Importance of Fire Regime and Vegetation Growth Rates in Species Distributions in the Cape Floristic Region

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NRF National Research Foundation
SAEON South African Environmental Observation Network

Background

Contains approx. 9000 plant species , 69% endemic, fynbos being most dominant

Generates almost R77 million a year – ecotourism, wildflowers, food and drugs

Threats include agricultural expansion, urban encroachment and invasion of alien plant species

Fire dependent ecosystem

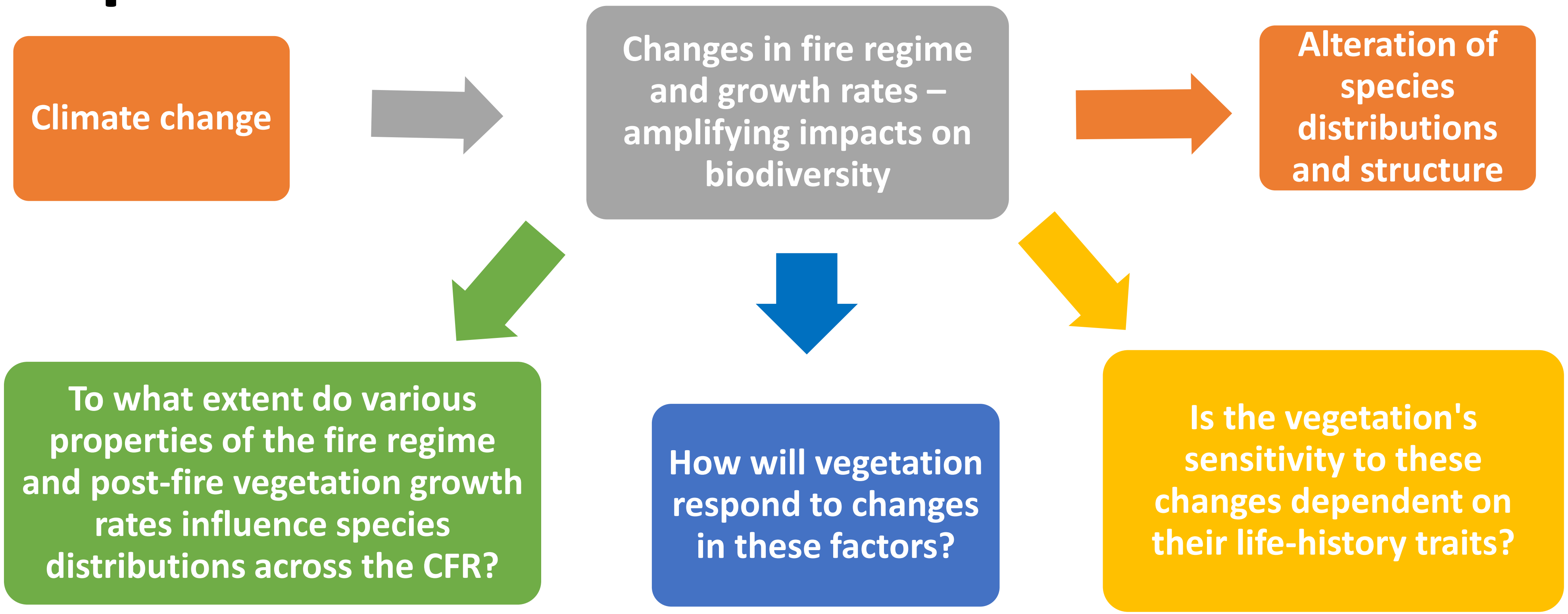
Climate change projections:

1) Rise in temperatures

2) Increase in rainfall inland and towards the east of the CFR

3) Decrease in winter rainfall in areas lying south-west of the CFR

Research problem

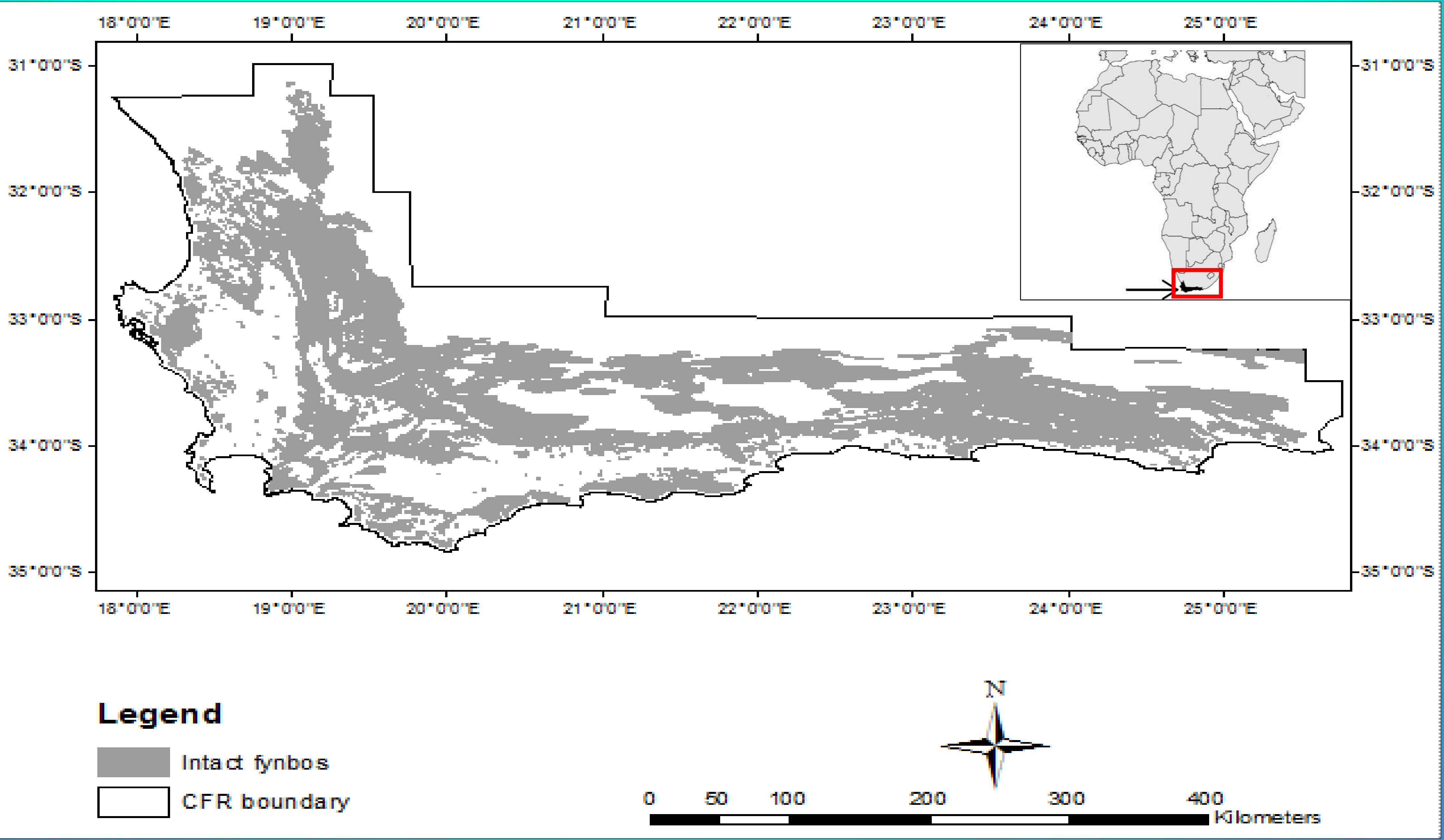


- Much of what we know regarding impacts of climate change on species distributions is based on species distribution models (SDMs).
- SDMs are popularly used in predicting climate driven shifts in vegetation distributions.
  - ➢ However, traditional SDMs are based on abiotic variables (e.g. climate & soils) and <u>overlook other critical components such as fire regime, post-fire vegetation growth rates and differences in species' life histories which determine species distribution in the CFR</u>.

Aim & objectives

- Gain a better understanding of the role of fire regime and vegetation growth rates in constraining vegetation distribution in CFR by:
  - Incorporating fire and vegetation growth variables into a SDM.
  - Comparing the contribution of fire and vegetation growth information relative to climate and soils in predicting species distributions.
  - Assessing whether the importance of fire and vegetation growth information varies between species of differing growth form and/or fire response strategy.

Study area


18°0'0"E
19°0'0"E
20°0'0"E
21°0'0"E
22°0'0"E
23°0'0"E
24°0'0"E
25°0'0"E
31°0'0"S
32°0'0"S
33°0'0"S
34°0'0"S
35°0'0"S
Legend
Intact fynbos
CFR boundary
N
0 50 100 200 300 400
Kilometers

Methods

- The Maximum Entropy (MaxEnt) software package was used to model species distributions and measure the relative contribution of a selected set of environmental variables in predicting species occurrence across the study area.
- MaxEnt uses correlations between environmental variables and species occurrence data in order to identify where a species is most likely to occur.
- Ideal tool to use in cases where presence-only data exists, i.e.: we know where the species occur, but we do not know where they do not.

Methods – species occurrence data

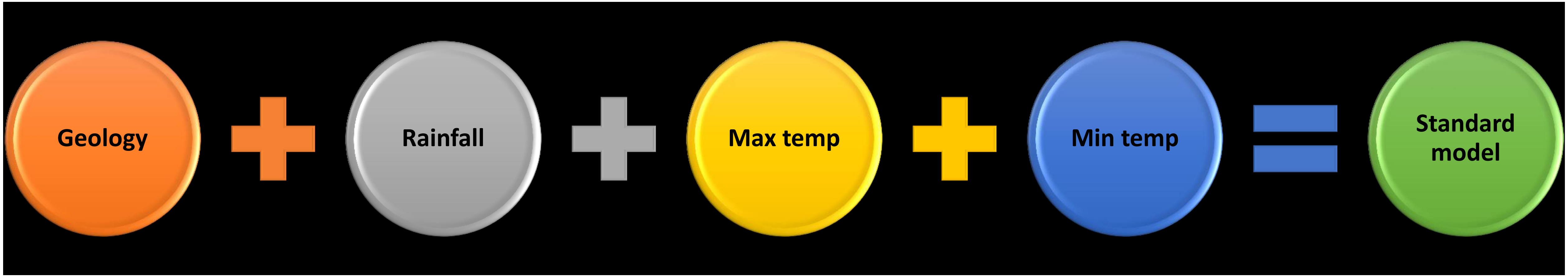
- 72 plant species, with a combined total of 2089 locality points, were selected from a herbarium specimen dataset collected by Hoffman (2012).
- The selection of species was based on:
  - ✓ Minimum spatial accuracy of 2km, >15 locality points.
  - ✓ Plant species that could be classified according to growth forms (geophytes, graminoids and shrubs) and fire response traits (obligate seeders, resprouters and facultative seeders).
- The data set was classified according to growth form and fire response traits – we expect the responsiveness of species to the inclusion of fire regime and vegetation growth information in the models would be reflected by these two factors.

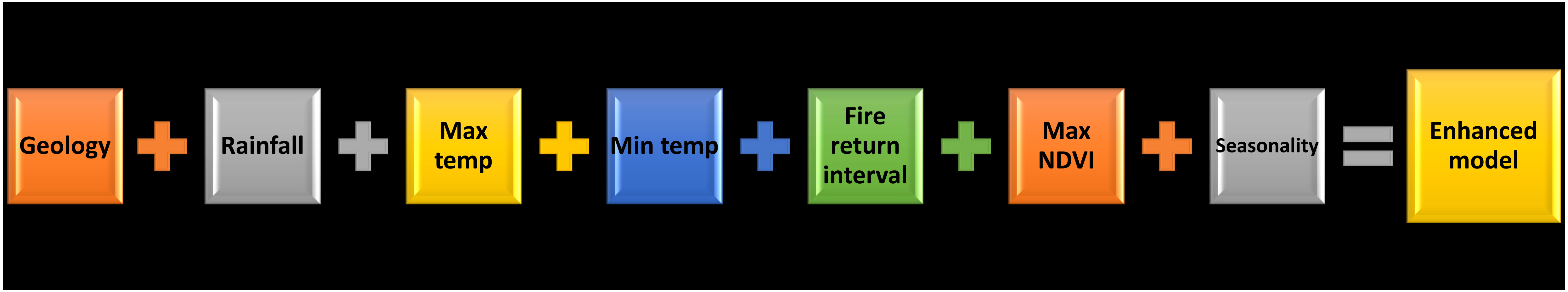
Count of Species	Fire Response Trait			
Growth Form	Facultative seeders (FS)	Obligate resprouters (OR)	Obligate seeders (OS)	Total
Geophyte		14		14
Graminoid	13	19	5	37
Shrub	3	8	10	21
Total	16	41	15	72

Methods – environmental data

Variable	Source	Specifics
Fire return interval	Merow et al.2014	- Mean fire return intervals from 1980 - 2010 - Derived using a survival model between observed fire return times derived from satellite and field data (Wilson et al. 2010, de Klerk et al. 2012) and satellite-derived post-fire ecosystem recovery trajectories
Vegetation growth parameters	Wilson et al. 2010	- Three biomass parameters: maximum NDVI and seasonality derived from a NDVI dataset (MOD13A1). - Ten years (2000-2010) of MODIS 500m resolution 16-day gridded NDVI product.
Temperature	Wilson & Silander 2013	- 20 years of daily meteorological observations (maximum and minimum temperatures) for the CFR. - Mean winter minimum temperatures, and mean summer maximum temperature
Precipitation	Wilson & Silander 2013	- 20 years of daily meteorological observations (maximum and minimum precipitation) for the CFR. - Total winter rainfall and total summer rainfall
Geology	T. Rebelo & G. Midgley	- Derived from 1:250 000 layers from the Council for Geosciences - Combined layer of soil pH, texture and fertility

Methods – models…



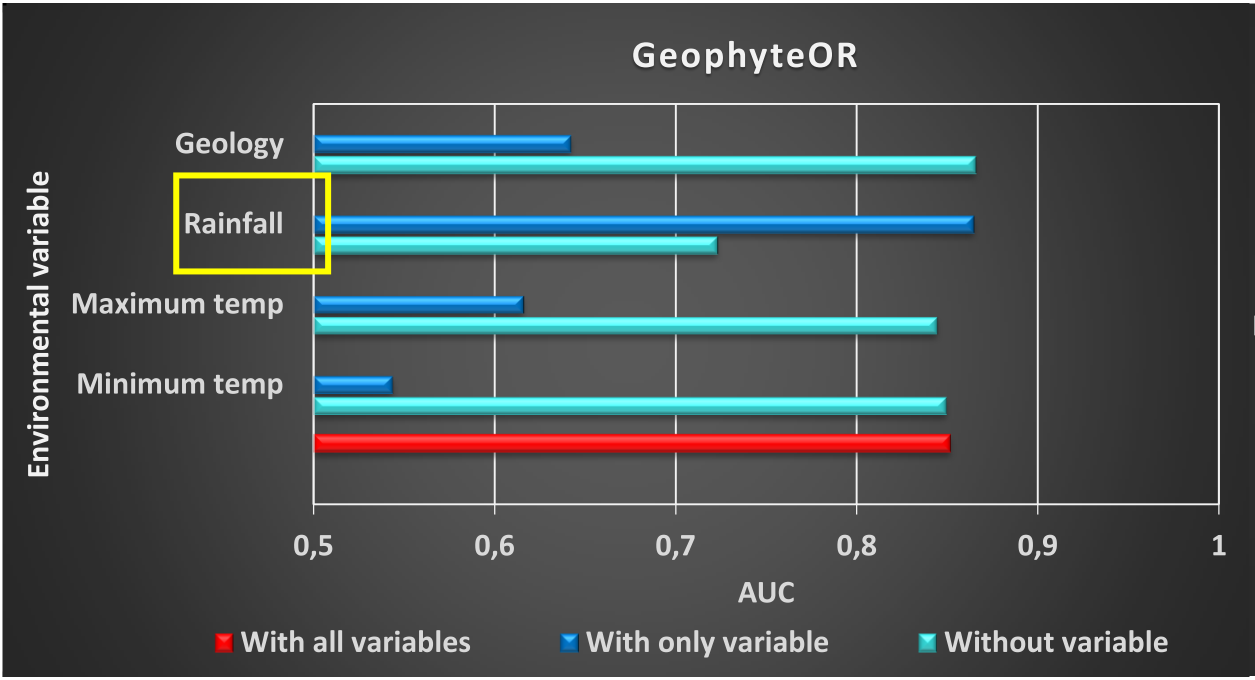


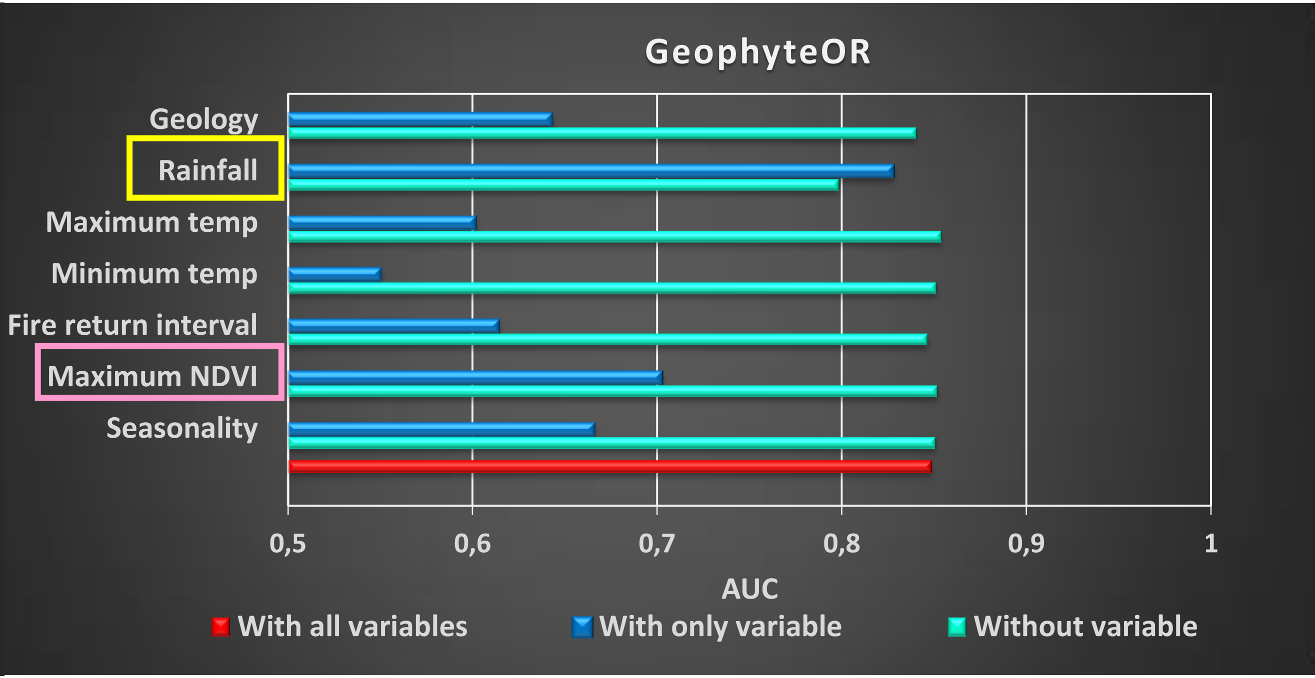
Preliminary results

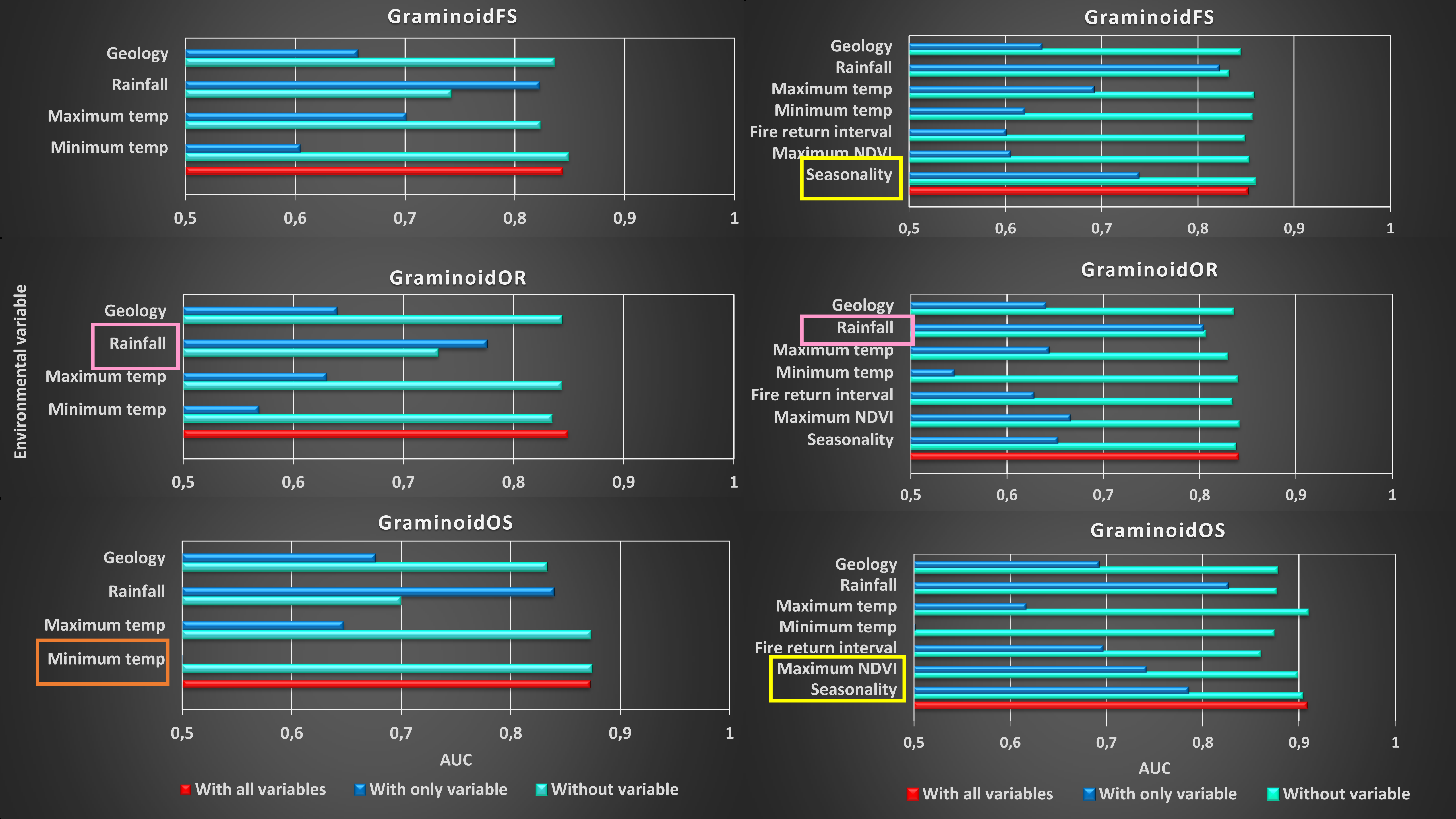
- MaxEnt measures the explanatory power of a variable, i.e.: how useful each environmental variable is in informing the model where a species is most likely to occur.
- This done using Area Under the Receiver Operator Curve (ROC AUC) values as an index of how well the model can identify species occurrence, based on a scale of 0 to 1.
  - 0 – 0.5, performs no better than random chance
  - 0.5 - 0.7, fairly accurate
  - 0.7–0.9, good accuracy
  - >0.9, perfect
- The resulting AUC values were grouped according to growth form and fire response trait, i.e. Geophyte-resprouter (GeophyteOR) and compared between the standard model and the enhanced model.

Variable importance

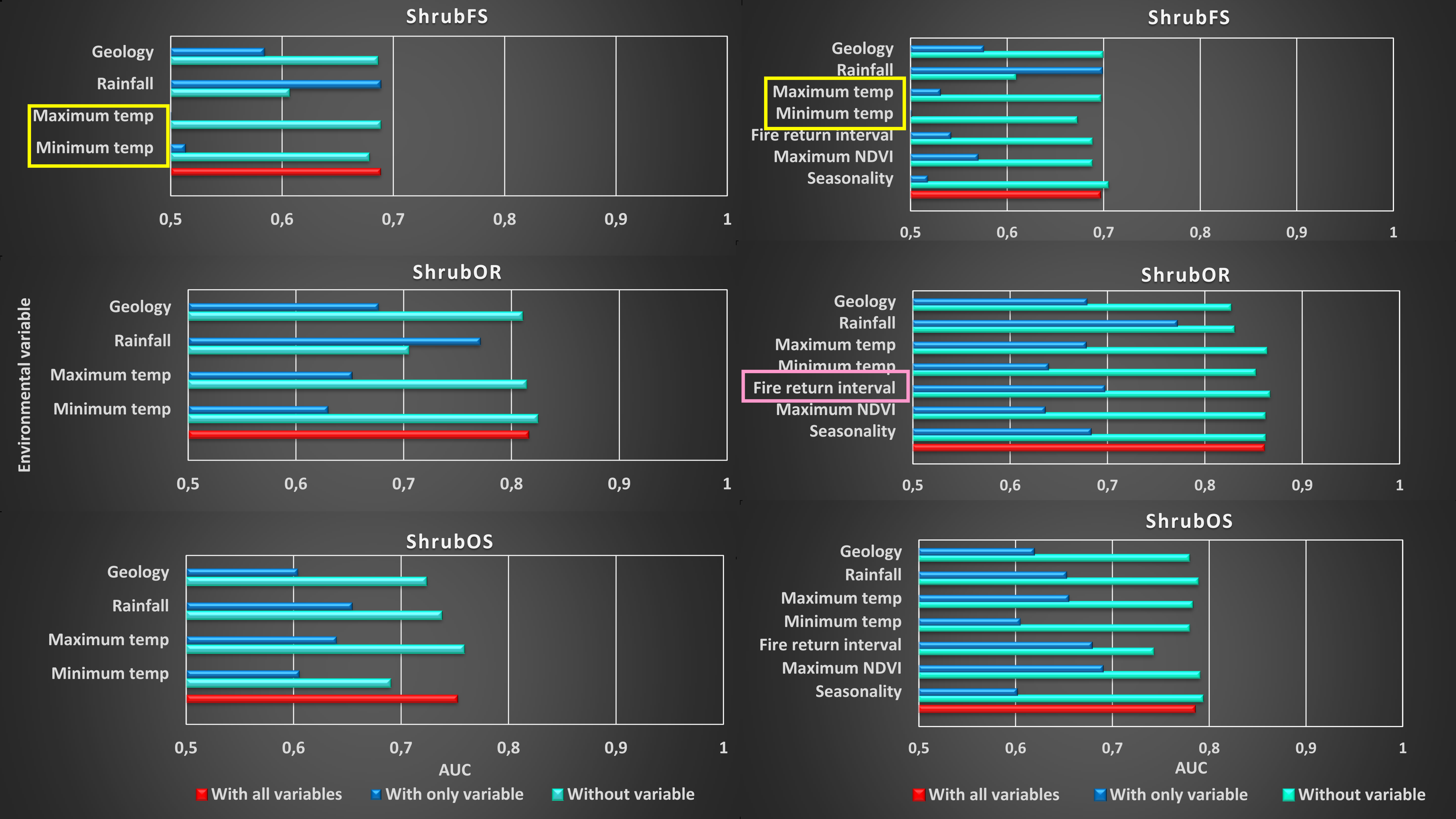
- The importance of the different variables was assessed by looking at the AUC values of the model with just one variable, without that variable and with all variables.





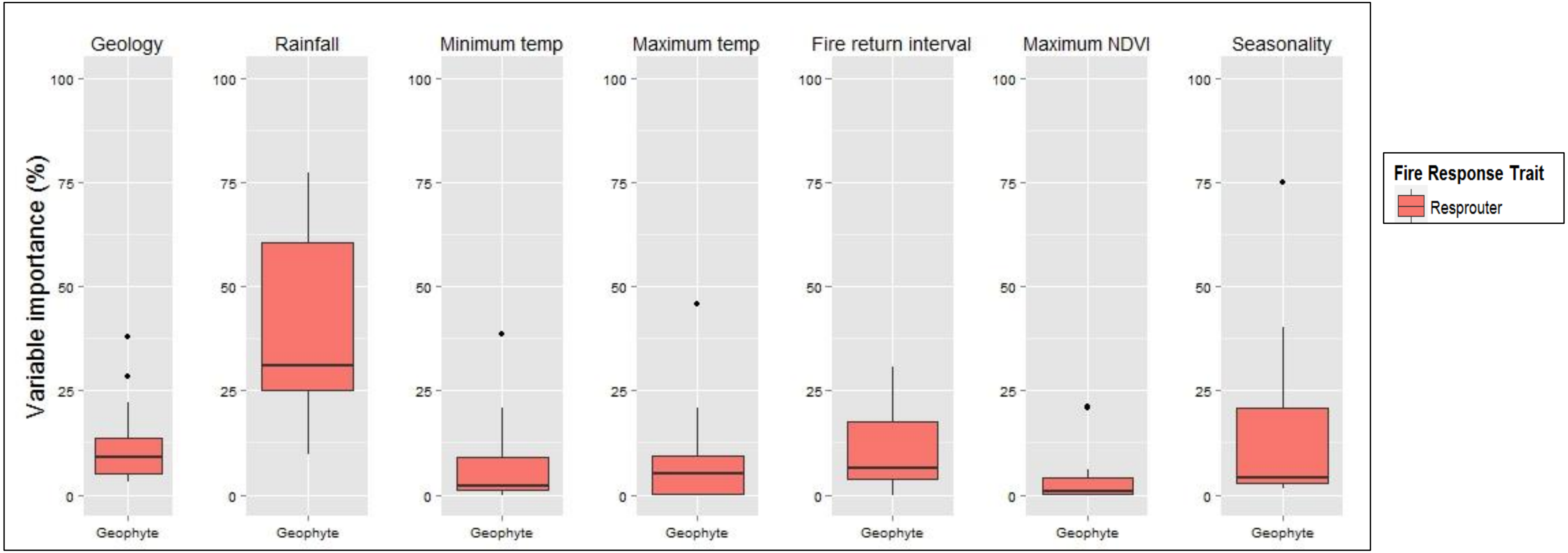


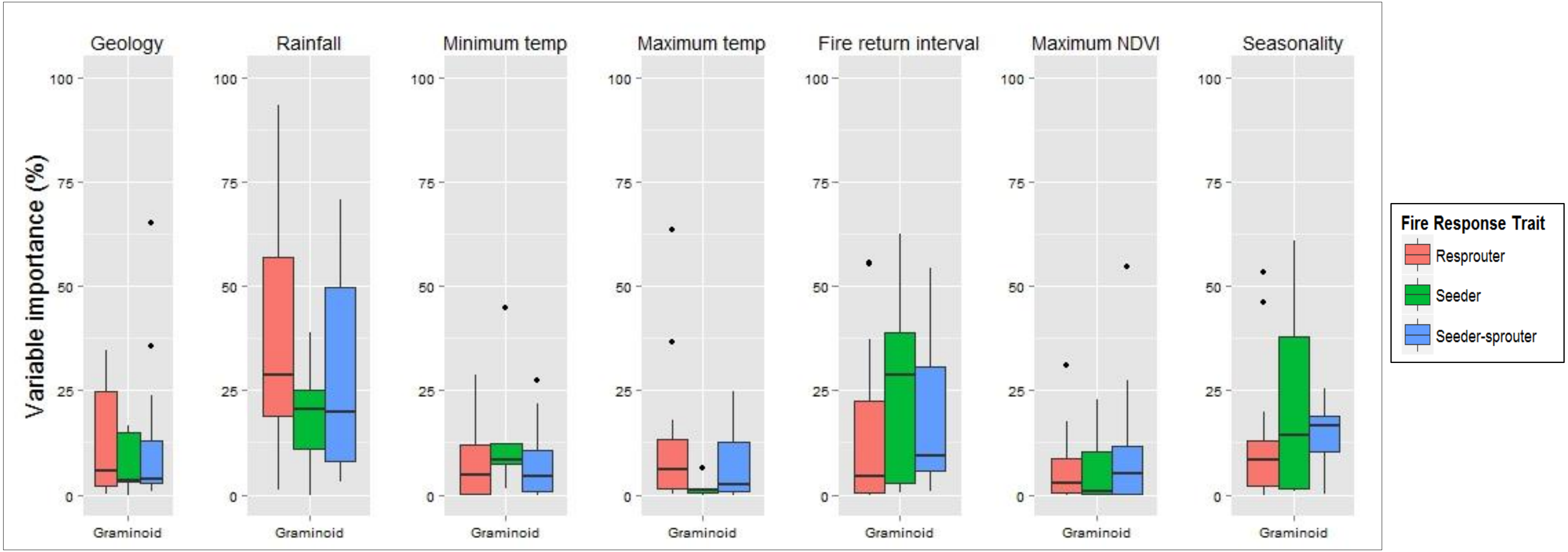
GraminoidFS
Geology
Rainfall
Maximum temp
Minimum temp
Fire return interval
Maximum NDVI
Seasonality
GraminoidOR
GraminoidOS
Environmental variable
0,5
0,6
0,7
0,8
0,9
1
AUC
With all variables
With only variable
Without variable

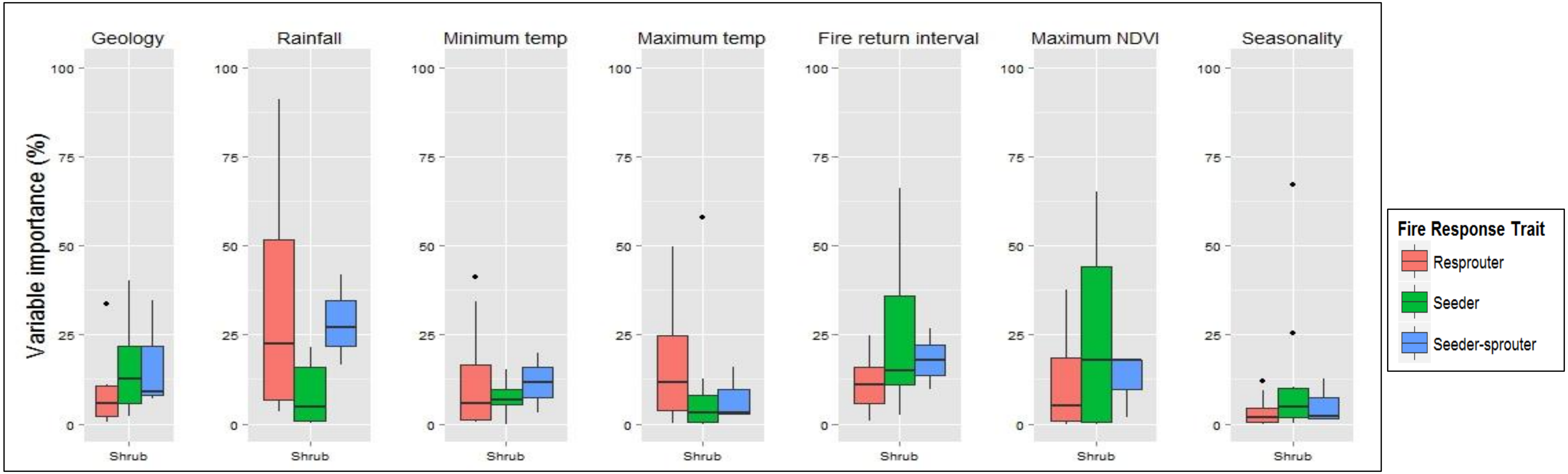

ShrubFS
Geology
Rainfall
Maximum temp
Minimum temp
0,5
0,6
0,7
0,8
0,9
1
ShrubFS
Geology
Rainfall
Maximum temp
Minimum temp
Fire return interval
Maximum NDVI
Seasonality
ShrubOR
Environmental variable
ShrubOR
Fire return interval
ShrubOS
ShrubOS
AUC
With all variables
With only variable
Without variable

Variable importance

- MaxENT also gives an output describing the predictive power of a variable as a percentage, this is referred as variable importance.
- The variable importance was used here to look at how the explanatory power of the different environmental variables varied across and within growth form-response trait categories




Geology
Rainfall
Minimum temp
Maximum temp
Fire return interval
Maximum NDVI
Seasonality
Variable importance (%)
100
75
50
25
0
Graminoid
Fire Response Trait
Resprouter
Seeder
Seeder-sprouter



Geology
Rainfall
Minimum temp
Maximum temp
Fire return interval
Maximum NDVI
Seasonality
Variable importance (%)
100
75
50
25
0
Shrub
Fire Response Trait
Resprouter
Seeder
Seeder-sprouter

Insights

- While climate (particularly rainfall) is an important driver of species distributions in the CFR, fire and vegetation growth rate information are variables that show significant explanatory power in identifying species occurrence.
- Need to take advantage of existing and future information derived from field surveys and remote sensing to go beyond using traditional SDMs and possibly improve the predictive accuracy of SDMs.
- The importance of environmental factors such as climate, fire, etc. in limiting species distributions varies across and within growth forms as well as fire response traits.
- How species will respond to changes in climate, and more so in fire and growth regimes can therefore be considered a function of their respective life histories.
- SDMs that give consideration to these life histories are better equipped to capture underlying ecosystem responses to changes in the environment that drive species distributions in the CFR.


Thank you!!
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Questions??