PREDICTING SPATIAL VARIATION IN THE UPPER LIMIT OF TREES ON THE ALPINE MOUNTAINS OF LUTRUWITA/TASMANIA

by Jamie B Kirkpatrick

(with four figures and one table)

Kirkpatrick, JB (2024). Predicting spatial variation in the upper limit of trees on the alpine mountains of Lutruwita/Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 158: 7–15. ISSN: 0080-4703. School of Geography, Planning and Spatial Sciences, University of Tasmania, Private Bag 78, Hobart, Tasmania 7001, Australia. Email: j.kirkpatrick@utas.edu.au

Climate change threatens obligate alpine plants with restricted distributions, especially where mountain peaks are not far above the climatic treeline (henceforth 'treeline'), as in Lutruwita/Tasmania where there are at least ten plant species that are only known to occur above the treeline and many more that only occur in alpine vegetation above and below the treeline. In a context of global warming, it is important to know the elevation of the treeline on each of the numerous alpine habitat islands in the state. Using the satellite image and contour layers in LISTmap, the highest elevation of trees on 49 alpine islands that had peaks above their treeline was determined. I then derived a predictive equation that explained 80.1% of the variance in this dataset and applied it to 141 alpine peaks. This analysis indicated that there were ten peaks on which the modelled treeline was more than 250 m elevation below the summit and 12 peaks on which the modelled treeline was more than 125 m in elevation above the summit. These results indicate that species extinctions in the alpine zone may not be imminent but are possible, especially for the eight Tasmanian endemics that are only known from above the treeline. Modelling of alpine lower limits and of the environmental ranges of the potentially threatened species is desirable.
Key Words: alpine, climate change, climatic treeline, Lutruwita, Tasmania.

INTRODUCTION

Climate change threatens obligate alpine plants with restricted distributions, especially where mountain peaks are not far above the climatic treeline (Dirnbock *et al.* 2011). Styger and Balmer (2009) suggest that the climatic treeline (henceforth 'treeline') in Lutruwita/Tasmania could be 250 m higher than at present by the year 2100. They assumed a 1.5°C rise in temperature and a 0.6°C environmental lapse rate. The former assumption now appears optimistic. On the other hand, there may be consequences of climate change that counteract the effects of sea level warming on the treeline. The best documented of these effects relates to increases in wind speed that have resulted from a steepening pressure gradient over Lutruwita/Tasmania. This increase has affected the steepness of environmental lapse rates, maintaining snow incidence at high elevations (Kirkpatrick *et al.* 2017). The Lutruwita/Tasmania treelines, where monitored over decades, have not changed (Harrison-Day *et al.* 2016, Balmer *et al.* 2021). This lack of response is no guarantee of a lack of change in the coming decades.

Prospective treeline change is potentially significant for the conservation of the Tasmanian biota, as there are at least ten vascular plants that do not occur below the climatic treeline in Lutruwita/Tasmania (Kirkpatrick 1986) of which eight are Tasmanian endemics. The alpine vegetation is recognised to have world heritage significance (Kirkpatrick *et al.* 1993, Balmer *et al.* 2004). It is therefore important to understand the variability of treeline altitude in relation to the altitude of the highest peak in the alpine habitat islands of Lutruwita/Tasmania.

Alpine vegetation in Lutruwita/Tasmania occurs as an archipelago of habitat islands (Kirkpatrick 1997). The treeless vegetation that occurs up to 300 m below the climatic treeline is floristically and structurally highly similar to that above the treeline, so the convention, followed herein, has been to include it as part of the alpine zone (Kirkpatrick 1997), and to refer to the part of the alpine zone above the climatic treeline as 'true alpine'. The lower limit of the alpine vegetation below the treeline corresponds with the upper limit of lowland sedgeland and heath in which buttongrass *Gymnoschoenus sphaerocephalus* is usually prominent. This boundary is associated with a persistent temperature inversion (Kirkpatrick *et al.* 1996). On the more fertile eastern mountains, the transition from alpine vegetation below the climatic treeline to lowland treeless vegetation is associated with the transition from *Eucalyptus coccifera* subalpine forest and woodland to montane forest dominated variously by *E. delegatensis*, *E. rodwayi*, *E. pauciflora* and *E. dalrympleana*.

I made the earliest attempt to determine the spatial variability of treeline elevation in Lutruwita/Tasmania in Kirkpatrick (1982). I applied an environmental lapse rate of 0.65°C per 100 m elevation to the mean temperature of the warmest month data from climatic stations near Tasmanian alpine mountains and assumed that a mean temperature of the warmest month of 10°C corresponded with the treeline. Using this approach, the treeline varied between 746 m and 1418 m for climate stations, but the stations recording temperature were sparse over most of the range of alpine habitat islands. Global data led Paulsen and Korner (2014) to the more refined predictor of three months with daily mean temperatures above 0.9°C and with an overall temperature mean in these months higher than 6.4°C.

The recording of temperature data on transects up kunanyi/Mt Wellington (Nunez & Colhoun 1986) and up Mt Sprent in the remote southwest (Kirkpatrick *et al.* 1996), indicated that neither a linear environmental lapse rate nor a spatially constant environmental lapse rate could be assumed. These uncertainties suggested that an alternative approach to determining the altitudes of treelines within Lutruwita/Tasmania was desirable.

A recent review of southern hemisphere treelines (Hansson *et al.* 2023, p. 6) stated that the Tasmanian treeline 'generally rises from the southeast to the northwest'. The treeline certainly rises with increasing solar radiation from the southeast to northwest of individual mountains, but not between mountains. Between mountains it rises from the southwest to the northeast (Kirkpatrick 1982) in response to increasing continentality of climate and latitude (Kirkpatrick & Fowler 1998). The strong role of the maritime-continental climate gradient in affecting treeline elevation has also been recently documented for Norway (Byrne *et al.* 2022).

In this paper, I used observations of maximum treeline elevation on a subset of mountains where the treeline was below the peak, to develop a predictive equation. I then applied this equation to all the alpine mountains of Lutruwita/Tasmania (fig. 1). These data will be used in later work to indicate the relative susceptibility of the species in their alpine vegetation to anthropogenically induced warming.

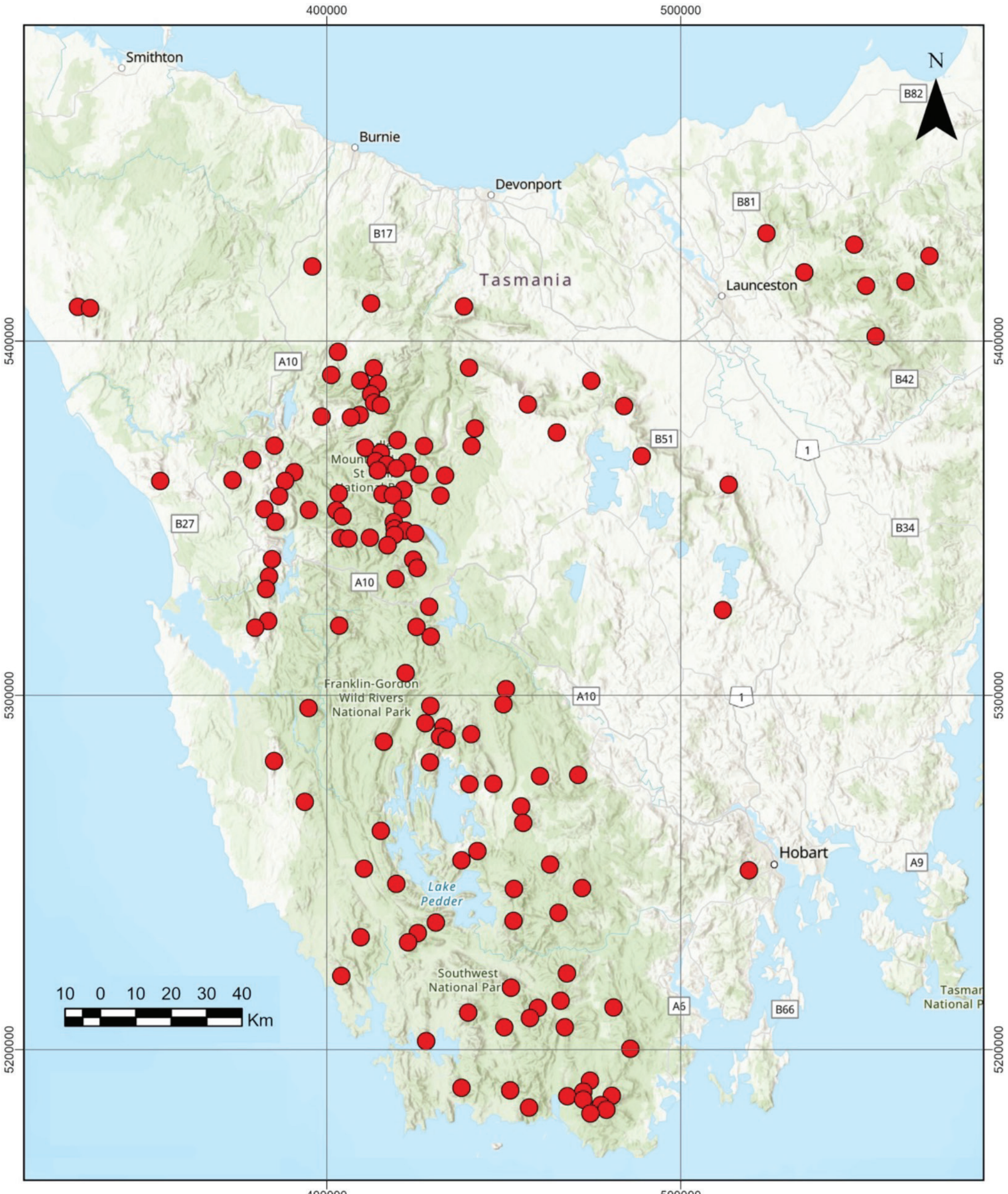

Figure 1 – Locations of the alpine peaks in table 1 (map created by Raiza Sartori).

METHODS

Data collection

Forty-nine mountains with alpine vegetation that I had previously ground-truthed and had an uppermost limit of trees below their peaks for apparently climatic reasons were selected in the first stage of data collection (fig. 2).

I examined the satellite images superimposed with the 10 m contour layer on LISTmap (Land Information Services Tasmania 2024) for each of these 49 mountains. I systematically searched for the highest altitude unambiguous trees, progressively following around individual contours, moving upward if trees were perceived above a contour. Places where the images were distorted in the rectification process were not included. When I found the highest tree, I recorded the nearest 10 m contour value. Trees were identified by their shadows, colour and canopy characteristics. The altitude of the peak was also recorded, mostly by reference to spot heights in topographic maps, but, for those without spot heights, in reference to the 10 m contours. The location of the peak was recorded in GDA94 MGA55.

I used the measurement tool in LISTmap to determine distances (km) of each peak to high energy coasts to the southwest, west and northwest, to indicate 'maritimeness' of climate, as most weather comes from these directions. Estuaries, such as Macquarie Harbour and the Tamar, were regarded to have low energy coasts. I recorded the dominant type of rock on each mountain in three classes (quartzite or quartzitic conglomerate; dolerite; and rocks of intermediate fertility, which were mostly sedimentary rocks in the Parmeener Supergroup).

I collected all the above data except the altitude of treeline from 92 other mountains that I knew supported alpine vegetation from my fieldwork, the literature or that I determined to have alpine vegetation from the satellite images. The resolution of these images is such that it is possible to discern buttongrass *Gymnoschoenus sphaerocephalus* hummock sedgeland from treeless vegetation lacking these hummocks. If such vegetation was above the hummock sedgeland and extended to the peak, it was assumed to be alpine.

Data analysis

I used the Best Subsets routine in Minitab21 to produce the best two multiple regression equations for each potential number of variables explaining treeline (m). These variables were: eastings (AGD94 MGA55); northings (AGD94 MGA55); distance to coast to the southwest (km); distance to coast to the west (km), distance to the coast to the northwest (km); minimum of these three distances to coast (km); mean of the three distances to coast (km). The best model, with a Mallows CP of 4.5, and an r^2 of 76.4 %, incorporated mean distance to coast, northings and distance to coast to the west. Mean distance to coast was the most explanatory single predictor linear relationship (r^2 = 67.2 %). Examination of the graph of this relationship indicated that it was quadratic, confirmed by later analyses (r^2 = 76.9 %). The residuals from this quadratic relationship were related to each of the remaining predictor variables, with only northings having a Pearson's correlation coefficient with $P < 0.05$. A linear regression was the best fit with the residuals. The residuals from the two variable model explaining treeline (incorporating the quadratic relationship with distance from coast and the linear relationship of northings with its residuals) were related to geological type using one-way ANOVA and to the remaining variables using the Pearson's correlation coefficient. There were no variables with a $P < 0.05$ and no indication in graphs that any polynomial fit would result in rejection of the null hypothesis. The two variable

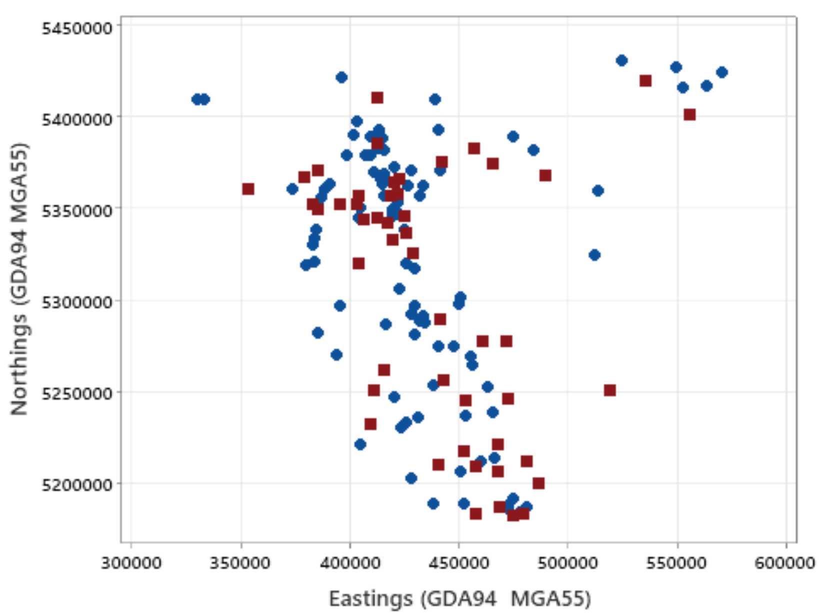

Figure 2 – Locations of the 141 peaks, showing the 49 peaks used for modelling (red squares) and the remaining peaks (blue diamonds).

model was accepted and applied to the full set of peaks. The elevation of the modelled treeline was then subtracted from the elevation of the individual peaks.

RESULTS

The most explanatory equation (r^2 = 80.1 %, fig. 3) to predict the treeline (m) incorporated mean distance from the coast (km) and northings (AGD94 MGA55):

*Treeline = (790.4 + 6.592 * mean distance - 0.02039 * mean distance²) + (-1597 + 0.000301*northings)*

There were many alpine peaks that were 125 m or less below the modelled treeline, but only a few that exceeded this deficit (fig. 4, table 1). Table Mountain was the extreme case at 257 m. The other alpine mountains with peaks more than 125 m below the modelled treeline were Mt Maurice (235 m), Mt Lee (229 m), Jubilee Range (211 m), The Needles (191 m), Mt Lewis (186 m), Mt Edith (174 m), Sentinel Range (170 m), Mt Arthur (169 m), Mt Norfolk (160 m), Granite Tor (144 m) and Mt Curly (132 m).

There were many mountains that were up to 225 m above the modelled alpine treeline (fig. 4, table 1). The extreme was Mt Ossa (366 m), followed by Eldon Peak (313 m), Mt Pelion West (310 m), Frenchmans Cap (304 m), Cradle Mt (299 m), Du Cane Range (279 m), Mt Thetis (263 m), Mt Anne (262 m), Pindars Peak (249 m), Mt Olympus (245 m), Mt Gell (245 m) and Ben Lomond (232 m).

DISCUSSION

There were potential errors in the measurement of treeline elevation, some of which were unavoidable. As the elevation of the treeline relates to summer heat (Paulsen & Korner 2014), the combinations of slope and aspect that orthogonally receive radiation in summer will have trees at higher elevation than other combinations. North-facing slopes could be expected to have the highest treelines if the slopes are appropriate, which is not necessarily the case. Also, many Tasmanian mountains have cliffs or extensive unvegetated block streams to the north, resulting in the highest elevation trees being on gentler, less rocky, slopes on other aspects. The quartzite mountains near the coast in the far southwest tend to only have trees on their south-facing slopes. These mountains have high negative residuals in the model (fig. 3, table 1). Some of the mountains selected to formulate the predictive equation may have had potential treelines above their peaks, as indicated in table 1, because the treeline was depressed by other factors, such as extreme exposure to strong winds or frequent burning.

Despite the above limitations, the model has very high explanatory value, enabling the identification of relative susceptibility of alpine vegetation islands to future warming. It is likely to be more accurate than climatic formulae such as TREELIM (Byrne *et al.* 2022) because it is based on trees ground-truthed in the field. The analysis suggests that a 250 m rise in the treeline will not eliminate true alpine vegetation, which will survive on at least eight mountains, which cover the edaphic range from the quartzite Frenchmans Cap to the dolerite Mt Ossa. However, it could eliminate at least one of the ten true alpine obligate species of Kirkpatrick (1986), as *Veronica ciliolata* only occurs on Ben Lomond, a mountain with a 232 m gap between treeline and peak.

It also indicates that there are many mountains currently supporting alpine vegetation below the current climatic treeline that might struggle to do so in the 250 m rise scenario (fig. 4, table 1). Over most of the state, alpine vegetation extends 100–300 m in elevation below the treeline, where trees are excluded by poor drainage and/

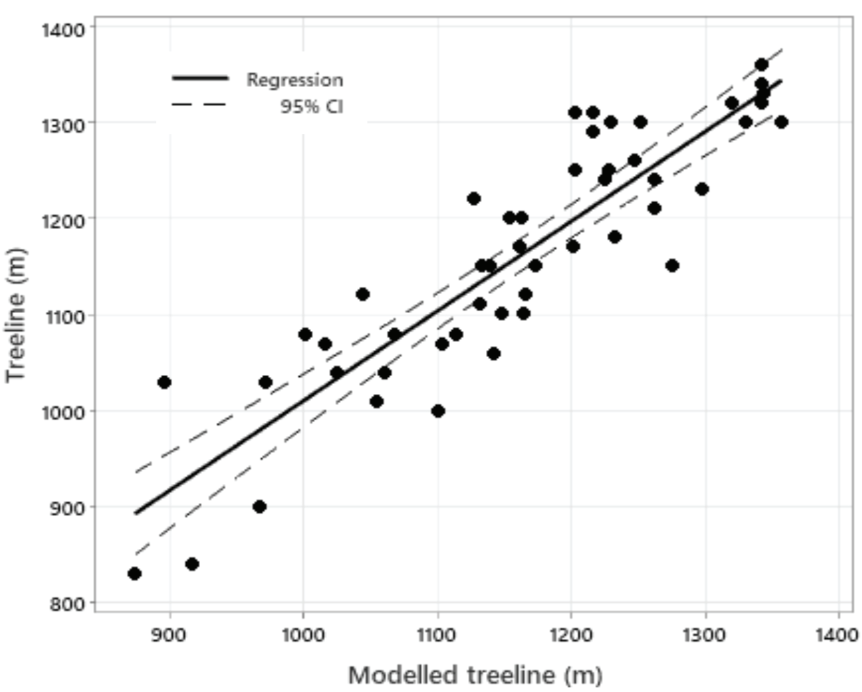

Figure 3 – The relationship between the modelled and observed treeline for 49 Tasmanian alpine areas.

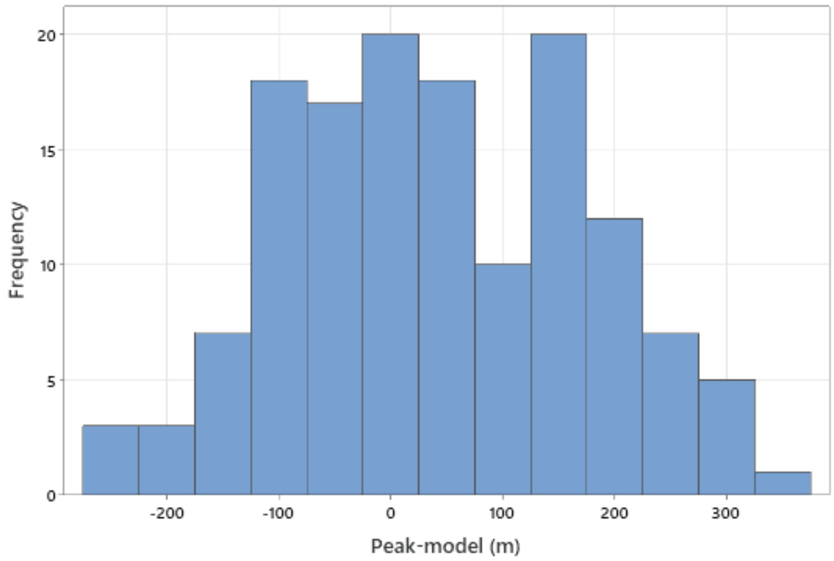

Figure 4 – The altitude between the modelled treeline and the peak for 141 peaks with alpine vegetation in Lutruwita/Tasmania.

or fire regimes. In the southwest on quartzite mountains the value is approximately 100 m, while on the Central Plateau it is approximately 300 m.

Further work is needed to build a model predicting this lower limit and to identify the downslope limits of taxa confined to the true alpine and/or alpine zones using records more recent than 1986 as well as earlier records.

REFERENCES

Balmer, J, Kirkpatrick, JB, Brown, MJ, Styger, J & Whinam, J (2021). Establishment Report for the Tasmanian Wilderness World Heritage Area Climate Change Monitoring Program: Moorland – Alpine Transition in Southwest Tasmania, Part I. Nature Conservation Report 2021/03, Department of Primary Industries, Parks, Water and Environment, Hobart: 86 pp.

Balmer, J, Whinam, J, Kelman, J, Kirkpatrick, JB & Lazarus, E (2004). A Review of the Floristic Values of the Tasmanian Wilderness World Heritage Area. Nature Conservation Report 2004/3, Department of Primary Industries, Water and Environment, Hobart: 129 pp.

Byrne, J, Renssen, H, Bui, DT & Odland, A (2022). Assessment of the TREELIM model in predicting present treeline along a longitudinal continentality-maritimity gradient in south-western Norway. *Geografiska Annaler: Series A, Physical Geography* 104: 90–108. DOI: 10.1080/04353676.2022.2054147

Dirnbock, T, Essl, F & Rabbitsch, W (2011). Disproportional risk for habitat loss of high-altitude endemic species under climate change. *Global Change Biology* 17: 990–996, doi: 10.1111/j.1365-2486.2010.02266.x

Hansson, A, Shulmeister, J, Dargusch, P & Hill, G (2023). A review of factors controlling Southern Hemisphere treelines and the implications of climate change on future treeline dynamics. *Agricultural and Forest Meteorology* 332: 109375.

Harrison-Day, V, Annandale, B, Balmer, J & Kirkpatrick, JB (2016). Decadal scale vegetation dynamics above the alpine treeline, Mount Rufus, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 150: 9–17.

Kirkpatrick, JB (1982). Phytogeographical analysis of Tasmanian alpine floras. *Journal of Biogeography* 9: 255–271.

Kirkpatrick, JB (1986). Tasmanian alpine biogeography and ecology and interpretation of the past. In Barlow, BA (ed). *Flora and Fauna of Alpine Australasia: Ages and Origins.* CSIRO, Melbourne: 229–242.

Kirkpatrick, JB (1997). *Alpine Tasmania: An Illustrated Guide to the Flora and Vegetation*. Oxford University Press, Melbourne: xii & 196 pp.

Kirkpatrick, JB & Fowler, M (1998). Locating likely glacial refugia in Tasmania using palynological and ecological information to test alternative climatic models. *Biological Conservation* 85: 171–182.

Kirkpatrick, JB, Hutchinson, MN & MacQuillan, PB (1993). Alpine ecosystems. *In* Smith, S & Banks, MR, (eds). *Tasmanian Wilderness – World Heritage Values*. Royal Society of Tasmania, Hobart: 73–79.

Kirkpatrick, JB, Nunez, M, Bridle, K & Chladil, M (1996). Explaining a sharp transition from sedgeland to alpine vegetation on Mount Sprent, south-west Tasmania. *Journal of Vegetation Science* 7: 763–768.

Kirkpatrick, JB, Nunez, M, Bridle, KL, Parry, J & Gibson, N (2017). Causes and consequences of variation in snow incidence on the high mountains of Tasmania, 1983–2013. *Australian Journal of Botany* 65: 214–224.

Land Information Services Tasmania (2024). https://maps.thelist.tas.gov.au/listmap/app/list/map (accessed April 2024).

Paulsen, J & Korner, C (2014). A climate-based model to predict potential treeline position around the globe. *Alpine Botany* 124: 1–12.

Styger, J & Balmer, J (2009). Alpine Treeline Ecotone monitoring program within the Tasmanian Wilderness World Heritage Area. Nature Conservation Report 2009/4, Department of Primary Industries, Parks, Water and Environment. Tasmania: 33 pp.

(accepted 27 May 2024)

Table 1 – Location (GDA94 MGA55), measured treeline elevation (AT, m), modelled treeline elevation (MT, m), peak elevation (PE, m) and peak elevation-modelled treeline elevation (PE-MT, m) for Tasmanian mountains with alpine vegetation. *not part of the modelling set.

Mountain	Easting	Northing	AT	MT	PE	PE–MT
Mt Arthur	524288	5430386	*	1356.56	1188	–168.560
Mt Maurice	549070	5427238	*	1357.31	1122	–235.314
Mt Victoria	570337	5424020	*	1332.86	1213	–119.856
St Valentines	395967	5421065	*	1231.81	1107	–124.810
Mt Barrow	534861	5419425	1300	1356.34	1414	57.664
Mt Saddleback	563508	5416814	*	1346.47	1256	–90.465
Ben Nevis	552376	5415561	*	1349.66	1368	18.345
Black Bluff	412543	5410559	1150	1274.74	1339	64.256
Mt Roland	438709	5409745	*	1275.35	1234	–41.348
Mt Norfolk	329680	5409676	*	919.98	759	160.983
Mt Edith	333145	5409284	*	945.28	771	–174.278
Ben Lomond	555090	5401389	1360	1340.57	1573	232.429
Mt Beecroft	403103	5397007	*	1248.92	1140	–108.922
Western Bluff	440174	5392470	*	1283.89	1420	136.106
Mt Kate	413275	5392291	*	1258.70	1156	–102.700
Mt Remus	401207	5390375	*	1228.91	1110	–118.905
Brewery Knob	409424	5388937	*	1251.24	1203	–48.238
Quamby Bluff	474775	5388737	*	1324.19	1228	–96.192
Mt Campbell	414490	5387931	*	1260.98	1248	–12.975
Cradle Mountain	412576	5384992	1260	1246.26	1545	298.737
Little Mt Emmett	413387	5382628	*	1262.02	1250	–12.022
Ironstone Mt	456790	5382107	1330	1342.22	1444	101.780
Mt Emmett	415240	5381870	*	1250.98	1410	159.023
Drys Bluff	484046	5381660	*	1332.66	1330	–2.658
Un–named Mt4	409364	5379183	*	1242.59	1215	–27.594
Granite Tor	398476	5378633	*	1177.61	1034	–143.615
Mt Inglis	406783	5378473	*	1230.48	1281	50.525
Clumner Bluff	441875	5375372	1320	1318.27	1458	139.733
Wild Dog Tier	465032	5374195	1340	1341.21	1394	52.786
Mt Oakleigh	420002	5372014	*	1234.57	1286	51.435
Mt Murchison	385174	5370509	1000	1099.06	1278	178.939
Walls of Jerusalem	440879	5370370	*	1298.94	1499	200.065
Mt Pillinger	427496	5370349	*	1273.33	1270	–3.328
Mt Proteus	410860	5369837	*	1210.99	1152	–58.988
Mt Pelion West	415258	5368449	*	1249.70	1560	310.298
Sandbank Tier	488947	5367535	1320	1341.82	1401	59.183
Mt Read	378927	5366400	1040	1059.26	1123	63.741
Un–named Mt3	413796	5366127	*	1218.46	1211	–7.460
Pelion East	422622	5365719	1300	1328.89	1461	132.114
Mt Thetis	416976	5365109	*	1218.15	1482	263.846
Mt Ossa	419790	5364097	1300	1251.12	1617	365.883
Perrins Bluff	414376	5363456	*	1216.60	1420	203.401
Un–named Mt2	390841	5363049	*	1120.01	1026	–94.011

Table 1 cont.

Mountain	Easting	Northing	AT	MT	PE	PE–MT
Cathedral Mt	426167	5362335	*	1261.08	1387	125.922
Mt Ragoona	433409	5362072	*	1275.51	1350	74.488
Mt Dundas	373361	5360712	*	1002.31	1143	140.694
Mt Agnew	352909	5360535	830	872.86	848	–24.861
Sticht Range	388154	5360459	*	1082.48	1080	–2.479
Millers Bluff	513598	5359489	*	1338.31	1213	–125.307
Du Cane Range	421646	5358055	1300	1228.37	1507	278.630
Dome Hill	403412	5356962	1150	1132.09	1177	44.914
Macs Mt	415719	5356839	*	1213.54	1413	199.455
Walled Mt	418666	5356493	1310	1214.50	1431	216.497
Mtns of Jupiter	432093	5356401	*	1269.13	1326	56.870
Walford Peak	386569	5356223	*	1051.38	1009	–42.378
Mt Gould	421310	5352609	*	1220.64	1485	264.357
Tyndall Range	382348	5352536	1040	1023.88	1191	167.117
Eldon Peak	394974	5352354	1220	1126.57	1440	313.425
Eldon Bluff	402717	5352170	1170	1159.65	1361	201.353
Castle Mt	404419	5350563	*	1154.05	1208	53.947
Mt Sedgewick	385431	5348981	1120	1042.71	1146	103.289
Mt Manfred	418974	5348935	*	1210.10	1382	171.901
Mt Cuvier	419167	5346951	*	1210.57	1378	167.432
Mt Byron	422163	5346493	*	1214.65	1375	160.348
Mt Olympus	424982	5345663	1250	1226.63	1472	245.366
Coal Hill	419171	5345367	*	1201.43	1190	–11.430
Pyramid Mt	412186	5344550	1200	1161.14	1269	107.862
Camp/Last Hill	403870	5344406	*	1143.08	1172	28.918
Rocky Hill	406166	5344227	1150	1137.72	1194	56.281
Goulds Sugarloaf	417166	5342350	1250	1201.62	1425	223.379
Mt Owen	384563	5338420	*	1011.15	1145	133.849
Mt Hugel	424389	5338314	*	1240.63	1403	162.368
Mt Rufus	425560	5335993	1290	1215.64	1416	200.359
Mt Huxley	383692	5333604	*	997.63	925	–72.635
Mt Gell	419395	5332807	1310	1202.02	1447	244.983
Mt Jukes	382898	5329974	*	987.79	1169	181.213
King William I	428874	5325030	1240	1224.36	1324	99.645
Table Mt	511888	5324035	*	1326.81	1070	–256.813
Mt Darwin	383395	5321002	*	988.60	1033	44.398
Frenchmans Cap	403539	5319669	1060	1140.87	1445	304.126
Loddon Bluff	425401	5319353	*	1193.60	1220	26.400
Mt Sorell	379811	5319052	*	966.65	1143	176.351
King William II	429365	5316573	*	1203.54	1361	157.455
Algonkian Mt	422239	5306224	*	1155.82	1073	–82.819
Mt Shakespeare	450679	5301781	*	1247.85	1221	–26.852
Wylds Craig	449922	5297502	*	1239.86	1339	99.140
Innes High Rocky	429247	5296975	*	1169.84	1083	–86.842

Table 1 cont.

Mountain	Easting	Northing	AT	MT	PE	PE–MT
Elliot Range	394819	5296398	*	1026.88	911	–115.883
White Pyramid	427879	5292138	*	1173.03	1071	–102.025
Mt Curly	433001	5291111	*	1196.93	1065	–131.934
Denison Range	440753	5289064	1170	1200.49	1290	89.515
Unnamed Range	431992	5288383	*	1180.96	1078	–102.955
Pokana Peak	433848	5287471	*	1186.20	1127	–59.196
Prince of Wales	416069	5286913	*	1115.09	1069	–46.086
Mt Lee	385073	5281516	*	962.55	734	–228.545
The Pleiades	429205	5281148	*	1160.37	1082	–78.367
Mt Field East	471008	5277501	1240	1261.72	1274	12.276
Mt Field West	460270	5277219	1210	1260.94	1439	178.056
The Thumbs	447097	5274995	*	1191.03	1204	12.970
Clear Hill	440369	5274949	*	1185.68	1198	12.318
Mt Lewis	393724	5269898	*	983.66	798	–185.658
The Needles	454945	5268680	*	1223.30	1032	–191.296
Mt Mueller	455530	5264059	*	1219.19	1245	25.806
Mt Sprent	415230	5261799	1010	1054.31	1058	3.693
Mt Wedge	442561	5256103	1100	1163.33	1147	–16.327
Sentinel Range	438034	5253413	*	1143.60	974	–169.600
Jubilee Range	463137	5252260	*	1223.65	1013	–210.653
High Dome	410467	5251027	1200	1152.49	1366	213.515
kunanyi/Mt Wellington	519211	5250590	1230	1296.47	1271	–25.466
Double Peak	419708	5246799	*	1043.67	1061	17.333
Snowy Range	472178	5245576	1180	1230.93	1398	167.066
Mt Anne	452920	5245411	1150	1172.44	1435	262.558
Mt Weld	465526	5238637	*	1192.43	1344	151.574
Schnells Ridge	452739	5236374	*	1148.07	1087	–61.075
Folded Range	430775	5235819	*	1046.49	966	–80.487
Mt Maconochie	425657	5232893	*	1004.50	958	–46.497
Prosting Range	409531	5231699	840	916.47	894	–22.474
Greystone Bluff	423021	5230315	*	982.02	1019	36.982
Mt Picton	467798	5221496	1120	1164.14	1327	162.855
Mt Hean	404107	5220807	*	807.90	749	–58.903
Western Arthurs	452042	5217470	1070	1102.23	1160	57.771
South Picton Range	466043	5213759	*	1129.22	1082	–47.217
Hartz Peak	481078	5211896	1100	1147.72	1254	106.281
Mt Hopetoun	459645	5211721	*	1116.10	1087	–29.101
Mt Norold	439913	5210412	900	965.75	970	4.248
Eastern Arthurs	457388	5208973	1080	1066.51	1225	158.490
Mt Pollux	450169	5206359	*	1004.65	916	–88.654
Mt Bobs	467292	5206308	1080	1113.20	1111	–2.196
Mt Rugby	428026	5202374	*	875.26	773	–102.260
Adamsons Peak	485790	5200258	1110	1130.03	1225	94.972
Mt Bisdee	474405	5191259	*	1034.59	1005	–29.594

Table 1 cont.

Mountain	**Easting**	**Northing**	**AT**	**MT**	**PE**	**PE–MT**
Mt Counsel	438113	5189185	*	880.95	802	–78.952
Mt Louisa	451804	5188489	*	921.91	931	9.094
Mt Victoria Cross	472508	5188155	*	1026.01	1120	93.985
Moonlight Ridge	480539	5187017	*	1071.24	1036	–35.245
Precipitous Bluff	467961	5186883	1030	970.64	1145	174.358
Mt Wylly	472448	5185921	*	1014.45	1110	95.551
Maxwell Ridge	477513	5184358	*	1050.40	1060	9.597
Ironbound Range	457180	5183595	1030	894.49	1061	166.508
Mt La Perouse	479056	5182996	1070	1015.14	1161	145.862
Pindars Peak	474491	5182002	1080	1000.55	1250	249.452