

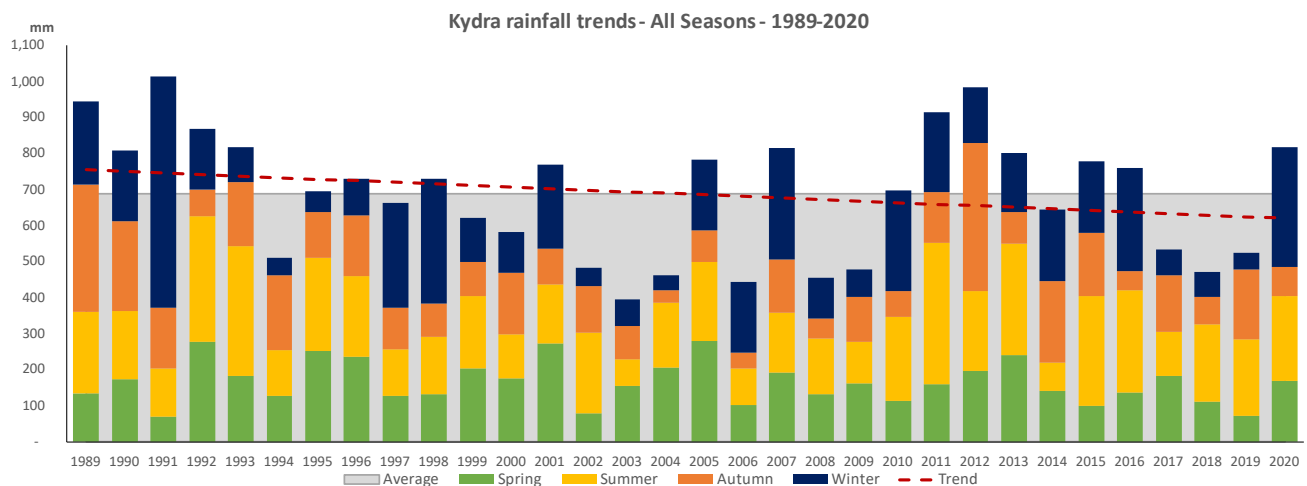
The Effects of Rainfall and Temperature on a Monaro Stream – Boiling the Frog Slowly?

The Kydra and Kybeyan have been prime trout fishing streams in the Eastern Monaro for generations of fly anglers over close to a century. In recent decades there has been a growing sense among anglers that the fishing is not what it was, possibly due to the impact of climate change on rainfall and temperature.

The Rainfall Story

Rod Whiteway, Secretary of the Kydra-Kybeyan Branch of the Monaro Acclimatisation Society, has been collecting monthly rainfall on the Kydra for well over 30 years. Recently his monthly totals have been grouped into seasons by year, enabling a closer examination of the rainfall time series.¹

The graph below of yearly rainfall by seasonal contribution highlights the gradual recovery from the devastating drought starting in 2002 that so damaged the Monaro fishery. It also shows the recent prolonged drought beginning in 2017 and ending with the heavy winter rainfall of 2020. Recent trout stockings will hopefully enable the fishery to recover from the effects of this drought.



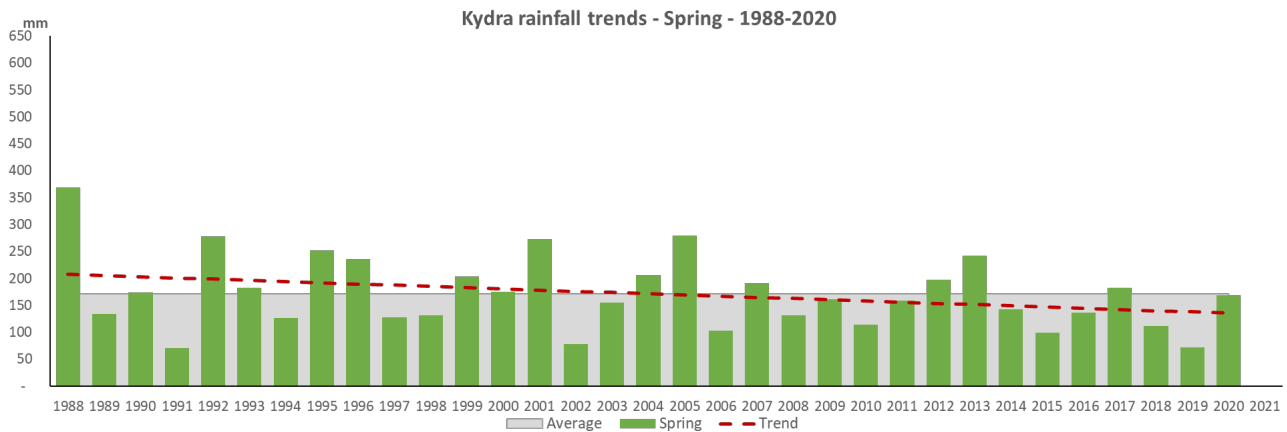
The graph also suggests a downward trend in annual rainfall that has dropped below the long-term average since 2004. To gain a closer understanding of the seasonal drivers of this pattern, the rainfall for each season has been regressed to reveal its characteristics, including long-term average and trend, as displayed in the graphs below.

Spring (September-November)

Spring rainfall on average has accounted for just under a quarter of total rainfall. Over time, spring totals show a statistically significant² downward trend, falling below the average since about 2005.

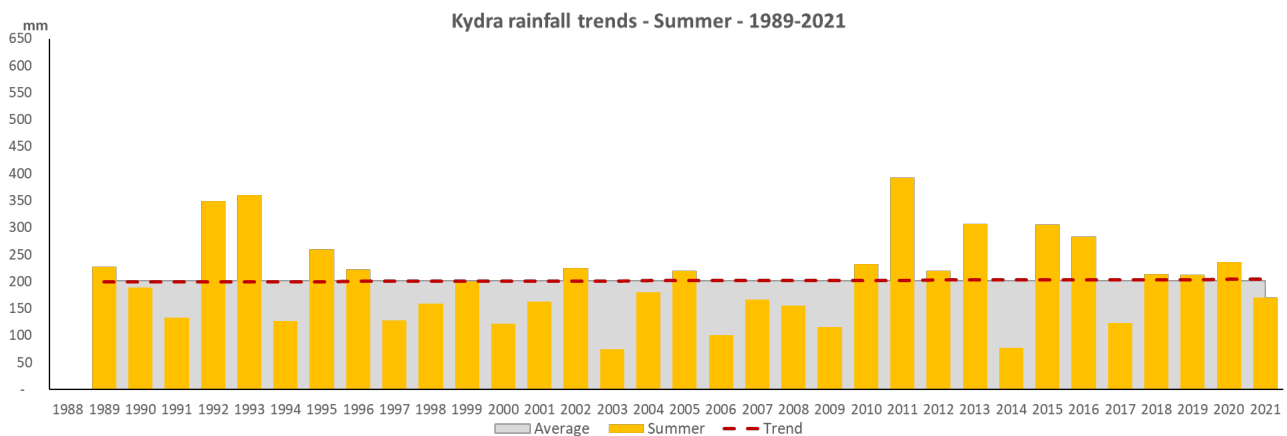
¹ Data are available from July 1988 through May 2021, enabling calculation of rainfall totals for spring over 1988 to 2020, summer and autumn over 1989 to 2021, and winter over 1989 to 2020. Years are defined to align with the seasons, for example with 1989 spanning December 1988 through November 1989, and therefore full year totals are available over 1989 to 2020.

² For a result to be statistically significant means that it is unlikely to have arisen by chance. If a result is not statistically significant, it is more likely to have been driven by random blips than a meaningful pattern.



Summer (December-February)

Summer rainfall on average has accounted for a little under 30% of total rainfall, the highest seasonal share. While the trend has stayed close to the average, there has been a marked increase in the variability of rainfall in the past decade. There have been twice as many above average rainfall summers in the second half of the full period than in the first half. Unfortunately, these come all too frequently in the form of shortish heavy downfalls in the midst of drought conditions, rather than steady soaking falls.

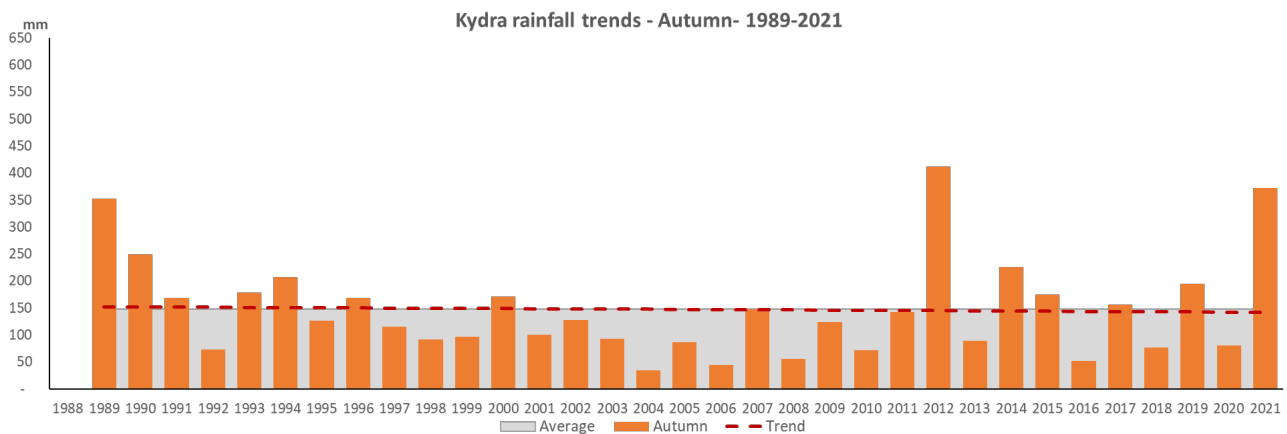


Summer of 2020 was a case in point. In his 2019/20 Kydra-Kybeyan Newsletter, Rod Whiteway wrote:

“The Kydra was reduced to a series of disconnected holes that got perilously lower as the season progressed. At one stage I held grave fears for the platypus populations of all streams. Early in February, in one of the best pools on the Kydra, I found two dead four pounders. There was still a good depth of water in one corner of the pool, but the water temperature must have gotten too high despite there being good shade. A good fall of rain towards the end of February/early March provided some respite for the eastern Monaro, but also more damaging hot water surges for the Bobundara.”

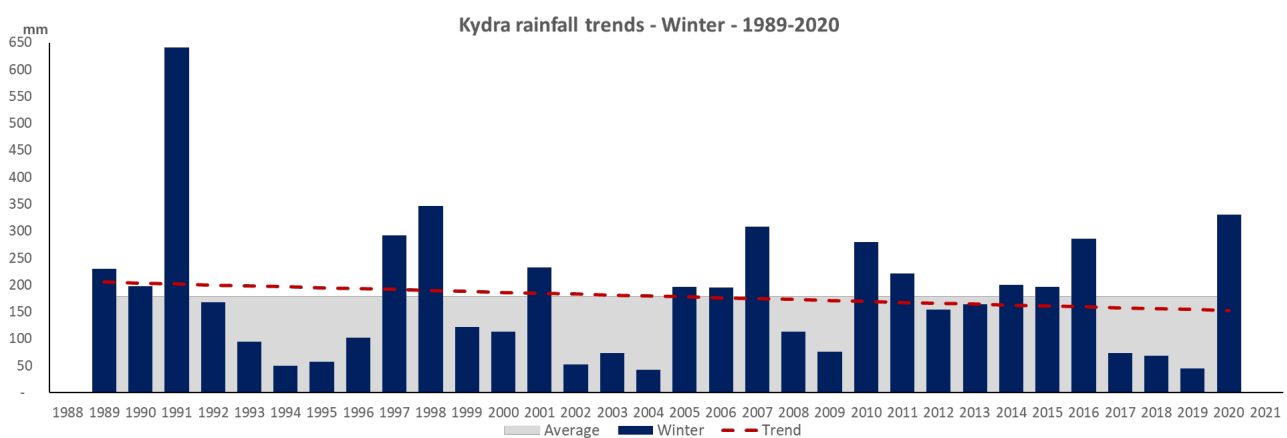
During a drought, a sudden downpour (unless associated with significant hail) can lead to trout-killing increases in water temperature, as inflows are heated by hot earth and rocks. Heavy falls on bare earth also deposit large amounts of choking silt into the stream. This happened during the recent drought and probably killed more fish in the Bobundara and the Maclaughlin than prior low water levels. The flat trend in summer rainfall therefore does not do justice to the real story of the 2020 summer, and some others before it.

Autumn (March-May)



Autumn rainfall on average has accounted for around 20% of total rainfall, the smallest seasonal share. Again, the trend has stayed close to the average but with a notable increase in variability over the past decade, with particularly heavy seasonal rainfalls in 2012 and 2021. The impression given is of increasing dependence on autumn rains, as on summer rains, in recent years to prop up the annual rainfall. However, it is worth noting that dry autumns have counteracted wet ones to produce the relatively flat trend overall. There are many years when the rainfall was well below the autumn average, compromising brown trout spawning activity because of low river levels.

Winter (June -August)



Winter rainfall on average has accounted for just over a quarter of total rainfall on the Kydra. The trend is negative but not statistically significant and is in part driven by the extraordinary rainfalls of 1991. To illustrate, halving the 1991 rainfall figure would result in a flat trend.

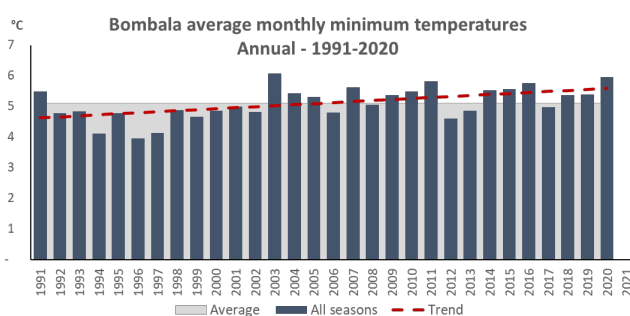
For all seasons, including for spring, the trend needs to be interpreted cautiously, given the extreme volatility of seasonal rainfall. Of greater importance is the increasing volatility of rainfall patterns, particularly in summer and autumn, in the second half of the period.

The Temperature Story

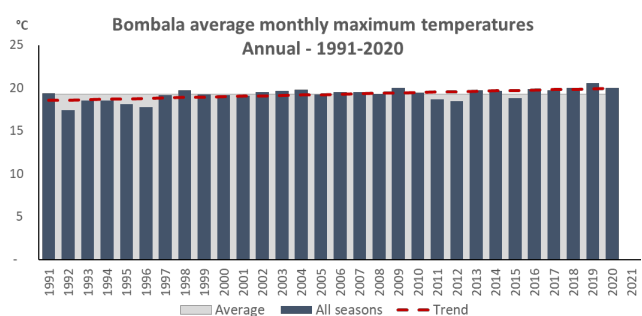
If trend air temperatures have been rising in the Monaro, as many anglers believe, even small decreases in rainfall in a given year can assume greater significance as river evaporation rates increase. We have no longitudinal data on air temperature in the Kydra area. However, continuous³ monthly Bureau of Meteorology data for Bombala, a reasonable geographic proxy⁴ for the Kydra area, are available from 1991⁵ to 2020,⁶ roughly coincident with the Kydra rainfall data.

Rising minimum air temperatures are as important as rising maximums because they inhibit the cooling of water temperatures at night. The graphs below show, for monthly mean maximums and minimums,⁷ annual totals (December of previous year plus January-November of current year) and totals by season, together with long term average temperatures and linear trends.

Annual (December-November)

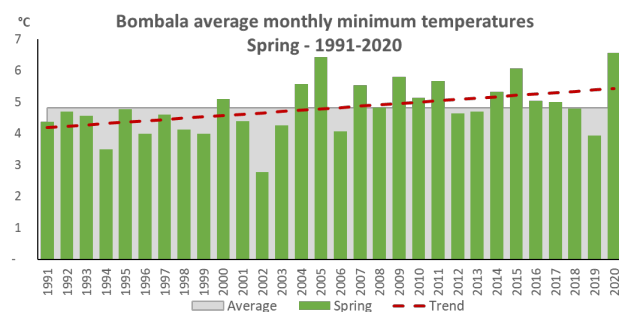


Minimum annual trend is statistically significant.

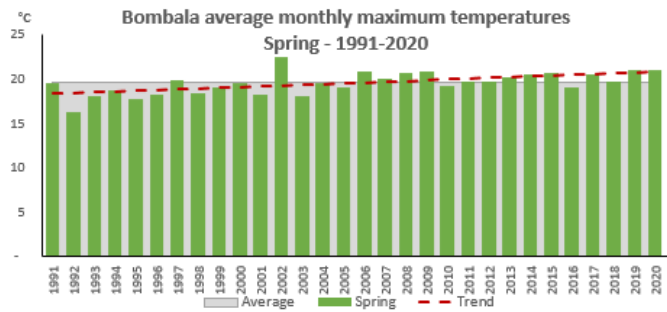


Maximum annual trend is statistically significant.

Spring (September-November)



Minimum spring trend is statistically significant.



Maximum spring trend is statistically significant.

³ Apart from one missing monthly maximum in 1996, three missing minimums in 1996 and two in 2002, for which the estimated values will not have materially affected the regressed trends.

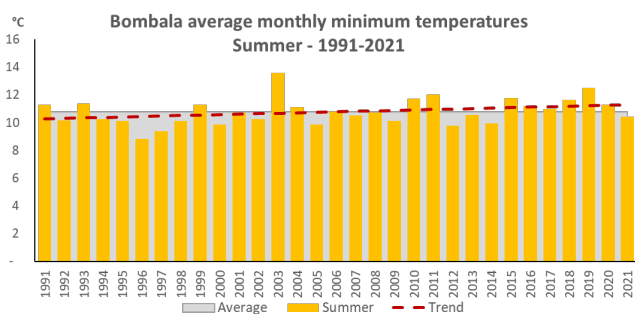
⁴ Nimmitabel is closer, 12 km from the Kydra where the Kybeyan Road crosses it, but continuous BOM monthly temperature data are only available to 1973. Bombala is 57 km from Nimmitabel. Cooma is 38 km from Nimmitabel, but there are gaps in its BOM monthly maximum and minimum temperature data in 1996, 1997, 1998 and 2020.

⁵ Including December 1990, which supports annual time series from December of the previous year to November of the current year and time series for summer from December to February.

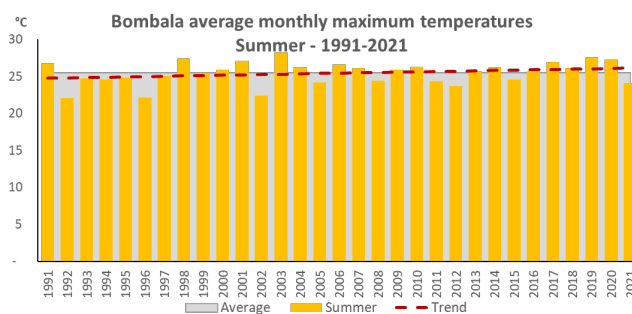
⁶ And for January to August 2021, giving 31 years of time series for summer, autumn and winter. Spring and annual time series cover 30 years.

⁷ The monthly mean maximum and minimum temperatures are, respectively, the averages of all daily maximums and minimums for the month.

Summer (December-February)

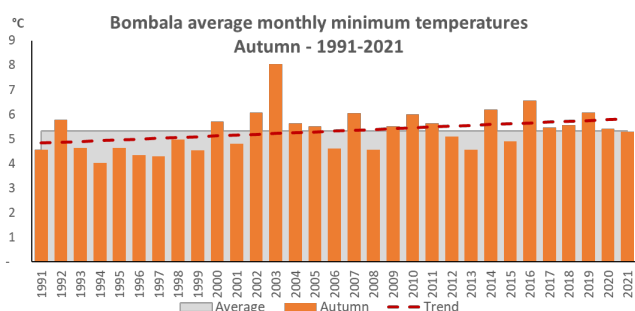


Minimum summer trend is statistically significant.

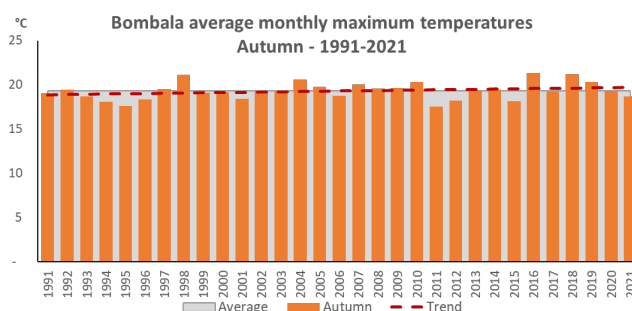


Maximum summer trend is not statistically significant.

Autumn (March-May)

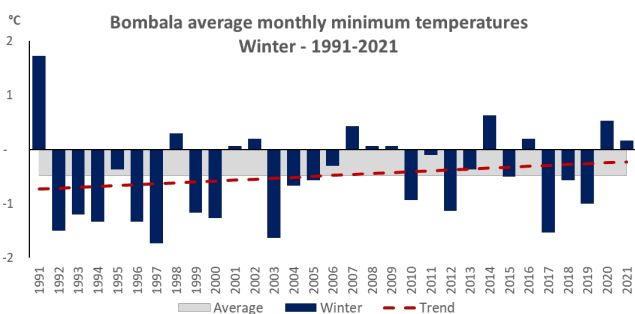


Minimum autumn trend is statistically significant.

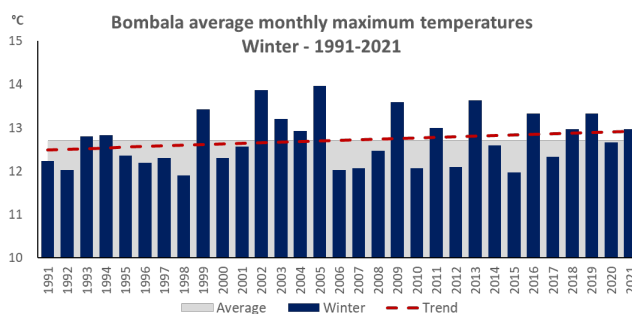


Maximum autumn trend is not statistically significant.

Winter (June -August)



Minimum winter trend is not statistically significant.



Maximum winter trend is not statistically significant.

In summary, over the past three decades there have been statistically significant increases in mean minimum temperature for the annual series, and for spring, summer and autumn, with trend lines rising by about one degree. There have been statistically significant increases in mean maximum temperature for the annual series (by one and a half degrees) and, most notably, for spring (by two and a half degrees).⁸

⁸ While the trends for mean minimum temperature in winter and mean maximum temperature in summer, autumn and winter are all positive, they are not statistically significant.

What does all this mean?

The Kydra does not represent the whole Monaro river system. However, the coastal weather patterns influencing the Kydra, Kybeyan and upper Maclaughlin, including the cooling easterly mists in summer that are a feature particularly of the Kydra and Kybeyan, provide them with an advantage over parts of the Monaro that lie in a rain shadow. The health of these rivers is “the canary in the coal mine” for the entire Monaro fishery.

This is the context for the analysis of rainfalls on the Kydra, which suggests a trend towards declining rainfalls in spring, on which we have traditionally relied for topping up aquifers and promoting spring growth in weed beds, aquatic insects and trout. It also points to a growing volatility in summer and autumn rainfalls, with spikes and drops threatening the health of the trout population. And it is the context for the analysis of air temperatures, which confirms statistically significant rising trends in maximums in total and for spring, and in minimums in total and for summer, autumn and spring, exacerbating the effects of reducing rainfall. The trend rises in spring temperatures are particularly concerning in the context of its trend drop in rainfall.

The rainfall and temperature data all give support to climate change predictions for South-Eastern Australia of increased air temperatures and decreased but more volatile rainfall. The Monaro Acclimatisation Society is sufficiently concerned about the apparent effects of rising air temperatures and reduced rainfall on water temperatures to have entered a partnership with NSW Fisheries to place water temperature loggers in four Monaro streams, the Kybeyan, Kydra, Maclaughlin and Bobundara. But is the frog already boiled?⁹

Freddy von Reibnitz

⁹ Anyone who would like a copy of the underlying Excel files can contact me on fvr@webone.com.au.