

Analysis of several bioclimatic indices for viticulture zoning in the Pacific Northwest

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Table S1: Bioclimatic indices applied for climatic zoning.

Bioclimatic Index	Equation	Reference
Growing Season Temperature (GST)	$\frac{\sum_{Apr1}^{Oct31} (Tmax + Tmin) / 2}{n}$	Jones, 2005a
Winkler Index (WI) or Growing Degree Days (GDD)	$\sum_{Apr1}^{Oct31} \max \left[\left(\frac{[Tmax + Tmin]}{2} \right) - 10, 0 \right]$	Winkler et al. 1974, Jones et al. 2010
Huglin Index (HI)	$\sum_{Apr1}^{Sep30} \max \left(\left[\frac{[Tmean - 10] + [Tmax - 10]}{2} \right], 0 \right) \cdot k$ Where k is an adjustment for latitude /day length.	Huglin 1978
Biologically Effective Degree Days (BEDD)	$\sum_{Apr1}^{Oct31} \min \left[\left(\max \left[\left(\frac{[Tmax + Tmin]}{2} \right) - 10, 0 \right] \right), 9 \right] \cdot DTRadj \cdot k$ Where $DTR adj = \begin{cases} 0.25[DTR - 13], [DTR] > 13 \\ 0, 10 < [DTR] < 13 \\ 0.25[DTR - 10], [DTR] < 10 \end{cases}$ Where k is an adjustment for latitude/day length.	Gladstones, 1992
Mean Thermal Amplitude (MTA)	$\frac{1}{n} \sum_1^n (Tmax - Tmin)$ For the month of September in the Northern Hemisphere.	Mullins et al., 1992; Ramos et al., 2008

Cool Night Index (CI)	Average daily <i>T_{min}</i> for the month of September (Northern Hemisphere).	Tonietto and Carbonneau, 2004
Minimum Temperature (Min. Temp.)	Daily minimum value for each year.	Hidalgo, 2002
Latitude Temperature Index (LTI)	$LTI = MTWM . (60 - latitude)$ <i>MTWM</i> is the mean temperature of the warmest month of the growing season.	Jackson and Cherry, 1988
Frost Free Days (FFD)	Number of days between the last frost in spring and the first frost in Autumn.	Magarey, 1998
Growing Season Precipitation (GSP)	$\sum_{Apr}^{Sep} (P)$ <p>Where <i>P</i> is the daily precipitation (mm).</p>	Blanco-Ward et al., 2007
Growing Season Suitability (GSS)	Fraction of days between April to September where <i>T_{avg}</i> > 10°C.	Malheiro et al., 2010; Santos et al., 2012b
Length of Growing Season (LGS)	Number of days between April first to end of October where <i>T_{avg}</i> > 10°C.	Jackson, 2008
Hydrothermic Index (Hyl)	$\sum_{April}^{Aug} (P . T)$ <p>Where <i>P</i> is the daily precipitation (mm).</p>	Branas et al., 1974

Table S2: American Viticultural Areas (AVAs) in Washington and Oregon and various key bioclimatic indices computed over a 30-year period (1983-2012).

Bioclimatic Indices	Ancient Lakes of the Columbia Valley					Columbia Gorge				
	Min.	Max.	Mean	±SD	Group letter	Min.	Max.	Mean	±SD	Group letter
Biologically Effective Degree Days (BEDD)	231	305	283	11.9	H	211	564	466	71.49	I
Cold Damage Index (Five-years)	3	17	11	2.9	D	2	40	13	7.04	C
Cold Damage Index (10-years)	3	21	13	3.6	E	3	61	23	12.66	B
Cold Damage Index (20-years)	7	40	23	6.9	F	9	104	43	20.38	C
Cold Damage Index (30-years)	9	58	30	11.1	G	10	140	56	29.07	C
Cool Night Index (CI)	8.0	10.3	9.3	0.5	D	5.7	8.9	7.4	0.58	H
Dynamic Minimum Temperature	23	38	31	3.4	C	9	30	18	5.20	I
Frost Free Days (FFD)	159	186	171	5.9	F	145	189	164	9.39	I
Growing Degree Days (GDD)	1379	1725	1525	61.5	D	858	1372	1089	109.62	J
Growing Season Precipitation (GSP)	47.0	80.4	59.0	5.5	FGH	138.4	387.5	262.0	63.52	B
Out of Growing Season Precipitation (Out-GSP)	69.5	90.6	77.9	4.7	H	123.2	288.0	195.4	37.28	B
Growing Season Suitability (GSS)	0.86	0.92	0.90	0.0	D	0.73	0.89	0.82	0.03	J
Growoing Season Temperature (GST)	15.4	17.2	16.2	0.3	D	12.6	15.6	14.0	0.63	J
Huglin Index (HI)	2089	2464	2248	61.6	F	1394	2098	1740	126.12	J
Hydrothermic Index (Hyl)	756	1035	863	66.9	GH	992	1687	1305	146.02	C
Latitude Temperature Index (LTI)	289	315	299	4.8	I	262	313	285	10.09	J
Length of Growing Season (LGS)	171	188	179	2.8	E	145	182	165	7.58	I
Mean thermal amplitude (MTA)	15.1	17.4	16.2	0.5	HG	13.4	18.1	16.3	0.66	EF
Wind Speed Index (WS)	10	38	19	7.0	G	20	58	32	8.80	D

Table S2 (cont.): American Viticultural Areas (AVAs) in Washington and Oregon and various key bioclimatic indices computed over a 30-year period (1983-2012).

Bioclimatic Indices	Columbia Valley					Horse Heaven Hills				
	Min.	Max.	Mean	±SD	Group letter	Min.	Max.	Mean	±SD	Group letter
Biologically Effective Degree Days (BEDD)	79	609	331	94.6	G	282	549	437	63.1	E
Cold Damage Index (Five-years)	0	95	14	9.6	C	3	18	9	3.6	E
Cold Damage Index (10-years)	0	157	20	16.3	C	4	26	12	4.8	E
Cold Damage Index (20-years)	1	281	36	29.8	D	6	50	20	8.8	G
Cold Damage Index (30-years)	1	378	48	41.3	D	7	75	23	12.3	H
Cool Night Index (CI)	5.0	11.9	8.8	1.0	E	8.0	10.7	9.5	0.7	C
Dynamic Minimum Temperature	7	73	28	12.3	D	14	31	20	3.4	H
Frost Free Days (FFD)	116	212	168	14.2	G	159	196	178	7.0	E
Growing Degree Days (GDD)	740	1908	1414	198.0	F	1210	1705	1566	86.0	C
Growing Season Precipitation (GSP)	42.9	347.3	81.1	26.9	E	55.8	96.8	64.7	5.7	F
Out of Growing Season Precipitation (Out-GSP)	64.4	435.1	119.6	40.6	D	82.8	122.9	95.7	6.9	F
Growing Season Suitability (GSS)	0.66	0.95	0.87	0.0	F	0.82	0.93	0.90	0.0	C
Growing Season Temperature (GST)	11.5	18.1	15.6	1.1	F	14.5	17.2	16.4	0.5	C
Huglin Index (HI)	1263	2602	2124	227.8	G	1874	2431	2289	92.0	E
Hydrothermic Index (Hyl)	680	3218	1209	382.5	D	876	1299	1003	62.6	E
Latitude Temperature Index (LTI)	229	353	304	24.3	G	302	341	328	7.5	B
Length of Growing Season (LGS)	128	195	175	11.3	G	164	190	183	4.5	D
Mean thermal amplitude (MTA)	9.9	19.2	16.3	1.1	EF	14.0	17.3	16.1	0.9	H
Wind Speed Index (WS)	6	92	32	16.6	D	18	72	39	12.3	B

Table S2 (cont.): American Viticultural Areas (AVAs) in Washington and Oregon and various key bioclimatic indices computed over a 30-year period (1983-2012).

Bioclimatic Indices	Lake Chelan					Naches Heights				
	Min.	Max.	Mean	±SD	Group letter	Min.	Max.	Mean	±SD	Group letter
Biologically Effective Degree Days (BEDD)	148	241	204	18.9	J	215	358	295	37.6	D
Cold Damage Index (Five-years)	6	20	13	2.4	C	21	41	30	5.5	A
Cold Damage Index (10-years)	7	31	16	4.6	D	34	61	47	7.6	A
Cold Damage Index (20-years)	11	62	30	8.6	E	58	113	86	15.1	A
Cold Damage Index (30-years)	12	77	38	11.5	E	84	154	119	18.4	A
Cool Night Index (CI)	7.7	10.1	8.5	0.6	F	6.3	7.6	6.8	0.3	I
Dynamic Minimum Temperature	24	53	39	5.5	B	37	53	45	3.6	A
Frost Free Days (FFD)	151	184	166	5.8	HI	141	151	146	2.6	K
Growing Degree Days (GDD)	1073	1497	1329	72.2	H	1012	1362	1189	79.7	I
Growing Season Precipitation (GSP)	71.3	102.4	83.4	8.1	E	74.7	130.7	96.3	11.0	D
Out of Growing Season Precipitation (Out-GSP)	100.6	125.9	107.8	5.3	E	94.2	132.1	112.1	6.5	E
Growing Season Suitability (GSS)	0.80	0.89	0.86	0.0	H	0.78	0.87	0.83	0.0	I
Growing Season Temperature (GST)	13.6	16.0	15.1	0.4	H	13.3	15.3	14.4	0.5	I
Huglin Index (HI)	1716	2180	2019	93.0	H	1687	2130	1931	98.2	I
Hydrothermic Index (HyI)	1108	1263	1176	34.1	D	987	1103	1044	29.4	E
Latitude Temperature Index (LTI)	249	283	269	5.8	L	266	296	281	7.0	K
Length of Growing Season (LGS)	154	178	169	3.9	H	152	174	164	4.8	J
Mean thermal amplitude (MTA)	13.3	17.6	15.7	1.0	I	16.5	17.8	17.4	0.2	B
Wind Speed Index (WS)	22	32	27	2.2	F	31	44	39	2.7	B

Table S2 (cont.): American Viticultural Areas (AVAs) in Washington and Oregon and various key bioclimatic indices computed over a 30-year period (1983-2012).

Bioclimatic Indices	Puget Sound					Rattle Snake Hills				
	Min.	Max.	Mean	±SD	Group letter	Min.	Max.	Mean	±SD	Group letter
Biologically Effective Degree Days (BEDD)	68	685	319	138.4	K	268	400	329	34.4	C
Cold Damage Index (Five-years)	0	9	0	1.0	I	9	27	15	4.2	B
Cold Damage Index (10-years)	0	12	1	1.3	I	13	42	23	6.1	B
Cold Damage Index (20-years)	0	33	1	2.7	J	26	81	47	12.2	H
Cold Damage Index (30-years)	0	44	1	3.6	J	35	126	72	18.2	B
Cool Night Index (CI)	7.2	11.5	9.4	0.7	D	7.5	8.7	8.2	0.3	G
Dynamic Minimum Temperature	0	20	3	2.2	L	25	40	31	3.5	C
Frost Free Days (FFD)	91	266	230	19.1	A	146	165	157	3.8	J
Growing Degree Days (GDD)	619	1187	948	99.8	K	1176	1575	1386	102.6	G
Growing Season Precipitation (GSP)	119.9	860.9	331.8	93.9	A	53.4	63.9	56.8	2.1	HI
Out of Growing Season Precipitation (Out-GSP)	164.0	1289.6	414.9	121.1	A	80.0	106.9	90.2	6.1	FG
Growing Season Suitability (GSS)	0.00	0.91	0.86	0.0	G	0.82	0.91	0.87	0.0	F
Growing Season Temperature (GST)	11.6	14.9	13.6	0.5	K	14.3	16.5	15.5	0.6	G
Huglin Index (HI)	985	1719	1452	124.4	K	1833	2366	2138	135.0	G
Hydrothermic Index (Hyl)	1148	7010	3145	774.8	A	850	1031	936	33.4	F
Latitude Temperature Index (LTI)	183	253	223	18.2	M	285	318	302	8.3	H
Length of Growing Season (LGS)	0	190	176	7.5	F	162	184	174	5.6	G
Mean thermal amplitude (MTA)	7.8	14.4	11.4	1.2	J	14.9	17.9	17.1	0.7	D
Wind Speed Index (WS)	0	62	19	11.7	G	11	49	29	10.3	E

Table S2 (cont.): American Viticultural Areas (AVAs) in Washington and Oregon and various key bioclimatic indices computed over a 30-year period (1983-2012).

Bioclimatic Indices	Red Mountain					Rock District of Milton Free Water				
	Min.	Max.	Mean	±SD	Group letter	Min.	Max.	Mean	±SD	Group letter
Biologically Effective Degree Days (BEDD)	354	379	365	6.7	D	873	1075	1075	51.1	H
Cold Damage Index (Five-years)	4	4	4	0.0	H	3	7	5	1.1	H
Cold Damage Index (10-years)	5	6	5	0.4	H	3	7	5	1.1	H
Cold Damage Index (20-years)	12	14	13	0.7	H	3	8	5	1.4	I
Cold Damage Index (30-years)	14	16	15	0.7	I	13	33	22	6.3	H
Cool Night Index (CI)	9.5	9.6	9.5	0.0	C	9.7	10.5	10.2	0.2	A
Dynamic Minimum Temperature	18	19	18	0.3	I	11	12	12	0.3	K
Frost Free Days (FFD)	179	180	179	0.2	D	199	206	203	2.0	B
Growing Degree Days (GDD)	1597	1647	1622	13.8	B	1621	1660	1649	9.7	A
Growing Season Precipitation (GSP)	59.4	62.1	60.8	0.6	FGH	97.0	100.4	98.4	0.9	D
Out of Growing Season Precipitation (Out-GSP)	83.7	88.0	85.8	1.0	G	182.4	187.9	184.8	1.2	C
Growing Season Suitability (GSS)	0.91	0.92	0.92	0.0	B	0.92	0.93	0.92	0.0	A
Growing Season Temperature (GST)	16.6	16.9	16.7	0.1	B	16.8	16.9	16.9	0.0	A
Huglin Index (HI)	2332	2395	2362	17.7	C	2320	2353	2332	8.4	D
Hydrothermic Index (HyI)	901	937	916	7.5	FG	1998	2068	2040	17.0	B
Latitude Temperature Index (LTI)	323	327	325	1.0	C	334	338	337	1.0	A
Length of Growing Season (LGS)	185	187	186	0.6	B	188	190	189	0.4	A
Mean thermal amplitude (MTA)	16.2	16.5	16.4	0.1	E	15.1	16.1	15.6	0.3	I
Wind Speed Index (WS)	15	17	16	0.5	H	24	33	29	2.2	E

Table S2 (cont.): American Viticultural Areas (AVAs) in Washington and Oregon and various key bioclimatic indices computed over a 30-year period (1983-2012).

Bioclimatic Indices	Snipes Mountain					Wahluke Slope				
	Min.	Max.	Mean	±SD	Group letter	Min.	Max.	Mean	±SD	Group letter
Biologically Effective Degree Days (BEDD)	338	350	343	2.9	A	286	402	339	25.7	F
Cold Damage Index (Five-years)	6	8	7	0.5	F	1	17	6	4.5	G
Cold Damage Index (10-years)	10	13	12	0.7	E	1	22	7	5.7	G
Cold Damage Index (20-years)	20	27	25	1.6	F	1	40	13	10.8	H
Cold Damage Index (30-years)	28	38	33	2.7	F	1	58	18	14.4	I
Cool Night Index (CI)	8.5	8.9	8.7	0.1	E	8.5	11.9	10.0	0.9	B
Dynamic Minimum Temperature	23	25	24	0.4	F	14	35	22	5.3	G
Frost Free Days (FFD)	164	168	166	1.2	H	160	206	180	11.1	D
Growing Degree Days (GDD)	1609	1643	1624	9.0	B	1388	1908	1662	127.1	A
Growing Season Precipitation (GSP)	51.0	54.9	52.1	0.9	I	56.5	62.7	58.4	1.0	GH
Out of Growing Season Precipitation (Out-GSP)	77.4	79.3	78.1	0.6	H	65.5	85.0	73.3	4.8	H
Growing Season Suitability (GSS)	0.91	0.92	0.92	0.0	B	0.87	0.95	0.91	0.0	B
Growing Season Temperature (GST)	16.7	16.8	16.7	0.0	B	15.4	18.1	16.9	0.7	A
Huglin Index (HI)	2408	2453	2425	10.4	A	2109	2602	2397	122.3	B
Hydrothermic Index (Hyl)	830	850	840	5.2	H	770	924	834	36.5	H
Latitude Temperature Index (LTI)	321	324	322	0.8	D	296	340	319	10.9	E
Length of Growing Season (LGS)	186	187	186	0.4	B	173	195	185	5.5	BC
Mean thermal amplitude (MTA)	17.8	18.4	18.1	0.2	A	14.8	17.1	16.2	0.5	EFG
Wind Speed Index (WS)	49	59	56	2.7	A	17	41	27	5.6	F

Table S2 (cont.): American Viticultural Areas (AVAs) in Washington and Oregon and various key bioclimatic indices computed over a 30-year period (1983-2012).

Bioclimatic Indices	Walla Walla					Yakima Valley				
	Min.	Max.	Mean	±SD	Group letter	Min.	Max.	Mean	±SD	Group letter
Biologically Effective Degree Days (BEDD)	183	510	346	73.0	FG	212	456	331	37.9	B
Cold Damage Index (Five-years)	1	40	7	3.8	F	2	36	11	5.6	D
Cold Damage Index (10-years)	1	65	9	5.3	F	3	60	17	8.8	D
Cold Damage Index (20-years)	1	105	13	8.4	B	7	110	33	16.2	D
Cold Damage Index (30-years)	2	140	16	10.4	I	8	152	46	25.0	D
Cool Night Index (CI)	6.6	11.2	9.5	0.8	C	6.5	10.3	8.6	0.7	F
Dynamic Minimum Temperature	10	49	15	3.1	J	16	44	26	5.2	E
Frost Free Days (FFD)	144	212	189	11.3	C	140	186	164	8.6	I
Growing Degree Days (GDD)	909	1703	1566	95.4	C	1025	1684	1488	136.1	E
Growing Season Precipitation (GSP)	74.0	288.5	111.5	27.9	C	50.2	155.6	63.1	11.9	FG
Out of Growing Season Precipitation (Out-GSP)	129.4	417.9	197.3	39.2	B	67.8	125.9	86.8	11.0	G
Growing Season Suitability (GSS)	0.73	0.93	0.91	0.0	C	0.78	0.93	0.89	0.0	E
Growing Season Temperature (GST)	12.7	17.1	16.5	0.5	C	13.4	17.1	16.0	0.7	E
Huglin Index (HI)	1506	2391	2274	109.9	E	1686	2480	2248	166.4	F
Hydrothermic Index (Hyl)	1400	3185	2050	305.4	B	714	1158	916	81.1	FG
Latitude Temperature Index (LTI)	275	342	329	7.7	B	269	331	312	12.0	F
Length of Growing Season (LGS)	143	190	184	4.9	C	154	189	179	7.1	E
Mean thermal amplitude (MTA)	14.4	18.9	16.2	1.2	FHG	14.3	18.5	17.2	1.1	C
Wind Speed Index (WS)	14	61	33	13.8	D	11	68	37	15.6	C