LACIE-00433
JSC-11658

LARGE AREA CROP INVENTORY EXPERIMENT (LACIE)

CROP INVENTORY
LARGE AREA
EXPERIMENT
LACIE

NASA NOAA USDA

(NASA-TM-74833) LACIE: YIELD-WEATHER REGRESSION MODELS FOR THE CANADIAN PRAIRIES (NASA) 26 p HC A03/MF A01 CSCL 02C
N77-30575
Unclas
G3/43 44980

YIELD-WEATHER REGRESSION MODELS FOR THE CANADIAN PRAIRIES

National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

February, 1976

DOCUMENT

PREPARED BY

NOAA PERSONNEL

CENTER FOR CLIMATIC AND ENVIRONMENTAL ASSESSMENT

COLUMBIA, MISSOURI

TECHNICAL NOTE 76-2

FEBRUARY 1976

Jerry D. Hill

Authorized by

for Norton D. Strommen

Acting Director, CCEA

October 20, 1976

Yield-Weather Regression Models

for the Canadian Prairies

Sharon K. LeDuc

February 2, 1976

The Canadian prairie wheat region has in recent years produced about 4 1/4 percent of the world's wheat. Most of this wheat is exported and accounts for about 20 percent of the world's wheat exports. The major wheat growing area is shaded in Figure 1. There is generally a moisture shortage in this region due to the Rocky Mountains which restrict moisture from the Pacific Ocean. Most of the variability in wheat production is due to weather fluctuations. Climatic differences within the region accounts for a large portion of the variability in yields for different parts of the region. Separate regression models were developed for each of the areas indicated in Figure 1.

Yield Data

The available production and seeded acreage data determined what areas would be used for specifying the models. A consistent sample of yields for as many years as possible was required. Annual yields from 1933-1974 were available although the geographical areas for reporting acreage and production changed during the time period. For some model areas, this required reaggregation of available acreage and production data.

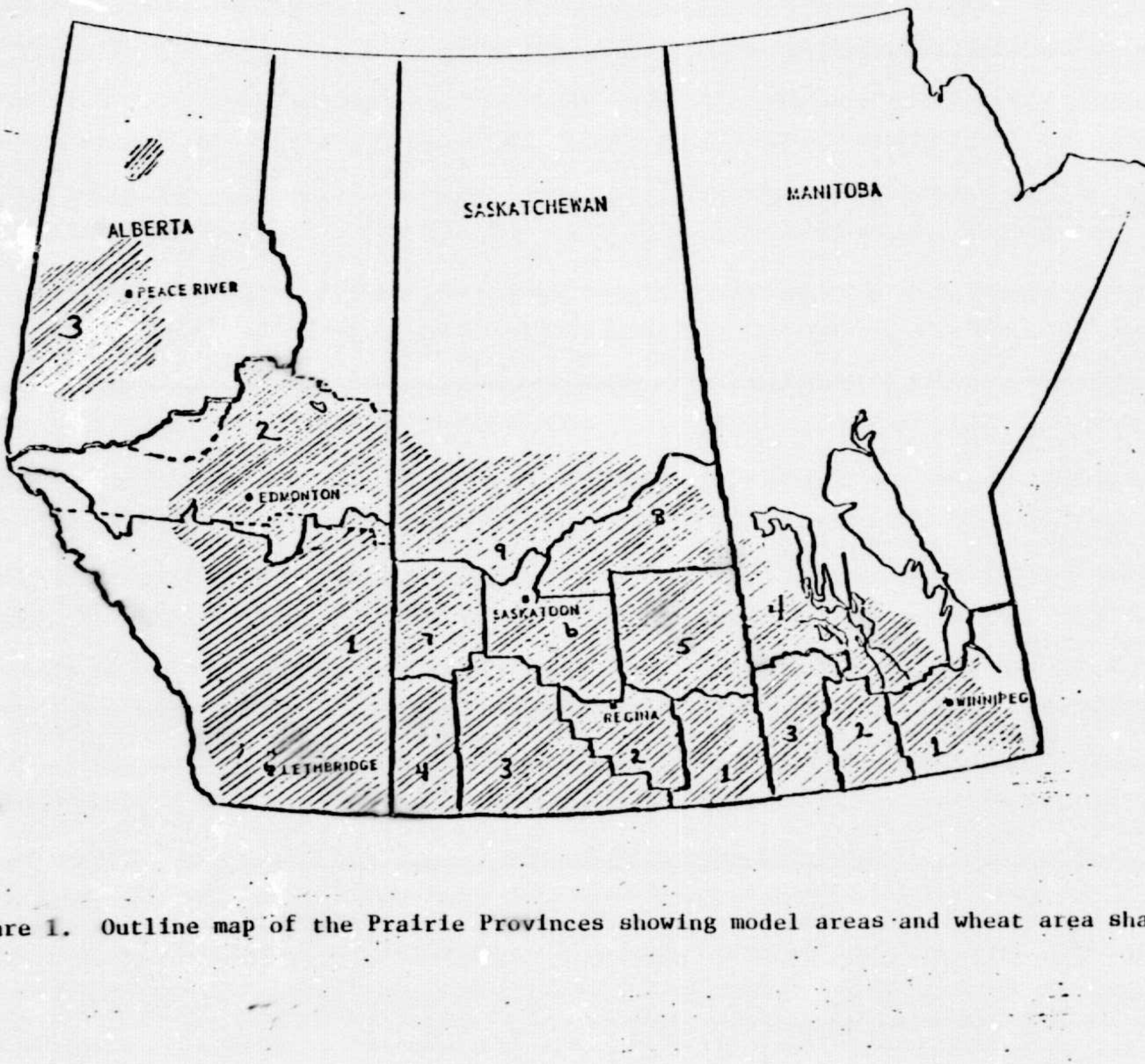

Figure 1. Outline map of the Prairie Provinces showing model areas and wheat area shaded.

Dividing the annual total production by the annual total seeded acreage in each area provided an annual yield for each model area for each year.

For Saskatchewan no reaggregation of production and planted acreage for the model areas was necessary. Model areas for Alberta differ prior to 1956 (dotted lines, Figure 1). Manitoba model regions are consistent, 1936-1974. There were slight deviations for 1933-1935.

Weather Data

Monthly weather summaries consisting of mean maximum temperature, mean minimum temperature, mean temperature and total precipitation were avilable for stations in the Prairie Provinces. All available stations were accepted if they were in the wheat producing region and if they had enough years of data available. Values for the monthly weather variables were averaged over all stations in the same model area. The number of stations varied for different areas. These are given in Table 1.

TABLE 1. Reaggregation of Reported Acres and Production into Model Areas.

Province and Reporting Area	Model Area	Reporting Areas	Number of Met. Stations
Alberta-	1	1-9	126
Census Divisions	2	10-14	61
	3	15	52
Saskatchewan-	1	1a, 1b	14
Crop District	2	2a, 2b	28
	3	3as, 3an, 3bs, 3bn	40
	4	4a, 4b	22
	5	5a, 5b	23
	6	6a, 6b	29
	7	7a, 7b	15
	8	8a, 8b	15
	9	9a, 9b	35
Manitoba-	1	3-6	12
Crop District	2	2, 8, 9	11
	3	1, 7, 10	10
	4	11-14	10

The monthly average temperature for a model area was sometimes converted to a measure of potential evapotranspiration (P.E.T.) using a method developed by Thornthwaite (1948) and is briefly explained in Appendix A. The P.E.T. was subtracted from the precipitation yielding a measure of the moisture available for that month.

The soil moisture available at planting is one of the variables affecting yields especially when fertilizer is applied (Read and Warder, 1974). To measure this the monthly precipitation values were accumulated for a period of 20 months prior to the normal month of planting which is May for most of Canada. The period of 20 months was used because of the extensive practice of summerfallowing. There have been minor changes in the percent of acres in summerfallow during the period 1916-68 (Figure 2). Any downward shift of this practice would result in decreasing the yield potential. The effect of summerfallow on yield can be seen in the following table.

TABLE 2. Summerfallow Versus Stubble Distribution and Yield for Wheat.

		Distribution (%)		Yield (Bu/A)	
Province	Year	Stubble	Summerfallow	Stubble	Summerfallow
Saskatchewan	1960	25	75	15.2	22.6
	1961	27	73	4.3	9.7
	1963	17	83	20.6	29.0
	1964	20	80	13.1	19.4
	1965	21	79	17.8	22.6
	1966	25	75	22.1	29.6
	1967	28	72	12.9	18.9
	1968	24	76	14.1	21.3
	1968-72 avg	15	85	16.7	25.5
	1972	18	82	16.8	24.9
	1973	16	84	18.6	25.5
	1974	20	80	16.0	22.5
Alberta	1968-72 avg	23	77	20.4	28.4
	1972	23	77	23.0	28.7
	1973	18	82	21.6	28.6
	1974	22	78	21.0	25.4

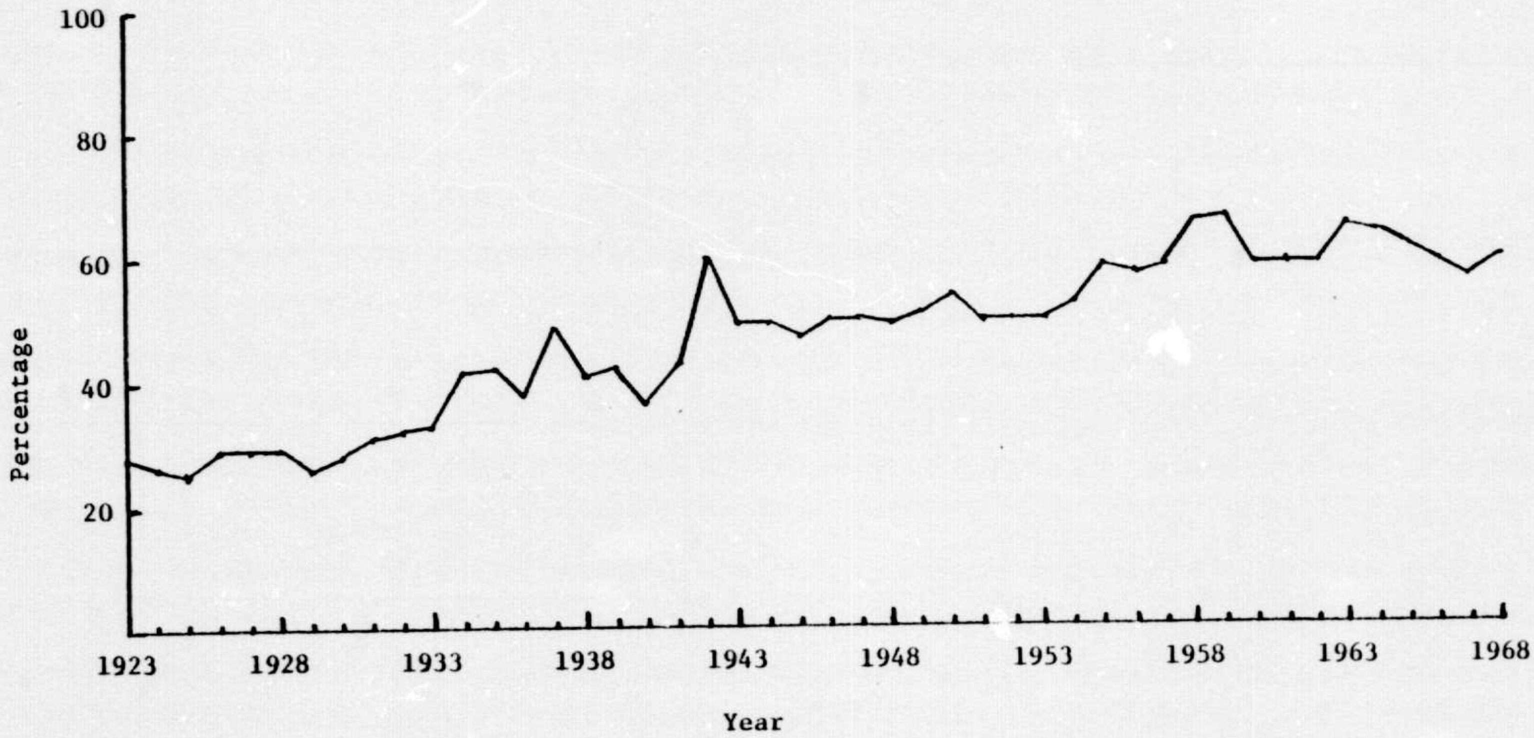

Figure 2. Percentage of Planted Acres in Saskatchewan Which Were Summerfallowed (1923-1968).

Although more humid than either Saskatchewan or Alberta, Manitoba summerfallow is also used quite extensively, largely as a weed control measure (Table 3). However, yield on stubble and summerfallow are not reported separately and wheat planted on fallow is also not reported separately.

TABLE 3. Manitoba Wheat Acres and Summerfallow.

Year	Summerfallow		Wheat Planted
		Acres	
1971	2,655,000		2,519,000
1972	2,900,000		2,600,000
1973	2,400,000		3,100,000

For some of the model areas farther north the mean minimum and mean maximum monthly temperatures are important as indicators of the length of the growing season.

All weather variables are in terms of deviations from normal (DFN), i.e., the sample average is subtracted. The square of this deviation is sometimes used (SDFN).

Regression Model

The general form of the regression model for yield y for a particular model area is

$$y_i = \alpha + \beta T_i + \sum_{j=1}^{k} \gamma_j W_{ij} + \varepsilon_i,$$

where:

y_i is the yield for year i;

α is the intercept estimated in the regression;

β, γ_j, $j = 1,2,\ldots,k$ are parameters estimated in the regression;

T_i is a time variable for ith year found by subtiacting 1932 from the year;

W_{ij} is one of the weather variables (the jth) described in the previous section for the ith year.

ε_i is the deviation of the yield from the regression for the ith year. (Errors are assumed to be independent and normally distributed with mean zero and unit standard deviation.)

Discussion of Models

The deviation from normal of summerfallow was a variable which was significant in all models for all models areas in Alberta and Saskatchewan except area 2 in Alberta and area 8 in Saskatchewan. The sign of the coefficient was positive for all these areas except for area 3 in Alberta. This area also had the third highest normal for summerfallow precipitation. Only areas 1 and 4 in Manitoba were higher.

In estimating the coefficients in the regression equations the years 1933-53 and 1955-74 were used with a few exceptions. Area 1 in Alberta and area 4 in Saskatchewan included 1954 and area 1 in Manitoba omitted 1963. The years omitted experienced severe losses due to rust (Williams, 1972). Although losses due to rust are affected by the weather the wheat must be vulnerable to the rust present.

The September minimum temperature DFN appears in the models for Alberta and for model area 9 in Saskatchewan. Higher minimum temperatures in September indicate higher yields except for model area 3 in Alberta. There they are associated with lower yields; however, higher maximum temperatures in May indicate higher yields.

The minimum temperature in April which is higher than normal indicates higher yields for model area 1 and area 5 in Saskatchewan, and 2 and 3 in Manitoba, and 2 in Alberta. The same effect was noticed for model areas 8 and 9 in Saskatchewan and 4 in Manitoba for estimates early in the growing season which neglect what can possibly happen later. However, for later estimates decreased yields were indicated. For model area 7 in Saskatchewan throughout the season higher minimum April temperatures indicated lower yields.

Higher precipitation in May increases yield in areas 1, 2, 3, and 4 in Saskatchewan, 3 in Manitoba, and 2 in Alberta.

For the months of June through August, the deviation from normal of the precipitation minus the potential evapotranspiration and/or the squared deviation were used. The estimated coefficients of the squared deviations were negative indicating extreme deviations in either direction decrease yields. With only two exceptions the estimated coefficients for the deviations were positive indicating more moisture improved yields. The fitted models for area 3 in Alberta and for area 9 in Saskatchewan indicated yields were decreased when August precipitation minus potential evapotranspiration was above normal. The models for area 7 and 8 in Saskatchewan do not contain meteorological variables for months after July.

REFERENCES

Read, D. W. L. and F. G. Warder, 1974: Influence of Soil and Climatic Factors on Fertilizer Response of Wheat Grown on Stubble Land in Southwestern Saskatchewan. Agronomy Journal, 66:245-248.

Thornthwaite, C. W., 1948: An Approach Toward a Rational Classification of Climate. Geographical Review, 38:55-94.

Williams, G. D. V., 1972: Geographical Variations in Yield-Weather Relationships over a Large Wheat Growing Region. Agric. Meteorol., 9:265-283.

APPENDIX A

Thornthwaite

1. Unadjusted Potential Transpiration, P.E.T. $P.E.T. = 1.6 \left(\frac{(10.0)(t)}{I}\right)^a$

in cm of water per 30 day month, with each day having 12 hours of sunlight.

If $i_k = (t_k/5.0)^{1.514}$, where

t_k = monthly normal temperature, C^o,

t_1 = monthly normal temperature, January

t_2 = monthly normal temperature, February

t_3 = monthly normal temperature, March

t_4 = monthly normal temperature, April

t_5 = monthly normal temperature, May

t_6 = monthly normal temperature, June

t_7 = monthly normal temperature, July

t_8 = monthly normal temperature, August

t_9 = monthly normal temperature, September

t_{10} = monthly normal temperature, October

t_{11} = monthly normal temperature, November

t_{12} = monthly normal temperature, December

$$I = \sum_{k=1}^{12} i_k$$

$a = (675)(10^{-9})I^3 - (771)(10^{-7})I^2 + (1792)(10^{-5})I + .49239.$

2. Adjusted P.E.T. = (c) (unadjusted P.E.T.), where c is a daylength factor =

$c = (h/12.0)$, where h = number of hours (to nearest hundredth) between sunrise and sunset for mid month.

MANITOBA DISTRICT 1 MODEL

Variable	Normal	Coefficient for Specified Truncation Time			
		Trend	June	July	August
Constant		17.471	18.214	19.074	19.609
Linear Trend 1931 = 1, ...		.156	.159	.112	.094
June pcp-pet (in.) SDFN C = 1.408	-1.458		-.488	-.377	-.463
July pcp-pet (in.) DFN C = 1.373	-2.457			1.248	1.343
August pcp-pet (in.) DFN C = 1.248	-1.733				.870
Se		3.903	3.742	3.466	3.216
R^2 (Adjusted)		.19	.25	.36	.40
R^2		.20	.29	.41	.48
SD of Yields (bu/A)	4.319				

PET is potential evapotranspiration from Thornthwaite (Latitude 50^{o}N, A = 1.107, I = 38.528)
DFN is Departure from Normal (average over sample 1931-74)
SDFN is square of DFN
C is daylength correction factor

Years in yield sample - 1933-53, 1955-62, 1964-74.

MANITOBA DISTRICT 2 MODEL

Variable	Normal	Trend	April	June	July	August
		Coefficient for Specified Truncation Time				
Constant		14.992	14.958	16.148	16.538	16.753
Linear Trend 1931 = 1, ...		.284	.285	.283	.261	.268
April Min Temp (°F) DFN	27.052		.384	.292	.254	.261
June pcp-pet (in.) DFN C = 1.408	-.990			.668	.476	.059
SDFN				-.392	-.355	-.252
July pcp-pet (in.) DFN C = 1.373	-2.354				.786	1.098
August pcp-pet (in.) DFN	-1.760					1.362
SDFN C = 1.248						-.337
Se		3.910	3.738	3.383	3.292	2.792
R^2 (Adjusted)		.44	.49	.58	.60	.71
R^2		.46	.51	.62	.65	.77
SD of Yields (bu/A)	5.229					

PET is potential evapotranspiration from Thornthwaite (Latitude 50° N, A = 1.158, I = 41.96)
DFN is Departure from Normal (average over sample 1931-74)
SDFN is square of DFN
C is daylength correction factor

Years in yield sample - 1933-53, 1955-74.

MANITOBA DISTRICT 4 MODEL

Revised 12 July 1976

Variable		Normal	Trend	April	June	July	August
			Coefficient for Specified Truncation Time				
Constant			18.629	18.393	19.974	22.123	22.279
Linear Trend, 1931=1, ...			.185	.194	.192	.133	.132
April Min Temp (^{o}F)	DFN	25.400		.255	.152	-.047	-.093
June Prec-P.E.T. (in.)	DFN				1.220	.932	.708
C=1.422	SDFN	-1.434			-.619	-.630	-.593
July Prec-P.E.T. (in.)	DFN	-2.815				1.477	1.455
C=1.384	SDFN					-.573	-.364
August Prec-P.E.T. (in.)	DFN	-2.046					.927
C=1.256	SDFN						.316
Se			4.329	4.276	3.453	3.047	2.865
R^2 (Adjusted)			.20	.22	.49	.61	.65

SD of Yields (Bu/A) = 4.854

P.E.T. is potential evapotranspiration from Thornthwaite (latitude 51^{o}N, A=.935, I=27.092).
DFN is departure from normal (average of sample years 1931-74).
SDFN is square of DFN.
C is daylength correction factor.

Years in yield sample: 1933-53, 1955-74.

SASKATCHEWAN DISTRICT 1 MODEL

Variable	Normal	Trend	April	May	June	July	August
			Coefficient for Specified Truncation Time				
Constant		9.826	10.284	10.882	9.876	10.041	10.107
Linear Trend 1931 = 1, ...		.[illegible]62	.335	.307	.402	.390	.387
Fallow pcp (in.) (20 mo. thru April) DFN	26.077		.505	.508	.381	.360	.385
April min temp (°F) DFN	26.320		.533	.561	.347	.296	.240
May pcp-pet (in.) DFN C = 1.327	-1.120			1.219	.908	.740	.693
June pcp-pet (in.) DFN	-1.266				2.054	1.965	1.828
SDFN C = 1.408					-.358	-.308	-.296
July pcp-pet (in.) DFN C = 1.373	-2.870					.675	.664
August pcp-pet (in.) DFN C = 1.248	-2.104						.568
Se		5.634	5.039	4.890	3.858	3.800	3.730
R^2 (Adjusted)		.38	.50	.53	.71	.72	.73
R^2		.39	.54	.58	.75	.77	.73
SD of Yields (bu/A)	7.150						

pet is potential evapotranspiration from Thornthwaite (Latitude 50°N, A = .936, I = 27.206)
DFN is Departure from Nornal (average over sample 1931-74)
SDFN is square of DFN
C is daylength correction factor

Years in yield sample 1933-53,55-74.

SASKATCHEWAN DISTRICT 2 MODEL

Variable	Normal	Coefficient for Specified Truncation Time					
		Trend	April	May	June	July	August
Constant		9.668	9.473	9.601	10.006	10.045	9.572
Linear Trend 1931 = 1, ...		.364	.370	.364	.415	.402	.441
Fallow pcp (in.) (20 mo. thru Apr) DFN	22.748		.414	.430	.372	.339	.366
May pcp-pet (in.) DFN C = 1.327	-1.324			.676	.691	.524	.365
June pcp-pet (in.) DFN C = 1.408	-1.473				1.995	1.839	1.519
SDFN					-.696	-.564	-.348
July pcp-pet (in.) DFN C = 1.373	-3.238					1.508	1.351
August pcp-pet (in.) DFN C = 1.248	-2.580						.821
SDFN							-.449
Se		5.353	5.196	5.191	3.711	3.323	3.302
R^2 (Adjusted)		.41	.44	.44	.72	.77	.77
R^2		.42	.47	.48	.75	.81	.82
SD of Yields (bu/A)	6.956						

Pet is potential evapotranspiration from Thornthwaite (Latitude 50° N, A = .958, I = 28.608)
DFN is Departure from Normal (average over sample 1931-74)
SDFN is square of DFN
C is daylength correction factor

SASKATCHEWAN DISTRICT 3 MODEL

Revised May 20, 1976

Variable	Normal	Coefficient for Specified Truncation Time				
		Trend	April	May	June	July
Constant		6.963	8.226	8.686	7.475	8.756
Linear Trend, 1931-74		.353	.294	.274	.328	.299
Fallow Prec. (in.) (20 months thru Apr) DFN	20.439	-----	.728	.741	.624	.625
May Prec. - P.E.T. (in.) (C=1.327) DFN	-1.507	-----	-----	1.370	1.198	1.201
Jun Prec. - P.E.T. (in.) (C=1.408) DFN	-1.738	-----	-----	-----	2.479	2.253
Jul Prec. - P.E.T. (in.) (C=1.373) DFN	-3.563	-----	-----	-----	-----	2.565
Jul Prec. - P.E.T. (in.) SDFN		-----	-----	-----	-----	-.451
Standard Error (bu/acre)		5.904	5.448	5.292	3.746	2.793
R^2		.36	.47	.51	.76	.88
R^2 (Adjusted)		.34	.44	.47	.74	.85

Standard Deviation of Yields = 7.014

P.E.T. = Potential Evapotranspiration from Thornthwaite (Latitude 50°N, A=.962, I=28.888)
DFN = Departure from Normal
SDFN = Squared Departure from Normal
C = Day Length Correction

SASKATCHEWAN DISTRICT 4 MODEL

Variable	Normal	Trend	April	May	June	July	August
		Coefficient for Specified Truncation Time					
Constant	------	5.040	6.434	6.857	6.155	6.567	7.034
Linear Trend 1931=1, ...	------	.367	.303	.286	.316	.302	.314
Fallow Pcp (in.) (20 mo. thru Apr) DFN	20.725	-----	.983	.966	.799	.730	.788
May Pcp-P.E.T. (in.) DFN C=1.327	-1.599	-----	-----	1.420	1.284	1.072	.866
Jun Pcp-P.E.T. (in.) DFN C=1.408	-1.709	-----	-----	-----	2.009	2.041	1.960
Jul Pcp-P.E.T. (in.) DFN C=1.373	-3.622	-----	-----	-----	-----	1.367	1.455
Aug Pcp-P.E.T. (in.) DFN	------	-----	-----	-----	-----	-----	.978
SDFN C=1.248	-3.083	-----	-----	-----	-----	-----	-.510
Se		5.955	4.842	4.588	3.743	3.404	3.288
R^2 (Ajusted)		.36	.58	.61	.74	.79	.80
R^2		.38	.60	.64	.77	.81	.83
SD of Yields (Bu/A)	7.442						

P.E.T. is potential evapotranspiration from Thornthwaite (Latitude 50°N, A=.946, I=27.75).
DFN is Departure from Normal (average over sample 1931-74).
SDFN is square of DFN
C is daylength correction factor

Years in yield sample - 1933-74.

SASKATCHEWAN DISTRICT 5 MODEL

COEFFICIENT FOR SPECIFIED TRUNCATION TIME

VARIABLE	NORMAL	TREND	APRIL	JUNE	JULY	AUGUST
Constant		17.050	17.699	18.359	18.758	18.727
Linear Trend 1931-74 (1931=1,...)		.223	.195	.275	.253	.266
Fallow Prec. (in.) (20 mos thru April) DFN	25.483	---	.402	.287	.282	.298
April Minimum Temp (°F) DFN	24.911	---	.332	.129	.098	.090
June Prec. - PET (in.) (C=1.422) DFN	-.942	---	---	2.081	1.944	1.868
June Prec. - PET (in.) SDFN		---	---	-1.132	-1.078	-.959
July Prec. - PET (in.) (C=1.384) DFN	-2.829	---	---	---	.674	.600
August Prec. - PET (in.) (C=1.256) SDFN	-2.249	---	---	---	---	-.344
Standard Error (bu/A)		5.044	4.861	3.234	3.201	3.182
R^2		.237	.328	.719	.733	.744

Standard Deviation of Yields = 5.701

PET = Potential Evapotranspiration. From Thornthwaite (Latitude 51°N, A=.910, I=25.459)
DFN = Departure From Normal (average over sample 1931-74)
SDFN - Squared Departure From Normal

C = Daylength correction factor

SASKATCHEWAN DISTRICT 6 MODEL

VARIABLE	NORMAL	COEFFICIENT FOR SPECIFIED TRUNCATION TIME				
		TREND	APRIL	JUNE	JULY	AUGUST
Constant		8.614	9.077	8.184	9.409	9.521
Linear Trend 1931-74 (1931=1,...)		.364	.342	.384	.336	.333
Fallow Prec. (in.) (20 mos. thru April) DFN	21.479	---	.541	.626	.564	.595
June Prec. - PET (in.) (C=1.422) DFN	-1.802	---	---	2.405	2.379	2.336
July Prec. - PET (in.) (C=1.384) DFN	-3.309	---	---	---	2.391	2.423
August Prec. - PET (in.) (C=1.256) DFN	-2.854	---	---	---	---	.530
Standard Error (bu/A)		5.732	5.533	3.828	2.902	2.879
R^2		.400	.447	.742	.856	.862

Standard Deviation of Yields = 7.247

PET = Potential Evapotranspiration. From Thornthwaite (Latitude 51°N, A = .946, I = 27.75)

DFN = Departure From Normal (average over sample 1931-74)
SDFN = Squared Departure From Normal

C = Day length correction factor

SASKATCHEWAN DISTRICT 7 MODEL

Variable	Normal	Coefficient for Specified Truncation			
		Trend	April	June	July
Constant	------	7.447	8.815	8.952	11.620
Linear Trend, 1931-74	------	.441	.419	.421	.335
Fallow Prec. (in.) (20 mos. thru Apr)	20.420	-----	1.216	.884	.829
Apr Min Temp (^{o}F)	25.954	-----	-.072	-.026	-.030
Jun Prec.-P.E.T. (in.) DFN (C=1.378)	-1.848	-----	-----	2.850	2.689
Jun Prec.-P.E.T. (in.) SDFN	------	-----	-----	-.433	-.317
Jul Prec.-P.E.T. (in.) DFN (C=1.402)	-3.161	-----	-----	-----	2.812
Jul Prec.-P.E.T. (in.) SDFN	------	-----	-----	-----	-.653
Standard Error (Bu/A)		6.181	5.317	4.271	3.225
R^2		.447	.612	.763	.873

Standard Deviation of Yields = 8.201

P.E.T. = Potential Evapotranspiration from Thornthwaite (Latitude 52^{o}N, A=.931, I=26.821)
DFN = Departure from Normal
SDFN = Squared Departure from Normal
C = Daylength Correction

SASKATCHEWAN DISTRICT 8 MODEL

VARIABLE	NORMAL	TREND	APRIL	JUNE	JULY
		COEFFICIENT FOR SPECIFIED TRUNCATION TIME			
Constant		17.378	17.307	18.243	20.474
Linear Trend 1931-74 (1931=1,...)		.233	.234	.249	.171
April Minimun Temp. (^{o}F) DFN	23.968	---	.206	.088	-.018
June Prec. - PET (in.) (C=1.456) DFN	-1.718	---	---	2.139	1.920
June Prec. - PET (in.) SDFN		---	---	-.440	-.354
July Prec. - PET (in.) (C=1.410) DFN	-2.755	---	---	---	1.415
July Prec. - PET (in.) SDFN		---	---	---	-.314
Standard Error (bu/A)		4.717	4.700	3.538	3.220
R^2		.279	.302	.626	.707

Standard Deviation of Yields = 5.481

PET = Potential Evapotranspiration. From Thornthwaite (Latitude 53^{o}N, A=.906, I=25.202)
DFN = Departure From Normal (average over sample 1931-74)
SDFN = Squared Departure From Normal
C = Day length correction

SASKATCHEWAN DISTRICT 9 MODEL

Variable		Normal	Trend	April	May	June	July	August	September
			Coefficient for Specified Truncation Time						
Constant		------	11.772	12.286	12.069	13.848	16.360	16.008	15.708
Linear Trend, 1931-74		------	.329	.305	.314	.312	.194	.199	.204
Fallow Prec. (in.) (20 Mos. thru Apr)	DFN	25.224	------	.368	.407	.342	.171	.114	.163
Apr Min Temp. (°F)	DFN	23.020	------	.238	.247	.142	-.018	-.009	.030
May Max Temp. (°F)	DFN	61.934	------	------	.369	.507	.167	-.022	.041
Jun Prec.-P.E.T. (in.)	DFN	-1.883	------	------	------	3.255	2.637	2.603	2.653
(C=1.456)	SDFN	------	------	------	------	-1.105	-.538	-.526	-.454
Jul Prec.-P.E.T. (in.)	DFN	-2.364	------	------	------	------	3.370	3.528	3.198
(C=1.401)	SDFN	------	------	------	------	------	-.327	-.200	-.122
Aug Prec.-P.E.T. (in.) (C=1.273)	DFN	-2.000	------	------	------	------	------	-1.004	-1.091
Sep Min Temp. (°F)	DFN	37.418	------	------	------	------	------	------	.297
Standard Error (Bu/A)			5.546	5.552	5.493	3.653	2.550	2.404	2.295
R^2			.358	.390	.419	.758	.889	.905	.916

Standard Deviation of Yields = 6.830

P.E.T. = Potential Evapotranspiration from Thornthwaite (Latitude 53°N, A=.864, I=22.456)
DFN = Departure from Normal
SDFN = Squared Departure from Normal
C = Daylength Correction

ALBERTA DISTRICT 1 MODEL

Variable	Normal	Trend	April	May	June	July	September
		Coefficient for Specified Truncation Time					
Constant	------	11.476	12.259	10.870	11.147	12.527	12.140
Linear Trend, 1931=1, ...	------	.355	.317	.3266	.3161	.264	.279
Fallow Prec. (in.) (20 Mos. thru Apr)	28.416	------	.455	.4816	.349	.392	.367
May Prec.-P.E.T. ($in.^2$) SDFN C=1.337	- .1011	------	------	1.3458	1.326	1.126	1.165
Jun Prec.-P.E.T. (in.) DFN C=1.422	-1.000	------	------	------	1.412	1.337	1.379
Jul Prec.-P.E.T. (in.) DFN C=1.384	-2.941	------	------	------	------	1.701	1.557
Sep Min Temp (^{o}F) DFN	38.414	------	------	------	------	------	.329
Se		4.367	4.075	3.829	3.246	2.771	2.66
R^2 (Adjusted)		.49	.56	.60	.72	.80	.81
R^2		.50	.58	.63	.74	.82	.84

Standard Deviation of Yields (Bu/A) = 6.1299

P.E.T. is potential evapotranspiration from Thornthwaite (Latitude 51^{o}N, A=.901, I=24.856)
DFN is Departure from Normal (Average over sample 1931-74)
SDFN is Squared Departure from Normal
C is Daylength Correction Factor

ALBERTA DISTRICT 2 MODEL

Variable		Normal	Trend	April	May	June	July	September
			Coefficient for Specified Truncation Time					
Constant		------	15.950	16.202	16.033	16.683	17.375	17.529
Linear Trend, 1931-74		------	.272	.259	.268	.245	.215	.209
Apr Min Temp (^{o}F)	DFN	25.577	------	.275	.240	.067	.076	.074
May Prec. (in.)	DFN	18.157	------	------	1.378	.401	.146	.295
Jun Prec.-P.E.T. (in.) C=1.456)	DFN	-.981	------	------	------	1.622	1.685	1.830
Jul Prec.-P.E.T. (in.) C=1.416	DFN	-1.401	------	------	------	------	.895	.878
Sep Min Temp (^{o}F)	DFN	37.268	------	------	------	------	------	368
Standard Error (Bu/A)			4.357	4.282	4.212	3.637	3.581	3.476
R^2			.390	.420	.460	.610	.630	.660

Standard Deviation of Yields = 5.469

P.E.T. = Potential Evapotranspiration from Thornthwaite (Latitude 55^{o}N, A=.835, I=20.649)
DFN = Departure from Normal (average over sample 1931-74)
SDFN = Squared Departure from Normal
C = Daylength Correction Factor

ALBERTA DISTRICT 3 MODEL

VARIABLE	NORMAL	COEFFICIENT FOR SPECIFIED TRUNCATION TIME						
		TREND	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Constant		18.935	18.267	17.234	20.279	20.757	20.674	20.017
Linear Trend 1931-74		.006	.010	.140	.049	.066	.063	.088
Fallow Precip. (in.) (20 mos. thru April) DFN	29.687	---	.024	-.250	-.222	-.311	-.283	-.288
May Maximum Temp. (^{o}F) DFN	61.093	---	---	.340	.170	.280	.207	.246
June Prec. - PET (in.) (C=1.456) DFN	-1.496	---	---	---	2.448	2.282	2.354	1.942
June Prec. - PET (in.) SDFN		---	---	---	-.443	-.502	-.493	-.446
July Prec. - PET (in.) (C=1.416) DFN	-1.909	---	---	---	---	.889	.995	.853
July Prec. - PET (in.) SDFN		---	---	---	---	-.442	-.374	-.367
August Prec. - PET (in.) (C=1.273) DFN	-1.603	---	---	---	---	---	-.646	-.538
Sept. Minimum Temp. (^{o}F) DFN	37.250	---	---	---	---	---	---	-.554
Standard Error (bu/A)		4.934	4.945	4.908	3.891	3.740	3.717	3.420
R^2		.025	.065	.103	.467	.535	.555	.635

Standard Deviation of Yields = 4.985

PET = Potential Evapotranspiration. From Thornwaite (Latitude 53°N, A = .851, I = 21.617)

DFN = Departure From Normal (average over sample 1931-1974)
SDFN = Squared Departure From Normal

C = Day length correction