Wellington's Climate

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INTRODUCTION

The continuously changing weather integrated over a long period comprises the climate of a locality. Climate influences plant life in many ways, but most fundamentally in its control of the exchange of energy, carbon dioxide, oxygen, and water between the atmosphere and plants. In looking at these exchanges one can consider a single leaf or twig, an individual plant, or a plant community as a whole.

Globally, the uneven supply of solar energy, the rotation of the earth, and the geographical shape of land masses and seas drive the earth's weather. Wellington's weather and climate are typical of a mid-latitude oceanic region, with westerly winds prevailing and weather dominated by a succession of anti-cyclones and low pressure systems, and fronts or low pressure troughs which bring bands of cloud and rain where air streams from differing source areas come together. This is a climate classified as "warm temperate rainy with warm summers and no marked dry season" where forests once covered the lowlands and farms now prosper. Wellington has a changeable, moderately sunny, rather wet and windy climate. The rugged topography and close proximity to Cook Strait concentrate the wind flow from either north-west or south-east (Fig. 1). There may be rapid weather changes, but it is seldom excessively hot or cold and there are few prolonged dry periods. Land above about 750 m reaches up into a much more severe climate: colder, wetter, windier and less sunny (Coulter 1973).

SOLAR RADIATION AND SUNSHINE

At Wellington a horizontal surface receives solar energy as visible light, infra-red radiation, and a small proportion of ultra-violet radiation at a maximum intensity of about 1.1 kW/m^2 at noon on a bright summer day. On average the total radiation which reaches the ground at Wellington ranges from 23 megajoules/m^2/day in December and January to 5 megajoules/m^2/day in June. This is about 55 percent and 35 percent, respectively, of the amounts that would be received if none were intercepted by clouds and other atmospheric constituents. This variation in the solar energy input is, of course, the essential difference between seasons which is reflected in changes of temperature. The amount of available energy limits the amount of evaporation, and (assuming uniform efficiency of photosynthesis) is a measure of the growth potential of plants.

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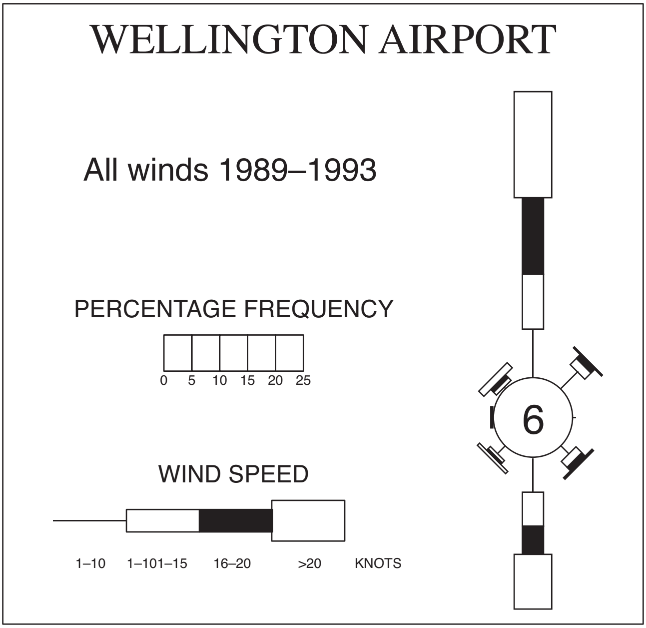

Fig. 1. Wind frequency analysis by direction and speed for Wellington Airport (Rongotai). Note: Directions are shown as compass points, wind speeds in knots. Frequency of calms (%) in circle. (Supplied by NIWA. Copyright NIWA.)

The duration of bright sunshine averages 2019 hours per year at Kelburn or 48 percent of that possible. This is a moderately high value for New Zealand - not as much as Blenheim or Nelson's 2400 hours, but more than Levin's 1900 hours or Invercargill's 1660 or the 1400–1500 hour average of much of Great Britain.

Towards the high ranges north and east of Wellington there is often cloud and mist, and light intensities are low for long periods. Sunshine duration and solar radiation totals are much lower than around Wellington city. Because of the varied topography of the Wellington region there will be quite marked deviations between sites; sheltered valleys and gullies will be in shade for much of the day. Within a dense forest canopy, of course, light intensity is reduced to a very low level, and the micro-climate of any ground cover is very different from that of plants exposed to the sky.

TEMPERATURE AND HUMIDITY

January and February are the warmest months in Wellington with an average daily maximum temperature of 20˚C, while occasional days from December to March exceed 27˚C. July is the coldest month, with daytime maxima commonly in the range 10–12˚C and seldom exceeding 15˚C, while night temperature only very rarely falls below freezing point in the hill suburbs (Table 1). While maximum temperatures do not differ much from place to place in the region –

Table 1. Climatological summary, Wellington, based on observations 1928–1980 at Kelburn unless otherwise stated.
Lat. 41°17S. Long. 174° 46E. Alt. 125 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
RAINFALL (mm)													
Highest monthly/annual value*	257	251	256	328	301	280	309	269	281	329	253	386	1795
90 percentile value*	149	166	155	172	204	205	223	203	169	179	152	165	1559
Mean*	81	81	85	100	122	125	139	122	100	106	88	91	1240
10 percentile value*	23	27	27	39	53	60	68	58	42	41	35	29	960
Lowest monthly/annual value*	3	1	5	16	18	13	38	26	15	8	15	0	707
Maximum one-day rainfall*	114	161	145	126	145	87	88	113	96	105	67	152	161
Maximum two-day rainfall*	178	166	151	184	162	137	142	142	124	148	94	197	197
* includes observations at various sites in Wellington City 1862–1980													
Av. rain days 1.0 mm or more	7	7	8	10	12	13	14	13	11	11	10	9	125
TEMPERATURE OF THE AIR (°C)													
Highest recorded*	30.1	31.1	28.3	27.3	21.7	20.6	17.2	18.9	20.6	25.1	26.9	29.1	31.1
Av. monthly/annual maximum*	25.4	25.4	23.9	21.2	18.3	16.0	15.0	16.0	17.8	19.6	21.6	23.8	26.5
Av. daily maximum	20.0	20.1	18.9	16.5	13.7	11.6	10.9	11.7	13.3	15.0	16.8	18.7	15.6
Mean	16.4	16.6	15.6	13.6	11.0	8.9	8.2	8.9	10.2	11.8	13.4	15.2	12.5
Av. daily minimum	12.8	13.1	12.2	10.5	8.2	6.2	5.5	6.1	7.2	8.6	10.0	11.7	9.3
Av. monthly/annual minimum*	7.9	8.2	6.8	5.2	3.2	1.6	1.0	1.2	2.4	3.6	5.0	7.0	0.5
Lowest recorded*	4.1	4.7	3.9	2.1	-0.7	-1.2	-1.9	-1.6	-0.6	1.1	1.7	3.4	-1.9
* includes observations at various sites in Wellington City 1869–1980													
TEMPERATURE OF THE GROUND (°C)													
Av. at 30 cm depth	18.8	18.6	17.1	14.4	11.3	8.8	7.6	8.4	10.3	12.8	15.2	17.4	13.4

Table 1 (continued)

RELATIVE HUMIDITY													
9 a.m. av., % 1950–80	77	80	82	84	84	85	85	84	81	79	78	78	81
EVAPORATION RAISED PAN (mm)													
1971–80	162	121	102	63	39	30	28	38	58	95	124	141	1001
SUNSHINE (hours, 1935–80)													
Highest	304	267	242	204	171	165	140	204	243	256	267	313	2198
Mean	236	201	186	151	118	104	107	132	162	190	208	224	2019
Lowest	176	140	125	87	67	66	71	79	110	114	133	174	1798
Mean as % of possible	53	54	51	48	41	40	38	43	48	48	50	49	48
SOLAR RADIATION (Megajoules/m^2)													
Mean global/day 1954–80	23.5	20.0	14.9	10.3	6.5	5.2	5.5	8.1	12.7	17.7	21.3	23.0	14.1
WIND													
Av. days with gusts ≥ 63 km/h 1972–80	17.9	15.2	16.1	16.8	18.1	16.7	16.3	17.0	20.0	20.2	19.8	19.2	213.3
Av. days with gusts ≥ 96 km/h 1972–80	6.3	4.0	5.2	4.6	4.9	4.7	3.3	4.4	6.4	6.7	7.6	6.0	64.1
Mean daily windrun (km)	362	353	325	323	324	314	302	326	361	383	396	369	345
Mean hourly speed (km/h) 1962–80	22	21	20	20	20	20	19	21	23	23	24	22	21
SPECIAL PHENOMENA (av. days of)													
Snow	—	—	—	—	0.1	0.1	0.4	0.2	0.3	0.1	—	—	1.2
Hail	0.1	0.1	0.3	0.3	1.2	1.6	2.1	1.3	1.3	0.9	0.5	0.3	10.0
Thunder	0.4	0.3	0.3	0.3	0.5	0.5	0.3	0.3	0.4	0.3	0.5	0.5	4.6
Gale	2.0	2.0	1.4	1.5	2.0	1.3	1.5	1.5	2.1	2.9	2.9	1.8	22.9
Fog	0.4	0.6	1.1	1.1	1.2	1.6	1.4	1.2	0.5	0.5	0.4	0.6	10.6

(Adapted from N.Z. Met. Service Misc. Pub. 177)

Table 2. Average monthly/yearly frequency of air frosts (adapted from Goulter 1984).

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Wellington Airport	1969–1980	—	—	—	—	—	0.2	0.4	0.3	0.1	—	—	—	1.0
Wainuiomata	1970–1980	—	—	—	—	0.5	3.2	4.2	2.8	0.8	0.2	—	—	11.6
Wallaceville	1939–1980	—	—	0.1	1.0	3.3	7.7	9.8	6.3	3.3	1.0	0.2	—	32.7
Porirua	1968–1980	—	—	—	0.2	0.3	1.3	1.3	1.1	0.6	0.1	—	—	4.9
Pauatahanui	1968–1978	—	—	—	—	0.1	0.5	0.3	0.1	—	—	—	—	1.0
Paraparaumu Airport	1953–1980	—	—	—	—	0.7	2.9	4.2	1.7	0.5	—	—	—	10.0

they tend to be a little higher in sheltered sunny areas such as Eastbourne, Rongotai, and parts of the Hutt Valley than at Kelburn - night time temperatures may fall 2–4° lower in sheltered valleys than at Kelburn.

Kelburn has experienced air frosts on only two occasions since records commenced there in 1928, but in low lying coastal areas they average two to ten per year, while in inland valleys there are 30 to 50 per year. Ground frosts average 15 per year at Kelburn, on a hill top 125 m above the city; 72 per year at Wallaceville, on the flat in the upper Hutt Valley (Table 2).

Humidity of the air, and leaf surface wetness resulting from dew or mist are significant environmental factors for plants. Warm, damp conditions, in particular, promote fungus attacks, and favour some insect pests. In Wellington relative humidity is commonly between 70 and 80 percent by day, 80–90 percent at night. This is about 10 percent higher than is usual in inland and east coast districts of New Zealand.

By comparison with many other places in New Zealand Wellington does not experience great extremes of temperature, as it is tempered by the surrounding sea and its winds. Nor does it often experience very dry air or prolonged warm, humid conditions.

WIND

The wind flow across central New Zealand is concentrated through Cook Strait and blows across the Wellington area almost always from either north-west or south-east (Fig. 1). Winds from the northerly quarter are about twice as frequent as those from the south, but many of the most severe storms have been southerlies (and most rain falls with southerlies). Strong southerlies tend to be more frequent in winter. Late spring and early summer often have long spells of north-westerlies.

The overall average wind speed in Wellington City, 19–24 km/hr is high compared with that at inland stations, but is not very different from that at other places near the coast such as Invercargill or New Plymouth. On hilltops near the city, averages of about 32 km/hr have been recorded, while at Wallaceville in the Hutt Valley the average is only 9 km/hr.

Wind direction as well as speed is influenced by local topography. Wellington's winds are very turbulent, and it is their gustiness which so often makes them unpleasant and causes damage. Gusts of over 63 km/hr average about 160-215 days per year in Wellington city, compared with about 100 or more at Invercargill, 83 at Paraparaumu or 80 at New Plymouth airport. The strongest gust so far recorded in Wellington city was 198 km/hr at Kelburn on 10 April 1968 in a southerly storm. Still higher gust velocities have been recorded on some of the hilltop sites: 270 km/hr at Oteranga Bay (overlooking Cook Strait) during the same southerly storm; and 248 km/hr on two occasions at Hawkins Hill, both in northerly conditions.

The Rimutaka summit is notorious for its strong north-westerlies. Near here the effect of wind on vegetation is evident in the broken beech forest canopy on some of the higher ridges. It is also seen in wind-trimmed scrub on coastal cliffs. Gardeners well know the need for shelter in most of Wellington's suburbs. Sea salt carried by gales can have marked effects on vegetation, especially immediately behind the coast.

Although Wellington's reputation for windiness is well justified, and the proportion of calms is very small at coastal or hilltop sites, there are often calm periods in the valleys. The accumulation of smoke haze over the Hutt Valley on still winter nights shows that the Wellington region is not immune to air pollution, though it has not yet reached serious levels.

RAINFALL, EVAPORATION AND SOIL MOISTURE

The water balance of plants is directly related to the energy balance. It requires 2469 joules to evaporate 1 ml of water. In the Wellington region about one-third of the incoming solar radiation is used in this way. The average transpiration from vegetation cover, assuming water to be fully available, ranges from about 25 mm per month in winter to about 25 mm per week in mid-summer, or a total of about 660 mm per year. Evaporation from an open water surface at Wellington would be about 760 mm per year. This is quite a high value for the North Island and is a reflection of the moderately sunny and strongly windy character of Wellington.

If soil moisture in the root zone is insufficient to meet this transpirational demand, temperatures in the canopy will rise until the surplus energy is disposed of, mainly by turbulent air motions – a process which is efficient if there

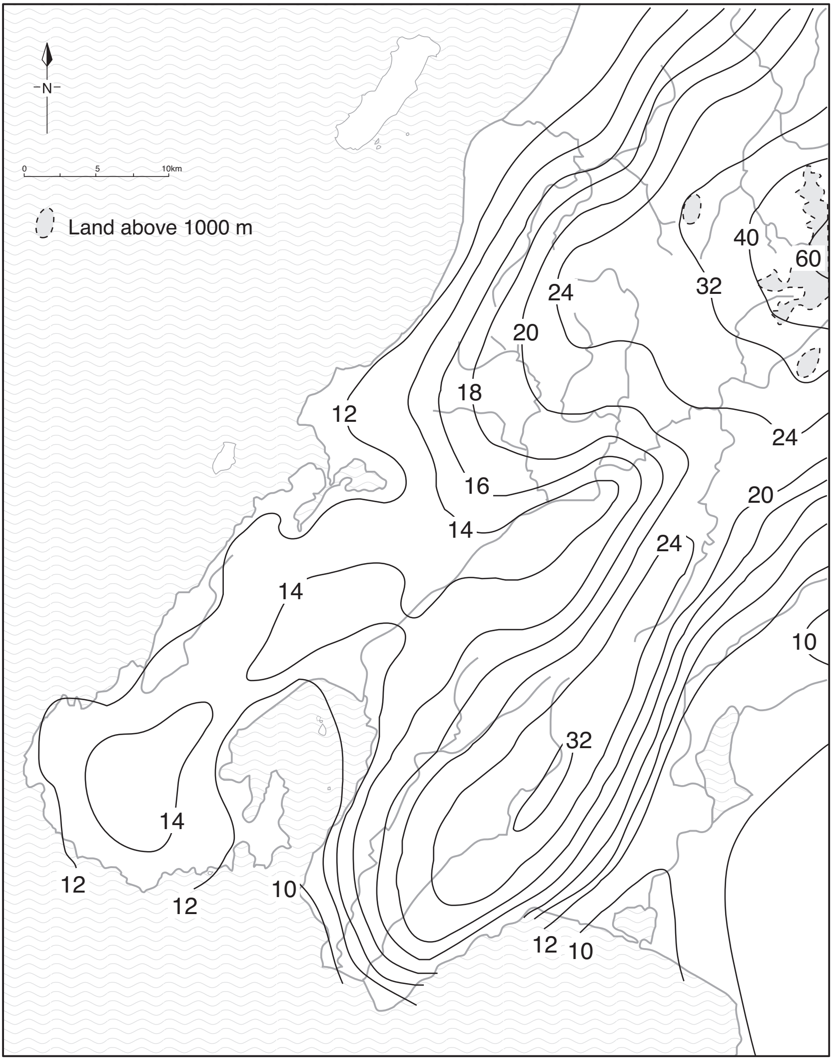

Fig. 2. Mean annual rainfall, decimetres (10 dm = 1000 mm), based on “normals” for 1941–70 (N.Z. Met Service 1973, 1975), Met Service normals for 1951–1980 (N.Z. Met Service 1984) and NIWA normals for 1960–1990 have also been referred to, as well as information from Wellington Regional Council. The isohyets as drawn are approximate only, because of sparseness of the raingauge network and the problems of rainfall measurements in remote and mountainous areas.

is wind or if the leaf surfaces are small or needle-shaped. If soil moisture is greatly depleted, severe water stress will arise in plant tissues, stomata will close, and exchange of carbon dioxide and photosynthesis will be prevented.

If the stress is too prolonged and severe, permanent damage will result. When soil moisture is depleted by the equivalent of 7 cm of rain, pasture growth is usually substantially reduced.

In total, Wellington's rainfall is more than enough for plant needs (Fig. 2), and, as it is relatively evenly distributed, few serious droughts are experienced. Winter months receive most rain, averaging around 125 mm, and summer months the least, averaging about 80 mm. There are, of course, wide variations from year to year (Table 1, note percentile values). In most years there are usually a few spells of several weeks' duration in summer and autumn and occasionally in spring, when not enough rain falls to maintain the soil moisture required for continuous pasture growth. Summer pasture production can generally be increased by spray irrigation, and gardeners well know the need for hosing in most years.

High intensity rain storms occur occasionally, and in the hills these rare events may have far-reaching influences on vegetation by causing slips and soil erosion and by altering stream beds. On average, one 24-hour fall in 50 years can be expected to exceed 165 mm in Wellington. In Wainuiomata the 50-year figure rises to about 305 mm. In 1939 a fall of 378 mm in 24 hours was recorded at Baring Head. It has been calculated that such a high intensity is to be expected only once in several centuries.

Exceptionally heavy rainfalls in 1974 and 1976 caused problems in areas of urban development where there were ground-slope failures and mudflows in the hill suburbs. Severe flooding occurred in the Hutt Valley and Petone area in the 1976 storm.

LOCAL CLIMATE VARIATIONS, SNOW AND FOG

There are differences in local climates in the region. These are related to aspect, to sheltering by the hills, and to altitude. Rainfall is lowest on average about Wellington Harbour and in the Plimmerton-Titahi Bay areas (about 1000–1200 mm annually), is higher in the Hutt Valley and hill suburbs (1250–1400 mm), and increases with proximity to the higher hills to about 2500 mm or more, as at Kaitoke and Orongorongo waterworks (Fig. 2). On the hills over 500 m above sea level, the frequency of rain, mist and high humidity is such that most trees and rocks are covered by mosses and filmy ferns. Near the headwaters of the Hutt and Otaki catchments, mean annual rainfall may exceed 600 mm.

Temperatures decrease on average by about 5°C per 1000 m of altitude, but, as stated earlier, on calm nights the valley bottoms are colder than the slopes. The mildest climates overall are probably north-facing slopes above the eastern bays or Porirua Harbour, which are sheltered from the full impact of southerly winds and are relatively frost-free.

Snow and hail fall rarely at the coast, but on the higher levels snow lies for brief periods once or twice in an average winter. Snow has fallen in Wellington

City on a few occasions, and there have been reports of snow lying in the hill suburbs. The first of these was on July 17–18, 1844, when it was said that snow lay for three days at Karori. A heavier fall occurred on 29–30 July, 1849 – "… the whole of the hills, and mountains in the distance, the house-tops and streets being covered with snow… The ground was covered to an average depth of three or four inches, whilst at Karori, which stands 600 ft above the level of the sea, the snow was nearly ten inches deep" (Wellington Independent, 1 August, 1849). On 16 September, 1926, another notable fall was recorded – "…On the route to Karori the everyday aspect was completely changed. The Botanic Gardens with spring flowers peeping through the transforming mantle of white, the leafless trees outlined in silvery tracery, and pines capped with snow, presented a beautiful appearance. The snowfall was heavy at Upper Hutt…" On this occasion, snow was reported at Tauranga, Rotorua and Napier, and a foot of snow fell in the Wairarapa. Other notable occurrences of snow in Wellington were in August 1886, August 1904, July 1918, August 1936, and July 1939.

Fog is not common, though sea fog sometimes drifts from Cook Strait onto areas around the south coast and the harbour, and shallow night fogs sometimes form inland in valleys.

STORMS

The storm of April 1968 which caused the loss of the "Wahine" developed from a tropical cyclone that moved southwards into the New Zealand region to pass just to the east of Cook Strait on the morning of the 10th. This was without doubt the most severe storm in Wellington since records have been kept. It gave hurricane force winds for several hours, with gusts of around 190 km/hr at several sites around Wellington city, and the wind speed averaged 145 km/hr for a time at Rongotai airport. Damage to radiata pine plantations on Miramar Peninsula and to individual mature trees in the Botanic Gardens and Otari Gardens were perhaps the most obvious effects on vegetation about Wellington, although native trees in many areas were also uprooted and broken.

The storm of February 1936 in which the "Rangatira" was driven ashore outside Wellington Harbour was somewhat similar in its origin and characteristics, but on that occasion it was in the eastern foothills of the Tararua Range to the north of Wellington that the most spectacular over-throwing of native bush occurred, with consequent filling of streams with debris. A downpour of rain in the Rimutaka Range in December 1962 gave similar results, but over a much smaller area. On that occasion rainfall in the affected area probably exceeded 40 mm in an hour, and 200 mm in 24 hours.

CONCLUSION

Wellington's climate is maritime rather than continental, so there is no dramatic change from season to season. The leaves of deciduous trees tend to be battered and browned, and blown off before they develop the colourful autumn tints seen in more sheltered inland areas. Summer temperatures are often not high enough for sufficient time to ripen fruits and vegetables that thrive in central Otago or Bay of Plenty, for example. Although the risk of a late killing frost is not great, there is always a chance of a cold southerly or a period of strong northerlies in late spring or early summer which will damage young growth. Besides the obvious effects of moderate storms which must be expected a few times each year, the catastrophic storms that may occur perhaps only once in a century or longer can have important effects on vegetation.

Changes in climatic conditions since the ice ages have had an influence on past and present vegetation patterns, but no definitive reconstruction of such changes has yet been worked out for this region. Regular meteorological records commenced in Wellington more than 100 years ago and they show for the most part apparently random fluctuations. There was, however, a definite trend over New Zealand towards milder temperatures from about the 1900s up to the 1980s (especially since the 1950s), but the greatest change in ten year averages was only about 0.5°C. These trends appear to be world-wide. No such clear-cut long-term trends have been identified in rainfall records.

Although Wellington's climate record is too short for us to see clearly what climate changes may have taken place in the past, in the light of evidence from other parts of the world, climatologists can no longer assume that climate has been essentially constant for thousands of years.

ACKNOWLEDGEMENTS

Thanks are due to NIWA and the Wellington Regional Council for recent climatological and rainfall data used for the figures.

GENERAL NOTE

The text is essentially as written about 1975. Some minor editorial changes have been made, e.g., units updated or corrected. More recent information has been used for the figures and tables. Some of the "extremes to date" quoted may no longer hold. A newly written version would, of course, be influenced by new information.

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