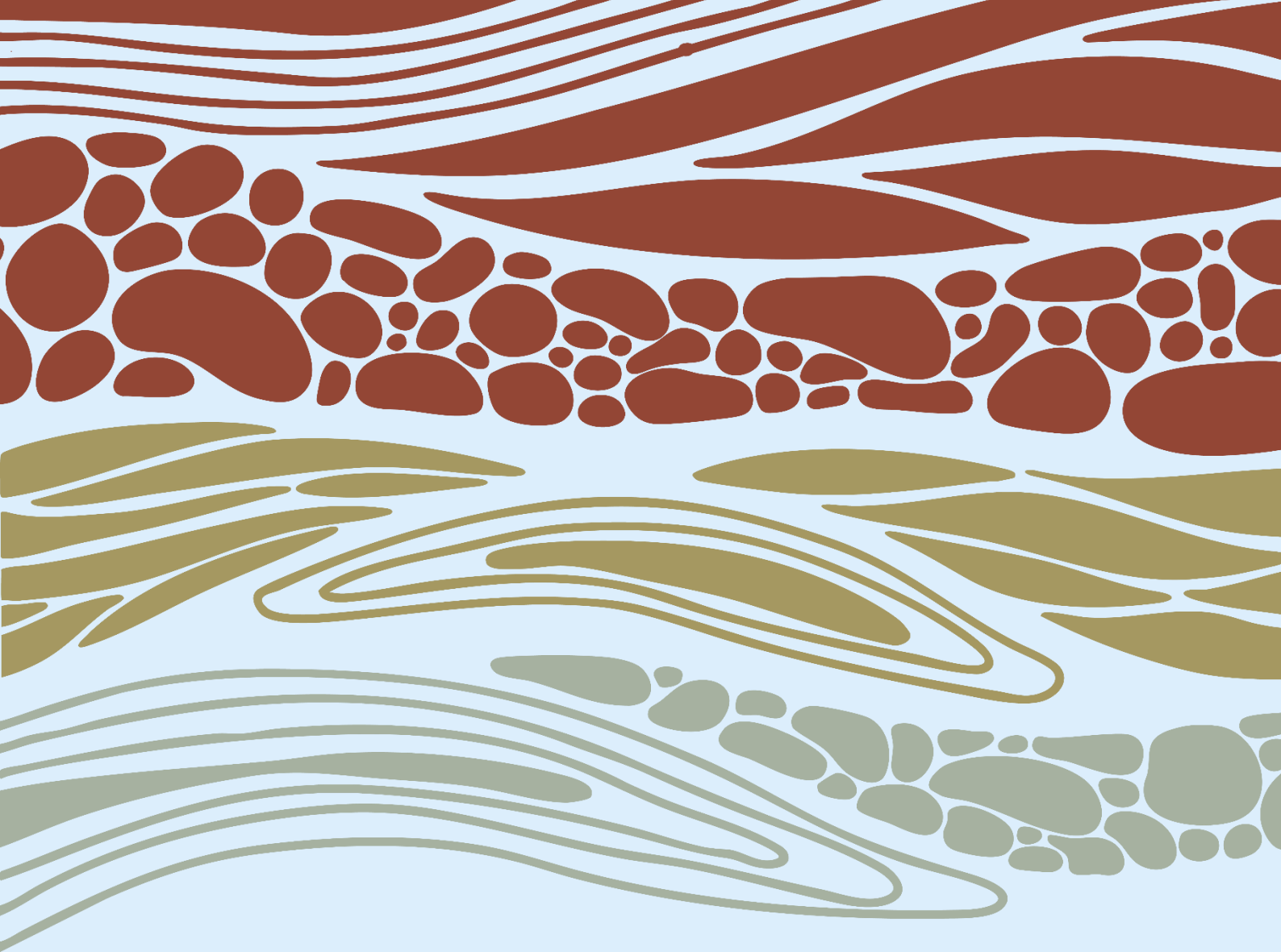




The impact of climate change on burning in Mimal

Research Summary Report by Katie Quail

September 2026



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About the research

We wanted to know if climate change is causing the good time for burning to change.

To answer this question, we started by yarning with some of the rangers and elders to find out about the indicators that are used to know when to start and stop burning. We talked about what is good fire weather and what is bad fire weather. We also talked about climate change and if anyone has been noticing any changes to the usual seasonal weather patterns or the indicators.

What were the indicators?

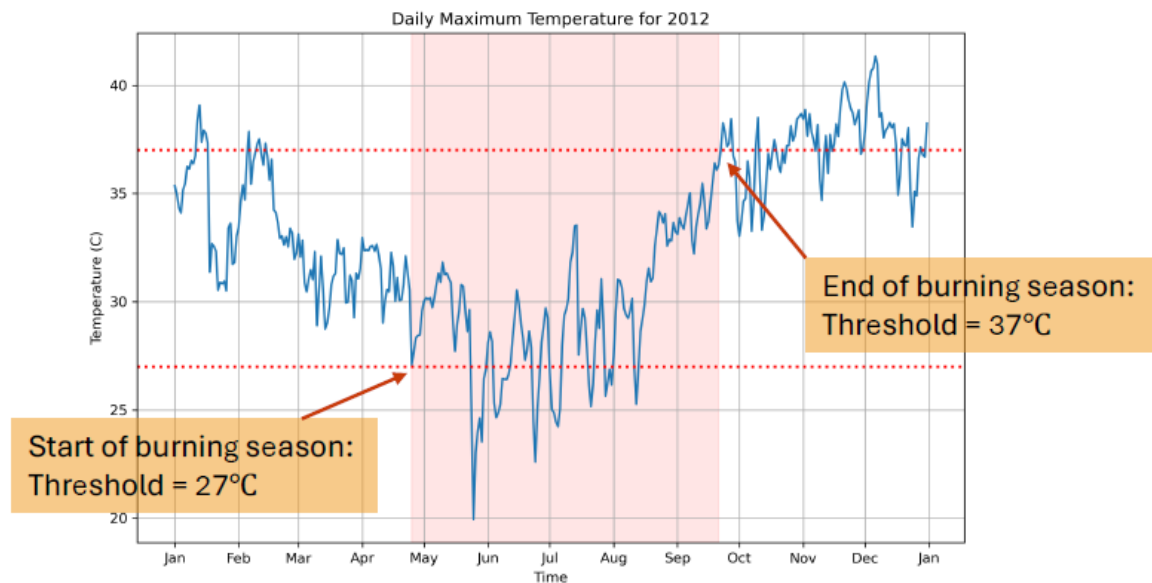
Climate related	Not climate related
The knock-em-down rains	Drying of the spear grass
Changes in temperature	Yellow/orange flowers
Wind speed and direction	Dragonflies
Humidity	Blackcurrant (juupi)
Clear skies at night	Waterlily
	Honey gum
	Bush potatoes
	The sound of the birds
	Animals getting fat
	Movement of the animals

To help us do this research we are using climate models. These are like computer programs that contain lots of information (data) about the climate from the past and in the future. This means that the easiest indicators for us to use are the ones that are related to the climate. The most important climate indicators you (the rangers and elders) talked about were the knock-em-down rains and changes in temperature. So we chose these indicators to see if they can tell us about what is going to happen to the burning season in the future.

Maximum temperature

You told us that:

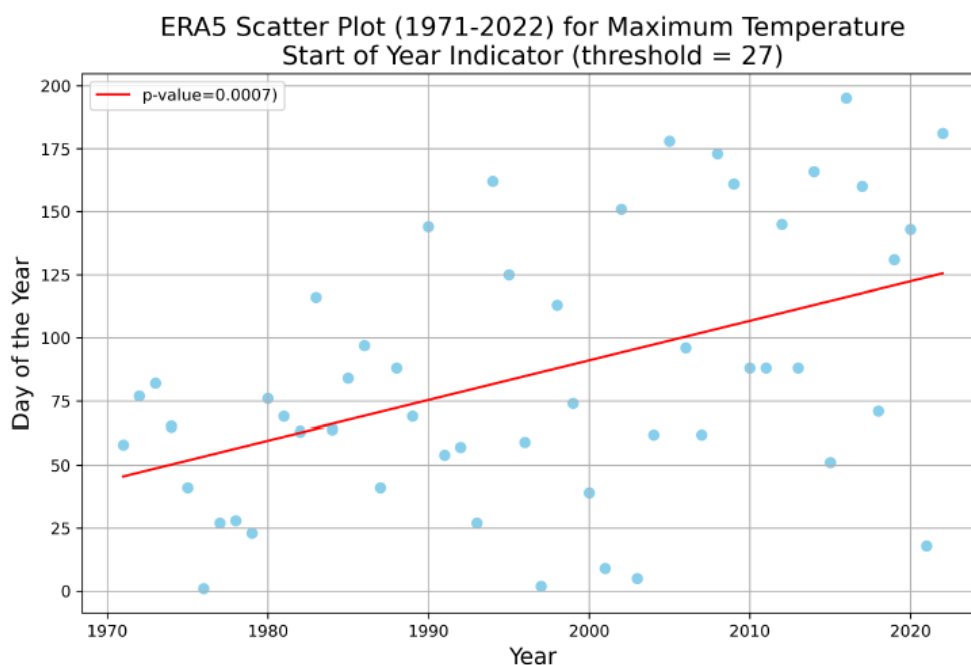
- When the temperature cools down, this is an indicator that the burning season is starting. Cool weather is good for burning.
- When the temperature gets too hot, this is an indicator that the burning season is ending, and you need to start fighting the fires. You said this happens around September.



We need to describe the indicators using specific thresholds that we can test using the climate models. To decide what threshold to use, we used the information you told us and looked at some time-series plots to see what the usual seasonal patterns are in Bulman. An example of this is shown above.

Start of season – what has been happening in Bulman?

First, we can check the data to see if the indicators have been changing in the past. The data we are using is called ERA5 and it's the closest thing we have to observations.



In this scatter plot, each dot shows the day of the year when the maximum temperature first dropped below 27 degrees. This is our indicator for the start of the burning season.

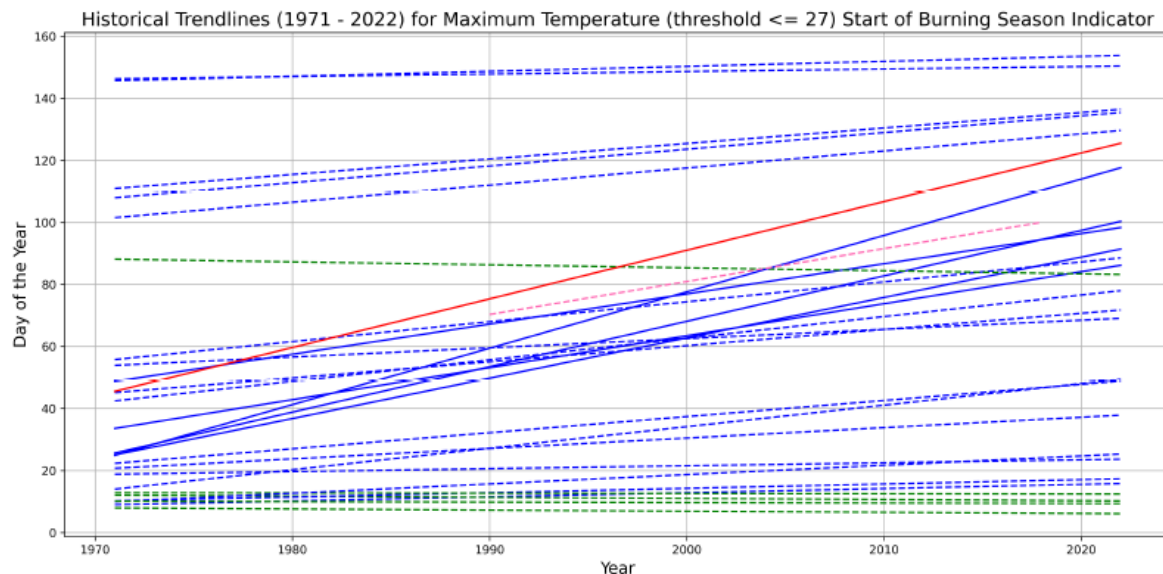


An increasing trendline means that over time, the maximum temperature indicator for the start of burning season has been happening later in the year.

Now let's check the climate models ...

We can use climate models to help us predict what will happen to these indicators in the future. But before we do, it's a good idea to check if the models have been making good predictions of the past. This helps us to know which models we can trust the most. They're the ones that are likely to give us the best result for the future.

Past trendlines for start of season



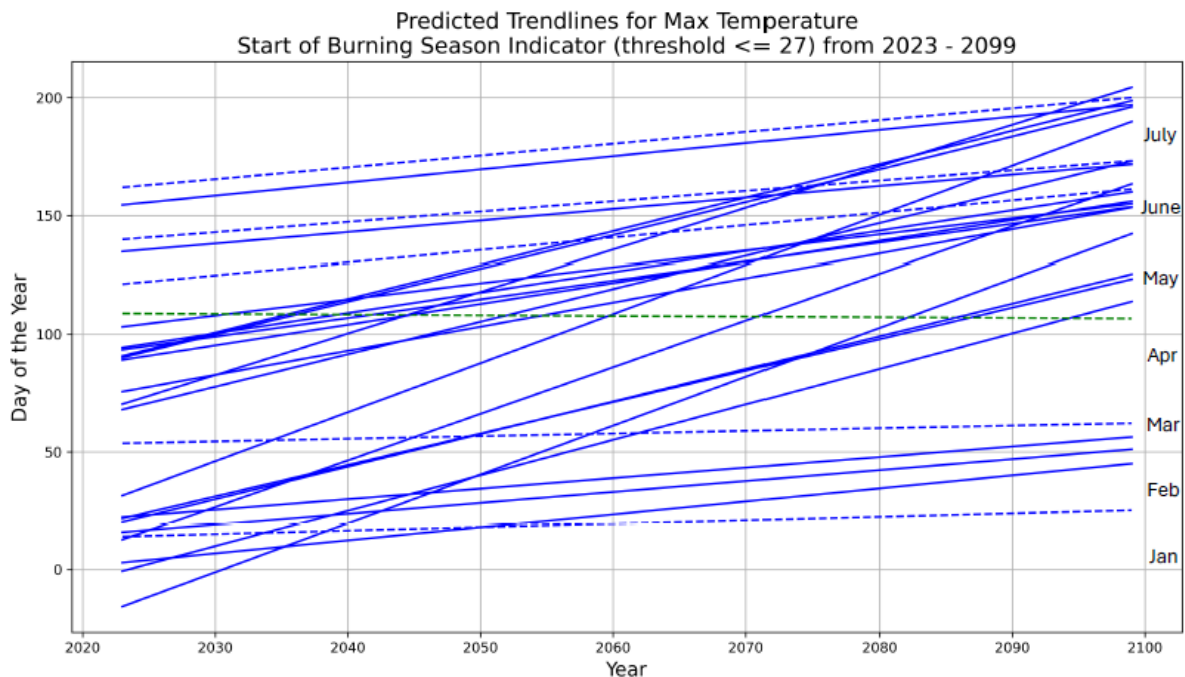
In this figure, the red line shows the trend from ERA5 which we saw in the scatter plot on the previous page. The blue and green lines show the trends from all the climate models. We want to compare the climate models to the closest thing we have to real observations which is the ERA5 data. Since ERA5 (in red) is increasing, we can trust the models in blue that also have an increasing trend more than the models in green that have decreasing trends.

What do the models say about the future?

Now that we know which models we can trust the most, we can look at what these models predict will happen in the future. This plot shows the results from all of the blue models that we saw on the previous page. If the line is dotted, it means the result was statistically not significant. This means that we can't really be sure that this will happen. If the line is solid, it means the result was statistically significant. This means we can be confident that this result is likely to happen.



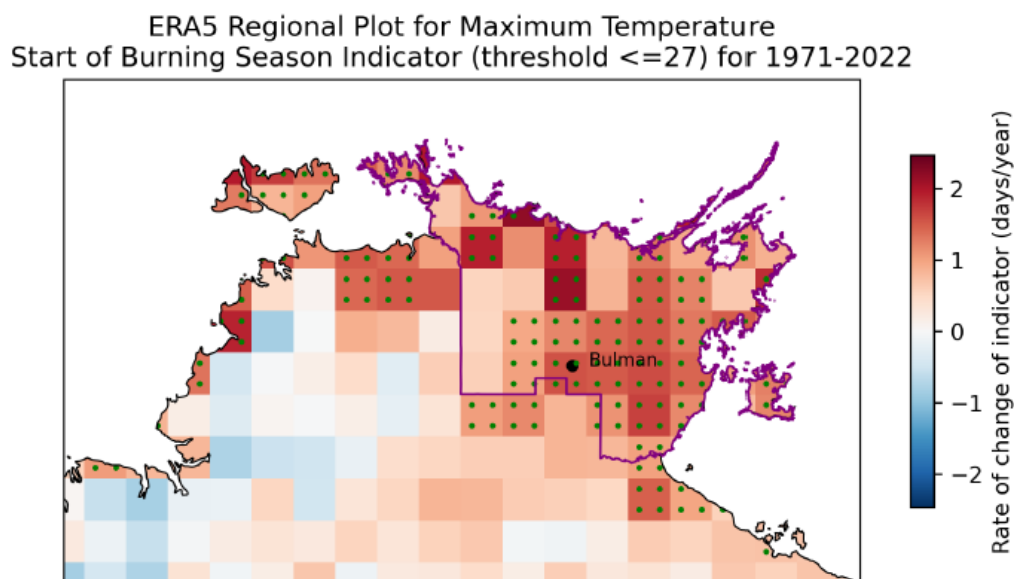
Future Trendlines for start of season



What we see in this figure is that most of the lines are increasing. This means that over time, the maximum temperature indicator for the start of the burning season is shifting to later in the year. We can also see that most of the lines are solid lines, which means we are confident about this result.

What about the region?

The results we have seen so far have been for Bulman. Now we can look at what is happening in the rest of the region.





In this figure, the colour shows the rate of change of the indicator. A darker red colour means that if you were to make a scatter plot for this location, it would have a steep increasing trendline. Blue colours would have a decreasing trendline. Lighter colours would have a flatter trendline.

The dots on the map show that in these locations, the results were significant. This means we can be more confident about the results in these areas.

This figure uses ERA5 data, our closest thing to observations. We can see that in the Arnhem land region, the red colour shows that over time the start of burning season indicator has been happening later in the year.

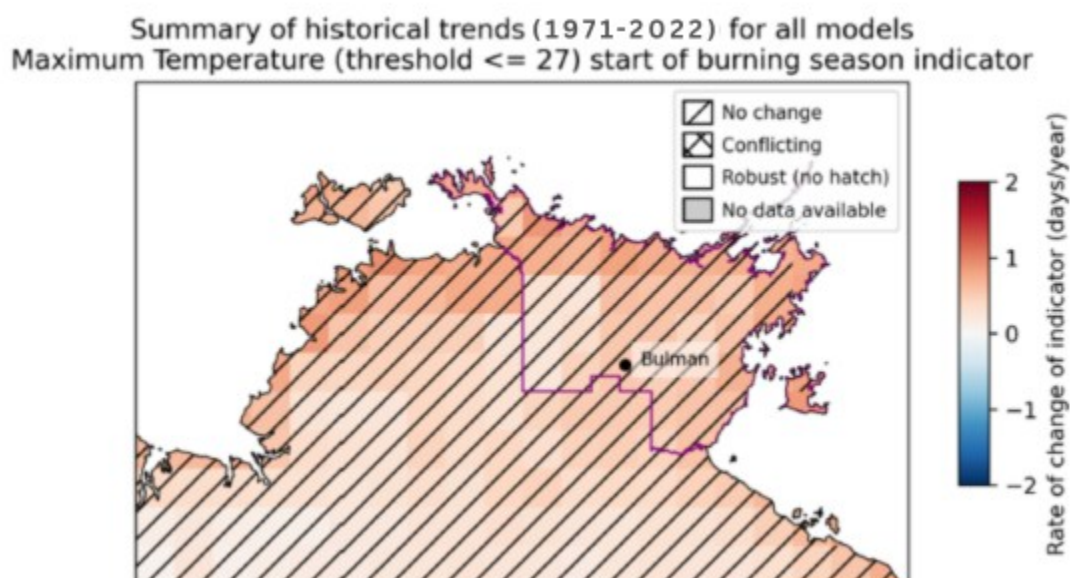
There are dots covering most of this region as well, which means we can be confident about this result.

Start of year summary plots

These summary plots combine the information from all of the climate models into one figure. Now, the colour shows the average rate of change of the indicator.

The dashed lines on the map show the areas where less than two thirds of the models were significant. We call this “no change” because we can’t be sure about these results.

The areas where there are no dashes are where two thirds or more of the models were significant, and they agree with each other about whether the change is increasing or decreasing. We call this “robust”, because it means we can be confident about our results in these areas.

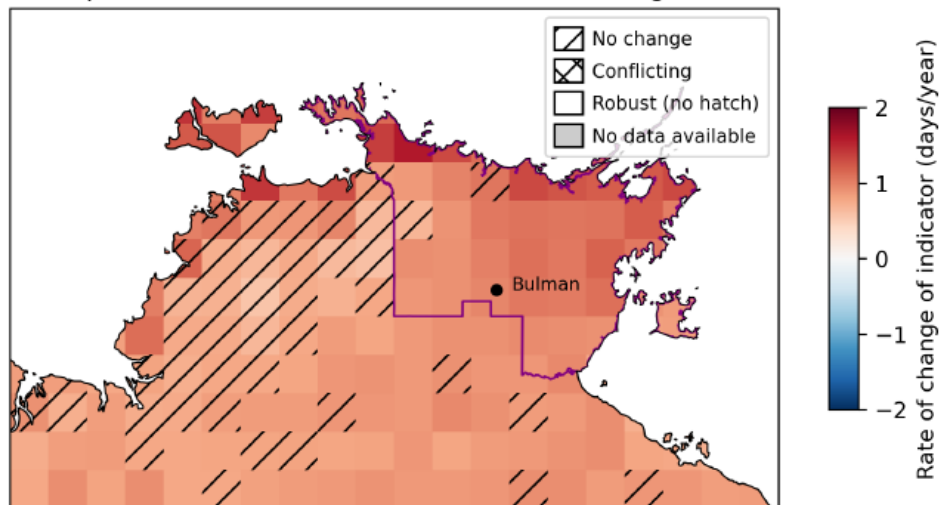


We can see that the whole region has a light red colour which means that, on average, the start of burning season indicator has been happening later in the year. However, we can also see dashes across the whole map. This means that we can’t be sure about these results. We could also say that there has been no change to the indicator.

Now we can look at summary plots for the future. This first plot includes data from all of our climate models.

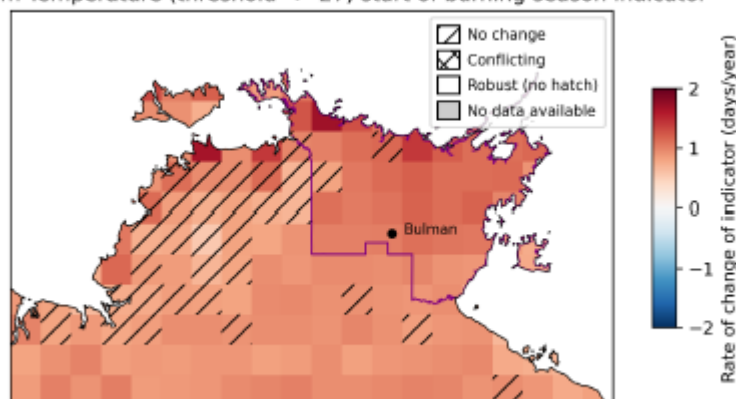


Summary of predicted trends (2022 - 2099) for all models
Maximum temperature (threshold ≤ 27) start of burning season indicator



We can see that the whole region has a red colour which means that, on average, the start of burning season indicator is predicted to shift later in the year. The darker the red, the faster this will happen. For Bulman and most of Arnhem land, there are no dashes which means the result is robust. We can say that we are confident about this result.

Summary of predicted trends (2022 - 2099) for positive models
Maximum Temperature (threshold ≤ 27) start of burning season indicator

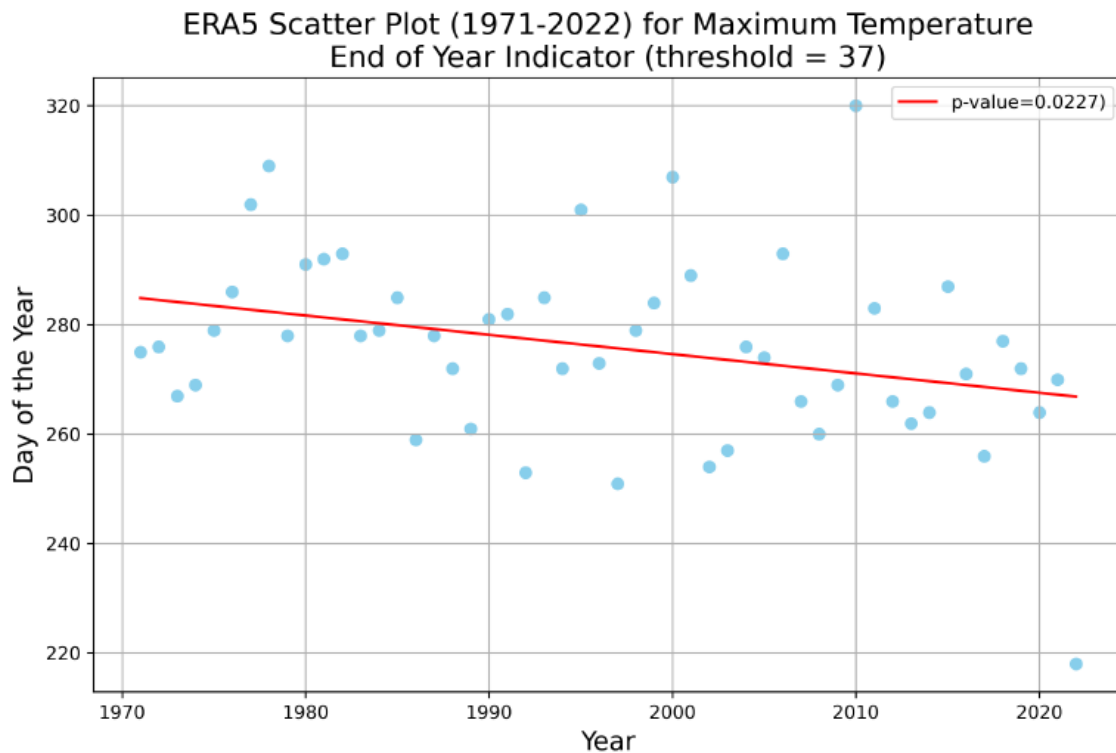


The plot on the left only includes the models that we trusted the most (the ones in blue from the trendline plot). It is very similar to the plot with all the models above, so we can keep the same conclusion as before.



End of season – what has been happening in Bulman?

We have seen the predictions for what will happen to the start of the burning season. Now, let's look at the ERA5 data (the closest thing to observations) for the end of the burning season.



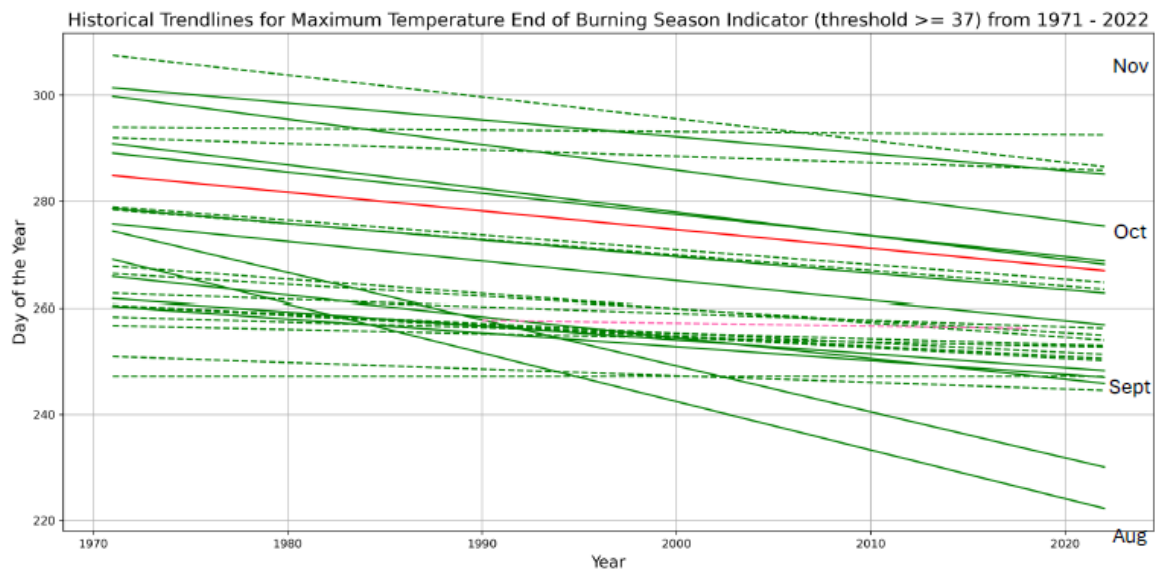
In this scatter plot, each dot shows the first day of the year after cool season when the maximum temperature was higher than 37 degrees. This is our indicator for the end of the burning season.

A decreasing trendline means that over time, the maximum temperature indicator for the end of burning season has been happening earlier in the year.

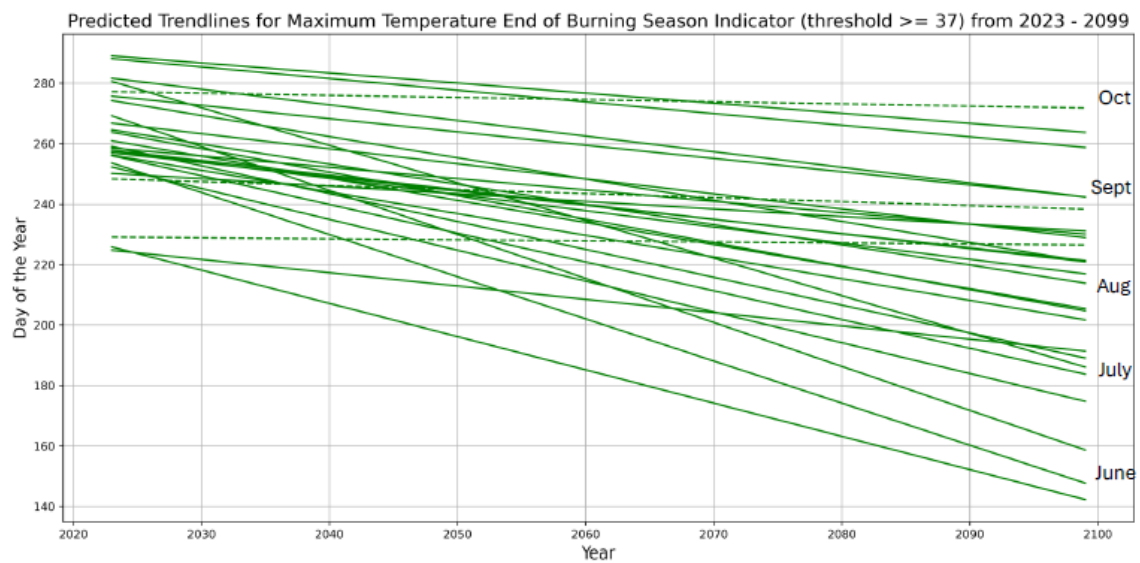
Just like we did for the start of season, we need to check how well the climate models have been predicting what has been happening to the end of season indicator in the past.



Past Trendlines for end of season



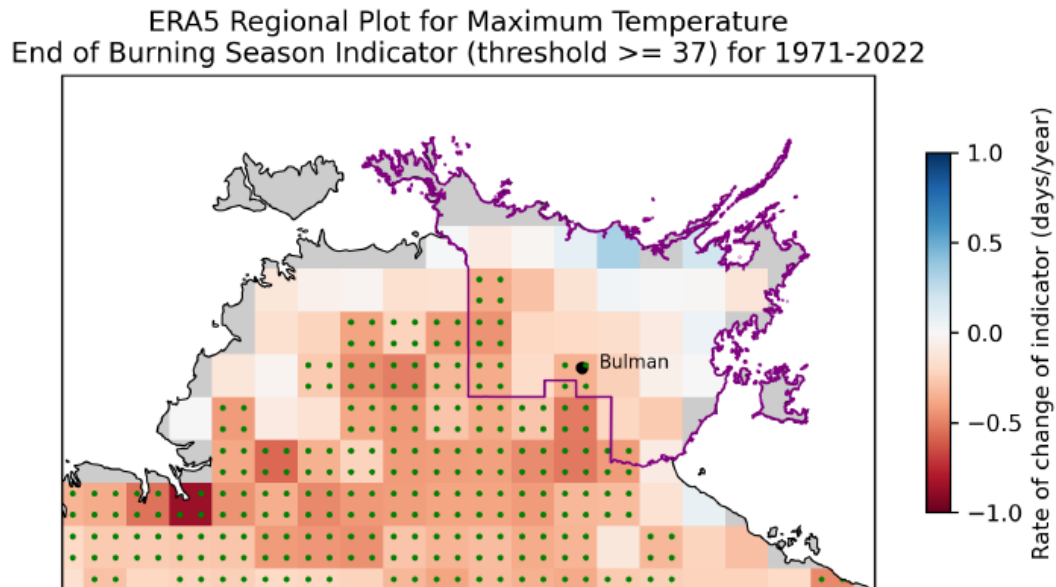
Future Trendlines for end of season



Here we see that all of the climate models are decreasing, and they are mostly solid lines. This means we can be confident that the end of season indicator is shifting to earlier in the year.

Results for the region

The results we have seen so far have been for Bulman. Now we can look at what is happening in the rest of the region.



In this figure, the colour shows the rate of change of the indicator. The darker the colour, the faster the indicator is changing. This time, red colours represent decreasing trends and blue colours represent increasing trends. This is because a decreasing trend means that the indicator (the first day after the cool season with a temperature of 37 degrees or higher) is happening earlier in the year, which is what would happen if the climate was getting hotter. We want red to represent the result under a warming climate.

This figure uses ERA5 data, our closest thing to observations. In most of the region, the red colour shows that over time the end of burning season indicator has been happening earlier in the year and the dots mean that we are confident about this result. However, this trend is less true closer to the coast. For most of Arnhem land, there are no dots which means we are not sure of the result here.

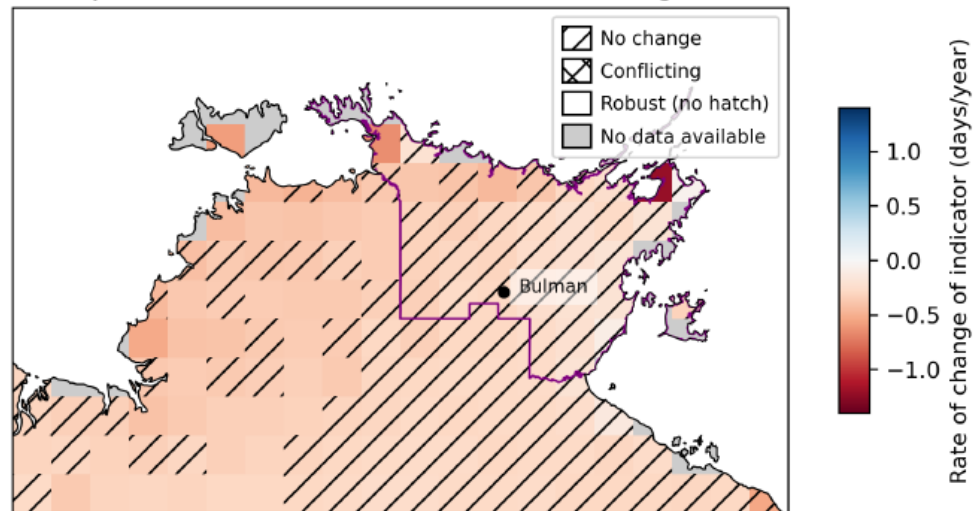
End of year summary plots

These summary plots are made using the same rules as the ones for the start of the burning season. The colour shows the average rate that the indicator is changing. The dashed lines show “no change” – these are areas where we can’t be sure about the results. No dashes are “robust” areas where we are confident about our results.

These plots also have some areas shown in grey. If an area is grey, it means that the temperature never went above 37 degrees for 50% or more of the years. If you imagined this as a scatter plot, it wouldn’t have many dots. When there are too few dots, we can’t trust the trendline, so we just don’t use it.



Summary of historical trends (1971 - 2022) for all models
Maximum Temperature (threshold ≥ 37) end of burning season indicator

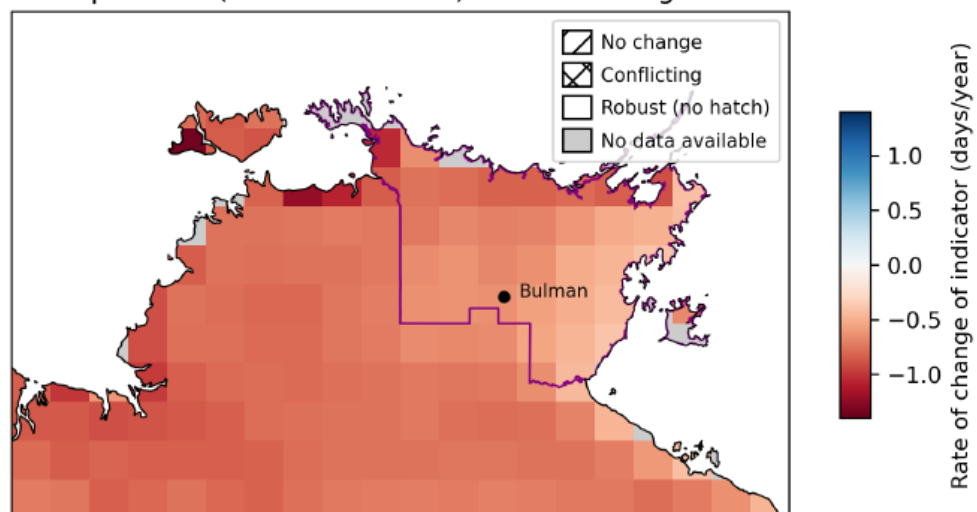


We can see that almost the whole region has a light red colour which means that, on average, the end of burning season indicator has been happening earlier in the year.

However, we can also see dashes across the whole map. This means that we can't be sure about these results. We could also say that there has been no change to the indicator.

Now we can look at the summary plots for the future. This first plot includes data from all of our climate models.

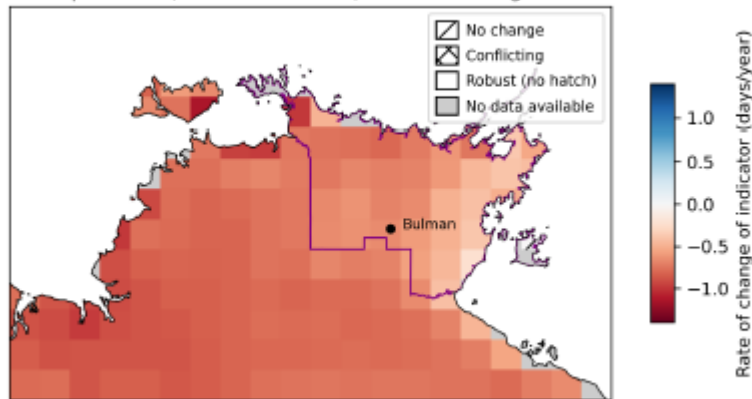
Summary of predicted trends (2023 - 2099) for all models
Maximum Temperature (threshold ≥ 37) end of burning season indicator



We can see that the whole region has a red colour which means that, on average, the end of burning season indicator is predicted to shift earlier in the year. The darker the red, the faster this will happen. There are no dashes for the entire region, which means that in all locations the result is robust. We can say that we are confident about this result.



Summary of predicted trends (2023 - 2099) for significant negative models
Maximum Temperature (threshold ≥ 37) end of burning season indicator

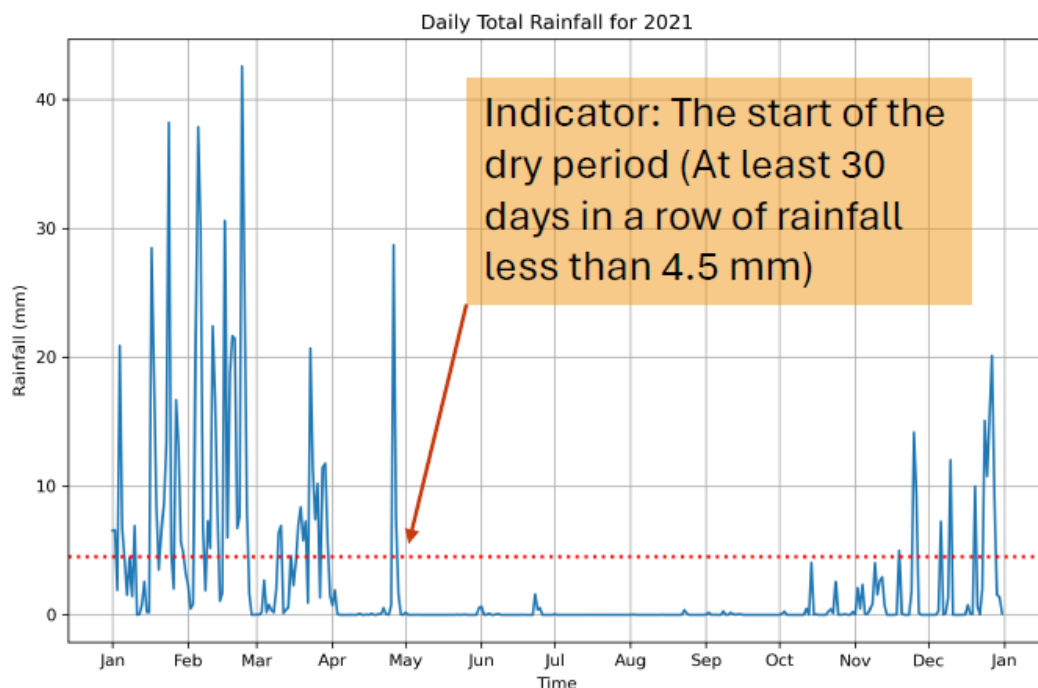


The plot on the left only includes the models that we trusted the most (the ones with a significant negative trendline). It is very similar to the plot with all the models above, so we can keep the same conclusion as before.

Knock-em-Down Rains

You told us that:

- The knock-em-down rains are the last rains that come at the end of the wet season and they flatten the grasses
- When the knock-em-down rains come, it's almost time to start burning.



To decide how to model this, we used the information you told us and looked at a time-series plot to see what the usual seasonal patterns are in Bulman.

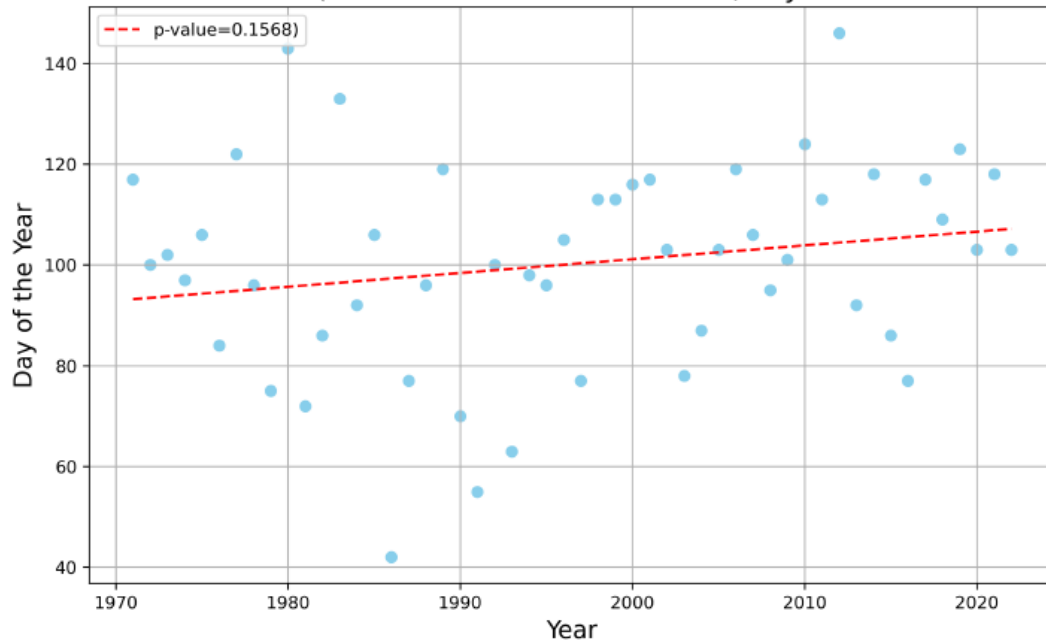
The rain can vary a lot from year to year, so we found that it was easier to look for the start of the dry period that begins after the knock-em-down rains rather than the rains themselves.



What has been happening in Bulman?

Let's look at the ERA5 data to check what's been happening in the past.

ERA5 Scatter Plot (1971-2022) for Knock-em-Down Rains
Start of Year Indicator (rainfall threshold ≤ 4.5 mm, days threshold ≥ 30 days)

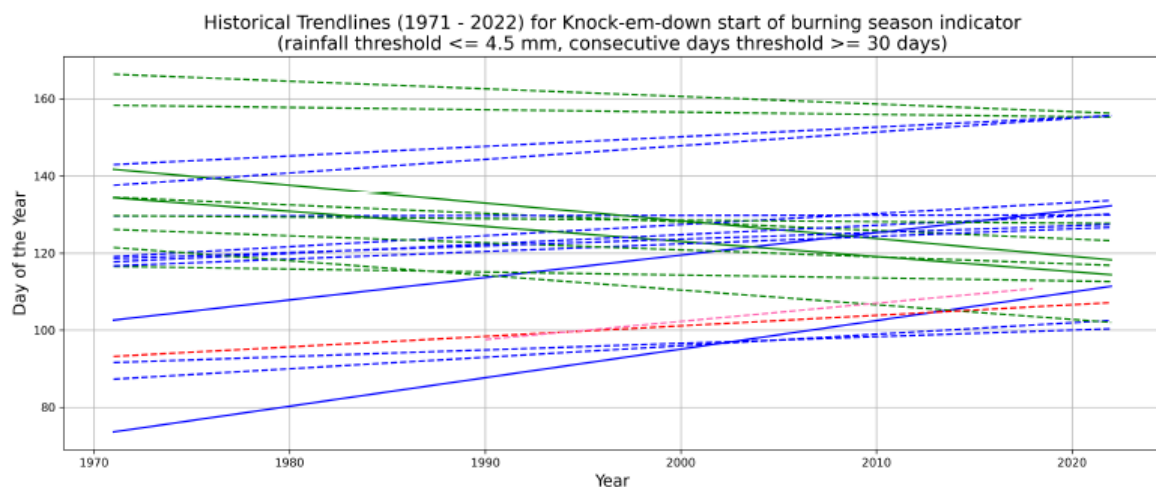


In this scatter plot, each dot shows the first day of the dry period which begins after the knock-em-down rains. We define the dry period as at least 30 days in a row of rainfall less than 5 mm. This is our indicator for the start of the burning season.

An increasing trendline means that over time, the knock-em-down rains indicator for the start of burning season has been happening later in the year. However, the line is dotted, which means we are not confident about this result.

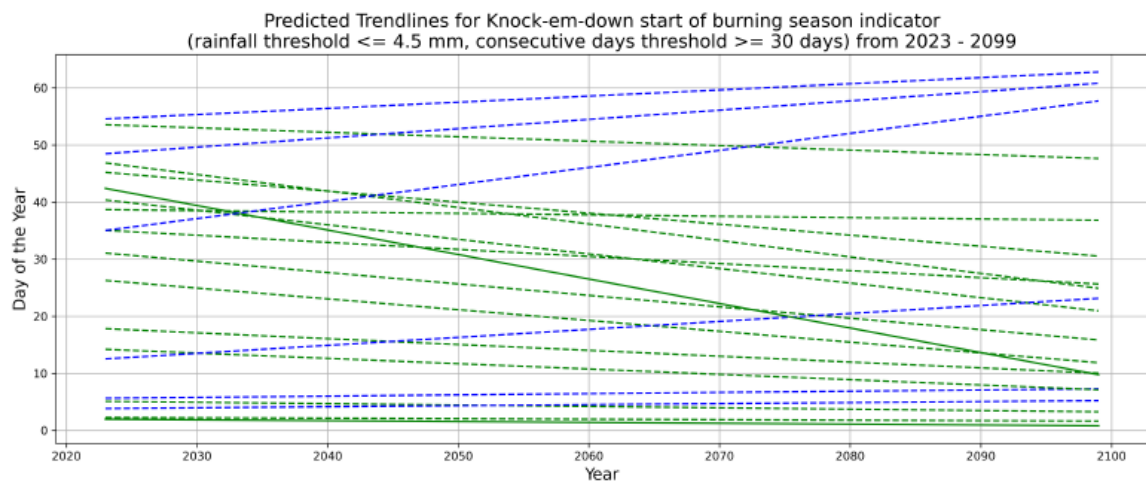
Now let's check the climate models...

Past Trendlines for end of season





Future Trendlines for end of season

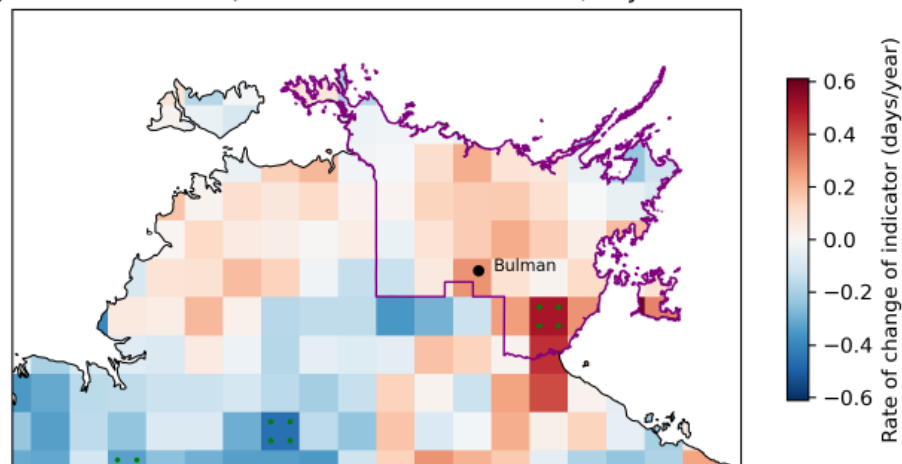


Here we see that some of the climate models are increasing and some are decreasing. There is not a clear pattern about what has happened in the past or what is predicted for the future. We cannot make any conclusions about whether the knock-em-down rains are changing based on these results.

Results for the region

The results we have seen so far have been for Bulman. Now we can look at what is happening in the rest of the region.

ERA5 Regional Plot for Knock-em-Down Rain (1971-2022)
Start of Burning Season Indicator (rainfall threshold ≤ 5 mm, days threshold ≥ 30 days)



In this figure, the colour shows the rate of change of the indicator. Here we see both red and blue, which means in some areas the rains are happening later (red) and in some areas they are happening earlier (blue). It is harder for the climate models to predict rainfall than it is for temperature, which could be part of the reason why the results are not as clear.

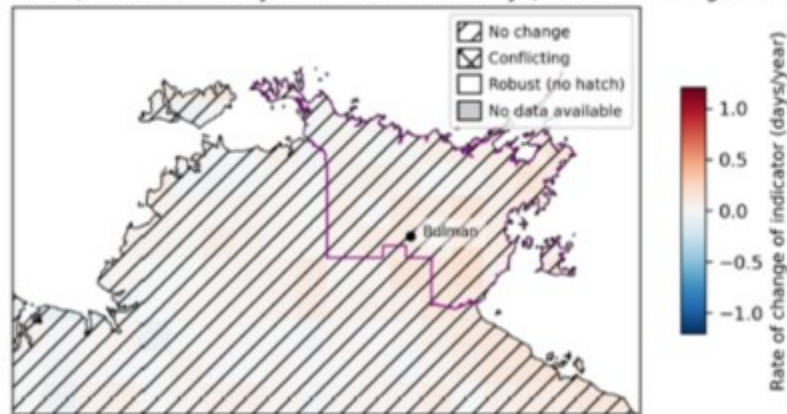
This figure uses ERA5 data, our closest thing to observations. We can see that in most of the Arnhem land region, the red colour shows that over time the knock-emdown rains have been happening later in the year, but there are almost no dots which means we are not very confident about this result. We cannot say for sure that the rains have been changing.



Summary plots

These summary plots are made using the same rules as the ones for temperature. First, let's look at the summary plot for the past.

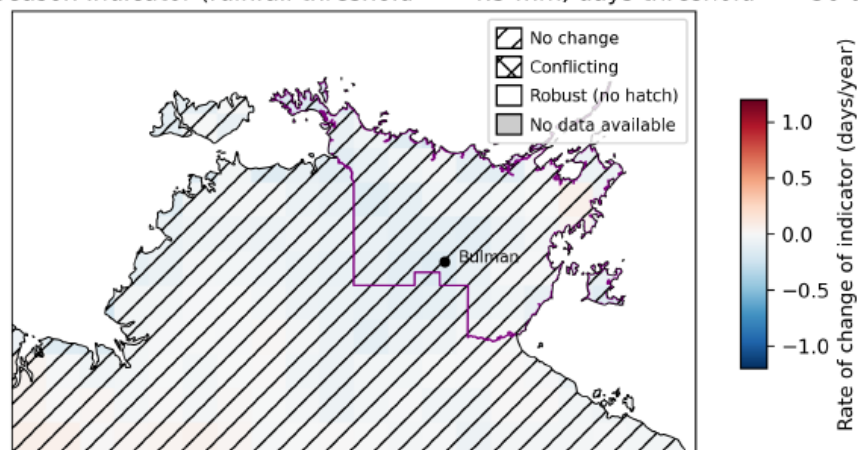
Summary of historical trends (1971-2022) for all models Knock-em-Down Rains (rainfall threshold ≤ 4.5 mm, consecutive days threshold ≥ 30 days) start of burning season indicator



We can see there is a very light colour for the whole region. The lighter the colour, the less the indicator has been changing. We also see dashes across the whole map. Based on this, we would say that there has been no change to the indicator.

Now we can look at the summary plots for the future.

Summary of Predicted Trends (2022 - 2099) for all models Knock-em-Down Rains Start of Burning Season Indicator (rainfall threshold ≤ 4.5 mm, days threshold ≥ 30 days)



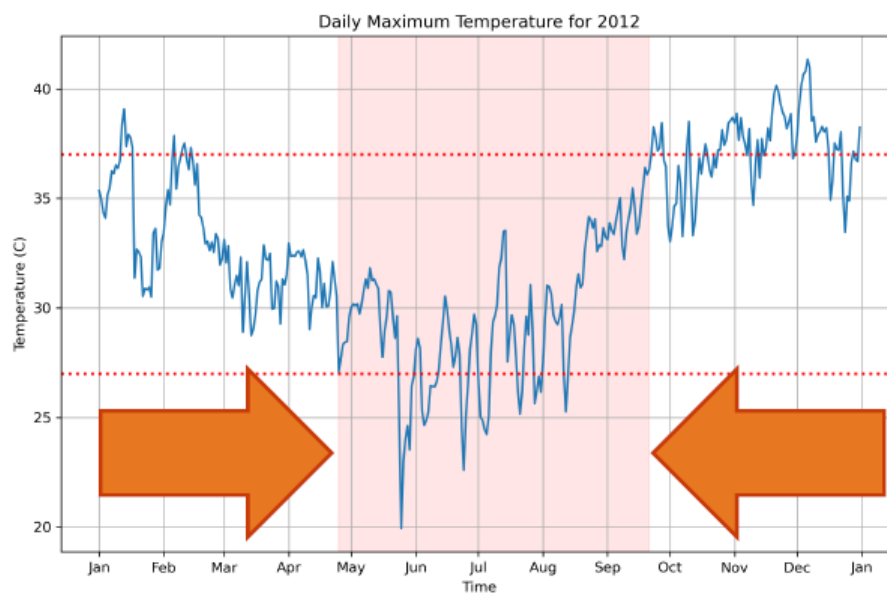
Again, we see that the whole region has a very light colour, close to white, and there are dashes covering the whole region. This means that our climate models do not predict any change for the knock-em-down rains in the future.



Conclusion

Maximum Temperature

- The start of the season is shifting later in the year
- The end of the season is shifting earlier in the year
- Overall, this means the good time to burn (when the temperature is cool) is getting shorter.
- We are confident about this result.



Knock-em-Down Rains

- The timing of the knock-em-down rains is not changing
- We are not confident about this result.

Thank you

Thank you to everyone who was involved in making this research happen – especially the rangers and elders from Mimal who shared their knowledge with me and taught me all about burning.



If you have any questions about the research or just want to get in touch to talk to me about them, please reach out!



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