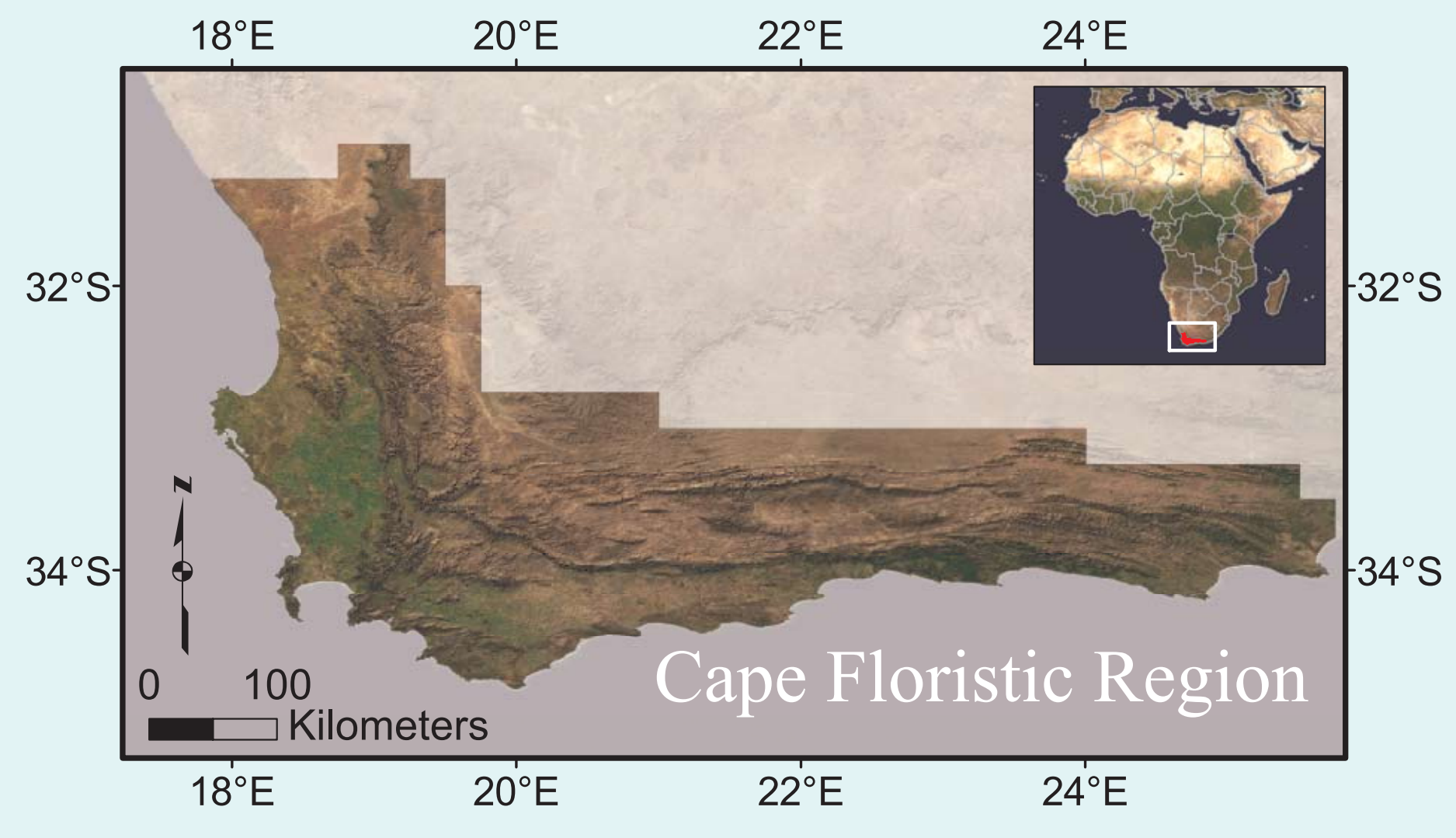


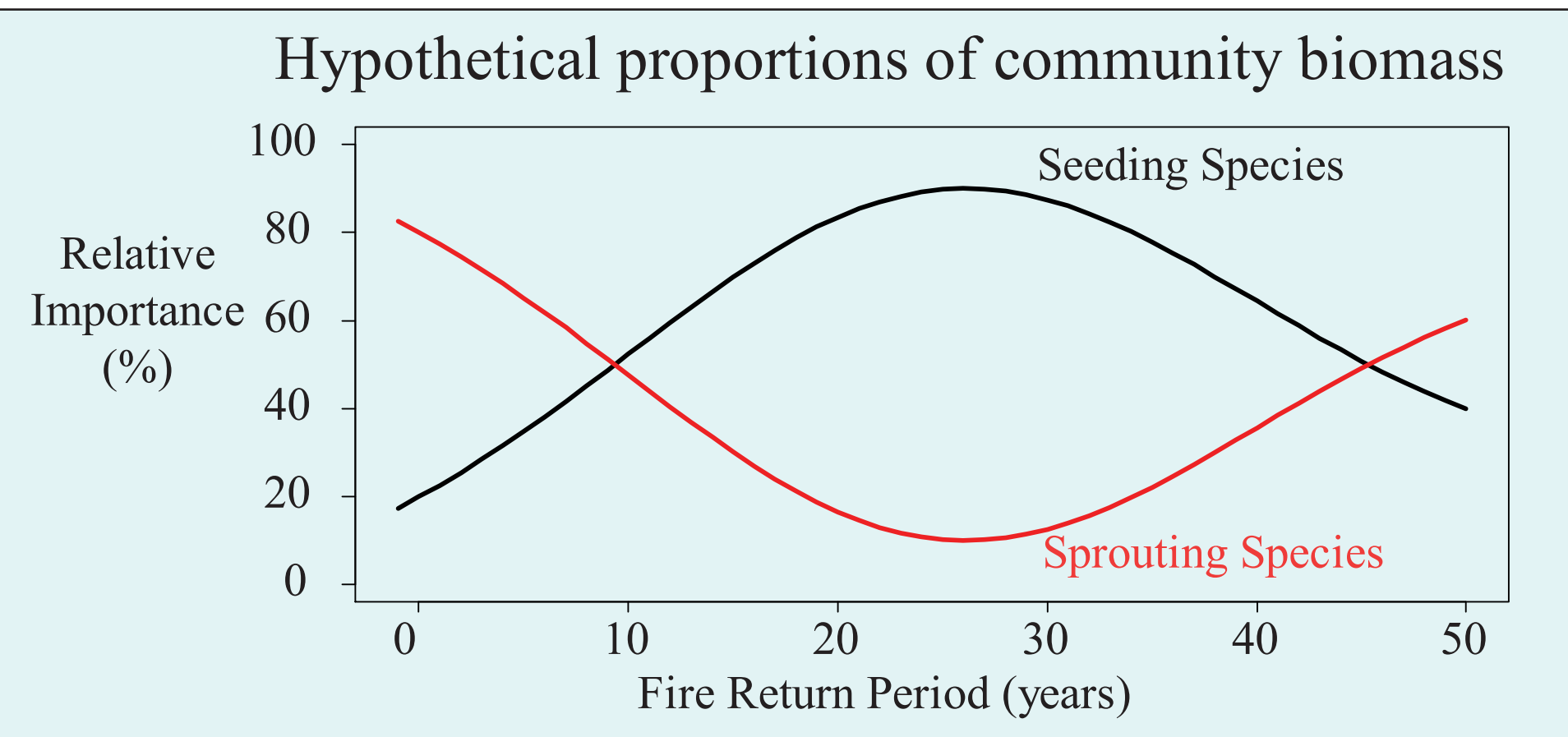
# The fire – weather relationship in the South African *Fynbos*: Implications under climate change

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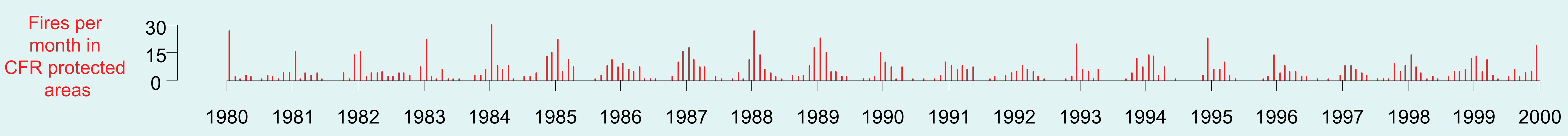
## Introduction

The Cape Floristic Region (CFR) of South Africa is an internationally recognized hotspot of floral biodiversity and is home to over 8,000 plant species, 69% of which are endemic. One important biome within the CFR is the *Fynbos* (Africans for “fine forest”), which is dominated by scleromorphic shrubs such as the *Proteacea*. In contrast to other regions with high levels of biodiversity, such as the Amazon rain forest which is dominated by locally rare species with large ranges, the CFR species tend to be locally abundant but have small ranges and limited dispersal capabilities. These factors make the region’s flora vulnerable to decreased precipitation and shifts in the seasonality of precipitation predicted under future climate change.



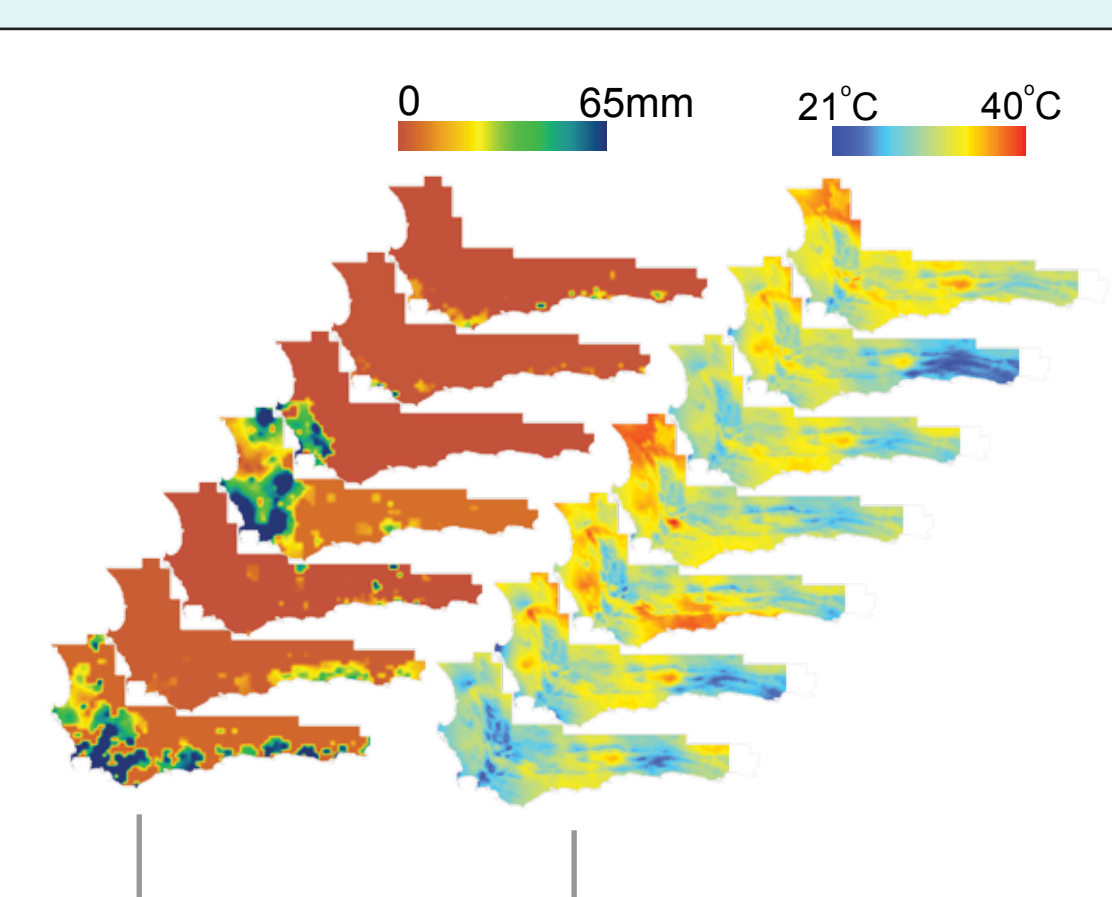
Various plant species have different strategies for responding to fire (some rely on seeds that require fire for germination, while others re-sprout from the rootstock), making fire return time an important determinant of the community makeup. This is especially true along ecosystem margins, where other environmental conditions are favorable for two or more ecosystem types (Bond, 1983). Thus a change in fire frequency may drive changes in community composition. Figure adapted from Booysen & Tainton (1984).

**Does variation in precipitation and temperature drive the occurrence of fire?  
How strongly do global-level weather cycles (El Niño) influence fire in the CFR?**



## Methods and Data

We constructed Bayesian hierarchical regression models to identify the sources of variability in annual fire occurrence. Models included spatial and temporal random effects, as well as a missing data model to handle censored fire observations. The data were collated into a grid of 2x2km cells in reserves in Mountain Fynbos regions of the CFR.



**Weather**  
Daily temperature and precipitation were interpolated for the region by the Climate Systems Analysis Group in Cape Town. These data were used to generate annual metrics of average and extreme weather for the spring summer months:

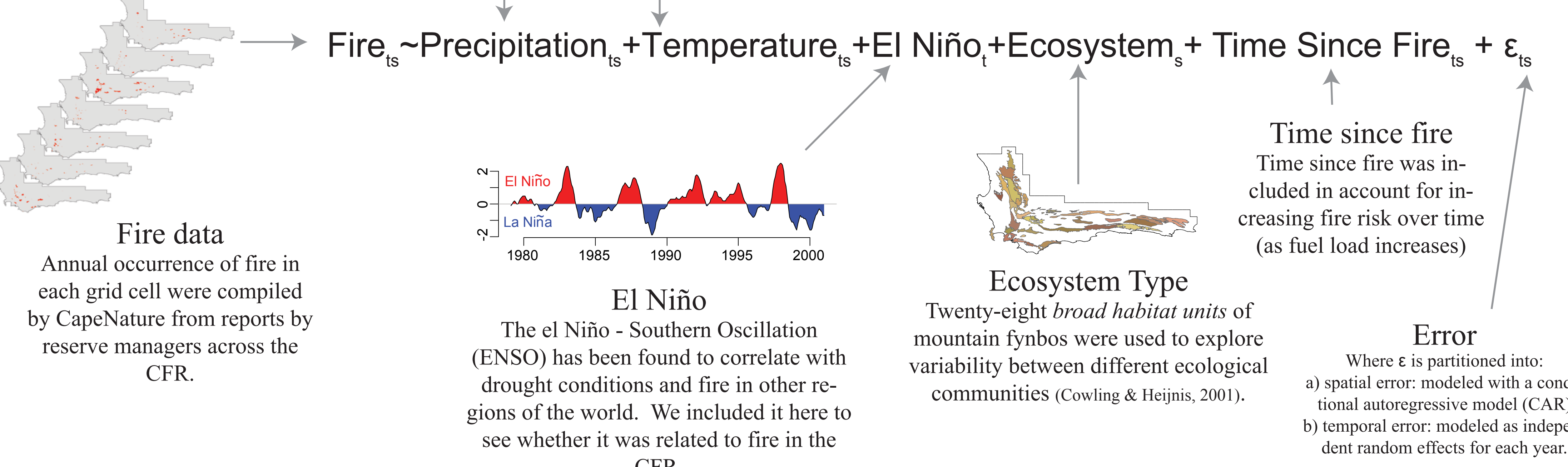
- Average temperature
- Temperature of the hottest week
- Total precipitation
- Length of the longest dry spell



### Meteorological Trends 1980-2000

We looked at change over the study period by conducting a linear regression in each cell of the interpolated temperature (0.05 degree) and precipitation (0.1 degree) data. The smoothed slope coefficients are displayed to the left. It is clear the west has experienced a decrease in spring - summer precipitation and an increase in the length of the longest dry spell. Temperature change has been more heterogeneous with warming in the majority of cells, but some pronounced areas of cooling in the west.

- Change in total spring / summer precipitation (mm): -10 to 11
- Change in the length of the longest dry-spell (days): -4.7 to 3.0
- Change in average spring summer temperature (°C): -0.10 to 0.16
- Change in the hottest week of the spring / summer (°C): -0.17 to 0.20



## Results & Discussion

Time since fire was the most important predictor of fire occurrence (because a critical mass of fuel is needed to sustain a fire). Total seasonal precipitation has a negative relationship with fire, while maximum drought length and mean seasonal temperature have positive relationships. This makes sense, as one would expect more fires in hotter, drier seasons (Figure 1). El Niño was also significantly correlated with fire occurrence.

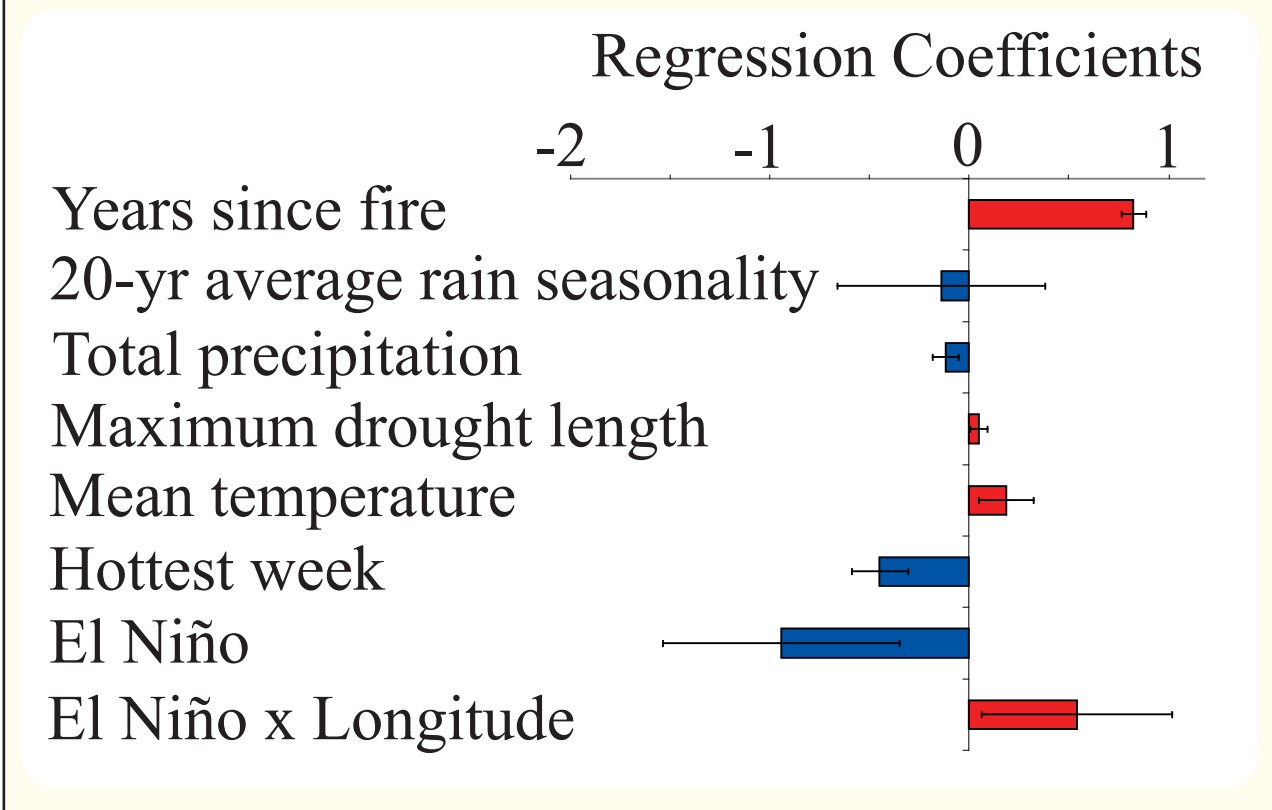


Figure 1: Regression Coefficients from the model. Positive coefficients represent factors that are positively associated with fire. The error bars are 95% credible intervals.

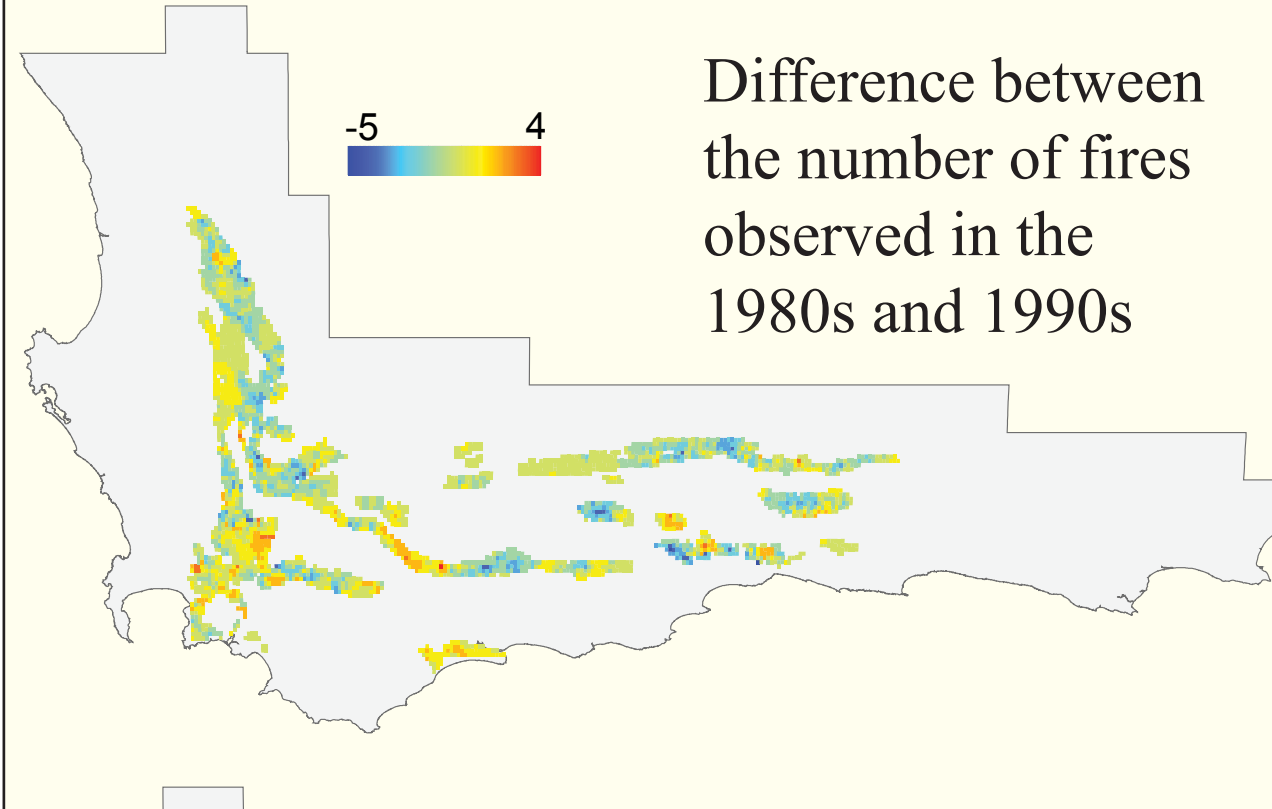


Figure 2: Map of the differences in the number of observed fire occurrences in the 1990s minus the 1980s. Note several areas in the west experienced more fires in the 1990s, while much of the east experience fewer fires.

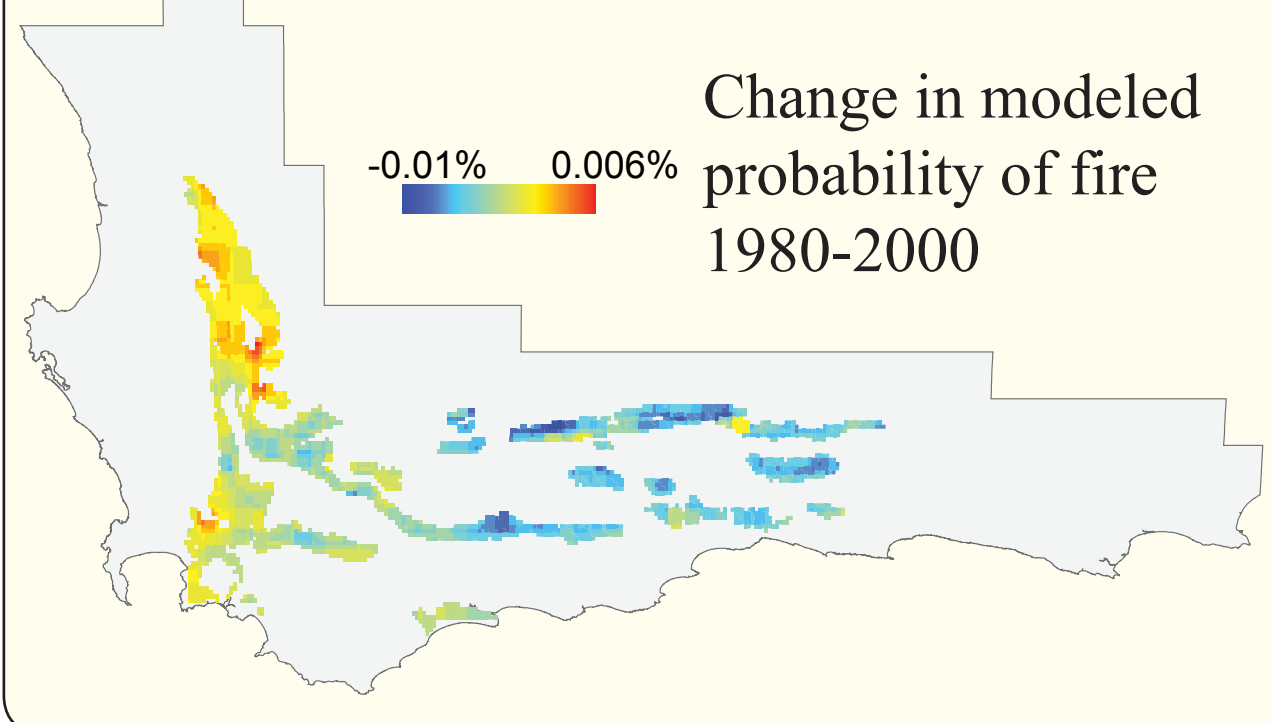


Figure 3: Map of trend from 1980-2000 in modeled fire probability due to climatic factors (i.e. trend in the climate component of the model, after correcting for time since fire and ecosystem type). These trends (average probability 1990-2000 minus 1980-1989) represent changes in fire probability due to observed weather conditions (including el Niño) experienced over the past 20 years. Note the east-west gradient in fire probability

## Conclusion

In the past 20 years the mountain fynbos regions of the CFR have become warmer and wetter in the east and slightly cooler and drier in the west. Our models reveal that fire is correlated with increased temperature and decreased precipitation and estimate that the meteorological changes over the past two decades have led to differential changes in fire probability. There was an increased probability of fire in the west and decrease in the east in the 1990s compared to the 1980s.



These results make it clear that regional and global variability in climate must be taken into account when considering the impacts of global climate change. The changes over the past 20 years have been different across the region, but have also been affected by the el Niño Southern Oscillation, which is a globally important phenomenon. The el Niño has strongly affected fire probability, primarily in the West, with strong el Niño corresponding to much lower fire probability and weak (la Niña) conditions with enhanced fire risk. As climate continues to change, we can expect more region-specific shifts in the fire regime which will likely lead to changes in community composition.

## Future Work: Remote Sensing

Due to the limited observational area and variable sampling effort of the reserve fire database, we plan to expand our analysis and include fires identified by satellite normalized difference vegetation index (NDVI). This dataset also offers the possibility of tracking phenological variability in the CFR vegetation.

The top image is a sample scene of 1km NDVI data from the NOAA-AVHRR satellite. Green cells indicate higher NDVI values (and thus greater plant ‘greenness’). The two lower images illustrate the NDVI from before and after a fire. Note the drastic decrease in NDVI values in the lower left corner. The images were taken 10 days apart. The red line in the lower scene is the outline of the fire from the reserve database used in this analysis.

## Literature cited:

de Booysen, P., N. Tainton. Ecological Effects of Fire in South African Ecosystems. Ecological Studies. Issue 48, page 86. 1984

Cowling, RM., CE Heijnis (2001) The identification of Broad Habitat Units as biodiversity entities for systematic conservation planning in the Cape Floristic Region. *South African Journal of Botany*. 67: 15-38.

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