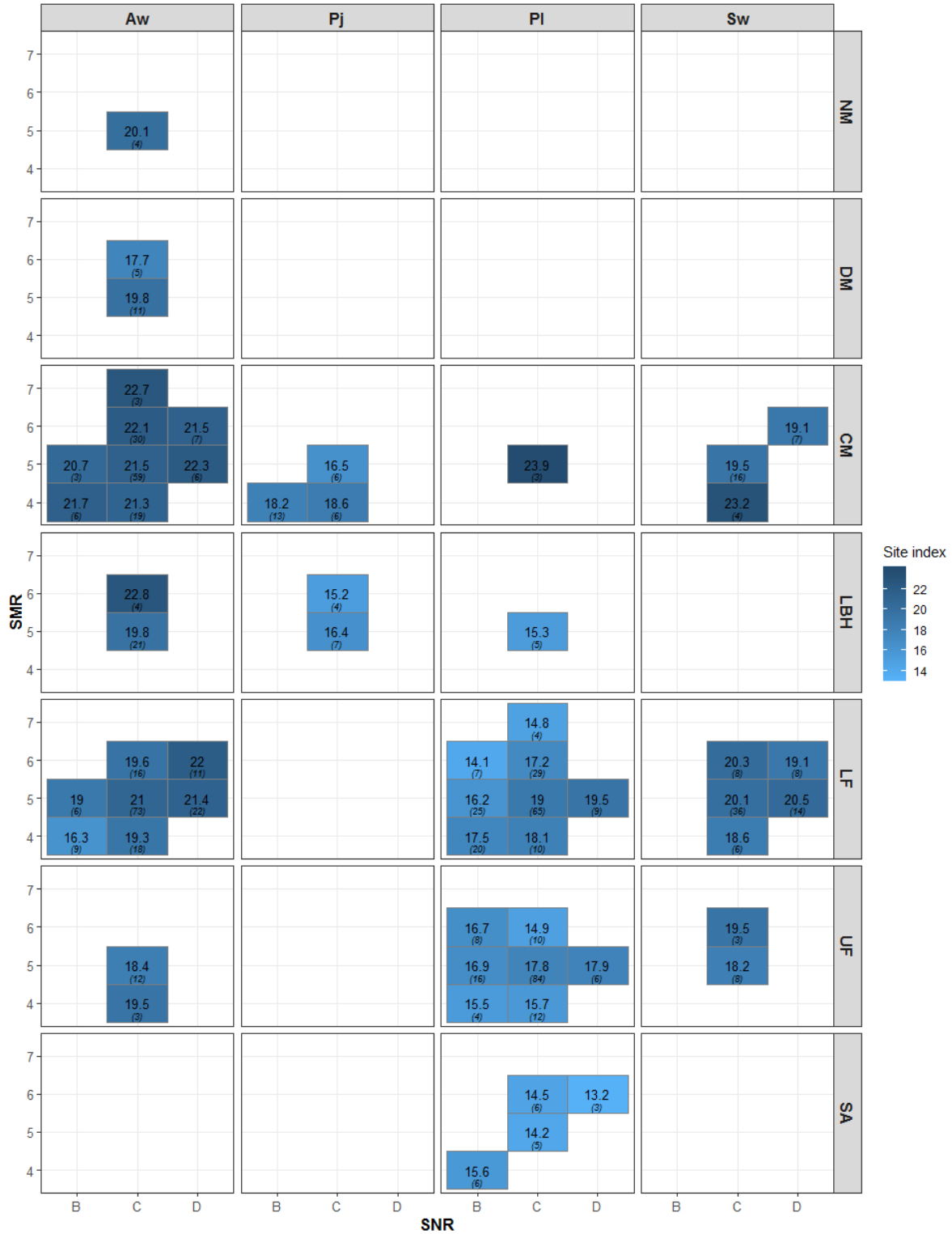


Figure 2. Mean site index (at age 50 breast height age) values by species, natural subregion, and edatope (Soil Moisture Regime (SMR) and Soil Nutrient Regime (SNR) combinations) ($n \geq 3$). Numbers in brackets indicate sample size. Natural Subregion: DM=Dry Mixedwood; CM=Central Mixedwoods; LBH=Lower Boreal Highlands; LF=Lower Foothills; UF=Upper Foothills; SA=Subalpine. SMR (Soil Moisture Regime): 3=Subseric; 4=Submesic; 5=Mesic; 6=Subhygric; 7= Hygric; 8=Subhydric. SNR (Soil Nutrient Regime): B=Poor; C=Medium; D=Rich.

Results from this study provide estimates of site index for the major tree species in Alberta and Saskatchewan based on ecosite (within natural subregion) or edatope. These can be used where direct estimation of site index of a species based on measurement of top height trees may not be possible. Despite the large sample size and efforts to fill in gaps, the sample size is still small for the less common ecosites. For use in MGM users must ensure that they are using SI based on breast height age 50 (Figures 1 or 2, or Appendix 1 or 2) and not total age 50 (Appendix 3 and 4).

Acknowledgements

We gratefully acknowledge funding support provided by the Forest Resource Improvement Association of Alberta (FRIAA) for this project. We are also grateful to industry partners, the Government of Alberta, and the Government of Saskatchewan for providing data used for this study and to the Forest Growth Organization of Western Canada (FGrOW), the WESBOGY (Western Boreal Growth and Yield) Project Team and the MGM Strategic Development Team for their support of MGM development and related projects.

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Appendix 1. Mean site index (at age 50 breast height age), standard deviation around the mean, and sample size by natural subregion and ecosite for each species ($n \geq 3$).

NSR	Ecosite	Pj			Aw			Sw			Pl		
		n	SI	sd	n	SI	sd	n	SI	sd	n	SI	sd
DM	d				15	19.3	2.22	4	20.4	2.78			
CM	a	10	15.9	2.34									
CM	b	12	17.9	2.57	10	19.0	2.68						
CM	c	28	17.8	2.81							3	24.6	2.46
CM	d	3	19.3	2.54	194	21.1	2.79	51	19.0	3.14			
CM	e				18	21.7	3.57	8	17.8	4.20			
CM	f							5	20.1	2.94			
LBH	c	11	17.3	2.15							12	16.7	2.77
LBH	d				32	20.1	3.28	3	19.8	1.05			
LBH	g	3	13.8	2.20									
LF	b										12	16.5	1.82
LF	c				5	17.1	3.40	3	17.8	1.55	14	19.2	2.38
LF	d				9	18.3	1.28	4	17.6	0.79	55	17.0	3.22
LF	e				84	20.2	2.38	37	18.9	2.80	72	19.4	2.70
LF	f				23	20.2	2.86	16	19.9	2.20	14	19.5	2.55
LF	g				4	18.2	3.44				3	18.5	2.01
LF	h										18	14.3	5.16
LF	i							4	20.1	1.58			
UF	a										5	12.4	1.18
UF	b										15	14.3	2.20
UF	c				5	17.9	2.94	5	16.2	1.96	35	16.0	2.85
UF	d				11	15.7	2.36	5	17.8	1.99	35	16.4	2.24
UF	e				13	17.7	3.24	12	17.3	2.25	53	17.4	2.71
UF	f				3	17.8	3.91	9	18.0	2.59	25	16.6	3.16
UF	g							4	17.8	2.66	3	15.7	2.20
UF	h							3	14.5	3.32	15	14.8	3.93
UF	j							4	16.5	2.03			
SA	b										3	12.4	2.16
SA	c										4	15.4	1.01
SA	d										10	15.5	0.80
SA	f										10	13.7	1.95
SA	g										4	13.9	2.21

Natural Subregion (NSR): DM=Dry Mixedwoods; CM=Central Mixedwoods; LBH=Lower Boreal Highlands; LF=Lower Foothills; UF=Upper Foothills; SA=Subalpine. See Beckingham and Archibald (1996) for description of ecosites in the DM, CM and LBH and Beckingham et al. (1996) for description of ecosites in the LF, UF and SA. SMR (Soil Moisture Regime): 3=Subxeric; 4=Submesic; 5=Mesic; 6=Subhygric; 7= Hygric; 8=Subhydric. SNR (Soil Nutrient Regime): B=Poor; C=Medium; D=Rich. n=sample size, SI=average SI, sd=standard deviation.

Appendix 2. Mean SI (at age 50 breast height age) of each species for each combination of SMR and SNR (edatope) found within each NSR (n_≥3). SASK considers plots from Saskatchewan which are predominantly distributed in, or very close, to the Mid-Boreal Lowland Natural Ecoregion.

NSR	SMR	SNR	Aw			Sw			Pj			Pi		
			n	mean SI	sd	n	mean SI	sd	n	mean SI	sd	n	mean SI	sd
CM	4	B	6	21.67	1.73				13	18.16	2.19			
CM	4	C	19	21.27	2.46	4	23.17	1.67	6	18.63	4.34			
CM	5	B	3	20.72	3.83									
CM	5	C	59	21.54	2.47	16	19.46	3.59	6	16.54	2.33	3	23.92	3.66
CM	5	D	6	22.3	3.70									
CM	6	C	30	22.15	2.97									
CM	6	D	7	21.55	4.10	7	19.05	1.92						
CM	7	C	3	22.71	1.52									
NM	5	C	4	20.1	1.46									
DM	5	C	11	19.80	2.29									
DM	6	C	5	17.70	1.69									
LBH	5	C	21	19.76	3.23				7	16.41	2.16	5	15.34	2.22
LBH	6	C	4	22.78	2.64				4	15.20	3.39			
LF	4	B	9	16.30	3.12							20	17.47	2.45
LF	4	C	18	19.33	2.53	6	18.56	1.36				10	18.11	1.86
LF	5	B	6	18.97	3.40							25	16.17	2.37
LF	5	C	73	21.00	2.68	36	20.06	1.69				65	18.95	1.92
LF	5	D	22	21.42	1.71	14	20.52	2.57				9	19.51	2.66
LF	6	B										7	14.07	4.79
LF	6	C	16	19.60	3.47	8	20.26	1.73				29	17.16	3.24
LF	6	D	11	22.02	3.08	8	19.12	2.95						
LF	7	C										4	14.76	3.77
SA	4	B										6	15.60	0.92
SA	5	C										5	14.24	1.67
SA	6	C										6	14.49	2.40
SA	6	D										3	13.22	2.60
UF	4	B										4	15.51	1.65
UF	4	C	3	19.50	1.73							12	15.68	2.94
UF	5	B										16	16.88	1.75
UF	5	C	12	18.44	1.72	8	18.22	1.53				84	16.88	1.75
UF	5	D										6	17.85	2.13
UF	6	C				3	19.51	0.76				10	17.89	1.95
SASK	2	B							4	14.66	1.44			
SASK	3	B	7	15.36	1.49				18	15.05	2.44			
SASK	4	B	5	17.69	1.27				15	15.29	2.86			
SASK	4	C	14	19.03	2.06	9	16.30	4.13	24	16.97	1.96			
SASK	5	B	4	17.13	2.77				12	14.79	3.79			
SASK	5	C	44	18.66	3.13	36	16.99	3.35	28	16.31	1.88			
SASK	5	D				3	16.19	1.06						
SASK	6	B							3	13.48	3.38			
SASK	6	C	10	17.47	2.41	8	14.89	2.18	4	14.02	2.32			
SASK	6	D							3	13.09	1.79			
SASK	7	C				3	15.12	2.39						

Natural Subregion (NSR): DM=Dry Mixedwoods; CM=Central Mixedwoods; LBH=Lower Boreal Highlands; LF=Lower Foothills; UF=Upper Foothills; SA=Subalpine. SMR (Soil Moisture Regime): 3=Subxeric; 4=Submesic; 5=Mesic; 6=Subhygric; 7= Hygric; 8=Subhydric. SNR (Soil Nutrient Regime): B=Poor; C=Medium; D=Rich. n=sample size, SI=average SI, sd=standard deviation.

Appendix 3. Mean site index (**total age=50**), standard deviation around the mean, and sample size by natural subregion and ecosite for each species (n_≥3).

NSR	Ecosite	Pj			Aw			Sw			PI		
		n	SI	sd	n	SI	sd	n	SI	sd	n	SI	sd
DM	d				15	18.8	2.31	4	18.6	2.95			
CM	a	10	14.4	2.41									
CM	b	12	16.5	2.64	10	18.4	2.79						
CM	c	28	16.4	2.88							3	23.4	2.52
CM	d	3	18.0	2.60	194	20.6	2.89	51	17.1	3.32			
CM	e				18	21.2	3.70	8	15.9	4.37			
CM	f							5	18.2	3.13			
LBH	c	11	15.9	2.21							12	15.2	2.84
LBH	d				32	19.6	3.40	3	17.9	1.11			
LBH	g	3	12.2	2.26									
LF	b										12	15.1	1.87
LF	c				5	16.4	3.55	3	15.8	1.64	14	17.8	2.44
LF	d				9	17.7	1.34	4	15.5	0.84	55	15.5	3.30
LF	e				84	19.7	2.48	37	16.9	2.96	72	18.1	2.77
LF	f				23	19.6	2.97	16	18.1	2.33	14	18.1	2.61
LF	g				4	17.5	3.59				3	17.1	2.06
LF	h										18	12.8	5.30
LF	i							4	18.2	1.68			
UF	a										5	10.9	1.22
UF	b										15	12.8	2.26
UF	c				5	17.3	3.07	5	14.1	2.05	35	14.6	2.92
UF	d				11	15.0	2.46	5	15.8	2.10	35	14.9	2.30
UF	e				13	17.1	3.38	12	15.2	2.37	53	16.0	2.78
UF	f				3	17.1	4.08	9	16.0	2.74	25	15.1	3.24
UF	g							4	15.8	2.82	3	14.3	2.26
UF	h							3	12.3	3.42	15	13.3	4.03
UF	j							4	14.4	2.14			
SA	b										3	10.8	2.22
SA	c										4	13.9	1.04
SA	d										10	14.1	0.82
SA	f										10	12.2	2.01
SA	g										4	12.4	2.27

Natural Subregion: DM=Dry Mixedwoods; CM=Central Mixedwoods; LBH=Lower Boreal Highlands; LF=Lower Foothills; UF=Upper Foothills; SA=Subalpine. SMR (Soil Moisture Regime): 3=Subxeric; 4=Submesic; 5=Mesic; 6=Subhygric; 7= Hygric; 8=Subhydric. SNR (Soil Nutrient Regime): B=Poor; C=Medium; D=Rich. n=sample size, SI=average SI, sd=standard deviation.

Appendix 4. Mean SI (total age=50) of each species for each combination of SMR and SNR (edatope) found within each NSR (n≥3). SASK considers plots from Saskatchewan which are predominantly distributed in, or very close, to the Mid-Boreal Lowland Natural Ecoregion.

NSR	SMR	SNR	Aw			Sw			Pj			Pi		
			n	mean SI	sd	n	mean SI	sd	n	mean SI	sd	n	mean SI	sd
CM	4	B	6	21.18	1.79				13	16.75	2.25			
CM	4	C	19	20.76	2.55	4	21.51	1.78	6	17.23	4.46			
CM	5	B	3	20.19	3.98									
CM	5	C	59	21.04	2.56	16	17.57	3.79	6	15.09	2.39	3	22.65	3.75
CM	5	D	6	21.86	3.85									
CM	6	C	30	21.67	3.08									
CM	6	D	7	21.04	4.24	7	17.12	2.04						
CM	7	C	3	22.26	1.57									
NM	5	C	4	19.51	1.52									
DM	5	C	11	19.24	2.38									
DM	6	C	5	17.05	1.77									
LBH	5	C	21	19.19	3.36				7	14.96	2.21	5	13.85	2.28
LBH	6	C	4	22.33	2.73				4	13.71	3.49			
LF	4	B	9	15.59	3.26							20	16.04	2.51
LF	4	C	18	18.74	2.63	6	16.60	1.44				10	16.70	1.91
LF	5	B	6	18.37	3.54							25	14.71	2.43
LF	5	C	73	20.49	2.79	36	18.19	1.79				65	17.56	1.96
LF	5	D	22	20.92	1.78	14	18.68	2.73				9	18.13	2.72
LF	6	B										7	12.55	4.92
LF	6	C	16	19.03	3.60	8	18.41	1.84				29	15.72	3.32
LF	6	D	11	21.54	3.20	8	17.20	3.13						
LF	7	C										4	13.26	3.88
SA	4	B										6	14.12	0.95
SA	5	C										5	12.72	1.72
SA	6	C										6	12.99	2.47
SA	6	D										3	11.68	2.67
UF	4	B										4	14.03	1.69
UF	4	C	3	18.93	1.80							12	14.21	3.02
UF	5	B										16	15.44	1.79
UF	5	C	12	17.83	1.80	8	16.25	1.62				84	16.43	2.19
UF	5	D										6	16.47	2.00
UF	6	C				3	17.61	0.81				10	15.23	2.73
SASK	2	B							4	13.16	1.48			
SASK	3	B	7	14.61	1.55				18	13.56	2.51			
SASK	4	B	5	17.04	1.33				15	13.80	2.94			
SASK	4	C	14	18.43	2.14	9	14.26	4.32	24	15.53	2.01			
SASK	5	B	4	16.45	2.89				12	13.29	3.89			
SASK	5	C	44	18.05	3.25	36	14.96	3.52	28	14.85	1.93			
SASK	5	D				3	14.09	1.11						
SASK	6	B							3	11.94	3.47			
SASK	6	C	10	17.47	2.41	8	12.75	2.25	4	12.50	2.39			
SASK	6	D							3	11.54	1.84			
SASK	7	C				3	12.98	2.49						

Natural Subregion: DM=Dry Mixedwoods; CM=Central Mixedwoods; LBH=Lower Boreal Highlands; LF=Lower Foothills; UF=Upper Foothills; SA=Subalpine. SMR (Soil Moisture Regime): 3=Subxeric; 4=Submesic; 5=Mesic; 6=Subhygric; 7= Hygric; 8=Subhydic. SNR (Soil Nutrient Regime): B=Poor; C=Medium; D=Rich. n=sample size, SI=average SI, sd=standard deviation.