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Grazing indices for the Central Karoo

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Grazing indices for the Central Karoo

Abstract

This paper presents Du Toit's Grazing Indices for eight Central Karoo locations. The Du Toit Index is a twelve-month moving total of rainfall, computed from monthly rainfall statistics, which assumes that the benefit of a specific rainfall event depreciates linearly over twelve months. Rainfall varies by a factor of four in this dataset, from 112 ± 52 mm per year at Laingsburg village to 410 ± 128 mm per year in the Sneeuberg. Six of the eight indices are based on more than 90 years' observations and the shortest series covers almost 60 years. The depth and duration of each drought is described relative to expectations at each location. A drought begins when the grazing index falls below the 10th percentile of observations on record and ends when it exceeds the 50th percentile. Sometimes this happens within three months and other times recovery can take years. By September 2019 the drought was ongoing at all but one site across the region and, at all but two sites, the current drought has reached the deepest level of record at some point during the last three years.

Producers can use this index to predict downside risk three to six months ahead and it can inform policy makers' budgeting process. The analysis also raises bigger questions about the opportunity cost of drought relief and the appropriate response to disaster relief in a time of climate change.

1 Introduction

According to the farm census the Central Karoo experienced a sharp decline in livestock numbers during the second half of the twentieth century (Figure 1). It is a great puzzle to ecologists who cannot decide if it was caused by natural or anthropomorphic factors (Dean et al., 1995). Economists offer their own explanations. Archer (2000) pointed to a change in production technology that enabled overgrazing, probably facilitated and aggravated by the wool boom of 1952, although some people have observed that cover improved remarkably since the wool boom (Shearing, 1994; Hoffman, 1995; Hoffman and Rhode, 2010). The cost prize-squeeze experienced by sheep farmers during the twentieth century (Nattrass & Conradie, 2015) might have pushed marginal properties into the lifestyle sector (Reed & Kleynhans, 2009) where they are no longer fully utilised (Conradie, 2019). Most likely the decline is a combination of the above (Conradie

et al., 2013). Regardless of the reason for the collapse in carrying capacity, Karoo agriculture is clearly financially much more vulnerable now than a hundred years ago, which makes a scientific approach to rangeland management all the more important.

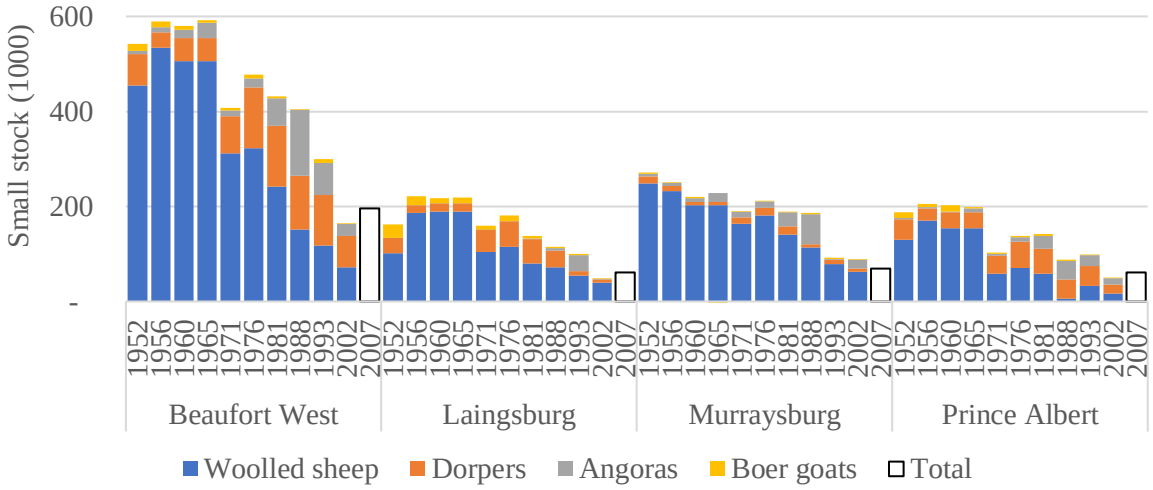

Figure 1 Official livestock numbers for the Central Karoo, 1952-2007

Rangeland scientists have warned that the Karoo might be on the brink of the next 20-year dry cycle (Du Toit & O'Connor, 2014), and the climate change prediction for the arid western half of South Africa is an almost certain rise in temperature combined with a probable increase in rainfall variability (Water Research Commission & South African Weather Service, 2017). Under these difficult conditions, it is important that producers can forecast grazing conditions for a few months ahead to manage market risk and fodder reserves.

The tool presented here is a simple grazing index based on monthly rainfall (Du Toit, 2010). It calculates a twelve-month moving total of depreciated millimetres. The benefit of a specific rainfall event is written off in a straight line over the course of a year and all depreciated millimetres add up over the preceding twelve months. This index is superior to raw rainfall data because it smooths out the Karoo's highly erratic precipitation patterns, as its vegetation does, which helps to establish the beginning and end of droughts. At this point the index does not distinguish between short sharp rainfall bursts and more gentle rains, and completely ignores the effect of temperature on subsequent evapo-transpiration, as most locations only have access to monthly precipitation data for a sufficiently long period for climate comparisons and lack temperature data altogether.

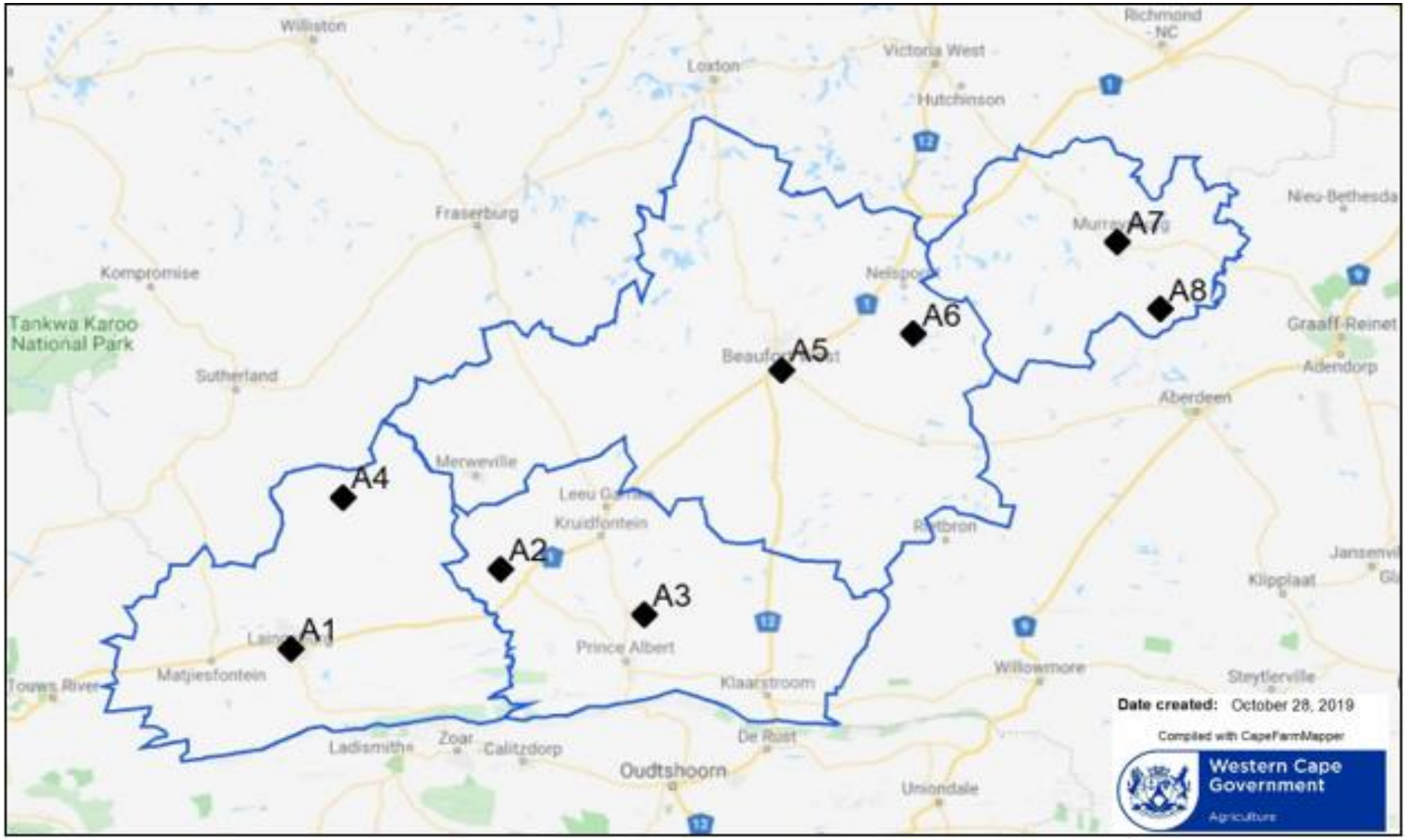

Figure 2 Regional map showing weather stations used in the study

For management purposes ideally each farm should have its own index, but if less than thirty years' rainfall data are available, producers could orientate themselves relative to the closest rainfall station on the map (Figure 2). These sites are Laingsburg village, Koup on the banks of the Dwyka River, the area around Prince Albert further to the east, in the rain shadow of the Swartberg, the Moorde-naarskaroo 80km north of Laingsburg village, below the escarpment, the area around the town of Beaufort West, Nelspoort on top of the Great Escarpment and a location in the Sneeuberg.

These representative data come with several warnings. Firstly, the grazing index reflects potential. It does not account for damage done to cover though historical overgrazing or for palatability; it only indicates how rainfall during the preceding twelve months will have affected the amount of fodder available on well-covered land at any given point in time. Producers will therefore have to calibrate the index to fodder availability on their own land, which is the main argument for building one's own index. Secondly, because the expected rainfall for the region is so low localised cloud bursts can have a big upside effect which could substantially overstate general conditions. Figures below show the magnitudes involved. Thirdly, the index treats all rainfall events as equivalent and ignores the effect of temperature on subsequent evapo-transpiration, although we think that this is a minor problem because every point captures a full season's worth of rainfall and, so far, evidence of seasonal shifts is limited.

Section 2 presents mean annual rainfall for selected sites (Table 1), followed by a worked example of index construction (Table 2) with some notes on interpretation. Section 3 reviews the current situation and drought history at each location, in rising order of expected rainfall. Each index is graphed for the past five years (Figures 3 to 10) and the full datasets are in the appendix. Section 4 sets out implications for producers, policy makers and private fodder donors.

2 Reference stations and worked example

These grazing indices are constructed from monthly rainfall data obtained from well-established weather stations at eight representative locations distributed across the Central Karoo District Municipality of the Western Cape. With records beginning in 1878, the Beaufort West station is the oldest in the group, followed by Nelspoort where the series starts in 1890, but we have almost 90 years' worth of data on all sites except Koup and Prince Albert, which start in 1961 and 1943 respectively. Moordenaarskaroo is the only incomplete series with gaps of eight months in 1965/6 and 21 months over the period 1973 to 1975. Since gaps amount to zero observations, the index undercounts real conditions during the decade 1965 to 1975, which lowers its drought threshold by a few points. No correction

was attempted. The sites are listed in rising order of rainfall, along a southeast to northwest gradient. Expected rainfall is not only lower in the rain shadow of the Swartberg but also more variable. The Sneeuberg which receives a combination of summer rainfall and winter snows has the most reliable precipitation in the district.

Table 1 Mean annual rainfall (mm) and its variability for selected sites in the Central Karoo District Municipality, with coverage

Location	Starting date	Mean rainfall	Standard deviation	Coefficient of variation
A1 Laingsburg village	1912	112	52	0.46
A2 Koup	1961	138	67	0.49
A3 Prince Albert	1943	168	65	0.39
A4 Moordenaarskaroo	1932	169	75	0.44
A5 Beaufort West	1878	238	93	0.39
A6 Nelspoort	1890	217	81	0.37
A7 Murraysburg village	1929	284	105	0.37
A8 Sneeuberg	1933	410	128	0.31

Each point on the index adds up depreciated rainfall over one calendar year using a set of straight-line depreciation weights. The first term in the calculation is the current month and its weight is 12 twelfths. A weight of 11 twelfths on the previous month's rainfall form the second term. The third term is constructed by multiplying the rainfall recorded two months ago with a weight of 10 twelfths. And so on. The construction method means that the grazing index for a weather station always begins one period later than its rainfall series. Multiplying by zero rainfall at any point lets that term drop out, but it is worth keeping in a spreadsheet so that the index can be updated automatically from one year to the next.

We have found both wide and long forms useful. In the wide form the data are arranged as a block with months in columns and each year entered as a row. In the long form there is only a single column with monthly entries running from one year to the next. The data in the appendix is in the wide form while the graphs in Figure 3 onwards are based on the long form. Note that following Du Toit (2010) we did not apply any seasonal weights to account for more optimal temperatures in spring and autumn, due to a lack of temperature and representative plant productivity data. Vegetation surveys have resumed (Saayman, 2018) but there is no attempt yet to link it to normalized differenced vegetation index (NDVI) data.

Table 2 A worked example of index construction with precipitation in Periods 1 and 2 feeding into an index starting in January of Period 2

	Period 1	**Period 2**	**Calculation for Period 2's grazing index**
Jan	-	7mm	$= 7 \times {}^{12}/_{12} + 0 \times {}^{11}/_{12} + 1 \times {}^{10}/_{12} + 0 \times {}^{9}/_{12} + 5 \times {}^{8}/_{12} + 1 \times {}^{7}/_{12} + 13 \times {}^{6}/_{12} + 22 \times {}^{5}/_{12} + 43 \times {}^{4}/_{12} + 18 \times {}^{3}/_{12} + 22 \times {}^{2}/_{12} + 0 \times {}^{1}/_{12} = 49.92$
Feb	-	-	$= 0 \times {}^{12}/_{12} + 7 \times {}^{11}/_{12} + 0 \times {}^{10}/_{12} + 1 \times {}^{9}/_{12} + 0 \times {}^{8}/_{12} + 5 \times {}^{7}/_{12} + 1 \times {}^{6}/_{12} + 13 \times {}^{5}/_{12} + 22 \times {}^{4}/_{12} + 43 \times {}^{3}/_{12} + 18 \times {}^{2}/_{12} + 22 \times {}^{1}/_{12} = 38.92$
Mar	22mm	-	$= 0 \times {}^{12}/_{12} + 0 \times {}^{11}/_{12} + 7 \times {}^{10}/_{12} + 0 \times {}^{9}/_{12} + 1 \times {}^{8}/_{12} + 0 \times {}^{7}/_{12} + 5 \times {}^{6}/_{12} + 1 \times {}^{5}/_{12} + 13 \times {}^{4}/_{12} + 22 \times {}^{3}/_{12} + 43 \times {}^{2}/_{12} + 18 \times {}^{1}/_{12} = 27.92$
Apr	1 mm	-	19
May	43mm	-	11
Jun	22mm	9mm	16
Jul	13mm	1mm	14
Aug	1mm	2mm	14
Sep	5mm	2mm	14
Oct	-	10mm	22
Nov	1mm	28mm	47
Dec	-	-	43

Du Toit (2010) defines the beginning of a drought as the point at which the grazing index value dips below the 10th percentile of years on record at the specific location, in other words when the index records a value that forms part of the 10% driest years on record. Stations were selected for maximum coverage in order to set the drought threshold correctly. These thresholds are indicated by the lower of the two grey lines in Figures 3 to 10 and is printed at the top of each dataset in the appendix. Threshold values were calculated with the "=percentile(range, 0.1)" function in Microsoft Excel(Microsoft Office 365 Proplus). According to Du Toit (2010) a drought continues until grazing conditions have return to normal, in other words, until the index rises above the 50th percentile of data on record for a location. This figure was calculated with "=percentile(range, 0.5)" and is represented by the top thin grey line in Figures 3 to 10. It is also printed at the top of each dataset in the appendix. The shaded entries in the datasets in the appendix

record the duration of each drought, which is seasonal if it lasts less than a year and serious if it continues for more than twelve months. In addition, we applied the notion of an intermittent drought in cases were several seasonal droughts follow in close succession. The beginning and end of such droughts are by inspection and hence highly subjective.

In the graphs, the actual value of the index is indicated in red and the monthly precipitation is indicated with a series of orange bars. Figures are comparable from one location to the next, but do not reflect local plant productivity. For example, a specific vegetation type will probably be most productive at its normal rainfall than another vegetation type which evolved under different conditions, but this needs to be investigated. Note that although the maximum values are reported in the same units, these values vary across locations. Rainfall coverage is until September 2019 and the index runs to the year's end.

3 Historical and current grazing conditions

Most of the Central Karoo District has a summer rainfall orientation, with the rainy season beginning in October and ending in April. Except for the two most westerly stations where the seasonal pattern is less pronounced, the expected grazing index is at its lowest at the beginning of the rainy season and at its highest at the end of the rainy season. This seasonality means that taking an average of index values over a period of a year is meaningless although relative index values are useful to express the depth of a drought.

3.1 Laingsburg village

In the beginning of 2015 grazing conditions were dismal around Laingsburg village (Figure 3). The drought began in December 2014 (this is in appendix A1). Despite good rains during June 2015, the index only rose above the site's expected value in May 2016 for a brief spell of eleven months before plunging back into drought in April 2017. Although strictly two separate events according to Du Toit's (2010) definition, a manager would consider the 2014/15 and 2017-19 droughts to be part of the same event. The most recent rainfall observation is for September 2019 and the index is plotted through to December assuming no further rainfall until the end of the year. Despite substantial recovery during 2019 the drought is ongoing and if Laingsburg receives no rain during the last three months of the year, 2019's recovery will have been reversed and the area will return to crisis.

Historical data shows that Laingsburg experienced two substantial droughts during the first half and one more during the second half of the 20th century. The first drought lasted three times as long as the second, from April 1919 to November 1933, when a thirteen-year period of prosperity began. The deepest point of the 1920s drought was reached in January 1925 when grazing capacity was reduced to 14% of its expected value for January for this location. This was similar to conditions observed in March 2015 when there was just 5% of the expected grazing available around Laingsburg. The second drought of the 20th century which began in April 1946 and continued until February 1950 was as deep as the 1920s drought and the current one. The third drought, which lasted from September 1966 until January 1973, was even shorter and only half as deep as the second drought of the 20th century. Except for two relatively short and not very serious droughts around the turn of the 21st century, this century has been drought free until the beginning of the current drought in December 2014.

Laingsburg's current drought is by far the worst on record. In April 2015 the site's index fell to 2.9 which is barely 5% of its expected value for April and the area has experienced its longest continuous spell of dry months on record between April 2017 and September 2019 (30 months). Given the depth of the current drought and the forty year's prosperity before that, it is no surprise that producers are not coping. A high rate of farm failures should be expected, and the extension service should pro-actively begin to formulate recovery plans and new grazing strategies for those that do survive. It is not a good place to attempt any land reform right now and Land Care should be vigilant about overgrazing on the commonage.

3.2 Koup area

The Koup area spans the Dwyka River which forms the eastern boundary of Laingsburg Magisterial District. The site's rainfall record begins in 1961 and the grazing index (appendix A2) indicates a drought from the middle of 1962 which lasted until November 1970. In the middle of it there were 20 consecutive months of drought, interrupted by four months of normal conditions before the area sank into drought for another 14 months. It was during this second spell that this 1960s drought reached its deepest point. The index shows that in December 1966 the area barely had 11% of its expected grazing for December and in January 1967 the index fell to 8% of its expected value for January. Conditions rapidly improved after that and within four months the drought was over, although it left an indelible impression on local producers.

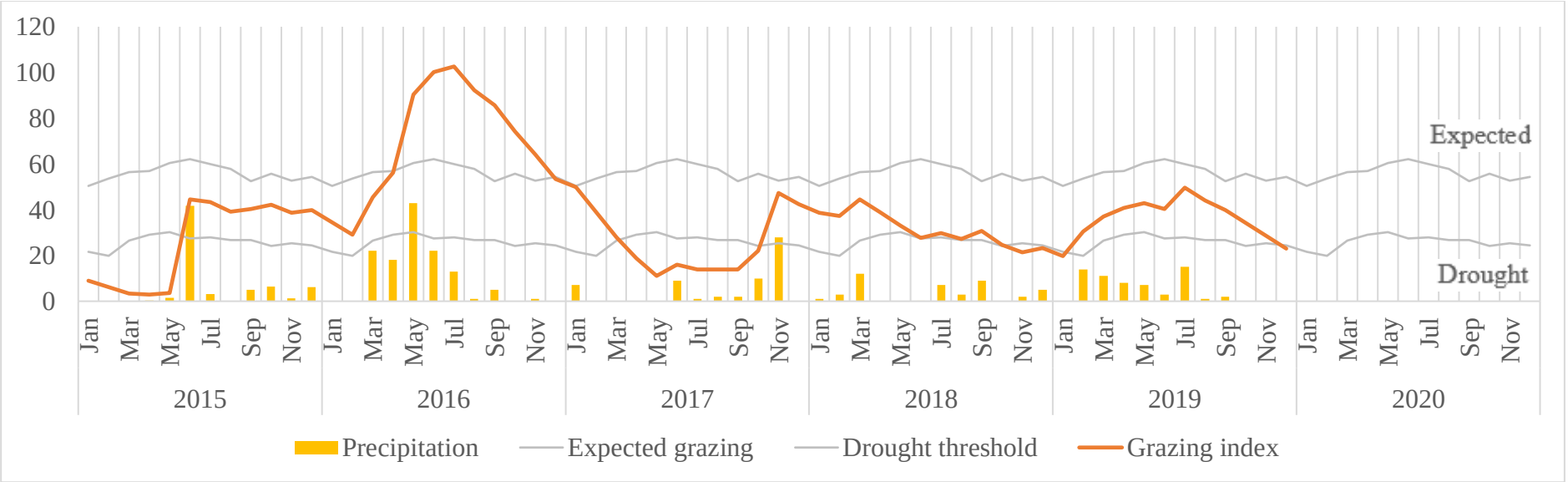

Figure 3 Recent grazing index for Laingsburg village

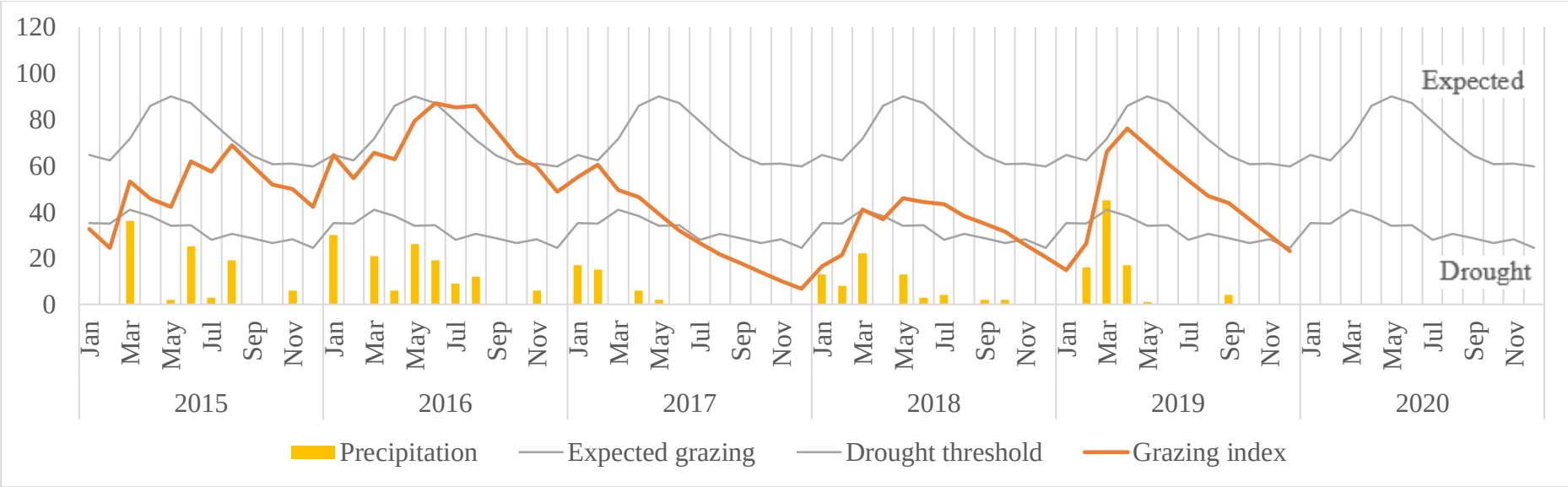

Figure 4 Recent grazing index for Koup

This drought is still legendary amongst the older generation. The Botes family of Bloufontein ended up at Nuy near Worcester in a *bywoners'* cottage on the farm Nuwerus for a few months, from where they trekked east to Langvlei siding near the lime factory on the road to Robertson. Langvlei's vegetation was quite unpalatable compared to what these Koup sheep were used to and, in their weakened state, many sheep lay down to die there. The family probably camped at Langvlei with two toddlers of which one was in poor health. There was also a drought in the Breede River Valley at the time, but grazing was available because local farms were in the process of moving out of mixed farming into specialised wine farming. The farm census shows the wine grape crop increasing by 50% between 1960 and 1965, while livestock numbers began to fall in 1960.

It is important for the reader to understand that the intensity of the 1960s drought in the Koup area is the result of the limited coverage of the Koup rainfall series. If data were available over a longer period, for example all the way back to the first world war or even better to the turn of the 20th century, chances are that the Koup index would reflect the same droughts that the area in the vicinity of Laingsburg experienced in the 1920s and again in the late 1940s. The effect of records of earlier droughts is to lower the drought threshold which could have made the 1960s drought seem shorter and possibly less severe, although one cannot say by how much.

Apart from two back-to-back seasonal droughts during the late 1970s and another seasonal drought in 2010/11, the Koup area experienced benign conditions until the onset of the current drought in January 2015 (Figure 4). This is a drought of two halves, consisting of a dry spell of 18 months interrupted by eleven months of normal conditions, followed by a further 28 months of drought which is ongoing (September 2019). This drought reached its deepest point in December 2017, when there was only 11% of the expected grazing available in the area, a similar crisis as the one experienced in December 1966.

Comparing these two events, it must be concluded that there is nothing exceptional about the current drought although, as in the case of Laingsburg, being unaccustomed to drought is resulting in severe hardship now. Conradie et al. (in press) recorded a large degree of distress amongst farmers which has already resulted in substantial land use change. This can be expected to continue and settling land reform beneficiaries in this area will be just as risky as in Laingsburg.

3.3 Prince Albert area

The past five years consisted of four dry seasons and one exceptional year in the Prince Albert area (Figure 5 above). The current drought began in April 2015 and technically ended in December of that year with a 12-month long respite during which the index averaged at 160% of expected value, but by May 2017 the area re-entered drought and this drought is ongoing (September 2019). It rained only twice during 2019, and if it does not rain again before the end of the year, the area will have spent 14 months below its drought threshold and 34 consecutive months in drought, which is the longest on record at any of the stations covered in this study. In September 2019 there was just over 30% of the expected grazing available, similar to the January figure of 27%. The previous lowest value for September of 26% was recorded in September 2017 in the early stages of the current drought. The lowest index value ever recording at this location occurred in April 1970 where there was only 12% of expected grazing available.

Producers are quick to point out that part of their difficulty with the current drought is the limited amount of drought relief provided by the Western Cape government. This aid is capped at 21 large stock units per producer. On small farms whose flocks on average consist of 375 sheep, the disaster relief coverage is 43%, but on large farms whose average flocks exceed 1200 sheep and goats, the coverage is a mere 11% (Conradie, 2019). We know that there have been generous private fodder donations as well, which are not being recorded and therefore we will not be able to properly assess the effects of the drought later.

The Prince Albert station's rainfall record begins in 1943 and its grazing index begins with an intermittent drought that lasted from the middle of 1946 to the end of 1952 (appendix A3). There was a second long, but not very deep, drought which lasted from March 1958 to February 1961. The intermittent drought registered in Koup in the 1960s was shorter in Prince Albert, where it started in the middle of 1966 and ended in 1971. Within this period March to July 1970 was a record low when the index never rose about 16% of availability. In this time the index stayed below the drought threshold for ten months, but when the drought broke, the index recovered within three months. We do not know how long it took for the vegetation to recover after that crisis. The site experienced a fourth, fairly serious, drought which lasted for 28 months from May 1978 to August 1980. At its deepest in January 1980 the index reflects a two-thirds shortage on expected grazing. Except for two brief seasonal droughts, the rest of the 1980s, 1990s and first fifteen years of the 21st century were prosperous times for Prince Albert, which again makes the point that the experience of drought is an important factor in helping producers to adjust to a specific set of climatic circumstances.

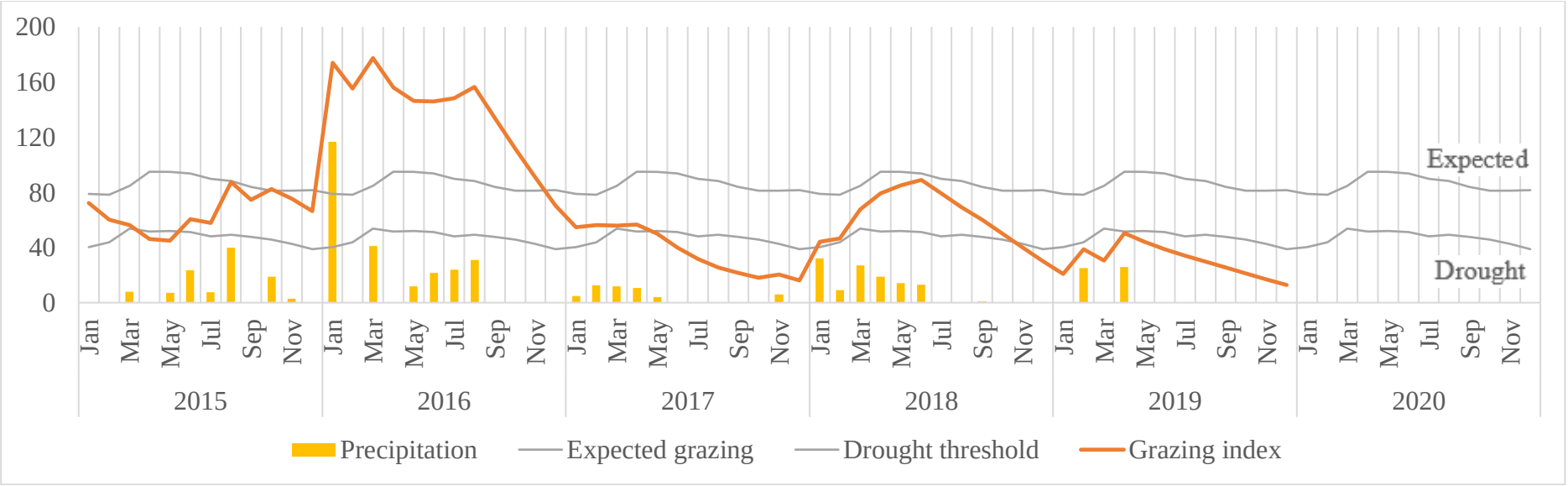

Figure 5 Recent grazing index for Prince Albert

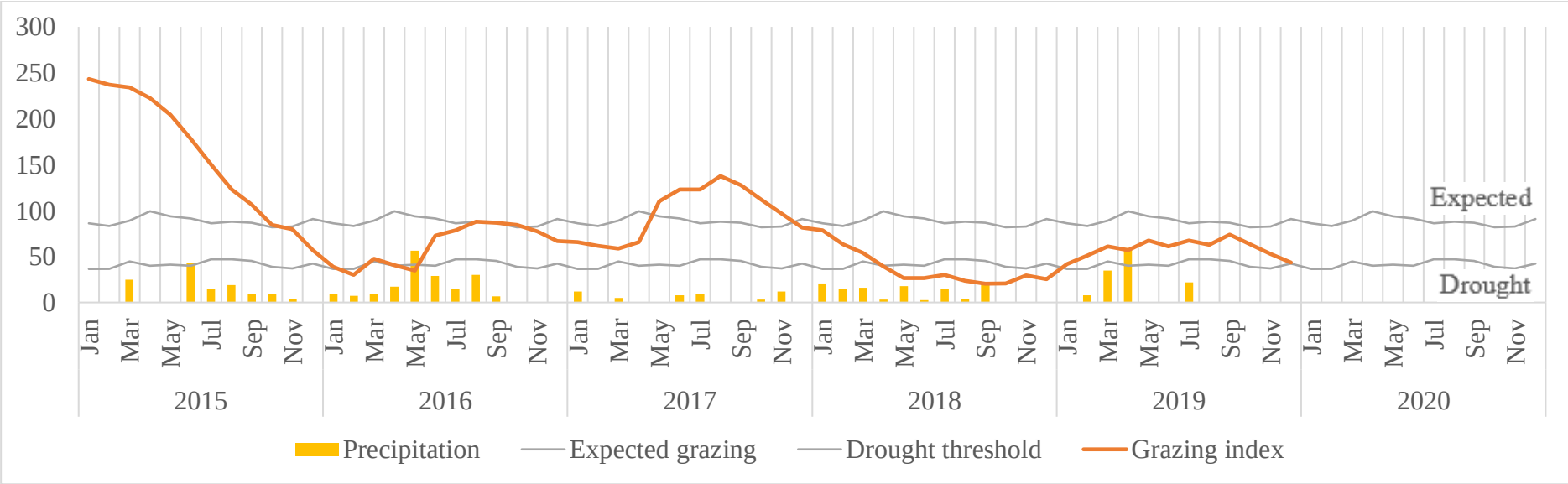

Figure 6 Recent grazing index for the Moordenaarskaroo

3.4 Moordenaarskaroo area

The Moordenaarskaroo is a remote farming area about 80km north of Laingsburg village, just below the escarpment. Like Laingsburg, it straddles the summer-winter divide and transhumance is still practiced, exploiting seasonal abundance on either side of the divide. Although this site has a higher rainfall than Laingsburg and the same even distribution throughout the year, its rainfall is as variable as the stations in the rain shadow of the Swartberg (this is in Table 1).

The Moordenaarskaroo experienced good conditions during the first half of 2015 (Figure 6). In January the grazing index stood at a value of 243 which falls inside the 90th percentile for January figures at this location. However, conditions deteriorated fast during the second half of the year to a value of 57 in December which is barely above the drought threshold. The index fell below the threshold in February 2016 and this drought continued for eight months. Then there was an 18-month reprieve until April 2018, when the current drought started. The most recent data point (September 2019) is the highest for the year, but if it does not rain again by the end of 2019, the recovery will have to start afresh.

The Moordenaarskaroo index begins just after the drought of 1933's Great Depression and is interrupted in 1965/66 and again in the period 1973 to 1975 when the weather station moved to the neighbouring farm. In this period the grazing index is abnormally low due to the lack of data.

The index in appendix A4 shows intermittent droughts for the first twenty years of its existence, but the gaps between the seasonal droughts were generally too large to link them together except for the period 1947 to 1954, a seven-year drought which did not include a single complete good year. Thereafter thirteen good years followed until the onset of the 1960s' drought, which began in November 1966 and ended in April 1968. The apparent drought of 1973 to 1976 corresponds to a gap in the rainfall record. Ignoring this, after 1968 the area experienced 48 years of good to average rainfall, which only ended in 2015.

The current drought was at its deepest in September 2018 when 40% of expected grazing was available. Other extremes were recorded in September 1973 (22%) and January 1953 (32%). The relatively short coverage at this station probably sets the drought threshold slightly higher than it should, but, even so, the current drought is neither the longest not the deepest on record.

3.5 Beaufort West village

The Beaufort West station's rainfall series begins in 1878, the longest of all our sites. The raw grazing index data in appendix A5 reveal few and longer cycles of drought and prosperity at this location than, for example, at Prince Albert where the cycles tended to be shorter. However, one should keep in mind that the particular pattern of drought and good times at each site is determined by the drought threshold, which in turn is a function of how long rainfall data has been collected a the site. This makes it difficult to do a definitive comparison across sites.

The first serious drought on record in Beaufort West began in October 1898 and ended in January 1900. After three good years another year-long drought followed in 1903. Thereafter the area experienced two decades of good precipitation. This was the first cycle. The next cycle was a drought that began in October 1924 and continued on-and-off for almost thirty years until January 1952, during the wool boom. Within these thirty years, the specific times of hardship were October 1924 to February 1928, the drought of the 1933 Great Depression, March 1935 to November 1937, and a period that coincided with the end of the Second World War, from November 1944 to February 1950. It is assumed that accurate recordkeeping continued during the war, but if not, this one could have been a phantom drought. The worst part of the thirty-year drought was at the outset, when the index stayed below the drought threshold for 23 consecutive months. On two occasions, in August and October 1927, the index reached less than 25% of expected conditions. The end of the thirty-years' drought was just as harsh, especially February and March 1949, when the index reached less than 20% of normal conditions.

After the thirty-year drought and the wool boom of 1952, Beaufort West entered a 65-year long period of average to good rainfall, which was only interrupted briefly by short and mild droughts in 1960, 1962, 1984 and 1990/91. Local residents report that drought relief was available during the 1990 /91 drought. The good times began in 1992 and continued until the middle of 2016.

The current drought began relatively late in this area, in February 2017 (Figure 7). There were signs of recovery during 2018 due to good summer rains, but the index fell below the drought threshold again in January 2019 and if it does not rain again during the last three months of this year, the area will be in the same situation that it encountered in 1949. The current drought is not particularly deep now, but if the rains fail during the early summer of 2019, new records will be set.

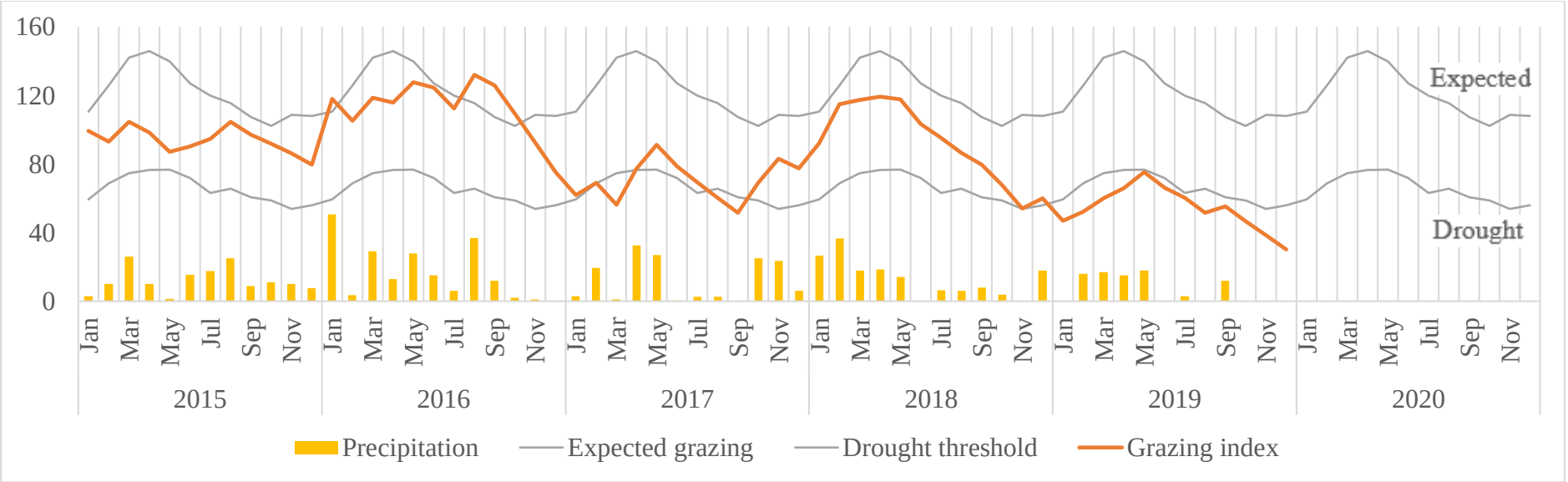

Figure 7 Recent grazing index for Beaufort West

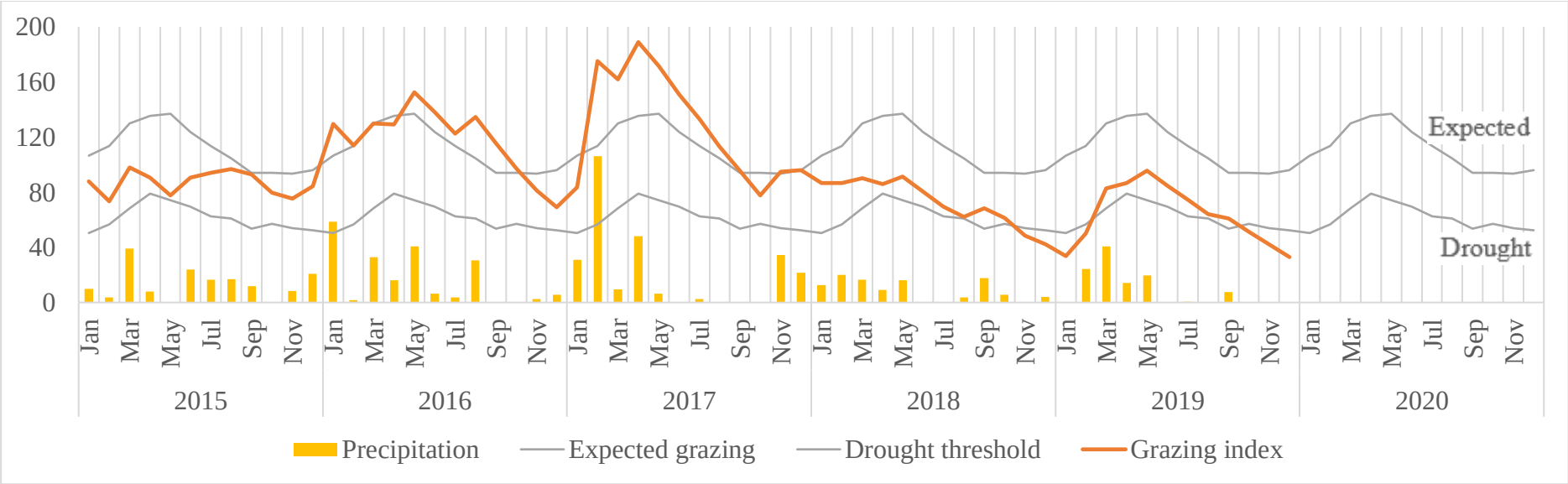

Figure 8 Recent grazing index for Nelspoort area

3.6 Nelspoort area

The Nelspoort grazing index, which starts in 1891, records the same drought as Beaufort West during the early 1900s (appendix A6). This one lasted from 1902 to 1905 and was less intermittent than in Beaufort West. After a brief period of good rainfall, the next drought continued on and off for 25 years until after the Great Depression. The decade from 1934 to 1944 was predominantly good. The next serious drought began in November 1944 and ended in July 1952. During the second half of the 20th century there were only two droughts lasting more than 12 months at a time, in 1960 and 1970. The 2004 season was also dry, and thereafter another decade of average to good rainfall followed, which ended with the beginning of the current drought. The deepest drought was recorded in January 1952 with an index value of 7%. During 2015 Nelspoort's grazing conditions were poor, but the index was never low enough to indicate a drought. Conditions were normal during 2016 and good during 2017 (Figure 8). Poor conditions escalated to a drought in November 2018 and by January 2019 grazing conditions were as poor as it ever was at this location.

3.7 Murraysburg village

Murraysburg experienced some of the best grazing conditions in the Central Karoo in the period since 2015 (Figure 9), even relative to the site's high expectations. Rainfall was normal for most of this period and above average during 2018. The index got close to the drought threshold in December 2016 and again a year later, but not quite low enough to indicate a drought in either case. The site began 2019 with 74% of expected grazing capacity, peaked in May with 92% of expected conditions and then began to decline. Now (September 2019) there is still more than 80% of the expected grazing available, but if no rain falls until the end of the year, a drought will be experienced in November.

In Murraysburg, the Great Depression's drought began in February 1931 and was broken in March 1934 (appendix A7). There were brief seasonal droughts in 1937 and 1938 and then good rainfall lasted until December 1948, after which it was dry until March 1950. The area also suffered a decade-long intermittent drought between 1957 and 1970, which at times was quite deep. Between September 1959 and April1960 the grazing index remained below the drought threshold for eight months. In 1964 it spent another four months below the threshold and from May 1966 it remained there for eleven months, still part of the same drought. Once the index rose above the drought threshold in April 1967, it only took one month for the drought to end. This began a period of good rainfall interrupted briefly by short droughts in 1984, 1990/1 and 1999. The period since has been good.

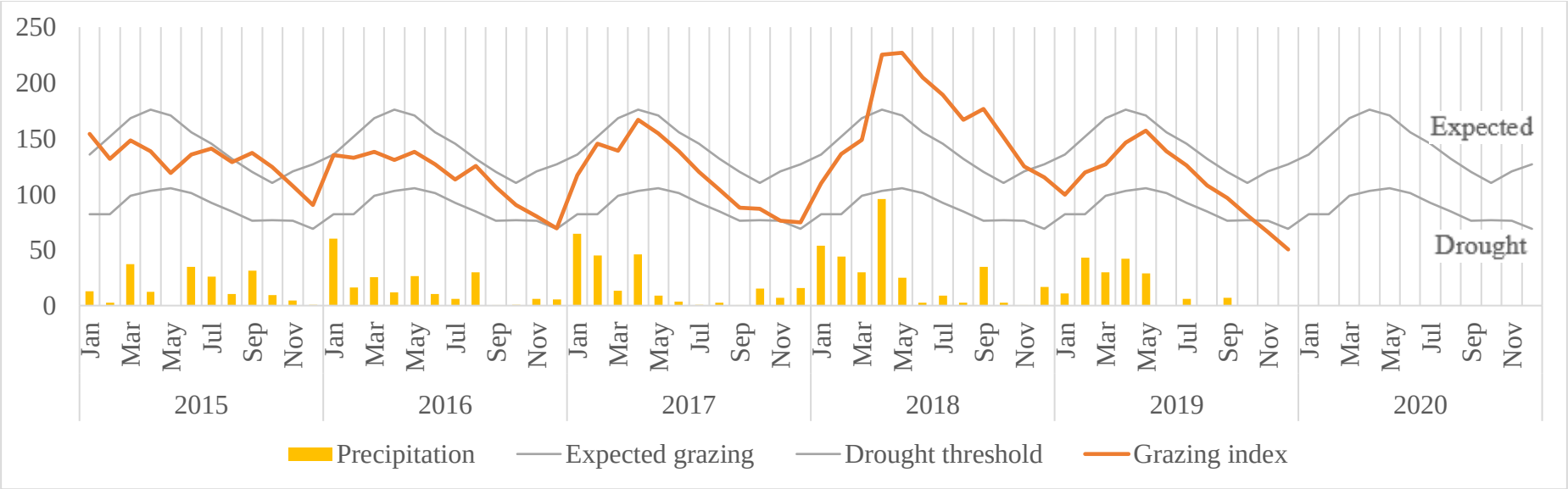

Figure 9 Recent grazing index for Murraysburg

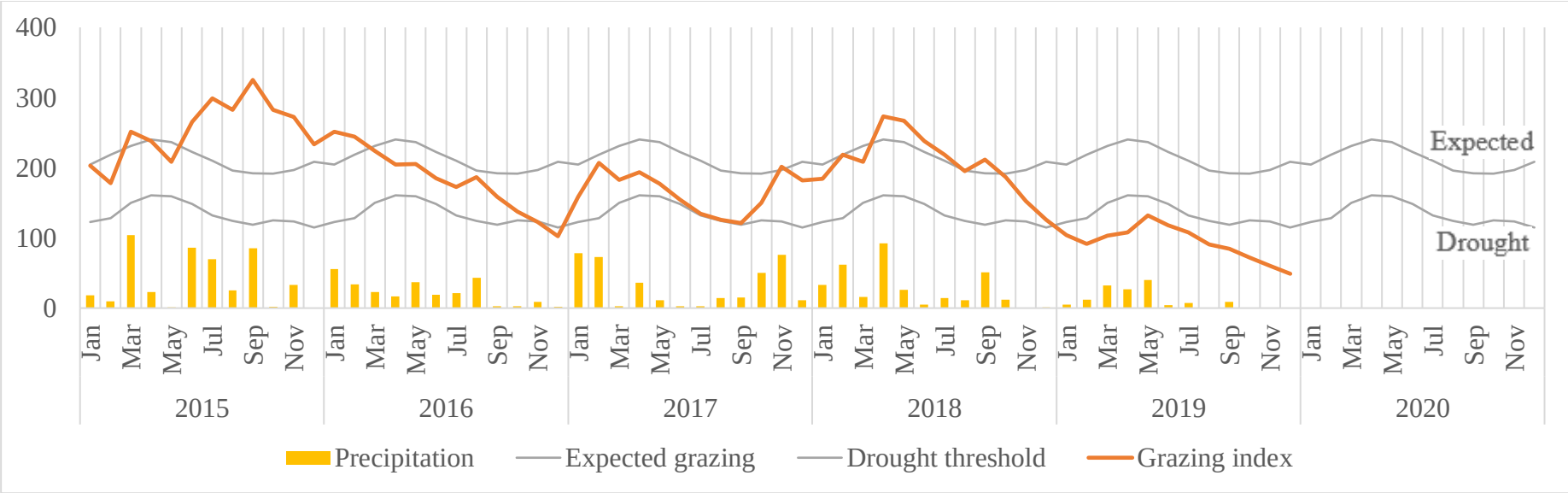

Figure 10 Recent grazing index for the Sneeuberg

3.8 Sneeuberg area

It is important to include the Sneeuberg location in this analysis because the expected precipitation at this location is 3.5 times higher than at Laingsburg and 75% higher than in Beaufort West, and it has the least variation in annual rainfall of all the sites in the study. This allows us to see if and how droughts affect high potential areas, which could have important implications for the distribution drought relief resources. The Sneeuberg is part of Murraysburg district and overlooks Graaff Reinet to the southeast. A substantial portion of its annual precipitation falls as snow during winter.

The Sneeuberg series begins with the Great Depression of 1933. It reflects three major droughts, the first of which took place from 1945 to 1950 (this is in appendix A8). The second was a less concentrated period of intermittent seasonal droughts that lasted much longer than the first drought, from 1960 to 1978, which does not quite coincide with a similar dry spell recorded for Murraysburg. The third drought was a serious four-year long event that never let up between March 1990 and October 1993. The worst part of this 1990s drought occurred during the first half of 1993 when the grazing index spent six months below the drought threshold. However, it was not the deepest drought on record. The index reached a minimum of 26% in January 1973 as part of a seven-month spell below the drought threshold. Using the period spent below the threshold as a measure of the severity, then the worst drought occurred during 1949/50 when the index remained there for thirteen months. Once recovery started, however, the index was back at expected levels within one month.

The Sneeuberg's grazing conditions were above average in 2015 and below average, but not technically dry, for most of 2016 (this is in Figure 10). A seasonal drought is indicated from November 2016 to October 2017, which was ended by good rains during the summer of 2017/18. The current drought only began in January 2019. The index did not fall below 40% of expected conditions during the first half of this year and remained well above the worst on record. However, since July 2019 the index has reached one record low after another and conditions can deteriorate even further if spring rains are late this year.

It is not clear if we have temperature data for the Sneeuberg site, and if we do, if anyone has paid any attention yet to the relationship between winter temperatures and winter precipitation. This is important because if the outlook for the Sneeuberg is less winter snow, this area could become much more marginal than it has been historically, but fortunately higher winter temperatures would also mean longer growing seasons which would balance out overall farm performance.

4 Discussion of implications

Grazing indices constructed from extensive rainfall records gathered across the Central Karoo District reveal how spatially variable the region's climate is and how erratic its year-on-year grazing conditions can be, even if the indigenous vegetation's ability to accumulate rainfall is considered. Except for the big regional droughts of the early 20th century, the late 1940s and the mid 1960s, each location's drought history is different. It is therefore unsurprising that the onset and depth of the current drought also varies from place to place. However, there are new lows being reached in this drought across the region, which has several important implications for producers, policy makers and society at large.

4.1 Producers

For producers, the main significance of these results is that they provide a long-term perspective on a specific situation that is likely to overturn producers' lived experience of prosperity which dominated since the beginning of the 21st century. The second potential gain is that familiarity with the index allows producers to update downside risk to which they can then respond timeously by shedding surplus livestock and stockpiling fodder at the right price up to six months before the worst of the drought hits. The third benefit to producers is that lobbying efforts can be informed with rich data.

For producers who would like to compile your own grazing index, the first step would be to study an existing grazing index for the location that is most like your own farm. If more than thirty years' rainfall data exist for your farm, a new index can be attempted. Begin by noting down the approximate dates of previous droughts and exceptionally good seasons. As was shown here, there is substantial variation across sites, but it will inspire confidence if the new index correctly indicates important historical moments. Farm diaries, wool delivery records, notes scribbled in the margins of rainfall ledgers and even the construction dates of important farm buildings could be more valuable than memory, which tends to become hazy over time. Ensure that at least one, but preferably several, of the important droughts are reflected in the index, as failing to do so will inflate the drought threshold which will undermine the validity of claims of hardship. If the farm's own data is insufficient, supplement with data from a neighboring farm or the closest station used in this study. Then build the index, compute the drought threshold and average conditions as explained in section 2 and plot out the results for the recent past. Be sure to include rainfall events as well, as was done in Figures 3 to 10. Discuss the graph with knowledgeable neighbors or rangeland

experts to check if the index reflects reality. Update regularly and use in farm diaries.

4.2 Policy makers

These results hold several important implications for the disaster relief authority. The most important conclusion is that it is necessary to budget for ongoing relief. In September 2019 all parts of the Central Karoo District, except the Murraysburg area, were dry, in parts for the past six years. Secondly, aim for a high level of spatial disaggregation in drought demarcations, as it was demonstrated here that both the duration and depth of drought vary substantially from place to place. Regularly review demarcations. If the availability of aid does not reflect conditions on the ground at any given time, the government runs the risk of being accused of being biased, which could encourage rent seeking. Part of the response needed is to put rainfall data and drought indices in the public domain where producers can engage directly with the data, and the academic community can access it for research.

Thirdly, the use of remote sensing seems promising although satellite data like NDVI was not around during the first half of the 20th century when the Karoo was much drier than it is now. It is also not clear that this data source can isolate climate stress from damage done through overgrazing. This needs to be researched. Fourthly, it is important to record NDVI properly during current drought, because this drought is setting new records. Geographers will have to think about how to do this it, but we probably need a network of ungrazed controls of lightly transformed vegetation like the Tierberg site in Prince Albert (Arena et al, 2018) to capture potential.

4.3 Private donors and society at large

This drought and climate change in general confront us with important questions about the moral foundation of disaster relief. If a poor village burns down as a result of a freak accident (e.g. Wupperthal in December 2018), the merits of restoration seem obvious. If the freak disaster in question is a once in a lifetime drought, the same principles apply. It was shown in this study that across many parts of the Central Karoo we are dealing with a once in a lifetime drought, although in most cases the historical record includes similar droughts. Things become difficult, however, if drought is the first sign of the onset of climate change, which we cannot know until later. The difficulties are twofold – namely fairness and affordability.

It seems fair to help a specific producer up to the expected value of his farm in any given drought, but we know that agriculture has marginal and productive parts and it is not obvious that farms in marginal areas should receive more, or less, aid than those in more productive areas. If climate change erodes productivity, say by 20%, it is in everyone's interest to let the system adjust, so it would be counter-productive to compensate agriculture for its productivity loss with scarce public resources in a country where needs are many and resources are few. Alan Winde, the premier of the Western Cape, articulated this well when he said he told a delegation of the Western Cape Wool Growers Association in his offices on 16 October 2016,

> 'of course, there should be more drought relief for the Karoo, and of course we [the Western Cape government] will apply for it with national government, but you should realize that if agriculture gets more aid, there will be fewer hip replacements done in the province's public hospitals'.

The principle applies equally to private donations.

If this drought is part of climate change, or even if it is just part of the next twenty year cycle of serious droughts in the Karoo, it would be more useful to invest in alternative livelihoods that are less susceptible to climate change, like nature-based tourism or wind farming. Archer (2000) has warned that technology can lead to irreversible damage to rangeland. Imprudent fodder donations can do the same.

5 Conclusion

This analysis demonstrates that a simple grazing index can identify the duration and depth of droughts cheaply and effectively. Given the simple data manipulation needed to construct these, and their potential value to generate useful information, this is should be promoted to producers and policy makers.

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Appendix

The expected grazing index printed at the top of each table is the 50th percentile of each month's observations, while the drought threshold is the 10th percentile. Shaded entries indicate when a drought is in effect. Du Toit (2010) defines the beginning of a drought as when the current value of the index drops below the threshold and recovery as complete when the current index exceeds expected conditions at the site.

A1 Laingsburg

Laingsburg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**50**	**54**	**56**	**57**	**60**	**62**	**60**	**58**	**53**	**56**	**53**	**54**
Threshold	**22**	**20**	**26**	**29**	**30**	**27**	**28**	**27**	**27**	**24**	**25**	**24**
1913	28	24	31	41	37	52	59	63	69	85	78	68
1914	68	64	63	52	63	73	65	92	80	69	72	62
1915	53	55	53	44	41	40	33	34	31	26	23	40
1916	41	41	71	69	85	86	85	79	71	61	51	52
1917	42	56	118	120	105	101	129	116	101	98	83	67
1918	53	38	50	41	42	44	53	47	73	67	59	51
1919	43	35	35	28	22	22	19	15	11	9	19	16
1920	14	45	40	35	53	65	79	86	79	68	58	87
1921	77	183	213	214	192	200	187	165	141	117	93	123
1922	129	101	100	96	85	71	60	50	40	34	33	23
1923	22	18	14	52	61	62	65	58	50	43	62	53
1924	63	54	44	34	28	23	18	26	21	17	12	9
1925	7	16	37	47	45	80	80	71	62	54	50	42
1926	33	30	22	16	19	13	17	18	20	93	101	91
1927	82	72	63	70	61	61	55	58	46	34	30	26
1928	22	21	36	35	31	26	22	22	19	16	27	28
1929	24	19	59	54	62	57	67	76	72	62	53	56
1930	68	57	51	43	47	40	32	26	31	31	29	23
1931	18	15	27	51	45	43	57	60	52	53	46	55
1932	47	45	36	35	48	44	37	31	39	33	34	29
1933	24	19	31	39	39	37	38	45	41	36	50	88
1934	96	90	102	93	89	78	66	54	44	86	105	89
1935	77	66	55	74	79	74	74	62	54	41	43	37
1936	31	25	36	34	30	26	44	52	65	58	78	95
1937	110	114	102	95	85	74	60	48	37	33	23	37
1938	36	36	45	77	69	70	62	54	51	58	65	54
1939	45	52	56	48	45	47	40	54	45	42	35	30
1940	39	61	87	84	78	68	58	75	69	61	102	88
1941	98	84	71	83	94	89	87	82	70	59	49	41
1942	38	31	25	31	31	32	27	23	22	54	48	78

Laingsburg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**50**	**54**	**56**	**57**	**60**	**62**	**60**	**58**	**53**	**56**	**53**	**54**
Threshold	**22**	**20**	**26**	**29**	**30**	**27**	**28**	**27**	**27**	**24**	**25**	**24**
1943	70	62	71	70	77	70	60	50	77	64	98	84
1944	74	72	68	57	54	45	36	31	52	43	35	31
1945	26	21	39	34	32	45	48	41	34	40	35	30
1946	24	22	27	23	18	18	17	14	13	11	9	7
1947	6	4	31	28	40	36	46	41	36	31	27	29
1948	33	27	41	68	76	68	59	55	48	62	53	51
1949	47	38	33	30	27	23	19	15	12	8	30	26
1950	23	20	58	76	76	68	65	60	91	81	76	75
1951	101	99	83	70	60	56	51	42	40	35	31	24
1952	17	57	55	52	51	56	65	108	109	98	128	118
1953	101	99	85	93	80	80	96	82	71	78	74	87
1954	75	64	58	77	96	85	89	102	90	77	79	66
1955	56	93	117	109	117	109	99	94	81	71	74	66
1956	93	102	157	140	129	124	122	106	89	84	69	59
1957	45	69	69	65	87	85	82	77	88	80	68	72
1958	59	47	37	42	64	56	48	46	39	36	32	45
1959	39	33	34	54	65	61	63	59	52	97	85	73
1960	65	55	44	36	46	47	45	40	33	25	24	53
1961	53	51	70	90	97	119	135	125	115	111	114	96
1962	97	93	76	62	50	67	63	98	86	88	81	70
1963	109	95	98	106	90	90	88	73	62	56	52	88
1964	86	75	71	63	53	44	36	33	49	41	57	47
1965	41	46	71	112	100	94	85	73	69	68	78	70
1966	58	46	37	40	41	41	35	33	26	21	16	13
1967	11	18	16	53	68	90	82	76	68	60	66	97
1968	84	70	61	48	71	69	60	51	46	55	48	39
1969	33	40	41	43	37	35	32	31	28	23	19	16
1970	12	18	14	11	11	18	23	30	27	41	36	33
1971	28	25	40	73	66	64	114	110	97	85	76	68
1972	64	52	52	45	36	27	19	16	18	15	16	16
1973	13	33	58	53	47	42	37	41	37	53	65	67
1974	64	78	84	126	122	112	97	104	88	73	68	55
1975	43	54	58	47	74	89	88	76	72	67	57	57
1976	72	66	63	116	107	97	85	73	62	56	78	64
1977	52	63	58	108	130	117	115	115	102	87	71	72
1978	117	98	86	84	71	67	60	53	44	35	51	48
1979	38	44	38	36	52	59	60	61	53	46	43	36
1980	30	24	35	28	35	33	38	63	83	76	113	109
1981	161	154	161	148	135	119	103	109	93	87	69	68
1982	57	47	39	130	115	114	105	90	78	82	115	99
1983	84	74	61	46	48	44	41	34	35	27	32	28
1984	24	20	94	86	98	87	83	72	72	75	63	57

Laingsburg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**50**	**54**	**56**	**57**	**60**	**62**	**60**	**58**	**53**	**56**	**53**	**54**
Threshold	**22**	**20**	**26**	**29**	**30**	**27**	**28**	**27**	**27**	**24**	**25**	**24**
1985	77	75	61	53	50	66	71	62	83	89	87	118
1986	102	89	78	66	53	62	52	53	43	56	64	54
1987	48	45	38	80	72	74	70	76	107	98	87	95
1988	82	71	78	87	75	78	67	66	68	59	49	82
1989	74	64	64	133	119	116	107	94	81	70	61	47
1990	37	36	30	70	84	86	77	68	59	51	42	35
1991	69	57	68	61	56	82	80	70	77	118	103	89
1992	74	74	75	66	64	61	63	62	53	46	62	54
1993	47	43	40	70	86	83	91	81	73	68	57	65
1994	66	54	60	60	52	51	49	42	41	52	44	57
1995	66	85	136	121	134	123	110	101	91	94	123	175
1996	151	147	129	112	102	92	105	101	84	115	139	128
1997	112	97	102	92	102	100	83	69	56	42	33	26
1998	21	15	18	13	30	26	27	27	32	29	38	52
1999	56	55	59	51	43	37	44	66	63	57	48	85
2000	94	112	237	218	194	180	157	133	112	91	77	55
2001	43	28	25	27	28	30	33	32	28	24	49	48
2002	42	58	53	47	49	43	38	42	37	30	23	39
2003	34	33	36	47	50	44	40	38	36	33	32	25
2004	27	27	25	57	50	48	43	52	46	75	66	72
2005	72	65	62	66	70	66	56	49	40	32	42	34
2006	28	32	26	25	52	46	59	65	58	50	44	39
2007	36	30	24	34	27	27	29	25	22	19	55	74
2008	66	73	77	67	58	55	59	57	47	38	38	31
2009	25	67	64	127	118	111	99	91	78	67	61	64
2010	56	60	57	45	40	42	41	35	29	34	27	30
2011	48	97	115	108	120	134	129	130	113	96	81	65
2012	51	43	37	61	50	41	36	49	44	49	43	64
2013	62	57	55	55	48	56	54	55	48	77	66	56
2014	122	108	120	105	92	79	69	58	47	35	27	18
2015	9	6	3	3	4	45	43	39	40	42	39	40
2016	34	29	46	56	90	100	103	92	86	74	64	53
2017	50	39	28	19	11	16	14	14	14	22	47	43
2018	39	37	45	39	33	28	30	27	31	25	21	23
2019	20	30	37	41	43	40	50	44	40	34	29	23

A2 Koup

Koup	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Threshold	**65**	**62**	**72**	**86**	**90**	**87**	**79**	**71**	**64**	**61**	**61**	**60**
Expected	**35**	**35**	**41**	**38**	**34**	**34**	**28**	**31**	**29**	**26**	**28**	**24**
1962	88	70	51	39	31	34	27	36	31	28	30	25
1963	60	61	66	63	85	89	87	76	65	55	50	50
1964	39	42	37	29	22	30	26	22	53	46	51	57
1965	50	43	67	83	72	62	73	62	63	54	65	55
1966	47	38	34	31	28	24	19	15	14	11	8	7
1967	5	26	41	68	94	103	93	82	74	63	66	77
1968	63	50	110	95	114	100	89	77	72	81	73	60
1969	48	59	62	71	60	53	45	38	30	27	22	17
1970	12	21	17	14	20	19	17	32	28	47	42	62
1971	73	75	106	117	107	146	130	125	107	90	79	70
1972	74	63	67	55	44	35	29	24	22	18	26	21
1973	16	35	80	109	99	95	91	80	68	95	84	76
1974	111	112	115	108	94	96	82	71	58	44	38	37
1975	57	48	107	95	107	128	114	111	100	87	71	76
1976	153	260	275	260	243	214	186	159	132	120	126	95
1977	83	104	112	150	141	125	109	96	85	69	64	76
1978	65	51	45	50	44	45	39	35	29	25	37	46
1979	40	65	63	55	78	74	88	79	68	64	53	43
1980	37	37	34	27	20	19	16	32	42	47	104	98
1981	145	132	178	158	158	137	116	148	124	126	102	90
1982	71	57	49	117	111	105	99	83	98	108	119	103
1983	87	72	61	48	61	51	54	44	46	49	49	48
1984	41	35	72	79	76	67	57	49	40	33	32	32
1985	94	102	97	94	90	109	106	92	82	92	96	121
1986	106	95	98	117	101	94	82	82	67	103	100	84
1987	72	62	52	99	86	74	63	52	117	100	88	87
1988	74	69	104	111	98	91	78	70	70	61	51	56
1989	50	43	54	86	76	74	64	55	46	68	70	67
1990	57	61	83	124	114	104	95	81	70	56	45	35
1991	52	47	36	28	24	40	36	31	35	83	80	78
1992	78	80	113	100	92	84	79	79	64	74	116	101
1993	86	93	81	80	93	89	81	75	72	74	65	84
1994	82	73	74	95	81	70	61	54	44	47	38	29
1995	47	53	86	75	108	97	86	95	86	82	95	184
1996	162	158	144	139	118	101	93	84	71	96	147	135
1997	122	106	119	103	106	100	84	68	53	41	31	24
1998	84	84	125	112	119	106	93	115	105	104	115	147
1999	128	129	134	117	100	84	78	65	51	43	39	52
2000	59	184	300	272	245	219	191	164	137	111	94	68
2001	50	31	51	70	70	69	76	77	79	110	144	126
2002	109	99	93	87	92	84	72	67	56	43	33	78

Koup	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Threshold	**65**	**62**	**72**	**86**	**90**	**87**	**79**	**71**	**64**	**61**	**61**	**60**
Expected	**35**	**35**	**41**	**38**	**34**	**34**	**28**	**31**	**29**	**26**	**28**	**24**
2003	68	62	92	86	103	91	79	67	60	71	61	48
2004	58	60	61	118	104	112	99	117	102	93	79	82
2005	85	72	90	91	110	95	82	72	62	51	106	90
2006	82	73	60	55	89	78	90	117	105	91	82	75
2007	64	53	42	45	36	39	31	24	20	24	43	59
2008	52	54	78	70	75	71	67	63	52	58	114	100
2009	87	74	68	125	109	104	95	81	66	55	59	50
2010	41	65	67	55	48	41	35	29	24	20	15	29
2011	23	56	75	68	76	68	74	84	73	65	54	45
2012	44	36	69	96	87	93	80	78	68	82	78	135
2013	146	140	133	115	106	91	76	70	55	52	42	38
2014	67	68	93	107	101	89	77	70	63	57	56	44
2015	33	25	53	46	42	62	58	69	60	52	50	42
2016	65	55	66	63	79	87	85	86	75	64	60	49
2017	55	60	50	46	39	32	26	22	18	14	10	7
2018	16	21	41	37	46	44	43	38	35	32	26	20
2019	15	26	66	76	69	61	54	47	44	37	30	23

A3 Prince Albert

Prince Albert	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**79**	**78**	**85**	**95**	**95**	**94**	**90**	**88**	**84**	**81**	**81**	**82**
Threshold	**40**	**44**	**54**	**52**	**52**	**51**	**48**	**49**	**48**	**46**	**43**	**39**
1944	87	88	96	90	100	90	89	90	104	96	82	70
1945	59	71	112	102	156	159	155	137	117	110	93	80
1946	63	47	62	63	53	49	43	44	55	52	45	38
1947	38	30	58	54	96	86	88	77	66	59	64	56
1948	50	80	92	95	89	80	80	85	73	76	64	125
1949	108	94	102	104	97	83	74	62	52	41	66	52
1950	45	52	60	64	73	64	70	66	105	101	131	124
1951	138	123	105	89	91	85	82	69	57	45	34	27
1952	23	51	49	45	39	39	41	57	67	72	92	95
1953	82	101	93	95	87	123	129	114	97	96	111	131
1954	113	102	142	147	189	164	146	147	128	106	110	90
1955	73	64	61	75	81	110	106	94	82	82	89	101
1956	121	113	165	145	131	123	117	100	84	72	86	82
1957	78	102	102	91	95	97	89	80	94	82	67	64
1958	57	48	39	60	79	71	61	68	58	53	50	72

Prince Albert	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**79**	**78**	**85**	**95**	**95**	**94**	**90**	**88**	**84**	**81**	**81**	**82**
Threshold	**40**	**44**	**54**	**52**	**52**	**51**	**48**	**49**	**48**	**46**	**43**	**39**
1959	62	90	79	90	93	83	88	78	67	81	69	63
1960	56	44	60	57	51	47	40	34	28	34	37	43
1961	37	31	129	144	140	164	175	163	149	130	114	98
1962	145	139	122	103	89	93	81	79	66	63	92	77
1963	89	96	102	153	157	152	144	142	124	111	101	115
1964	95	102	97	81	68	74	64	59	71	64	72	60
1965	51	45	82	112	100	88	99	91	84	77	101	95
1966	91	75	77	73	64	58	48	44	43	35	27	24
1967	19	26	33	82	124	150	137	122	117	103	108	92
1968	76	59	61	47	61	55	49	52	45	58	65	61
1969	53	56	85	117	106	93	85	75	66	55	45	35
1970	26	20	12	11	15	15	13	29	26	40	36	42
1971	70	78	91	94	105	101	124	130	113	96	81	85
1972	95	87	92	77	65	61	51	56	63	55	50	41
1973	32	50	110	123	112	108	108	93	80	100	86	95
1974	118	160	170	166	148	154	133	122	103	83	65	50
1975	57	60	63	64	82	102	102	97	86	74	62	79
1976	78	130	142	148	179	172	161	141	126	135	147	121
1977	127	162	160	186	191	171	156	153	143	118	114	106
1978	90	71	56	62	51	42	37	42	47	47	39	42
1979	36	61	54	46	65	62	75	64	55	47	41	33
1980	26	53	57	50	44	45	55	69	96	94	135	158
1981	168	147	188	191	188	161	145	164	137	130	121	99
1982	81	64	54	109	94	114	100	84	110	123	124	108
1983	92	76	65	50	65	59	64	53	65	76	68	60
1984	52	43	82	82	80	69	58	50	42	41	44	39
1985	79	79	73	86	88	94	101	88	79	70	57	147
1986	155	136	132	125	108	126	110	113	99	115	119	96
1987	82	76	66	77	72	69	60	49	90	78	69	62
1988	53	56	74	133	117	123	111	111	111	97	82	110
1989	123	152	170	181	165	160	139	124	104	98	108	110
1990	90	90	90	128	120	120	117	103	88	72	60	47
1991	51	39	30	21	16	37	35	31	42	115	103	117
1992	118	135	165	147	131	127	136	135	114	135	116	97
1993	79	98	84	120	113	110	99	92	84	80	73	82
1994	77	78	84	108	94	85	90	82	70	88	75	62
1995	52	42	110	98	146	130	113	132	127	120	132	173
1996	173	149	134	121	102	86	90	98	91	114	181	263
1997	252	224	220	198	200	193	165	136	108	81	57	39
1998	87	95	117	102	116	103	91	106	100	89	107	201
1999	179	156	164	144	138	118	108	100	85	79	73	144
2000	136	170	274	284	252	225	195	165	138	110	115	86

Prince Albert	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**79**	**78**	**85**	**95**	**95**	**94**	**90**	**88**	**84**	**81**	**81**	**82**
Threshold	**40**	**44**	**54**	**52**	**52**	**51**	**48**	**49**	**48**	**46**	**43**	**39**
2001	64	43	64	67	68	60	83	75	73	88	119	116
2002	104	101	87	110	121	113	107	107	92	76	61	75
2003	63	51	79	75	94	82	72	68	58	63	61	50
2004	51	66	68	111	97	125	116	125	116	105	89	79
2005	79	64	50	58	88	74	66	56	48	41	76	66
2006	64	57	47	91	150	135	154	174	157	157	146	126
2007	117	96	87	87	77	81	80	66	56	75	81	95
2008	83	80	75	63	64	69	88	86	73	60	64	54
2009	46	79	68	108	99	102	97	87	75	86	99	135
2010	116	122	125	106	91	92	81	68	54	59	49	82
2011	106	160	170	154	147	129	126	117	100	80	82	77
2012	74	66	83	88	86	94	93	91	78	75	61	85
2013	98	84	133	117	112	103	89	88	74	100	106	106
2014	189	166	171	176	164	142	121	110	112	120	114	92
2015	72	60	56	46	45	60	58	87	74	82	75	66
2016	174	155	177	156	146	146	148	156	134	112	91	70
2017	55	56	56	57	50	40	32	25	22	18	20	16
2018	44	47	67	79	85	89	79	69	60	50	40	30
2019	21	39	31	51	44	39	34	30	26	21	17	13

A4 Moordenaarskaroo

Moorde-naarskaroo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**86**	**83**	**89**	**99**	**94**	**91**	**86**	**88**	**87**	**82**	**83**	**91**
Threshold	**37**	**37**	**45**	**40**	**41**	**40**	**47**	**47**	**45**	**39**	**37**	**42**
1934	35	32	49	57	57	52	50	62	52	43	74	94
1935	95	112	127	116	103	91	94	78	69	90	111	94
1936	80	66	55	54	78	122	115	101	98	82	99	87
1937	74	62	50	37	42	32	47	53	51	44	96	126
1938	129	130	115	99	84	70	63	50	45	38	31	121
1939	133	119	123	132	123	122	110	93	87	91	81	62
1940	60	75	63	62	57	48	40	138	123	108	94	81
1941	83	145	141	136	117	101	86	103	101	90	124	106
1942	137	116	100	139	134	131	116	116	98	90	72	58
1943	45	35	31	23	17	20	16	12	10	36	38	61
1944	70	62	84	110	98	86	80	79	80	66	133	115
1945	99	84	88	81	86	90	86	85	98	82	68	59
1946	50	51	150	140	133	134	130	123	106	110	93	82

Moorde-naarskaroo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**86**	**83**	**89**	**99**	**94**	**91**	**86**	**88**	**87**	**82**	**83**	**91**
Threshold	**37**	**37**	**45**	**40**	**41**	**40**	**47**	**47**	**45**	**39**	**37**	**42**
1947	64	59	58	68	68	57	55	46	50	44	37	30
1948	24	17	55	48	55	49	67	59	51	63	75	80
1949	69	71	99	127	119	111	102	88	74	71	57	70
1950	57	50	55	57	61	53	49	43	41	33	63	54
1951	64	58	89	102	122	109	102	90	93	81	124	110
1952	128	137	117	99	95	81	67	55	51	39	26	19
1953	12	43	38	39	37	39	66	92	125	112	149	156
1954	137	166	172	167	148	157	142	124	119	122	116	141
1955	120	99	154	134	179	158	150	171	147	124	102	83
1956	66	76	89	102	94	100	94	102	90	91	113	105
1957	157	177	186	176	174	171	152	129	107	129	114	111
1958	110	120	149	130	117	132	130	111	113	93	76	92
1959	83	67	54	66	109	94	82	70	59	69	58	113
1960	99	114	101	100	91	87	82	79	65	62	60	46
1961	45	43	44	57	53	45	49	42	46	38	38	46
1962	60	52	145	221	201	190	227	209	199	177	178	148
1963	151	126	96	81	67	77	61	81	69	66	77	66
1964	102	105	105	112	106	98	89	74	62	49	46	58
1965	46	58	55	51	44	67	61	70	121	111	110	109
1966	103	96	98	123	112	94	86	69	54	45	35	27
1967	19	13	30	30	26	37	33	39	45	39	34	53
1968	46	49	41	54	90	127	114	109	96	83	75	69
1969	57	45	64	51	76	79	73	70	61	78	121	106
1970	96	140	121	118	101	97	84	76	66	63	49	39
1971	30	33	28	23	33	42	53	104	94	94	83	80
1972	86	73	92	91	93	82	157	175	156	144	128	109
1973	104	87	84	68	52	38	29	22	24	20	20	16
1974	13	17	44	41	40	36	31	26	22	18	14	11
1975	7	4	1	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	4	33	37	58	62	59	58	100
1977	155	279	293	276	258	237	220	187	156	136	141	107
1978	83	97	117	122	142	140	127	119	106	90	91	105
1979	103	84	79	94	79	79	68	73	67	61	58	69
1980	58	55	46	37	45	57	80	103	92	97	89	77
1981	66	89	100	88	80	71	57	67	76	65	128	113
1982	272	249	299	271	267	233	212	233	198	184	146	123
1983	98	83	71	138	122	136	123	108	108	110	133	114
1984	96	83	69	57	70	61	74	63	58	53	48	53
1985	64	55	85	78	81	70	64	62	61	71	60	53
1986	119	131	124	127	130	141	136	120	116	167	192	235
1987	212	196	174	244	212	213	184	177	148	141	139	114
1988	95	79	65	113	98	96	98	93	138	121	105	91

Moorde-naarskaroo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**86**	**83**	**89**	**99**	**94**	**91**	**86**	**88**	**87**	**82**	**83**	**91**
Threshold	**37**	**37**	**45**	**40**	**41**	**40**	**47**	**47**	**45**	**39**	**37**	**42**
1989	77	74	119	148	136	122	104	102	110	101	87	94
1990	84	85	75	117	103	107	99	94	85	119	121	105
1991	89	83	87	103	99	101	93	81	67	53	47	42
1992	105	91	85	78	67	91	87	76	87	146	127	113
1993	94	98	103	87	83	82	90	86	77	74	74	63
1994	58	81	70	80	85	72	70	63	63	64	56	68
1995	68	56	76	80	75	74	73	65	61	64	53	43
1996	35	43	59	51	63	54	47	48	45	52	65	104
1997	101	122	120	106	93	80	82	81	73	103	171	155
1998	136	118	126	116	117	132	119	101	81	72	64	61
1999	82	81	124	108	103	88	77	106	107	100	120	120
2000	109	112	101	87	95	80	73	68	66	63	74	112
2001	137	183	223	210	184	161	156	136	114	91	80	62
2002	44	39	49	70	69	60	94	106	102	112	152	140
2003	127	113	120	112	114	95	87	102	98	81	66	108
2004	93	79	102	121	165	145	126	122	104	93	104	95
2005	92	88	76	134	115	141	136	156	136	134	113	150
2006	139	117	120	115	113	97	81	68	56	44	83	68
2007	64	94	81	90	129	119	135	186	167	159	144	133
2008	121	100	85	102	94	87	95	83	72	77	85	218
2009	207	196	215	189	195	176	160	149	122	112	107	86
2010	71	77	66	100	88	92	83	74	62	68	82	95
2011	87	94	97	88	78	78	79	67	55	70	57	90
2012	86	138	150	174	198	222	226	230	200	170	153	123
2013	101	79	95	126	104	106	96	115	107	121	105	104
2014	107	104	109	93	84	96	89	102	88	106	115	152
2015	243	237	234	222	204	178	150	123	106	84	80	57
2016	39	30	48	41	35	73	79	88	87	85	77	67
2017	66	62	59	66	110	123	123	137	128	112	96	82
2018	79	63	54	40	27	27	30	24	20	21	29	25
2019	42	51	61	57	67	61	67	63	74	63	53	44

A5 Beaufort West

Beaufort West	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**111**	**126**	**142**	**146**	**140**	**127**	**120**	**115**	**107**	**102**	**109**	**108**
Threshold	**59**	**69**	**75**	**76**	**77**	**72**	**63**	**66**	**61**	**59**	**54**	**56**
1879	135	124	276	277	272	262	235	213	223	191	158	126
1880	93	105	126	137	132	116	100	100	86	106	138	118
1881	118	117	156	160	162	153	142	132	112	90	87	71
1882	78	72	76	112	100	87	75	72	96	82	82	115
1883	98	99	104	91	81	71	63	58	56	59	49	39
1884	130	152	146	135	131	135	117	99	90	73	66	49
1885	41	82	93	94	130	115	102	91	91	90	111	101
1886	118	130	124	134	116	102	105	91	82	80	64	101
1887	98	109	130	153	157	139	123	122	106	100	113	93
1888	85	121	149	145	146	132	124	118	116	98	88	80
1889	103	154	157	138	147	129	110	99	84	110	102	191
1890	182	258	258	257	250	224	206	174	151	134	175	149
1891	156	150	141	127	126	131	117	116	104	95	146	137
1892	119	133	168	146	134	125	113	93	127	139	153	171
1893	184	173	208	187	162	141	120	99	93	79	103	118
1894	121	135	226	243	222	204	177	163	138	131	140	138
1895	228	194	171	219	206	184	163	137	115	94	76	64
1896	72	109	102	93	86	83	72	103	92	88	132	119
1897	101	88	89	80	103	88	78	63	89	100	85	102
1898	140	140	151	134	126	109	91	74	63	52	43	42
1899	48	58	97	110	108	103	93	84	73	74	62	93
1900	102	125	157	147	138	124	127	137	117	102	83	152
1901	134	159	160	205	198	175	157	136	157	160	144	116
1902	95	98	150	131	114	98	85	79	86	80	80	71
1903	58	51	40	41	48	84	73	69	63	64	63	59
1904	138	135	155	136	119	107	118	103	92	119	99	83
1905	68	100	96	99	88	76	63	52	197	225	201	203
1906	179	161	212	199	262	234	204	179	179	208	232	263
1907	270	253	262	274	261	232	199	166	142	113	87	130
1908	130	109	100	95	87	88	91	85	74	91	79	67
1909	84	183	251	260	316	281	246	213	193	165	137	200
1910	211	243	228	204	174	160	144	121	104	87	64	44
1911	121	124	168	218	249	237	209	201	203	203	244	205
1912	203	202	188	190	161	168	143	123	104	82	67	66
1913	79	121	154	157	150	153	149	142	165	173	160	134
1914	128	156	179	193	195	212	186	173	148	148	150	143
1915	134	127	119	106	90	82	83	73	60	50	43	45
1916	86	74	109	126	121	111	97	86	77	76	67	70
1917	61	88	131	163	146	149	153	156	155	211	205	179
1918	173	150	370	327	292	254	240	203	177	170	139	111
1919	84	103	145	173	159	141	126	113	104	89	97	81

Beaufort West	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**111**	**126**	**142**	**146**	**140**	**127**	**120**	**115**	**107**	**102**	**109**	**108**
Threshold	**59**	**69**	**75**	**76**	**77**	**72**	**63**	**66**	**61**	**59**	**54**	**56**
1920	80	84	120	124	136	145	135	119	102	102	88	130
1921	109	237	318	346	333	310	272	237	207	172	198	237
1922	228	194	199	180	160	142	129	121	109	91	98	96
1923	92	120	126	161	149	136	144	126	107	91	103	91
1924	105	139	137	126	110	94	79	77	66	53	47	67
1925	76	82	136	148	139	138	132	120	161	140	122	124
1926	105	85	67	55	52	56	57	47	40	38	46	39
1927	35	42	40	37	32	28	29	25	27	25	39	56
1928	79	70	200	211	189	168	147	129	125	103	84	66
1929	61	90	111	103	104	97	111	141	166	178	157	162
1930	171	216	192	172	146	124	100	91	77	63	51	37
1931	60	48	117	121	108	98	134	129	121	124	135	159
1932	147	201	175	154	153	153	131	109	122	124	123	102
1933	84	72	73	69	56	48	44	89	77	65	84	102
1934	120	157	172	194	181	157	155	131	110	97	113	105
1935	85	82	68	70	90	98	86	79	85	72	65	55
1936	48	68	77	78	88	78	75	68	61	82	95	108
1937	102	117	102	88	75	64	56	45	42	44	45	280
1938	263	251	251	246	222	192	192	161	132	112	120	110
1939	116	237	223	225	199	174	153	196	167	166	135	108
1940	92	158	172	158	143	123	120	101	130	112	99	83
1941	87	101	86	131	117	110	99	115	98	124	108	98
1942	85	76	79	79	84	76	64	66	58	58	64	63
1943	59	60	62	62	69	63	58	70	73	66	126	128
1944	121	115	117	104	100	86	84	73	68	66	52	43
1945	51	47	67	72	77	78	75	66	56	51	43	38
1946	33	66	86	140	126	116	107	99	90	78	79	65
1947	53	67	75	63	61	55	54	46	41	35	42	54
1948	57	117	158	183	165	148	136	119	101	89	70	60
1949	46	32	28	32	45	40	35	34	33	30	95	97
1950	93	118	201	194	186	164	146	138	179	194	232	225
1951	217	205	175	151	134	120	101	79	72	55	41	32
1952	25	146	174	168	151	137	139	153	156	137	157	166
1953	141	141	140	142	128	116	122	106	103	185	187	226
1954	200	173	245	253	273	246	222	214	185	152	167	137
1955	140	142	124	108	91	86	83	74	61	49	73	77
1956	94	96	208	193	203	179	157	148	145	182	182	181
1957	156	158	154	133	115	123	108	87	126	103	86	124
1958	107	90	80	81	128	110	94	92	78	95	100	114
1959	116	139	127	121	127	110	94	84	68	80	72	68
1960	55	45	59	55	59	55	47	65	55	45	46	56
1961	76	66	241	281	267	238	228	212	183	157	158	127

Beaufort West	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**111**	**126**	**142**	**146**	**140**	**127**	**120**	**115**	**107**	**102**	**109**	**108**
Threshold	**59**	**69**	**75**	**76**	**77**	**72**	**63**	**66**	**61**	**59**	**54**	**56**
1962	104	82	70	77	74	71	60	67	57	79	98	95
1963	173	181	210	215	205	197	182	159	132	131	183	183
1964	152	155	140	122	104	107	91	97	158	149	171	173
1965	158	141	160	155	146	127	141	137	111	166	184	164
1966	156	133	120	115	109	91	72	73	82	69	81	73
1967	66	72	125	208	282	273	263	230	199	173	168	141
1968	112	83	92	67	75	72	62	57	64	66	63	55
1969	46	130	144	145	130	124	113	98	89	108	115	96
1970	84	75	63	60	82	74	67	132	115	122	109	162
1971	155	150	175	174	163	147	161	206	179	165	143	154
1972	175	160	180	182	170	147	121	99	85	68	53	49
1973	35	97	161	155	143	127	205	207	194	218	188	190
1974	259	333	321	305	290	266	222	190	156	123	119	89
1975	69	67	108	95	97	114	109	95	108	92	102	120
1976	187	235	373	350	332	305	270	233	206	234	217	174
1977	138	177	236	233	249	230	204	182	167	144	121	124
1978	106	92	93	83	68	69	59	65	54	62	55	102
1979	109	146	132	122	125	108	159	143	122	112	114	92
1980	98	101	111	95	81	66	52	63	93	93	119	106
1981	159	140	185	164	148	127	116	152	127	177	150	127
1982	138	128	107	115	141	120	111	92	79	92	111	99
1983	83	70	68	65	56	58	89	77	78	79	91	89
1984	83	72	106	113	101	89	74	67	55	57	65	62
1985	136	159	169	177	170	157	156	148	125	102	92	181
1986	199	194	186	176	153	139	117	111	108	149	188	156
1987	134	144	128	167	151	134	112	90	103	87	86	78
1988	65	88	116	160	142	136	120	120	116	99	88	119
1989	127	128	131	160	141	134	116	98	81	113	255	238
1990	210	210	207	235	210	193	166	137	107	77	58	60
1991	62	49	52	42	36	42	36	31	61	143	127	130
1992	115	127	140	123	114	114	118	115	98	99	103	87
1993	76	83	87	94	104	92	78	72	109	103	128	148
1994	168	177	190	181	162	141	144	126	105	100	80	67
1995	73	84	142	127	150	132	120	131	122	109	131	191
1996	207	228	229	207	179	154	136	145	130	118	225	198
1997	175	150	265	236	235	235	205	171	141	121	92	73
1998	95	110	121	114	98	86	76	142	136	150	143	162
1999	161	145	155	164	172	147	126	113	120	134	135	164
2000	232	252	377	341	301	266	229	192	163	130	133	99
2001	95	88	91	198	186	168	160	163	178	160	163	158
2002	158	143	165	140	136	127	120	169	155	133	122	229
2003	211	184	212	219	267	232	197	169	142	131	110	82

Beaufort West	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**111**	**126**	**142**	**146**	**140**	**127**	**120**	**115**	**107**	**102**	**109**	**108**
Threshold	**59**	**69**	**75**	**76**	**77**	**72**	**63**	**66**	**61**	**59**	**54**	**56**
2004	80	117	103	145	124	143	135	131	122	118	115	166
2005	154	156	154	185	172	150	128	116	102	88	148	123
2006	171	150	142	137	167	148	161	214	190	171	161	147
2007	122	125	119	202	173	153	145	121	113	172	173	213
2008	207	204	228	198	186	186	168	162	133	141	116	93
2009	79	115	105	146	129	118	111	95	85	98	132	138
2010	133	169	160	143	125	121	109	91	72	82	64	101
2011	140	195	233	227	260	258	279	265	227	242	218	225
2012	223	253	273	253	227	208	192	174	147	182	151	220
2013	210	204	215	190	163	157	152	136	111	132	124	192
2014	239	239	217	241	221	190	160	139	119	115	114	118
2015	99	93	105	98	87	90	94	105	97	92	86	80
2016	118	105	119	116	128	125	112	132	126	109	92	75
2017	62	69	56	77	91	79	69	60	52	69	83	78
2018	92	115	118	119	118	103	95	87	80	68	54	60
2019	47	52	60	66	75	66	60	52	55	47	38	30

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Nelspoort	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Threshold	**107**	**114**	**130**	**135**	**137**	**124**	**114**	**105**	**94**	**94**	**93**	**96**
Expected	**50**	**57**	**68**	**79**	**74**	**70**	**63**	**61**	**53**	**57**	**54**	**52**
1891	188	178	169	181	188	178	159	148	134	122	136	139
1892	132	120	163	157	144	141	129	120	139	139	149	137
1893	127	150	195	172	152	134	113	92	74	67	88	73
1894	144	122	253	257	240	224	196	177	152	143	163	141
1895	194	170	160	185	184	165	143	120	99	79	65	93
1896	91	144	130	117	126	119	104	109	95	102	147	133
1897	140	141	146	132	138	119	104	85	103	102	84	83
1898	189	192	184	166	161	139	118	97	78	60	60	50
1899	41	52	172	188	177	169	157	143	125	106	85	72
1900	66	81	103	142	135	122	116	115	100	94	78	178
1901	154	206	214	229	207	181	161	139	134	119	102	76
1902	61	53	68	83	80	78	67	63	72	71	86	106
1903	93	115	98	93	83	87	84	71	59	56	46	37
1904	56	69	91	80	71	63	70	64	60	72	61	61
1905	50	58	65	75	67	58	49	42	131	155	138	138
1906	124	123	174	186	213	189	163	136	128	136	129	133

Nelspoort	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Threshold	**107**	**114**	**130**	**135**	**137**	**124**	**114**	**105**	**94**	**94**	**93**	**96**
Expected	**50**	**57**	**68**	**79**	**74**	**70**	**63**	**61**	**53**	**57**	**54**	**52**
1907	119	163	158	164	159	143	125	105	87	76	59	88
1908	102	83	85	83	72	72	70	67	61	76	63	54
1909	63	96	128	157	169	150	133	119	113	94	86	122
1910	124	151	151	136	137	126	111	93	79	75	60	46
1911	44	39	66	57	49	51	45	62	75	106	121	106
1912	92	125	111	129	112	123	116	98	84	68	55	47
1913	48	223	282	269	241	227	204	180	153	129	105	77
1914	71	61	94	105	122	132	117	119	104	105	104	103
1915	106	117	97	94	79	71	73	64	53	47	41	47
1916	46	38	63	84	88	78	71	61	57	55	53	61
1917	51	123	182	216	194	194	185	187	174	162	149	124
1918	131	102	144	130	115	97	89	73	61	64	67	55
1919	42	99	124	133	119	105	91	77	65	79	91	82
1920	90	113	149	138	130	115	108	92	75	72	70	78
1921	62	127	196	251	243	228	202	175	156	129	103	78
1922	118	93	79	64	55	47	46	47	50	75	98	84
1923	87	95	127	161	148	133	132	112	93	104	116	105
1924	127	146	179	162	143	124	107	99	82	70	59	94
1925	94	117	217	223	210	199	185	167	188	171	154	155
1926	126	99	76	71	92	96	81	67	53	63	73	62
1927	56	56	66	62	51	43	36	30	23	45	67	89
1928	85	74	204	198	177	157	136	120	128	105	84	73
1929	70	89	85	83	93	89	120	161	245	219	193	211
1930	202	217	206	175	145	128	99	83	66	53	40	35
1931	75	63	130	117	104	91	124	116	103	113	122	145
1932	141	148	157	138	149	146	123	104	117	106	104	85
1933	69	55	86	99	84	72	66	99	87	75	115	120
1934	132	146	176	178	165	143	132	109	90	108	122	129
1935	118	110	97	122	152	162	141	126	128	106	93	81
1936	66	65	84	79	91	79	75	67	68	97	120	113
1937	115	111	93	79	76	64	62	50	46	38	46	100
1938	104	95	95	115	112	99	117	100	86	97	102	143
1939	157	228	243	233	208	181	172	237	203	219	184	150
1940	123	212	202	179	166	140	142	120	142	129	114	94
1941	115	141	153	200	176	159	136	155	131	144	121	126
1942	126	130	125	134	123	108	91	110	93	149	142	140
1943	125	106	126	134	139	121	104	107	96	82	139	143
1944	147	159	146	125	143	130	110	100	84	66	49	37
1945	41	55	110	103	106	104	118	104	90	77	64	63
1946	61	47	63	79	73	63	59	54	47	65	69	58
1947	48	47	71	72	83	73	63	53	44	35	34	55
1948	50	80	130	160	143	128	137	127	114	103	85	82

Nelspoort	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Threshold	**107**	**114**	**130**	**135**	**137**	**124**	**114**	**105**	**94**	**94**	**93**	**96**
Expected	**50**	**57**	**68**	**79**	**74**	**70**	**63**	**61**	**53**	**57**	**54**	**52**
1949	76	61	54	55	68	59	49	42	35	28	49	53
1950	57	104	150	243	229	205	182	169	203	202	231	233
1951	220	189	158	132	112	93	73	54	36	30	18	12
1952	8	83	100	105	97	91	98	109	111	98	115	158
1953	139	139	142	131	115	97	87	78	80	142	148	132
1954	115	111	189	182	220	202	174	147	125	99	104	85
1955	108	108	114	107	90	93	91	78	66	53	86	110
1956	141	151	267	240	234	210	182	160	149	150	174	206
1957	192	207	235	208	189	163	138	113	88	65	44	59
1958	72	57	49	51	116	104	93	83	88	106	91	112
1959	117	118	105	144	131	115	115	97	80	76	69	57
1960	52	41	57	46	51	44	37	62	54	46	61	60
1961	100	91	263	281	282	265	249	230	198	166	150	127
1962	109	105	105	87	73	76	65	62	53	56	48	43
1963	107	115	143	148	131	124	129	121	106	142	149	137
1964	114	118	111	95	80	88	73	65	89	92	105	113
1965	152	136	145	148	137	117	117	97	77	92	98	81
1966	104	113	97	162	143	126	108	101	107	88	75	61
1967	54	57	131	156	212	190	179	156	134	114	101	81
1968	61	41	52	48	54	48	46	44	56	69	67	63
1969	53	171	201	219	198	179	156	133	110	125	136	111
1970	87	76	61	60	88	79	68	101	86	83	70	95
1971	82	89	95	100	99	86	106	143	126	122	104	100
1972	114	105	167	154	136	115	95	82	72	59	57	51
1973	38	39	102	126	117	105	111	112	111	182	159	161
1974	246	328	311	294	293	270	231	203	166	129	148	123
1975	102	122	166	158	150	159	146	126	122	101	117	135
1976	182	210	260	239	224	197	177	150	129	168	164	145
1977	116	249	275	297	294	260	225	199	175	140	110	137
1978	117	94	106	103	89	78	67	68	56	55	43	73
1979	62	103	92	104	119	114	108	101	103	94	85	69
1980	79	101	92	91	77	70	59	78	84	76	94	80
1981	137	199	235	213	217	190	183	207	182	167	141	127
1982	98	74	69	175	153	136	141	122	118	149	182	158
1983	135	113	99	83	75	69	104	88	85	69	115	106
1984	94	81	87	98	83	94	78	66	64	59	76	66
1985	110	152	168	166	157	149	129	118	98	89	87	178
1986	202	201	203	198	174	160	137	114	91	106	99	74
1987	58	47	63	98	92	80	69	59	81	67	67	57
1988	47	64	92	112	113	125	112	97	118	102	92	135
1989	123	118	140	120	108	96	91	75	60	81	121	101
1990	111	140	122	163	143	128	109	91	73	57	57	75

Nelspoort	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Threshold	**107**	**114**	**130**	**135**	**137**	**124**	**114**	**105**	**94**	**94**	**93**	**96**
Expected	**50**	**57**	**68**	**79**	**74**	**70**	**63**	**61**	**53**	**57**	**54**	**52**
1991	83	68	58	47	41	38	32	26	46	106	92	102
1992	100	105	127	114	99	99	99	90	72	73	69	56
1993	72	91	87	80	86	85	73	70	109	101	118	133
1994	170	172	201	200	174	150	140	121	97	84	72	54
1995	50	79	120	106	142	126	110	108	110	96	150	176
1996	195	167	162	152	130	111	96	101	89	83	187	223
1997	232	207	257	256	237	243	207	172	147	114	83	61
1998	82	67	83	84	72	61	53	68	58	94	105	120
1999	141	124	123	107	109	93	77	61	52	89	81	111
2000	156	171	254	243	215	189	162	136	120	93	105	96
2001	127	122	164	195	174	158	150	140	191	205	265	229
2002	194	170	205	195	168	163	135	147	124	100	79	128
2003	110	92	115	119	141	122	104	87	73	65	63	48
2004	65	108	102	107	94	83	72	61	74	61	64	137
2005	141	195	190	245	261	233	204	174	144	135	144	112
2006	193	162	137	128	178	158	154	157	138	144	133	110
2007	105	102	85	104	86	72	59	47	47	84	80	137
2008	183	179	209	184	170	173	149	124	100	80	66	46
2009	32	132	131	148	131	124	131	114	98	115	96	118
2010	96	150	199	176	159	138	136	116	96	76	59	94
2011	113	200	222	214	242	230	237	214	184	206	171	155
2012	151	215	223	218	187	170	180	154	129	169	143	192
2013	187	161	151	157	137	126	133	112	91	115	109	131
2014	118	151	157	173	177	153	131	110	127	113	110	96
2015	88	73	98	91	78	91	94	97	93	80	75	84
2016	130	114	130	129	152	138	122	135	116	97	81	69
2017	84	175	162	189	172	151	133	113	95	78	95	96
2018	87	87	90	86	92	81	69	62	69	61	48	42
2019	34	50	83	87	96	85	75	64	61	51	42	33

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Murraysburg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**135**	**152**	**168**	**176**	**171**	**156**	**145**	**132**	**120**	**110**	**121**	**127**
Threshold	**82**	**82**	**98**	**103**	**105**	**101**	**92**	**84**	**76**	**77**	**76**	**69**
1930	174	268	251	228	207	177	148	125	104	99	103	82
1931	88	68	121	115	101	89	111	107	103	109	130	172
1932	160	210	235	208	197	188	168	141	132	129	119	94
1933	75	68	65	75	65	54	45	68	64	53	71	111
1934	126	148	182	193	171	149	127	105	86	110	146	148
1935	137	184	160	140	224	198	190	163	145	117	109	102
1936	82	91	174	180	170	151	132	114	96	100	135	113
1937	115	110	114	99	94	81	90	76	62	58	69	141
1938	173	179	164	149	137	118	114	95	76	84	119	117
1939	192	217	198	189	171	154	150	230	197	235	209	176
1940	170	239	253	244	241	205	185	152	161	131	119	99
1941	114	124	104	124	125	128	125	129	110	98	105	93
1942	95	123	135	143	134	127	111	123	112	127	119	105
1943	105	102	140	168	196	173	150	142	128	107	182	196
1944	188	167	279	247	264	238	210	201	169	153	119	93
1945	99	99	148	133	155	153	171	149	130	122	108	103
1946	106	97	99	125	144	137	121	112	99	106	121	122
1947	105	123	137	128	131	114	109	92	112	102	112	156
1948	179	194	218	243	218	192	168	143	116	96	80	65
1949	48	56	60	65	105	94	91	83	72	81	71	82
1950	98	168	273	364	342	306	273	245	269	227	227	203
1951	181	195	200	170	160	143	135	113	107	95	75	58
1952	43	169	179	175	187	170	161	155	139	129	120	130
1953	104	157	150	136	120	111	107	96	86	106	148	179
1954	160	149	216	251	256	225	204	179	149	118	157	129
1955	127	134	137	185	166	169	150	130	109	94	110	120
1956	109	121	169	146	147	134	117	102	86	104	93	138
1957	147	169	202	180	178	164	141	132	112	91	78	69
1958	77	61	51	48	105	96	84	76	89	81	95	145
1959	160	152	162	156	145	125	113	94	75	67	53	53
1960	46	53	85	97	123	119	115	144	127	110	105	98
1961	135	141	269	256	262	258	288	277	245	211	196	163
1962	160	204	185	165	138	128	105	94	78	68	84	68
1963	190	196	286	303	279	263	254	243	214	236	255	239
1964	199	177	170	147	124	109	88	78	73	77	95	103
1965	95	92	103	128	112	97	133	115	97	111	171	153
1966	154	148	138	122	104	93	74	60	50	40	51	47
1967	63	69	96	135	165	175	162	143	123	134	148	129
1968	106	85	145	176	175	166	145	134	128	115	113	113
1969	94	161	159	211	190	167	146	124	105	100	84	66
1970	49	70	56	49	105	103	94	106	92	101	88	109

Murraysburg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**135**	**152**	**168**	**176**	**171**	**156**	**145**	**132**	**120**	**110**	**121**	**127**
Threshold	**82**	**82**	**98**	**103**	**105**	**101**	**92**	**84**	**76**	**77**	**76**	**69**
1971	95	132	134	213	207	187	202	207	180	180	152	128
1972	183	155	203	191	172	156	132	111	106	99	84	66
1973	47	65	168	210	189	168	176	165	144	151	137	160
1974	211	359	445	409	409	373	323	327	278	228	250	201
1975	190	168	211	205	193	208	196	167	153	127	132	189
1976	305	354	452	440	413	365	335	293	253	290	242	206
1977	174	248	258	262	296	260	226	191	173	140	140	147
1978	120	113	138	130	112	102	98	97	81	73	67	131
1979	148	228	206	198	192	177	204	180	152	147	157	132
1980	107	126	163	158	136	125	106	124	120	100	139	140
1981	167	167	172	164	238	216	190	192	165	201	181	199
1982	192	174	163	190	162	148	142	125	143	144	168	175
1983	160	137	128	146	135	136	172	147	150	128	175	194
1984	174	165	162	176	161	142	117	108	87	71	91	75
1985	113	104	94	95	83	105	92	78	70	94	154	283
1986	297	299	297	283	247	221	187	158	124	124	160	127
1987	106	106	93	114	122	113	106	89	131	109	145	149
1988	135	326	353	377	359	357	323	277	306	262	224	274
1989	238	247	254	258	237	211	179	149	118	94	123	113
1990	117	127	118	144	127	141	124	109	91	73	61	53
1991	82	80	89	94	83	90	79	68	74	124	200	217
1992	190	180	189	180	159	146	135	155	126	158	140	120
1993	149	178	178	168	164	171	145	125	112	108	116	133
1994	145	152	219	217	190	170	147	124	101	95	80	75
1995	84	87	103	104	102	90	78	85	102	87	125	183
1996	235	241	249	239	210	181	162	157	137	126	221	228
1997	206	187	237	218	232	235	209	175	143	127	108	96
1998	95	87	125	125	119	103	92	79	76	71	66	58
1999	85	82	101	96	118	112	108	94	86	86	95	140
2000	165	151	223	250	220	202	175	163	174	152	164	133
2001	118	101	135	264	236	208	195	167	196	167	140	115
2002	140	124	123	104	113	126	115	133	125	109	92	100
2003	91	142	196	194	175	151	130	121	104	100	89	74
2004	111	110	111	160	143	146	136	117	99	91	83	109
2005	135	192	196	193	218	195	172	157	132	129	146	122
2006	192	221	236	243	262	236	240	323	285	256	222	207
2007	179	176	157	161	142	126	112	92	80	144	156	205
2008	212	261	276	259	244	256	238	226	195	175	157	152
2009	130	188	192	226	206	202	186	162	140	150	129	111
2010	231	229	231	207	188	174	162	139	115	109	101	113
2011	171	283	364	353	365	357	326	298	257	246	203	208
2012	224	282	339	319	278	265	299	271	230	226	186	228

Murraysburg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**135**	**152**	**168**	**176**	**171**	**156**	**145**	**132**	**120**	**110**	**121**	**127**
Threshold	**82**	**82**	**98**	**103**	**105**	**101**	**92**	**84**	**76**	**77**	**76**	**69**
2013	220	192	265	236	217	184	171	149	123	142	134	210
2014	227	248	239	249	239	209	179	160	168	151	170	169
2015	154	132	148	139	119	136	141	129	137	125	107	90
2016	135	133	138	131	138	127	113	126	106	90	80	69
2017	117	145	139	167	155	139	120	104	88	87	76	75
2018	110	136	149	225	227	205	189	167	176	151	125	115
2019	100	120	127	146	157	138	126	108	97	81	66	50

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Sneeuberg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**204**	**219**	**231**	**240**	**237**	**222**	**210**	**196**	**192**	**192**	**197**	**209**
Threshold	**122**	**128**	**150**	**161**	**159**	**148**	**132**	**125**	**119**	**125**	**124**	**115**
1934	215	246	296	309	289	255	287	245	206	227	240	230
1935	204	226	210	233	330	312	294	289	259	217	206	187
1936	153	158	219	192	236	206	185	159	166	197	255	243
1937	256	295	269	247	226	203	198	164	163	163	174	244
1938	249	237	231	229	217	207	193	164	134	141	196	179
1939	211	286	305	278	257	230	247	329	325	368	333	289
1940	247	274	281	241	285	240	215	176	190	162	163	137
1941	186	178	192	258	239	232	217	209	176	228	193	180
1942	200	194	199	207	233	213	183	181	170	205	223	224
1943	200	240	262	275	278	253	217	214	185	150	246	291
1944	264	237	248	213	250	225	209	196	193	172	135	108
1945	120	122	217	200	255	243	260	227	196	185	156	134
1946	124	127	133	159	159	147	136	123	114	120	148	151
1947	134	120	140	121	124	107	115	97	113	123	119	151
1948	159	207	278	355	315	283	268	233	200	181	150	134
1949	102	84	80	91	159	141	126	112	96	104	103	97
1950	108	194	287	373	402	362	341	325	347	330	347	308
1951	298	317	286	241	219	200	186	167	191	169	139	114
1952	93	244	247	247	235	216	206	208	223	233	222	228
1953	204	213	201	183	165	156	142	163	198	314	372	430
1954	413	375	465	478	482	436	398	352	300	268	276	227
1955	227	215	222	230	198	207	184	165	146	143	171	213
1956	197	228	252	225	252	232	200	178	179	212	324	363
1957	358	365	384	336	314	290	247	235	198	157	125	123
1958	205	174	164	151	235	209	181	174	184	169	169	219

Sneeuberg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**204**	**219**	**231**	**240**	**237**	**222**	**210**	**196**	**192**	**192**	**197**	**209**
Threshold	**122**	**128**	**150**	**161**	**159**	**148**	**132**	**125**	**119**	**125**	**124**	**115**
1959	203	210	228	259	250	218	230	216	187	174	146	139
1960	127	115	133	138	175	167	148	173	163	150	159	163
1961	169	147	314	338	337	335	344	324	286	250	247	217
1962	191	199	186	171	146	135	115	125	107	129	130	109
1963	251	276	367	372	353	329	289	272	242	257	268	274
1964	229	213	203	241	209	240	206	184	190	186	180	209
1965	194	164	155	185	186	238	263	240	212	276	295	258
1966	270	243	222	194	192	160	131	113	119	120	99	93
1967	86	87	143	172	257	265	244	220	189	232	237	202
1968	168	135	153	168	165	167	144	141	177	170	168	152
1969	129	228	253	281	270	240	210	177	164	194	175	144
1970	120	117	94	83	126	126	117	292	261	276	270	293
1971	274	308	330	311	295	254	287	360	313	304	260	220
1972	221	189	208	208	200	175	147	125	118	99	86	72
1973	54	87	168	260	232	207	221	217	192	190	168	171
1974	314	428	516	474	480	444	385	410	354	298	334	268
1975	226	198	271	292	272	291	272	234	210	174	166	230
1976	294	356	477	454	456	414	386	342	311	360	323	290
1977	240	359	354	360	431	395	342	298	275	232	215	224
1978	218	200	202	179	150	140	121	124	115	113	100	156
1979	167	232	215	200	203	188	237	253	222	232	202	171
1980	169	221	244	240	207	190	161	164	162	144	168	167
1981	188	213	221	211	288	268	239	262	237	272	241	252
1982	211	182	167	234	200	189	170	151	172	182	204	186
1983	178	155	155	170	161	182	302	265	265	247	272	327
1984	289	255	249	261	230	206	168	156	139	133	197	182
1985	246	325	305	301	278	257	231	194	168	219	244	309
1986	336	362	365	361	316	303	258	231	194	212	254	210
1987	173	187	165	174	173	165	149	128	236	207	264	268
1988	238	321	415	503	492	471	435	375	388	349	312	364
1989	366	375	385	419	385	341	295	262	219	239	255	205
1990	184	169	149	160	145	150	140	145	122	120	114	117
1991	142	130	132	124	124	135	122	107	112	167	182	204
1992	177	168	170	168	147	163	163	161	136	142	127	106
1993	103	104	99	137	132	144	128	117	176	167	199	247
1994	303	328	351	320	282	248	249	228	199	193	174	153
1995	167	198	194	192	237	217	191	187	199	181	203	236
1996	262	295	279	262	238	205	192	186	168	166	314	325
1997	301	313	366	351	349	411	368	312	259	234	207	187
1998	182	179	203	185	170	141	125	112	103	101	96	99
1999	144	146	156	162	190	168	160	147	132	207	193	242
2000	308	318	400	399	350	322	278	234	237	212	223	216

Sneeuberg	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Expected	**204**	**219**	**231**	**240**	**237**	**222**	**210**	**196**	**192**	**192**	**197**	**209**
Threshold	**122**	**128**	**150**	**161**	**159**	**148**	**132**	**125**	**119**	**125**	**124**	**115**
2001	257	226	254	325	303	268	253	218	303	286	318	289
2002	281	258	252	226	223	218	205	236	224	192	172	220
2003	193	172	266	249	262	235	202	188	163	157	174	146
2004	172	171	175	246	216	214	201	175	216	196	170	162
2005	176	188	167	188	208	184	159	158	131	139	172	148
2006	185	196	186	204	246	222	228	349	325	325	286	280
2007	248	231	218	217	196	168	144	118	98	159	156	231
2008	271	311	312	287	267	278	249	246	206	171	153	140
2009	122	273	295	318	287	292	268	234	205	207	193	184
2010	281	265	246	225	199	196	188	160	131	111	101	130
2011	217	335	380	384	409	430	402	361	308	336	293	318
2012	273	304	348	324	284	268	333	334	307	302	255	293
2013	297	267	330	291	268	239	216	199	166	249	237	286
2014	278	310	300	351	321	285	243	223	234	214	252	222
2015	203	178	251	238	209	265	299	282	325	282	273	233
2016	251	244	224	204	205	185	173	187	159	138	123	103
2017	158	207	183	193	177	155	134	126	121	150	202	182
2018	184	219	208	273	267	238	219	195	212	187	153	126
2019	104	91	103	108	132	118	108	91	84	72	60	49