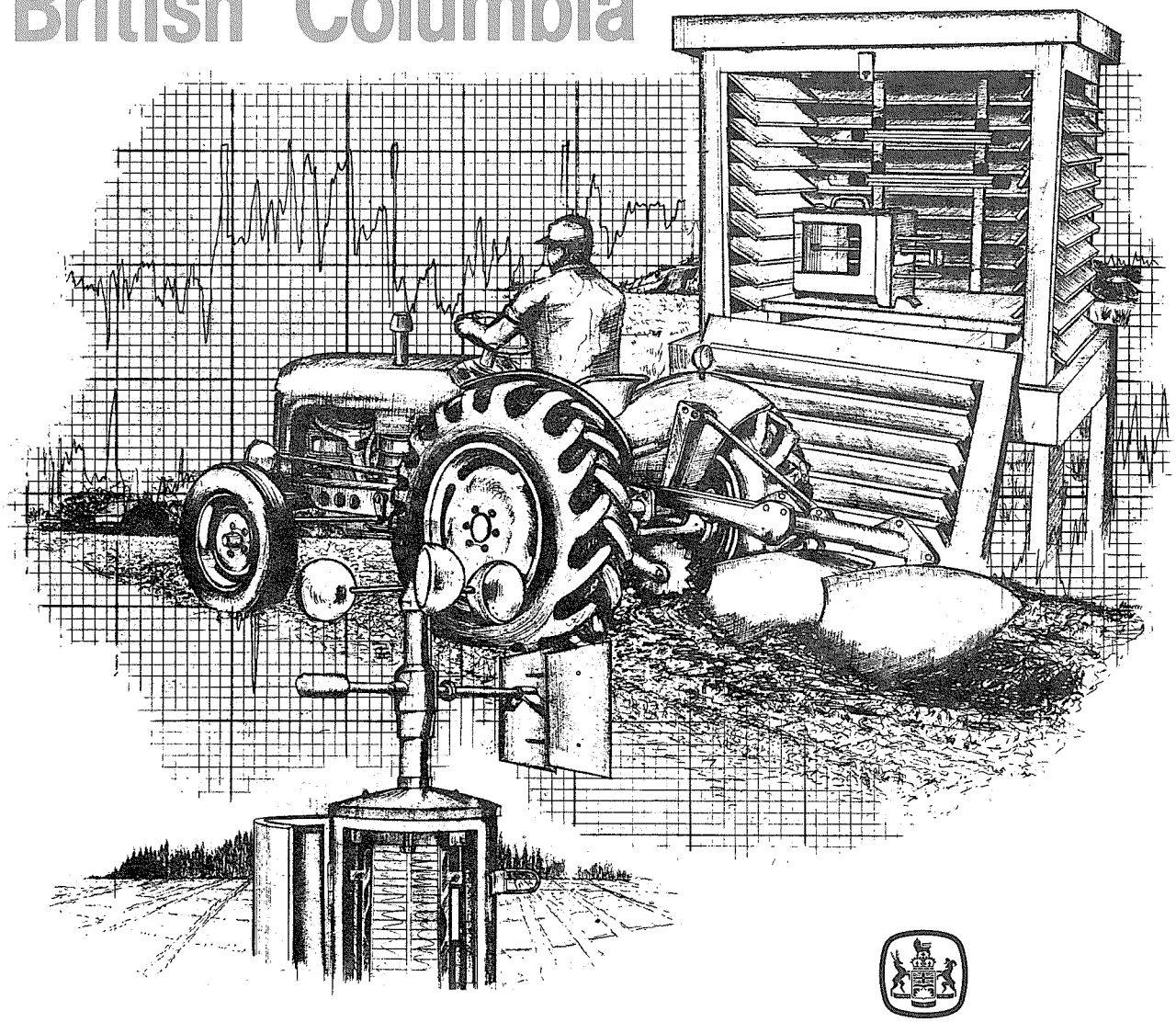
RAB Technical Paper 1

Climatic Capability Classification for Agriculture in British Columbia



Province of British Columbia
Ministry of the Environment

Province of British Columbia
Ministry of the Environment
RESOURCE ANALYSIS BRANCH

RAB TECHNICAL PAPER 1

CLIMATIC CAPABILITY CLASSIFICATION FOR AGRICULTURE IN BRITISH COLUMBIA

Prepared by Climate Division

VICTORIA
1978

Revised from Climatology Report No. 1 1972

Canadian Cataloguing in Publication Data
British Columbia. Climatology Division.
Climatic capability classification for agriculture in British Columbia.

A revision of Climatology report no. 1 published by British Columbia Land Inventory as Climate capability classification for agriculture in 1972.
Bibliography: p.
ISBN 0-7719-8105-8

1. Land use, Rural - British Columbia. 2. British Columbia - Climate. I. Canada. Land Inventory (B.C.). Climate capability classification for agriculture. II. Title.

HD319.B7B78 333.7'6'09711 C78-016085-1

ACKNOWLEDGEMENTS

This document is a revision of the "Climate Capability Classification for Agriculture" which was published by British Columbia Land Inventory in November 1972. Professional members of the Climate Division, Resource Analysis Branch, were primarily responsible for coordinating the revision.

The majority of the changes incorporated in this present document deal with the organization of the classification and the inclusion of some agroclimatological concepts. These changes are assembled from the suggestions of the members of the climatology group and from comments solicited from all District Agriculturists, Field Crops Specialists and District Horticulturists of the British Columbia Ministry of Agriculture, from Agriculture Canada's Research Station in British Columbia and at Beaverlodge, Alberta and also from the Agrometeorology Research and Service group of Agriculture Canada in Ottawa.

Acknowledgements are also due to Mr. A.C. Carter and Mr. J. Zacharias, B.C. Ministry of Agriculture, for their constructive comments while on the Editorial Review Committee.

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INTRODUCTION

The capability of a unit of land for agricultural production is dependent upon the combined influence of local climate and soils. This report details a system of classification which describes the agricultural capability as influenced by climate alone.

Maps depicting the "Climatic Capability for Agriculture" at a scale of 1:100,000 are drawn on the basis of this system. These, together with soil maps, provide the input for "Soil Capability for Agriculture" (Canada Land Inventory Report No. 2, 1969) maps which also are produced by the Resource Analysis Branch.

This mapping program was originated by the British Columbia Land Inventory (B.C.L.I.) and has been continued by the Resource Analysis Branch since 1975. The B.C.L.I. Climatology Report No. 1 was an adaptation of the system adopted by the Canada Land Inventory. Adjustments to the national system were necessary in order to consider crops other than cereal grains, and also to encompass the variety of climates in this Province.

The present publication provides some refinements and clarifications of the material presented in the B.C.L.I. Climatology Report No. 1, and presents a system of Effective Growing Degree Days for characterizing thermal regimes in coastal areas of British Columbia.

As a final note, it should be emphasized that this classification system identifies only the climatic limitations to general agricultural capability. It indicates the range of crops which are climatically suitable to a land unit as indicated by the average climate over the past twenty or thirty years. The weather in any particular year or short-term trends in local climate may change the short-term agricultural capability. It is intended that the frequency tables to be presented on each Climatic Capability For Agriculture map, as well as the maps of individual climatic parameters and the report for each area mapped, will assist in answering such planning and management questions.

GENERAL CONSIDERATIONS, ASSUMPTIONS AND DEFINITIONS

The climate of British Columbia reflects the topography of the region, its proximity to the Pacific Ocean and the interior characteristics of the continent. To accomplish the final objective of presenting and characterizing this diverse climate in terms of its capability for agriculture, short-term climatological networks are operated by the Resource Analysis Branch on a regional basis to form the major source of climatological information (Wilson, 1976). Data from these networks are supplemented by data gathered by the Atmospheric Environment Service of Canada (AES) and other government and private agencies gathering climatological information.

Climatological parameter maps can then be presented as an interpretation of these data as influenced by physiographic and topographic characteristics (elevation, slope, aspect, landform, etc.). From a combination of parameter maps, the Climatic Capability for Agriculture of any land unit can be identified.

As the climatological parameters for this capability classification are derived from long-term average values, or from short-term data which are adjusted to represent long-term (30 year) averages, year-to-year climatological variability is not considered. However, indications of this variability will be included in the legend of each Climatic Capability for Agriculture map.

All data used to map and/or derive the ratings are collected from provincial and federal climatological installations which conform to national and World Meteorological Organization standards. The instruments utilized are of high quality and reliability. Thermographs and thermometers are situated within a standard Stevenson screen at a height of 1.2 metres above ground. Precipitation data are collected by standardized recording rain gauges and/or storage gauges.

The classification is based on the following assumptions:

1) Ratings are based on presently available information and on current methodology, but may change as new information and methodology become available.

2) The degree of limitation determines the basic class designation (a number, sometimes followed by a small letter). A subclass, indicated by a capital letter following the class designation, denotes the climatic factor which causes the limitation (see section on SUBCLASSES).

3) It is assumed that normal agricultural management practices are being utilized in any specific region. The effects of alternative management practices and man-made alterations of climate are not considered in determining the rating, but may be indicated in a regional report.

4) The examples of the range of crops provided for in each class reflect the Climatic Class. In general, crops growing in areas of lower climatic classes can be grown in areas of higher climatic classes. Therefore, the wider the range of crops, the higher the class.

The classification is based on both thermal and moisture parameters which are defined as follows:

1) Freeze Free Period*(FFP): the greatest number of consecutive days in a calendar year free of a temperature of $0^{o}C$ or less (Baier and Oiellet, 1970).

2) Growing Degree Days (GDD): the accumulated difference between the mean daily temperature and the standard base temperature of $5^{o}C$ on days when mean daily temperature is above $5^{o}C$. The first/last day of any consecutive five-day period when the mean daily temperature is equal to or greater than $5^{o}C$ is defined as the start/end of the period of accumulation.

3) Effective Growing Degree Days (EGDD): the accumulated product of daily GDD and the Crop Development Index (see Appendix 1). The period of accumulation is the same as that of the GDD.

4) Climatic Moisture Deficit (CMD) and Climatic Moisture Surplus (CMS): the algebraic difference between the seasonal (May-September) precipitation (P) and seasonal potential evapotranspiration (PE). Deficits are negative and surpluses are positive values.

*The term Freeze-Free Period replaces Frost Free Period as the standard terminology.

REVISIONS INTRODUCED

The "Climate Capability Classification for Agriculture" (Climatology Report No. 1, 1972) is a unique provincial classification. However some inherent weaknesses have been realized while, at the same time, new ideas have been developed which are worthy of inclusion into the classification. These changes are made with the intention of making the classification more useful to both the agriculturist and climatologist. The revisions encompass a number of aspects, but the basic concept of the scheme is left unaltered. The major changes are as follows:

1) Due to the change from old Canadian to S.I. (metric) units, all temperatures and derived thermal units are expressed in degrees Celsius (^{o}C). Similarly, precipitation and other derived moisture parameters are presented in millimetres (mm).

2) The Canadian Committee on Agricultural Meteorology has approved and recommended the use of 5^{o} C as the base temperature (Treidl, R.A., 1976) in calculating the Growing Degree Day (GDD). This change to the new base temperature unavoidably resulted in adjusting the GDD ranges which were based on 5.6^{o}C (42^{o}F) in each climatic class. A constant adjustment figure of 115^{o}C days, determined from several representative stations throughout the province, was added to the earlier GDD value.

3) The classification in Climatology Report No. 1 was primarily designed to characterize the interior portions of the province, the Lower Fraser Valley area, and the southeastern side of Vancouver Island. It was recognized that the Growing Degree Day and the Freeze-Free Period classes did not apply to most of the coastal areas of the Province. For this reason, a regional classification to cover the coastal areas* (see Figure 1) has been incorporated in which the Effective Growing Growing Degree Day (EGDD) is considered as a measure of thermal capability (see Appendix 1) instead of the Growing Degree Day (GDD) and the Freeze Free Periods have been appropriately adjusted.

4) The Climatic Moisture Deficit (CMD) was previously defined as CMD = P - PE + 10 where P and PE represents the growing season (May to September) Precipitation and Potential Evapotranspiration, respectively, and the additional 10 inches (254 mm) of water represented the assumed maximum available water for 1.2 metres of soil profile. It was originally intended that the moisture rating could be adjusted by a user to take into account the actual plant-available water storage capacity of any particular soil and, particularly, that this would be performed by the pedologist drawing the Soil Capability for Agriculture map. The definition has been modified due to the following problems that arose:

   a) Using the definition above, it was mathematically impossible for a user to adjust for available water storage capacity when the value of

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*These areas where the difference between the July mean temperature and the January mean temperature is less than or equal to 20^{o}C on the valley bottom.

(P - PE) was less than 254 mm (since the climatologist would have to map a zero deficit).

b) Adjustment for incomplete recharge of available water by the start of the growing season (when available), in some cases, was not possible; and

c) Excess May-September precipitation was not indicated whenever it existed.

In this revised version, the Climatic Moisture Deficit (CMD) has been re-defined as any negative difference between precipitation (P) and the potential evapotranspiration (PE) from May 1st to September 30th. It then becomes possible for the soil classifier to review his legend and adjust the climatic moisture deficit and the unimproved (dry-land) rating according to the Available Water Storage Capacity (AWSC) of the soil and/or the water available at the start of the growing season (if known). The adjusted CMD would then be equal to (P - PE + AWSC). This adjusted value should be used to indicate the dry-land rating on the Soil Capability for Agriculture maps.

5) To account for any excess seasonal (May-September) precipitation, a new limiting criterion, Climatic Moisture Surplis (CMS), is introduced. When excessive moisture becomes limiting the capability class is determined by the value of $\frac{CMS}{PE}$ where CMS is defined as positive values of (P - PE). The pedologist would have to adjust CMS in the same way as CMD was adjusted in (4). The adjusted CMS, similarly, should be used to indicate the unimproved (undrained) rating on the soil capability for Agriculture map.

6) In the 1972 edition, Climatic Classes 1d, 1c, $1b_1$, $1b_2$, $1b_3$, $1a_1$, and $1a_2$ are specific regional climatic classes characterized by the capability for growing tree fruit. In an attempt to simplify the classification, the number of classes capable of commercial tree fruit production was reduced. This was accomplished by an exclusive use of the "E" limitation to identify areas where the occurrence of extreme minimum winter temperatures would injure or kill dormant or near-dormant fruit trees. This resulted in the following new class designations: Class $1b_1$ becomes 1b; Class $1b_2$ becomes 1bE; Class $1a_2$ becomes 1a; and Class $1a_1$ becomes Class 1aE. Classes 1d and 1c remain the same. Class $1b_3$ was deleted and the areas once characteristic of this class are reclassified according to the new coastal classification scheme.

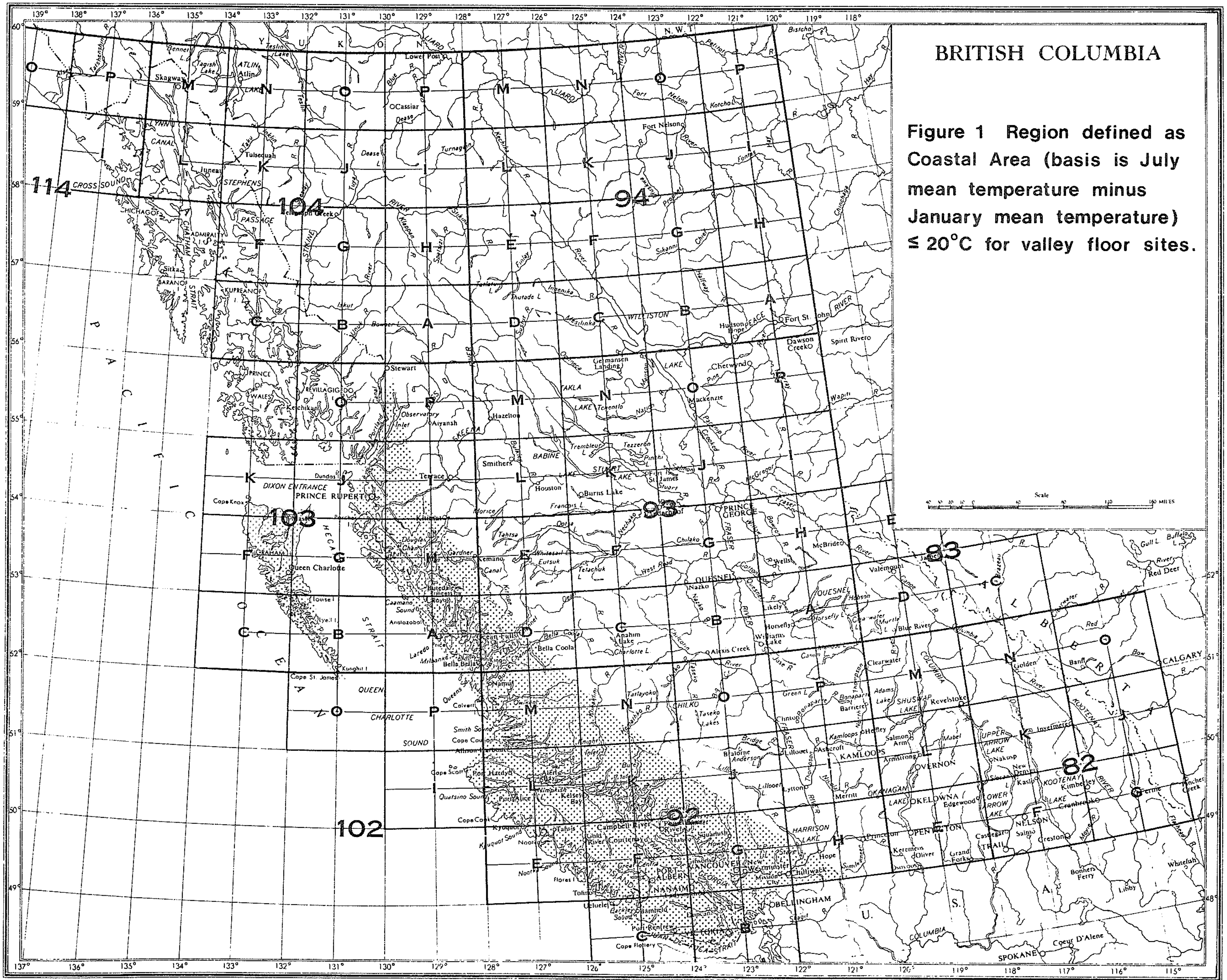

Figure 1 Region defined as Coastal Area (basis is July mean temperature minus January mean temperature) ≤ 20°C for valley floor sites.

SUBCLASSES

A capability class is designated by a number, sometimes followed by a small letter, such that Class 1d has the highest capability and Class 7 has the lowest capability. With the exception of Class 1d for the interior areas of the province and Class 1 for the coastal areas, the capability classes are influenced by thermal and/or moisture limitations. The degree of the limitation(s) determines the capability class while the nature of the limitation(s) indicates which thermal and/or moisture characteristics are suppressing the agricultural capabilities.

The following subclasses denote the climatic limitations which adversely affect the capability of the land to support agriculture.

SUBCLASS A - Drought or aridity occurring between May 1st and September 30th resulting in moisture deficits will limit plant growth. The climatic moisture deficit criterion is being used for this limitation.

SUBCLASS F - Minimum temperature near freezing will adversely affect plant growth during the growing season. In this classification the Freeze Free Period (FFP) of $0^{o}C$ is being used.

SUBCLASS G - Insufficient heat units (Growing Degree Day or Effective Growing Degree Day) during the growing season.

SUBCLASS E - Extreme minimum temperatures occurring during the winter season will injure or kill dormant or near dormant fruit trees. Either cropping history or minimum temperature of less than $-35^{o}C$ can be used as the indicator of this subclass.

SUBCLASS Y - Excess precipitation between May 1st and September 30th will cause flooding, poor trafficability and generally poor yield and harvest conditions. The ratio of the climatic moisture surplus and Potential Evapotranspiration is being used as the criterion for this limitation.

EXPLANATION OF MAP SYMBOLS

The Climatic Capability for Agriculture maps have two ratings (symbols) per unit. The first symbol indicates that capability class as determined by the moisture regime limitations while the second symbol, shown in brackets on the map, indicates that class as determined by thermal limitations. The improved capability rating (lands being irrigated or drained) is synonymous with the class representing the thermal limitations since it is assumed that the moisture limitations are eliminated. The unimproved ratings (dry-land or undrained) is determined by the most severe limitation imposed by the moisture and/or the thermal criteria.

EXAMPLE I.

$(\overset{4A}{3GF})$ 4A represents the moisture rating and 3GF the thermal rating. This dual symbol indicates an unimproved (dry-land) capability rating of Class 4 with a limitation due to a lack of moisture (A). The improved (irrigated) capability rating is Class 3 with limitations due to an insufficient accumulation of heat units (G) and to reduced freeze free period (F).

EXAMPLE II.

$(\overset{3A}{3GF})$ indicates an area where the unimproved (dry-land) capability rating is Class 3 with limitations due to lack of moisture (A), insufficient accumulations of heat units (G) and reduced freeze free period (F). Irrigation will not improve the capability rating of this land unit as the thermal characteristics continue to apply a Class 3 limitation.

EXAMPLE III.

$(\overset{3A}{4G})$ indicates an area with both unimproved and improved ratings of 4G since the thermal limitation is more severe than class 3A. However, irrigation will improve the moisture regime.

EXAMPLE IV.

$(\overset{4A}{3GF^{7} - 4F^{3}})$ this characterizes a complex unit with an improved (irrigated) capability of Class 3 for 70% of the area, with limitations due to insufficient accumulations of heat units (G), and reduced freeze free period (F) and Class 4 for 30% of the area with a limitation due to reduced freeze free period (F). Because the moisture regime limitation indicates a Class 4 capability, the unimproved (dry-land) capability of this complex unit is Class 4 for 70% of the area with limitation due to insufficient moisture (A) and Class 4 for 30% of the unit with limitations due to insufficient moisture (A) and reduced freeze free period (F). Complex units usually occur where the data, mapping procedures, or mapping scale do not allow the further subdivision of a unit of land.

On the Climatic Capability for Agriculture maps, the isolines delineate units of different moisture-limited and thermally-limited classes.

Climatic Class 4

Limitations:

The freeze free period is 50 to 59 days in the interior areas of the province and 80 to 99 days in coastal areas. The range of growing degree days above 5°C is 1030 to 1169 for the interior areas. The range of effective growing degree days for the coastal areas is 491 to 649. There is a climatic moisture deficit of 191 to 265 mm (7.5 to 10.4 inches) during the growing season, or there is a climatic moisture surplus/potential evapotranspiration ratio between 0.76 and 1.00.

Range of Crops:

Examples are hardy varieties of cool season loving vegetables (lettuce, peas, spinach, cabbage), forage crops, and periodically cereal crops are capable of being grown.

Climatic Class 5

Limitations:

The freeze free period is 30 to 49 days in the interior areas of the province and 60 to 79 days in coastal areas. The range of growing degree days above 5°C is 780 to 1029 for the interior areas. The range of effective growing degree days above 5°C for the coastal areas is 421 to 490. There is a climatic moisture deficit of 266 to 340 mm (10.5 to 13.4 inches) during the growing season, or there is a climatic moisture surplus/potential evapotranspiration ratio greater than 1.00.

Range of Crops:

Only forage crops are produced.

Climatic Class 6

Limitations:

The freeze free period is less than 30 days in the interior areas of the province and 40 to 59 days in coastal areas. The range of growing degree days above 5°C is 670 to 779 for the interior areas. The range of effective growing degree days above 5°C for the coastal areas is from 245 to 420. There is a climatic moisture deficit of 341 to 415 mm (13.4 to 16.3 inches) during the growing season.

Range of Crops:

The area is limited to native browse (grazing) species of plants.

Climatic Class 7

Limitations:

The freeze free period is highly variable and less than 30 days in the interior areas of the province and less than 40 days in coastal areas. The number of growing degree days above 5°C is less than 670 for the interior areas. There are less than 245 effective growing degree days for coastal areas. There is a climatic moisture deficit of greater than 415 mm. (16.3 inches).

Range of Crops:

There is no potential for agriculture.

CLASSIFICATION OF MAJOR INTERIOR AND COASTAL SITES IN BRITISH COLUMBIA

Tables 1 and 2 indicate the Climatic Capability for Agriculture classes for some Atmospheric Environment Service stations with long-term climatological data. These tables are meant to provide an overview of the regional distribution of the classes throughout the Province. In using them it should be remembered that the classes apply specifically to the locations of the climatic stations, and that local variations of climate around the stations typically produce changes in the classes indicated.

The TECHNICAL PAPER is one of four Regular Publication series produced by the Resource Analysis Branch. TECHNICAL PAPERS deal with methods of data collection, analysis techniques, classification systems and interpretive methods developed or used by the Branch.

RAB Technical Paper 1 - Climatic Capability Classification for Agriculture in British Columbia.

TABLE 1. THE CLIMATIC CLASSES FOR AGRICULTURE OF SOME MAJOR INTERIOR SITES - BRITISH COLUMBIA

Location*	Latitude (N) (deg.)	(min)	Longitude (W) (deg)	(min)	Elev. (m)	GDD	FFP (days)	P (mm)	PE (mm)	P-PE (mm)	$\frac{(P-PE)^+}{PE}$	CLASSIFICATION Thermal Class	Moisture Class	Improved Rating	Unimproved Rating
Alberfeldie	49	30	115	21	805	1687	132	229	470	-241	-	1aF	4A	1aF	4A
Aleza Lake	54	07	122	04	625	1173	87	337	367	-30	-	2GF	1A	2GF	2GF
Armstrong	50	26	119	12	375	1862	119	179	565	-387	-	1F	6A	1F	6A
Ashcroft M	50	43	121	20	488	2058	143	108	503	-395	-	1aF	6A	1aF	6A
Baldonnel	56	14	120	41	686	1230	93	250	335	-85	-	2G	2A	2G	2AG
Barkerville	53	04	121	31	1274	732	47	474	309	+165	0.53	6G	2Y	6G	6G
Beatton R. A.	57	23	121	23	840	1601	75	262	282	-20	-	2F	1A	2F	2F
Big Creek	51	44	123	02	1134	985	41	188	423	-235	-	5GF	4A	5GF	5GF
Blue R. North	52	09	119	17	689	1288	106	408	403	+5	0.01	2G	1Y	2G	2G
Columbia Gard.	49	03	117	36	433	2075	133	211	607	-396	-	1aF	6A	1aF	6A
Cranbrook A.	49	36	115	47	930	1550	91	179	532	-353	-	1F	6A	1F	6A
Crescent Valley	49	27	117	34	610	1662	96	247	572	-325	-	1F	5A	1F	5A
Creston	49	06	116	31	598	1881	148	186	473	-287	-	1aF	5A	1aF	5A
Dease Lake	58	25	130	00	816	757	44	211	292	-81	-	6G	2A	6G	6G
Elko	49	18	115	06	939	1709	131	261	461	-200	-	1aGF	4A	1aGF	4A
Fauquier	49	52	118	04	473	1775	149	239	479	-240	-	1aGF	4A	1aGF	4A
Fernie	49	30	115	03	1003	1336	98	304	432	-128	-	1GF	3A	1GF	3A
Ft. Nelson A.	58	50	122	35	375	1274	104	271	295	-24	-	2G	1A	2G	2G
Ft. St. James	54	27	124	15	686	1069	76	218	342	-124	-	3G	3A	3G	3AG
Ft. St. John A.	56	14	120	44	694	1300	55	244	278	-34	-	4F	1A	4F	4F
Germansen Lndg.	55	47	124	42	747	894	54	209	325	-116	-	5G	3A	5G	5G
Golden	51	18	116	58	788	1572	103	178	537	-359	-	1F	6A	1F	6A
Grand Forks	49	02	118	28	532	1951	121	174	615	-441	-	1aF	7A	1aF	7A
Greenwood	49	05	118	41	759	1520	90	202	622	-420	-	1F	7A	1F	7A
Hedley	49	21	120	05	525	2002	148	146	545	-399	-	1aF	6A	1aF	6A
Heffley Creek	50	55	120	11	683	1550	108	144	471	-327	-	1F	5A	1F	5A
Joe Rich Cr.	49	51	119	08	875	1195	39	264	530	-266	-	5F	4A	5F	5F
Kamloops CDA	50	43	120	26	351	2337	152	120	564	-444	-	1bE	7A	1bE	7A
Kaslo	49	55	116	55	588	1651	144	242	422	-180	-	1aGF	3A	1aGF	3A
Kelowna CDA	49	52	119	25	485	1945	151	139	489	-350	-	1bG	6A	1bG	6A
Keremeos	49	12	119	47	430	2434	184	107	534	-427	-	1d	7A	1d	7A
Kimberley A.	49	44	115	47	915	1530	92	163	540	-377	-	2F	6A	1F	6A
Kleena Kleene	51	59	124	56	899	935	25	148	462	-314	-	6F	5A	6F	6F
Lytton	50	14	121	35	258	2539	185	90	517	-427	-	1d	7A	1d	7A
McCulloch	49	48	119	12	1250	902	20	269	472	-203	-	6F	4A	6F	6F
New Hazelton	55	14	127	36	314	1247	93	236	371	-135	-	2G	3A	2G	3A
Okanagan Centre	50	04	119	27	348	2057	170	141	495	-354	-	1cG	6A	1cG	6A
Old Glory Mtn.	49	09	117	55	2348	421	22	272	86	+186	2.16	7GF	7Y	7GF	7YGF
Oliver	49	10	119	33	305	2225	137	122	620	-498	-	1aF	7A	1aF	7A
Osoyoos	49	03	119	31	326	2467	179	127	517	-391	-	1d	6A	1d	6A
Penticton A.	49	28	119	36	342	2115	142	128	549	-421	-	1aF	7A	1aF	7A
Pr. Geo. A.	53	53	122	40	676	1181	78	288	356	-68	-	2GF	2A	2GF	2AGF
Princeton A.	49	28	120	31	696	1599	99	125	539	-414	-	1F	7A	1F	7A
Quesnel A.	53	02	122	31	545	1425	98	259	424	-165	-	1GF	3A	1GF	3A
Revelstoke	51	00	118	12	456	1856	140	323	499	-176	-	1aF	3A	1aF	3A
Salmon Arm	50	42	119	15	506	1944	147	206	488	-282	-	1aF	5A	1aF	5A
Smith R. A.	59	54	126	26	673	888	52	241	294	-53	-	5G	2A	5G	5G
Smithers CDA	54	44	127	06	515	1071	52	208	388	-180	-	4F	3A	4F	4F
South Slocan	49	28	117	32	457	1960	140	243	598	-355	-	1aF	6A	1aF	6A
Summerland CDA	49	34	119	39	455	2211	174	131	513	-382	-	1cG	6A	1cG	6A
Tahtsa Lk. West	53	37	127	42	863	623	57	393	233	+160	+0.69	7G	3Y	7G	7G
Tatlayoko Lake	51	39	124	23	848	1128	57	146	447	-301	-	4F	5A	4F	5A
Telkwa	54	39	126	50	683	1077	80	213	350	-137	-	3G	3A	3G	3AG
Terrace A.	54	28	128	35	219	1406	155	269	298	-29	-	1G	1A	1G	1AG
Valemont	52	49	119	15	797	1288	73	215	449	-234	-	3F	4A	3F	4A

TABLE 1 (continued)

Location	Latitude (N) (deg.)	(min)	Longitude (W) (deg)	(min)	Elev. (m)	GDD	FFP (days)	P (mm)	PE (mm)	P-PE (mm)	$\frac{(P-PE)^+}{PE}$	CLASSIFICATION Thermal Class	Moisture Class	Improved Rating	Unimproved Rating
Vernon Coldstream R.	50	14	119	12	482	1905	153	176	471	-295	-	1bG	5A	1bG	5A
Waneta	49	01	117	35	558	1890	130	222	600	-378	-	1aF	6A	1aF	6A
Warfield	49	06	117	45	606	2170	182	216	484	-268	-	1cG	5A	1cG	5A
Westwold	50	28	119	45	616	1576	90	153	530	-377	-	1F	6A	1F	6A
Wms. Lk. A.	52	09	122	08	674	1404	101	207	364	-157	-	1GF	3A	1GF	3A
Wistaria	53	49	126	10	873	923	67	191	303	-112	-	5G	2A	5G	5G

ABBREVIATIONS:

GDD - Growing Degree Days above $5^{o}C$

FFP - Freeze Free Period

P - Seasonal (May-September) Precipitation

PE - Estimated Seasonal (May-September) Potential Evapotranspiration Values were determined using Baier and Robertson's (1965) formulae

P-PE - Climatic Moisture Deficit (negative) or Climatic Moisture Surplus (positive)

$(P-PE)^+/PE$ - Ratio of the Climatic Moisture Surplus and the May-September Potential Evapotranspiration.

*Long-term records from the Atmospheric Environment Service were used in determining the climatological parameters in this table. A - Airport; CDA - Canada Department of Agriculture.

TABLE 2. THE CLIMATIC CLASSES FOR AGRICULTURE OF SOME COASTAL SITES IN BRITISH COLUMBIA

Location*	Latitude (N) (deg)	(min)	Longitude (W) (deg)	(min)	EGDD	FFP (days)	P (mm)	PE (mm)	(P-PE) (mm)	(P-PE)+ PE	CLASSIFICATION Thermal Class	Moisture Class	Improved Rating	Unimproved Rating
Abbotsford A.	49	01	122	22	976	169	306	404	-98	-	1	2A	1	2A
Chatham Pt.	50	20	125	26	843	250	469	295	174	0.59	1	3Y	1	3Y
Comox A.	49	43	124	54	965	179	189	363	-174	-	1	3A	1	3A
Duncan	48	47	123	43	1158	164	157	461	-304	-	1	5A	1	5A
Estevan Pt.	49	23	126	32	734	225	567	258	309	1.20	3G	5Y	3G	5Y
Langara	54	15	133	03	536	236	509	220	289	1.31	4G	5Y	4G	5Y
Quatsino	50	32	127	39	783	212	400	335	65	0.19	2G	1Y	2G	2G
Saanichton CDA	48	37	123	25	957	226	140	342	-202	-	1	4A	1	4A
Steveston	49	07	123	11	928	172	208	385	-177	-	1	3A	1	3A

ABBREVIATIONS:

EGDD - Effective Growing Degree Days above 5°C.

FFP - Freeze Free Period

P - Seasonal (May-September) Precipitation

PE - Estimated Seasonal (May-September) Potential Evapotranspiration. Values were determined using Baier and Robertson's (1965) Formulae

(P-PE) - Climatic Moisture Deficit (negative) and Climatic Moisture Surplus (positive)

*Long term records from the Atmospheric Environment Service were used in determining the climatological parameters in this table. A - Airport; CDA - Canada Department of Agriculture.

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APPENDIX I

CLIMATIC CAPABILITY FOR AGRICULTURE CLASSIFICATION

SUMMARY OF LIMITATIONS

CLASS	GDD ABOVE 5°C	EGDD ABOVE 5°C	FFP (DAYS) INTERIOR	FFP (DAYS) COASTAL	CMD (negative (P-PE) (mm)	(CMS/PE) RATIO
1d	2225		>150			
1c	2060-2225		>150			
1b	1780-2059		>150			
1a	1505-1779		120-150			
1	1310-1504	>825	90-119	>150	<40	< .33
2	1170-1309	736-825	75-89	120-150	40 to 115	from .34 to .55
3	1030-1169	650-735	60-74	100-119	116 to 190	from .56 to .75
4	1030-1169	491-649	50-59	80-99	191 to 265	from .76 to 1.00
5	780-1029	421-490	30-49	60-79	266 to 340	1.00
6	670-779	245-420	<30	40-59	341 to 415	
7	<670	<245	<30	<40	>415	

GDD = Growing Degree Days Above 5°C

EGDD = Effective Growing Degree Days Above 5°C

FFP = Freeze Free Period (Base 0°C)

CMD = Climatic Moisture Deficit, i.e. the negative difference between May-September precipitation (P) and Potential Evapotranspiration (PE)

CMS = Climatic Moisture Surplus, i.e. the positive difference between the May to September precipitation (P) and Potential Evapotranspiration (PE)

APPENDIX II

Effective Growing Degree Day (EGDD) as a Criterion for Classifying Climate Capability for Agriculture for the Coastal Areas of British Columbia.

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INTRODUCTION

The maritime and coastal climates of British Columbia are characterized by mild winters and cool summers, due to the moderating effects of surrounding bodies of water. This situation results in longer freeze free periods and growing seasons, as well as substantial accumulations of seasonal growing degree days (GDD). These GDD, however, misleadingly appear to adequately support higher agricultural climatic capabilities (Climatology Report No. 1, 1972) in terms of thermal capacity. In reality, these climatic capability classes, when applied to the coast, are over-rated. Hence, an adjustment using a more suitable thermal criterion is necessary.

Since these GDD are accumulated from temperatures at the lower end of the scale (near the base temperature of $5^{o}C$) they should not be considered as Effective Growing Degree Days (EGDD). This is due to the fact that the temperature-crop development relationship is not linear (Coligado and Brown, 1975a, Aitken, 1974), contrary to what is assumed by the GDD concept. In a linear relationship, GDD accumulated near the threshold-value are being given an over-rated contribution to crop development*. Hence, 2500 GDD accumulated in a mid-latitude maritime (coastal) site should not be considered equivalent to 2500 GDD accumulated in a continental (inland) station where GDD's are obtained from higher average temperatures for the most part of the relatively shorter growing season. The scheme presented here adjusts for the inadequacy of the GDD as a criterion for classifying coastal agricultural climate by using the Effective Growing Degree Day instead.

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*The progress from one phenological stage to the next.

THE EFFECTIVE GROWING DEGREE DAY (EGDD)

To calculate EGDD, a Crop Development Index (CDI) has to be determined first. In formulating the CDI, the data on corn development and the mathematical relationships derived by Coligado and Brown (1975a and 1975b) were used. In this study, the crop development response time (t_T) and mean daily temperature (T in ^oC) are related as (see Figure 1):

$$t_T = k_T\ (T^{-m_T});\ 0^oC < T \leq 25^oC \qquad (1)$$

where k_T and m_T are the coefficient and exponent, respectively.

The change in time $(\Delta t)_{T_i}$ in crop development due to suboptimal temperature becomes:

$$(\Delta t)_{T_i} = t_{T_i} - t_{T_o} = k_T\ (T_i^{-m_T} - T_o^{-m_T}) \qquad (2)$$

where T_i represents mean temperature for a particular day i and T_o is the optimum mean daily temperature (25^oC). When T_i is between 25 and 30^oC, T_i is set equal to 25^oC. That means that between these temperatures, crop development response does not change. Beyond 30^oC, development time increases again with temperature. When the upper temperature threshold is reached the plant does not develop and dies (see Figure 1).

Even in the most continental area of British Columbia, the probability of occurrence of a mean daily temperature of 30^oC is nil. In fact, at Oliver, the highest mean daily temperature ever recorded (1941-1974) is only 28^oC.

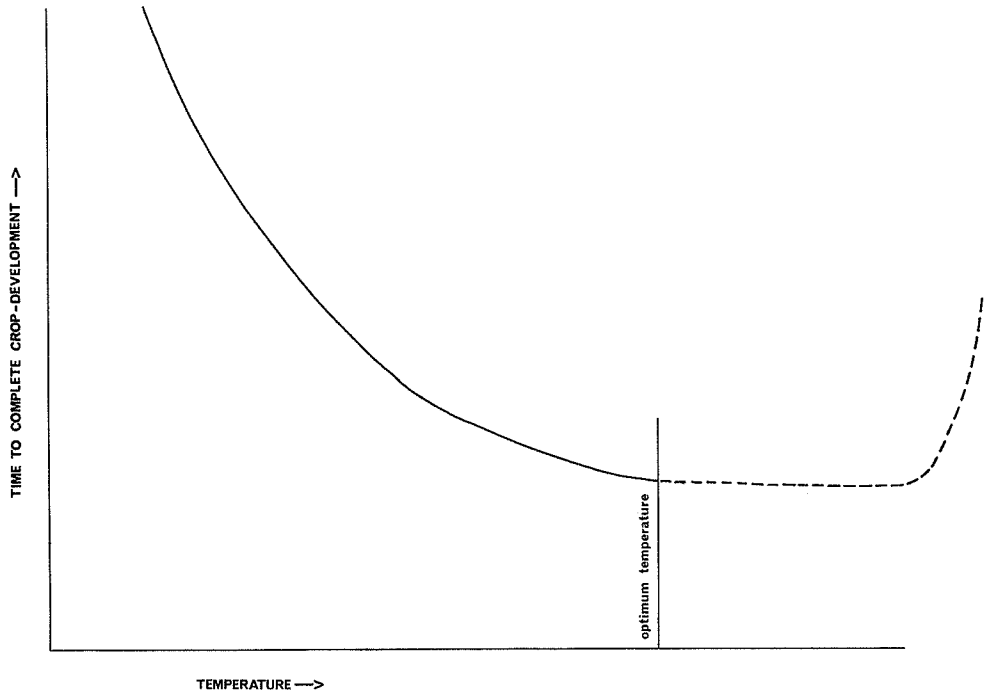

Figure 1 A schematic diagram showing the relationship of time of crop-development and temperature.

The response to daily temperature range (R in ^{o}C) is related to crop development time (t_R) as a linear function (see Figure 2) such that:

$$t_R = a_R + b_R.R \tag{3}$$

where a_R is a constant and b_R represents the development rate (day/^{o}C) due to R.

The value of b_R, however, changes with daily mean temperature (Figure 2) in a manner expressed as:

$$b_R = k_R(T^{-m_R}) \tag{4}$$

where k_R and m_R are the coefficient and exponent, respectively. The change in crop development time due to sub-optimal temperature ranges then becomes:

$$(\Delta t)_{R_i} = b_R(R_i - R_o) = k_R T^{-m_R}(R_i - R_o) \tag{5}$$

where R_i = temperature range for a particular day i and R_o = optimum temperature range.

In summary, the model determines the "delay" or change in time of crop development contributed by sub-optimal daily mean temperature and temperature range.

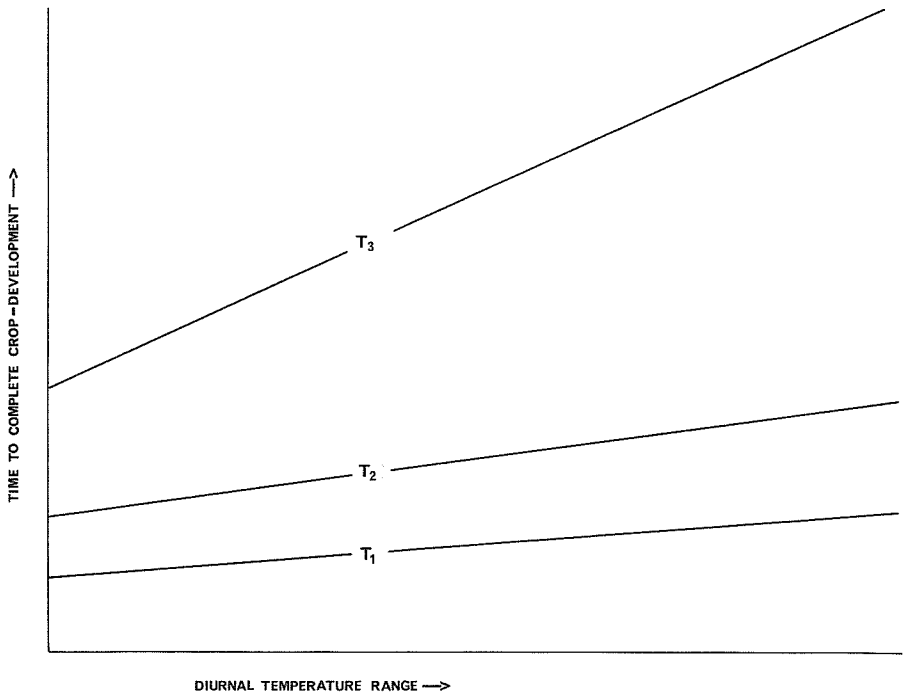

Figure 2 A schematic diagram showing the effect of diurnal temperature range on time of crop-development when temperature decreases from T_1 to T_3.

An optimum mean daily temperature of 25°C to 30°C and a temperature range of 0°C (constant day and night temperatures) were considered under a constant 15-hour period. In applying these relationships a daily photoperiod of 15 hours was considered to be a reasonable average value for the growing season in British Columbia, and mathematical identities to Equations (2) and (5) were derived. Due to the length of these derivations, only the solutions have been included in this paper. It is shown that Equation (2) becomes:

$$(\Delta t)_{T_i} = k_T T_i^{-m_T} + k_P T_i^{-m_P} - 10.01 \qquad (6)$$

where k_P and m_P are the coefficient and exponent, respectively, and Equation (5) becomes:

$$(\Delta t)_{R_i} = k_T T_i^{-m_T} + k_R T_i^{-m_R}(R_i) - 9.06 \qquad (7)$$

The values of the coefficients and exponents used in the above relationships are as follows:

$k_T = 56.0$, $m_T = 0.566$, $k_P = 2730.5$, $m_P = 2.475$, $k_R = 11497.6$ and $m_R = 3.757$.

The Crop Development Index (CDI) is then defined as the ratio of the shortest time (t_o) of development under optimum conditions to the sum of the "delays" ($\Delta t_{T_i} + \Delta t_{R_i}$) and t_o, i.e.

$$(CDI)_i = \frac{t_o}{t_o + (\Delta t)_{T_i} + (\Delta t)_{R_i}} \qquad (8)$$

where $t_o = k_T T_o^{-m_P} + 2740.5 T_o^{-m_P} = 10$ days. Values of CDI range from 0 to 1 (see Table 1). For a particular day i, the Effective Growing Degree Day $(EGDD)_i$ is determined as the product of the Growing Degree Day $(GDD)_i$ and $(CDI)_i$, where the GDD is equal to the daily mean temperature minus a base temperature of 5°C. The summation of the daily EGDD for the growing season (T>5°C) is used as one of the limitation-criteria in the revised classification.

In determining the EGDD ranges for the coastal areas, CDI values for a group of stations that have the best climate capability in British Columbia sites (Keremeos, Oliver and Osoyoos) were determined. The average CDI value for these stations is 0.63. Then the GDD range in each climatic class listed in Climatology Report No. 1 (1972) was multiplied by 0.63, resulting in the new set of ranges listed for each class (Classes 1 to 7) in the publication. The EGDD ranges for Classes 1 to 3 are straight conversions in the above manner. Classes 3 and 4 in the above classification have the same GDD range but have different freeze free periods. Since freeze free period is not, in general, a primary limitation in coastal areas, the EGDD ranges for Classes 4 to 6 were upgraded one class and a new range for Class 7 was established.

TABLE 1

VARIATION OF CROP DEVELOPMENT INDEX AS A FUNCTION OF MEAN TEMPERATURE AND TEMPERATURE RANGE

MEAN DAILY TEMPERATURES (^{o}C)

DIURNAL TEMPERATURE RANGE (^{o}C)

	1	5	10	15	20	25
0	.004	.5	.33	.54	.76	1.00
1	.001	.12	.31	.53	.75	.99
2	.000	.09	.29	.52	.74	.99
3		.07	.27	.51	.74	.98
4		.05	.26	.49	.73	.98
5			.25	.48	.72	.97
6			.24	.47	.71	.96
7				.46	.71	.96
8				.46	.70	.95
9					.69	.95
10					.68	.94
11					.68	.93
12	Minimum and some maximum temperatures at these				.67	.93
13	ranges generally harmful to plants.					.92
14						.92
15						.91

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