Revised moisture factor for land suitability rating system (LSRS) for use in climate change studies.

Background:

The existing LSRS for small grain cereals uses Precipitation – Potential Evapotranspiration (P-PE) accumulated from May 1 to August 31 to determine point deductions for moisture (Fig. 1). Point deductions are calculated as follows:

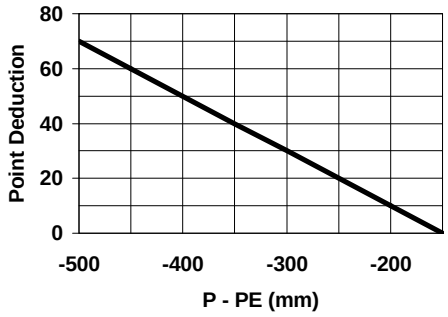


Figure 1. Point deduction for moisture index values (P – PE) for existing LSRS.

Point deduction = -30.0 - 0.2 (P - PE),
where P - PE is in mm (Eq'n 1)

If DEFICIT4 is used from the Java program (which is PE-P rather than P-PE), then the equations becomes as follows:

Point deduction = 0.2 (DEFICIT4) – 30.0 (Eq'n 2)

Proposed New Moisture Index:

Under climate change scenarios, small grain cereals can be seeded considerably earlier than under present climate, and thus much of the accumulated values of PE-P occur after wheat and barley are mature and have been harvested. This tends to overestimate the impact of climate change on the moisture index. Therefore a new index is being proposed (DEFwheat) for climate change studies which bases the accumulation of PE-P over a period beginning on the estimated date of seeding of spring cereals until the estimated time when wheat is mature. This index will be used as a surrogate for both wheat and barley. The average seeding date is estimated as 10 days after average mean daily air temperature reaches 5ºC. This is the same date when the effective growing degree-days (EGDD) accumulations begin in the LSRS, except that the limit of April 1 as the earliest start date is removed. The end date is estimated by the biometeorological time scale (BMTS), which takes both temperature and daylength into account in predicting maturity stages in wheat.

The existing point deduction system for the moisture index (P-PE) is valid for both wheat and barley. It is not intented that the revised index changes the existing ratings for present-day (1961-1990) climate to any great extent. The new PE-P based on wheat (DEFwheat) should provide similar point deductions for a given location as the old value. Therefore, the DEFwheat values will be scaled so that the deduction based on DEFICIT4 will have a similar value as DEFwheat for a given location. A regression relationship between DEFwheat and DEFICT4 based on 1961-1990 data will be used to scale the data. The same scaling based on the 1961-90 relationship will be used for future periods (e.g 2040-2069), since similar DEFwheat values for both periods should give the same point deductions. This relationship is shown in Fig. 2 for 22 grid points selected from across Canada. Vancouver data

was removed from the regression because it is a major outlier, i.e. DEFICIT4 was 153 mm, while DEFwheat was –128 mm. The relationship is also shown for barley.

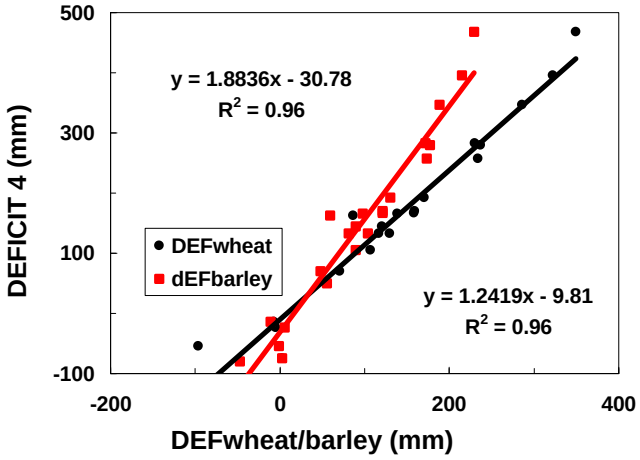


Fig. 2. Relationship of DEFICIT4 with DEFwheat and DEFbarley (1961-1990 data, excluding Vancouver.

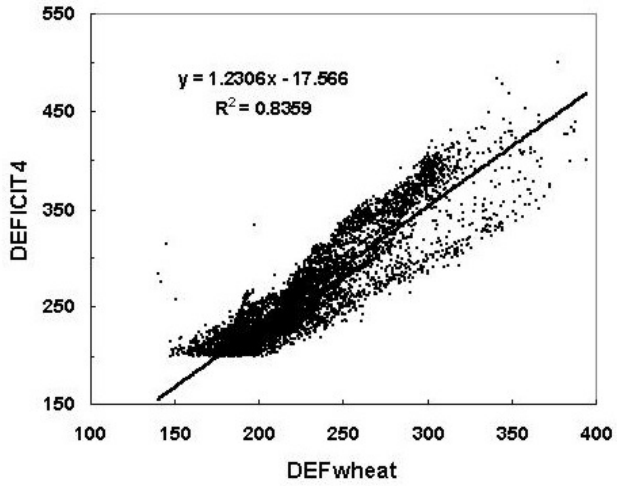


Fig. 3. DEFICIT4 (mm) vs. DEFwheat,(mm) based on 9,979 grid points, 1961-1990 data.

This relationship is relatively independent of data. Similar results were obtained by selecting a narrow strip of data along the Alberta/Saskatchewan border.

It is proposed that the final relationship to be used to scale the DEFwheat values will be based on a regression using all appropriate grid points across Canada from the 500 arc second grid data. The results are shown in Fig. 3. This figure is based on a total of 9,979 grid points (out of an original 58,539 points). The following data was removed from this analysis: i) all DEFICIT4 values less than 200 mm (these would all fall under Class 1A ratings and are not very important in the relationship); ii) all EGDD values less than 500 as these would all be a CLASS 7H rating and not relevant to the relationship; iii) an additional 18 grid points which had DEFwheat values less than 140 mm, as these were all outliers on the west coast (similar to Vancouver), having relatively high DEFICIT4 values (i.e. typically 250 to 300 mm).

Comparison of scaled values of DEFwheat using the relationships in Figs. 2 and 3 are shown in Table 1.

Table 1. Comparison of scaled values of scaled values of DEFwheat using relationships shown in Figure 2 and in Figure 3.

DEFwheat (X) (mm) (unscaled)	Scaled Deficit (Y) (mm)	
	Based on Fig.2	Based on Fig. 3
0	-10	-18
100	114	105
200	239	229
300	363	352
400	487	475
500	611	598

There is only a small difference between scaled deficit values using these two regression relationships developed from different datasets, indicating the robustness of this relation.

Thus DEFwheat values will be scaled using the following relationship:

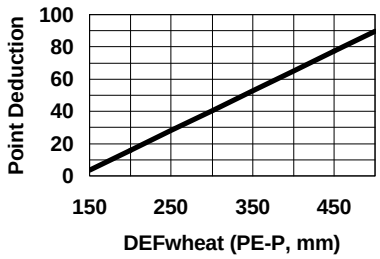


Fig. 4. Equivalent point deductions for unscaled values of DEFwheat

Scaled Deficit = 1.2306 (DEFwheat) – 17.566 (Eq'n 3)

Point deductions for scaled DEFwheat values are then determined using the scale in Fig. 1 as before. Scaling the DEFwheat values using the regression is equivalent to using the point deductions for unscaled values shown in Fig. 4. as in the following equation:

Point Deduction = 0.2461 (DEFwheat) – 33.51 (Eq'n 4)

Comparisons of old and new moisture index:

Comparison of point deductions using DEFICIT4 with those based on DEFwheat are shown in Fig. 5 and Table 2 for 23 selected locations across Canada (same dataset as used in Fig. 2, except that Vancouver is included). Point deductions for the 1961-1990 period are very similar as expected and as desired. For the 2040-69 period, the point deductions for DEFICIT4 are generally higher than the deductions for DEFwheat, i.e. climate change has less impact on DEFwheat, as expected. Note that fewer than 23 points appear on the graph since a number are zero value.

It was noted earlier that the Vancouver grid point was a major outlier in the DEFICIT4 vs. DEFwheat relationship (shown in Fig.2). However, Table 2 indicates that the resulting point deductions and Class values are similar for both old and new ratings, i.e. Class values of 1A indicate no moisture limitations using either method.

Comparisons of point deductions for a sample of the entire 500 arc second grid data are presented in Figs. 6 and 7 for the 1961-90 and 2040-69 periods, respectively. The original 58,539 grid points were reduced to 19,605 grid points by removing all DEFICIT4 values of <150 mm. The remaining grid points were then sorted by DEFICIT4 values and every 40th value was then selected. This left a sample of 491 grid points.

Fig. 6 indicates that the point deductions for DEFICIT4 and DEFwheat fall close to the 1:1 relationship, which is

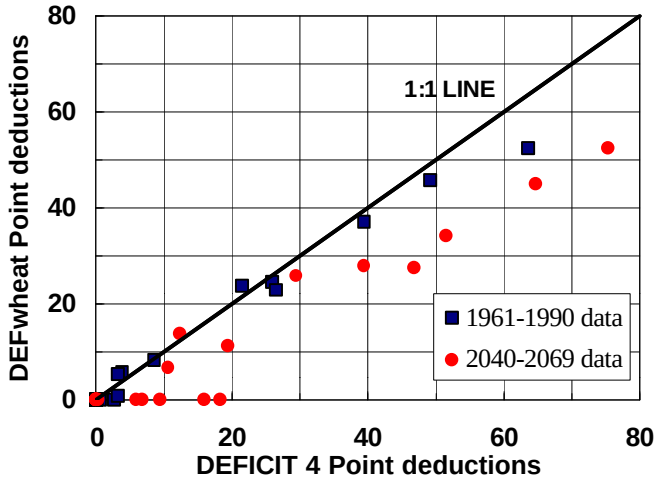
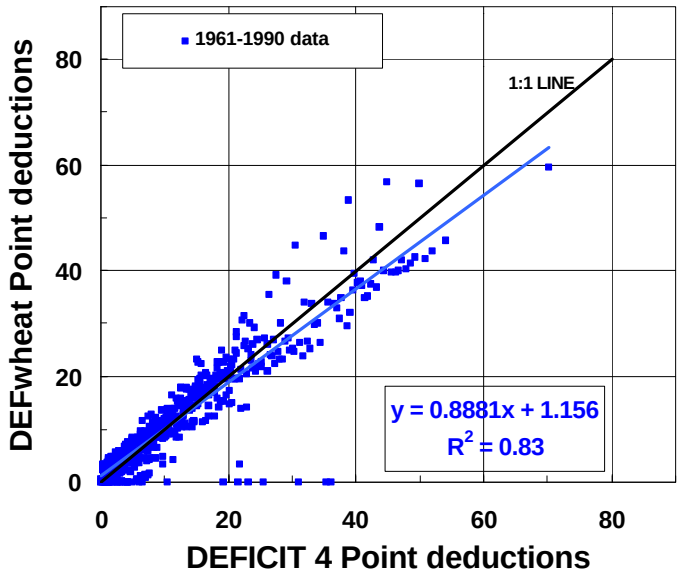
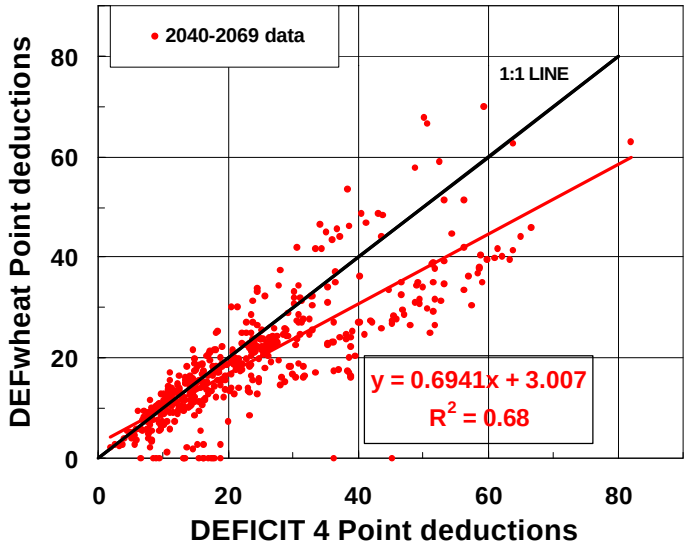


Fig. 5. Comparison of point deductions for moisture using DEFICIT4 and DEFwheat at 23 locations.

desirable. The outliers in Fig. 6 with zero points for DEFwheat and 20 to 40 points for DEFICIT4 all come from the west coast (around 123 to 124º W, and 52 to 53º N) and have EGDD2 values which are less than 100, i.e. the limiting factor will be heat and the moisture factor is therefore not important for these grid points. The differences in the point deductions



. Figure 6. Comparison of point deductions for moisture using DEFICIT 4 and DEFwheat as moisture factors in the LSRS based on 1961-1990 data. It is assumed that the temperature factor (H) is non-limiting in all cases. Point deductions for DEFwheat are based on scaled values.



. Figure 7. Comparison of point deductions for moisture using DEFICIT 4 and DEFwheat as moisture factors in the LSRS based on 2040-2069 data. It is assumed that the temperature factor (H) is non-limiting in all cases. Point deductions for DEFwheat are based on scaled values.

Table 2. Comparison of Deficits, point deductions and class values for old (LSRS) and new (WHEAT) moisture deficit rating systems for present and future climate at 23 locations across Canada (note: it is assumed that the heat factor is not limiting in all cases, i.e. the EGDD2 values shown were not used).

	Period: 1961-90									Period: 2040-69								
Location near grid		LSRS				WHEAT					LSRS				WHEAT			
	EGDD2	Deficit4	Points	CLASS		DEFWheat	Points	CLASS		EGDD2	Deficit4	Points	CLASS		DEFWheat	Points	CLASS	
Vancouver	1923	153	1	1	A	-128	0	1	A	2416	241	18	1	A	-280	0	1	A
Oliver	1922	468	64	4	A	349	52	3	A	2480	527	75	5	A	350	53	3	A
Fort Nelson	1214	170	4	1	A	159	6	1	A	1720	203	11	1	A	163	7	1	A
Lethbridge	1474	347	39	2	A	286	37	2	A	2150	407	51	3	A	275	34	2	A
Edmonton	1306	167	3	1	A	158	5	1	A	1909	212	12	1	A	192	14	1	A
Fort Vermillion	1244	257	21	2	A	233	24	2	A	1737	297	29	2	A	241	26	2	A
Mankota	1312	396	49	3	A	322	46	3	A	1993	474	65	4	A	318	45	3	A
Prince Albert	1283	280	26	2	A	237	25	2	A	1828	347	39	2	A	250	28	2	A
Brandon	1501	283	27	2	A	230	23	2	A	2178	384	47	3	A	248	28	2	A
Flin Flon	1257	193	9	1	A	170	8	1	A	1727	247	19	1	A	183	11	1	A
Churchill	495	50	0	1	A	56	0	1	A	983	63	0	1	A	55	0	1	A
Harrow	2440	163	3	1	A	86	0	1	A	3074	229	16	1	A	43	0	1	A
Ottawa	1686	166	3	1	A	139	1	1	A	2208	197	9	1	A	127	0	1	A
Kapuskasing	1115	133	0	1	A	130	0	1	A	1556	151	0	1	A	132	0	1	A
Huntingdon	1918	145	0	1	A	120	0	1	A	2459	184	7	1	A	112	0	1	A
Normandin	1245	106	0	1	A	107	0	1	A	1686	144	0	1	A	124	0	1	A
Deception Bay	25	-75	0	1	A	3	0	1	A	442	-37	0	1	A	-6	0	1	A
Fredericton	1534	133	0	1	A	116	0	1	A	2001	179	6	1	A	116	0	1	A
Halifax	1559	-13	0	1	A	-8	0	1	A	1973	16	0	1	A	-25	0	1	A
Sydney	1366	-23	0	1	A	-5	0	1	A	1711	-14	0	1	A	-16	0	1	A
Charlottetown	1563	70	0	1	A	70	0	1	A	1985	96	0	1	A	50	0	1	A
St. John's	1120	-54	0	1	A	-97	0	1	A	1309	-58	0	1	A	-49	0	1	A
Hopedale	425	-80	0	1	A	-48	0	1	A	498	-79	0	1	A	-57	0	1	A

between DEFWheat and DEFICIT 4 are equal or greater than ± 10 points in only 15 of the 491 cases. In other words, in 97% of the cases, the deductions are within 10 points of each other. In 85% of the cases, they are within 5 points of each other.

Fig. 7 indicates that for the 2040 to 2069 period, the point deduction for DEFwheat tends to be below that of DEFICIT4 for most grid points. Point deductions at DEFICIT4 values near 60 are typically around 40 for DEFwheat. The Class values for these deficits are 4A and 2-3A respectively. The two outliers in Fig. 7 for DEFwheat points = 0 are on the west coast (about 50 to 52º N, 125º W). Cases where DEFwheat deductions are greater than DEFICIT4 by about 10 to 18 points are typically in the west coast between 123 to 126º W and 51 to 53º N. In some cases the stop dates for wheat are past the fall frost date in these cases.

Conclusions:

The new point deductions and class ratings based on the moisture deficits during the wheat growing period compare well with those used in the present LSRS for 1961-1990. Thus adopting scaled values of DEFwheat do not cause a major change in the ratings for present climate.

For future climate, the new ratings generally result in less severe point deductions than the ratings based on the present LSRS criteria. This is desirable, as small grains are seeded earlier under climate change and therefore do not experience as much moisture stress as indicated by the present deficit calculations.

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