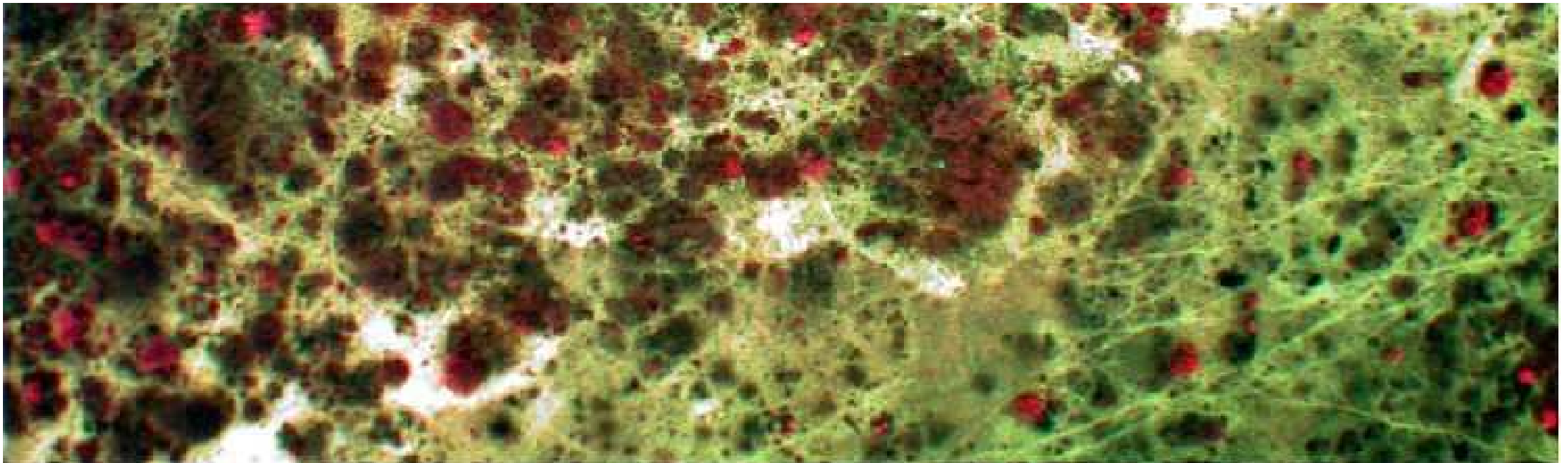


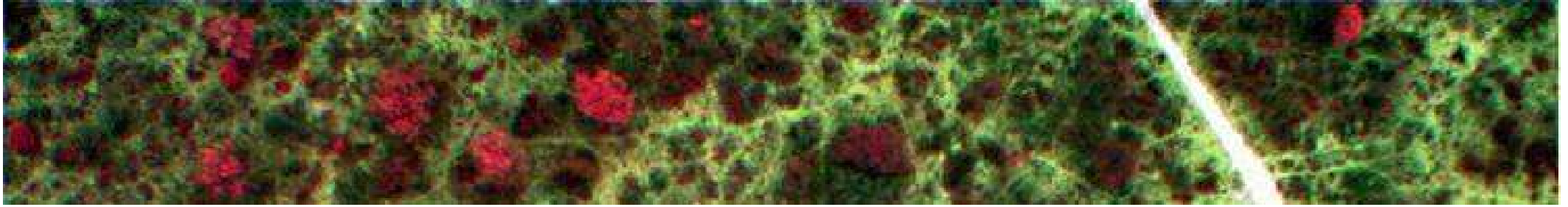
Landscape and leaf-level phenological patterns of grasses and trees in an African savanna

Delgado-Cartay, M.D. ^{1,3}, Combrink, H. J ^{2,4}, Higgins. S.I.^{1,5} , February. E ^{2,6},

¹Institut für Physische Geographie, Goethe Universitaet Frankfurt am Main, Germany

²TreeGrass Programme, Department of Botany, University of Cape Town, South Africa





Aim: To have a better understanding of savanna leaf phenology

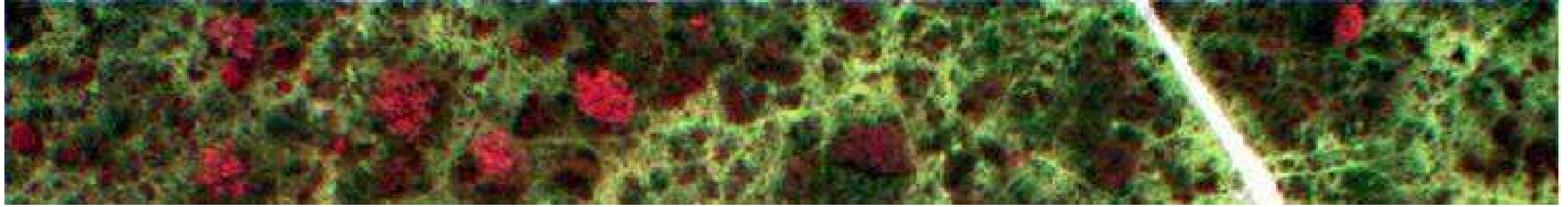
For the 2008-2009 rainy season we evaluated:

1) phenological patterns (indexed by NDVI) of grasses and trees along a rainfall gradient

- landscape level
- leaf level

2) associations between phenological response and environmental variables

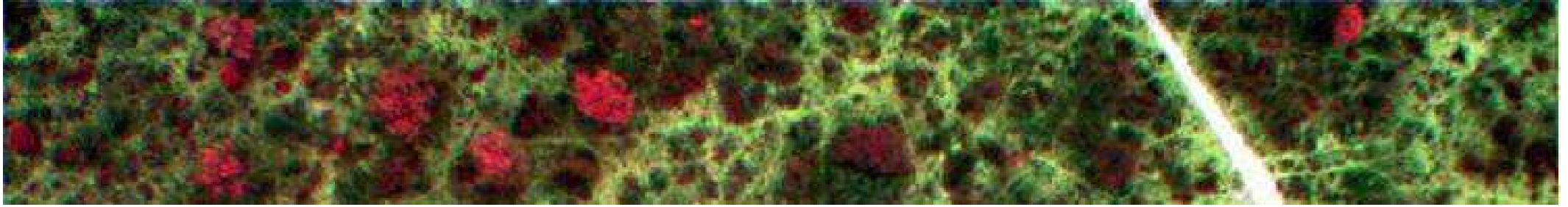
3) potential tree species belonging to the observed phenological syndromes



Rainfall gradient in the KNP: weather stations at each site

Site	Precipitation (mm/year)
Site 1	470
Site 2	530
Site 3	570
Site 4	630
Site 5	670
Site 6	730
Site 7	770
Site 8	820





Landscape NDVI:

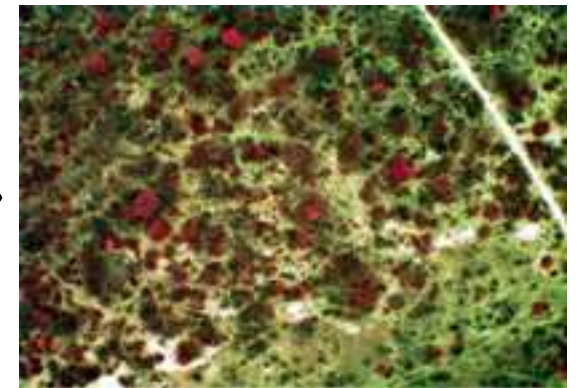
High-spatial resolution,
multispectral aerial
photographs.

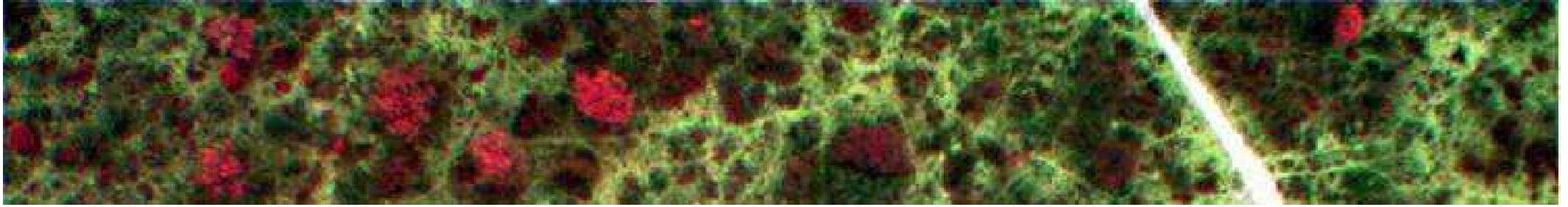
Flights characteristics:

- Altitude: 450m a.g.l
- Area: ~ 375m x 280m
- ~ 10.5 ha
- Pixel size: ~15cm



-  Green Band
-  Red Band
-  NIR Band





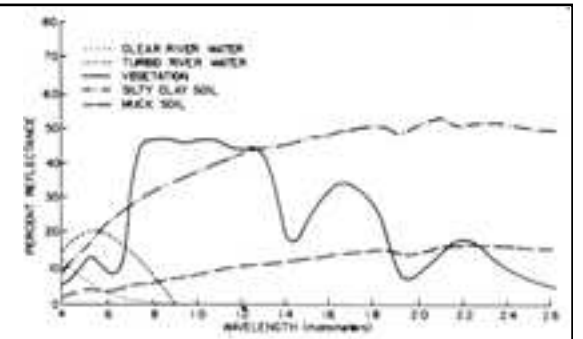
Monitored species

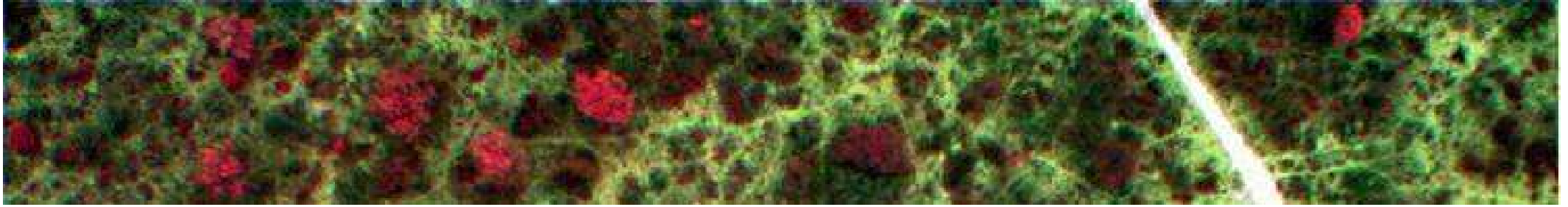
Grasses:

Schmidtia pappophoroides (SC)
Brachiaria nigropedata (BRA)
Eragrostis rigidior (ERA)
Setaria sphacelata (SE)
Panicum maximum (PA)

Trees:

- *Combretum apiculatum* (CA)
- *Sclerocarya birrea* (SB)
- *Terminalia sericea* (TS)

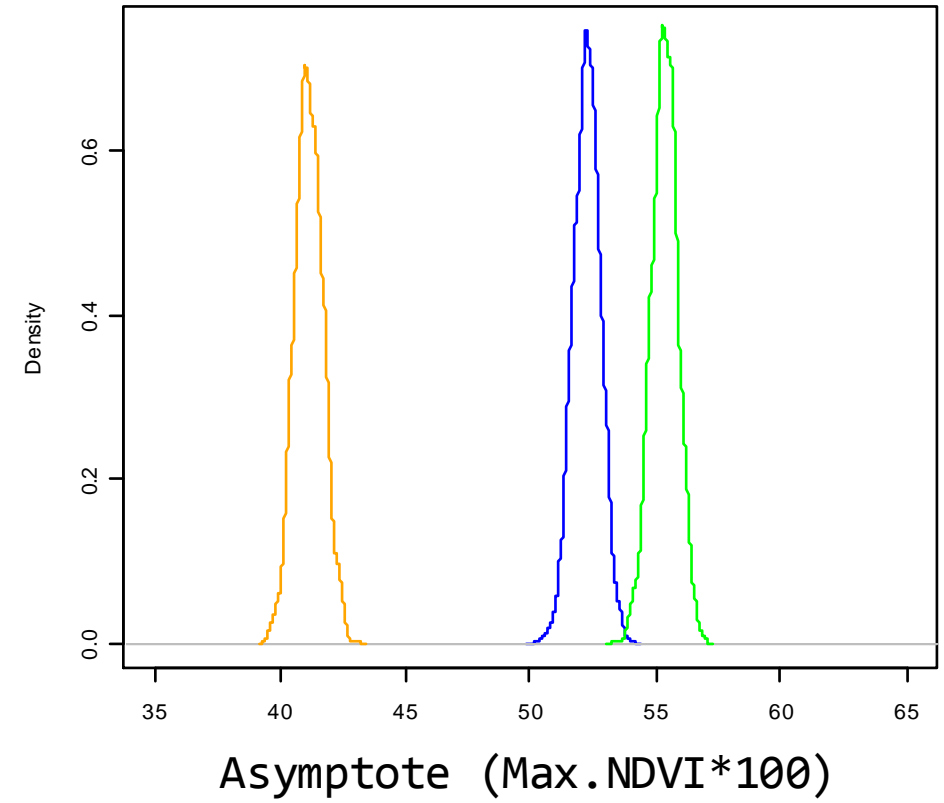
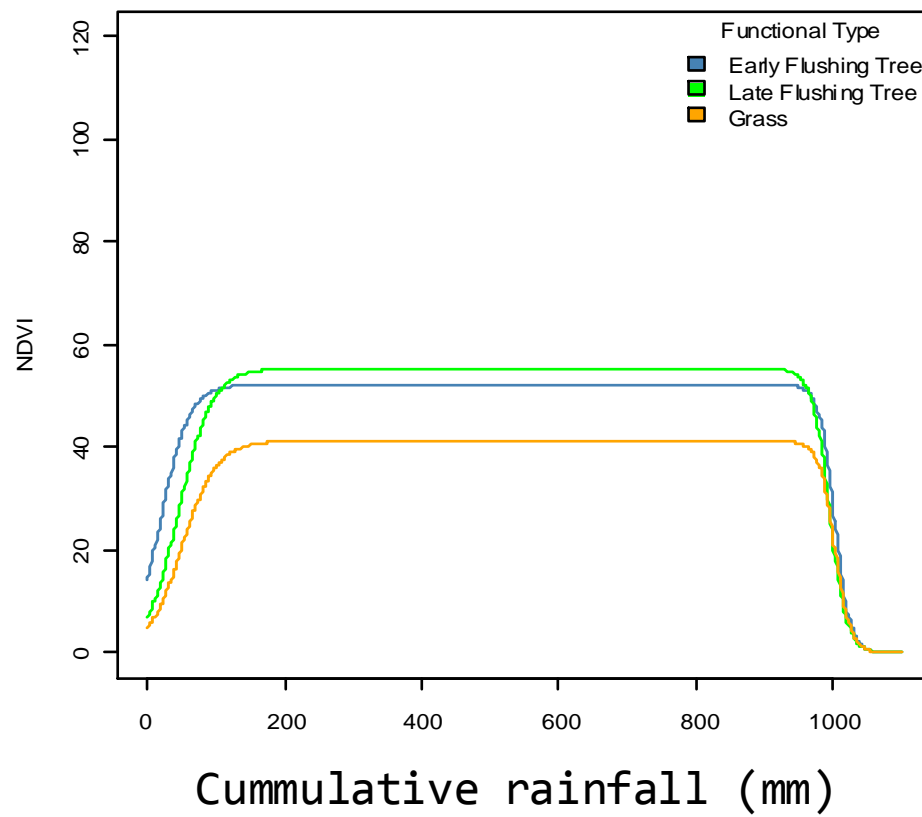


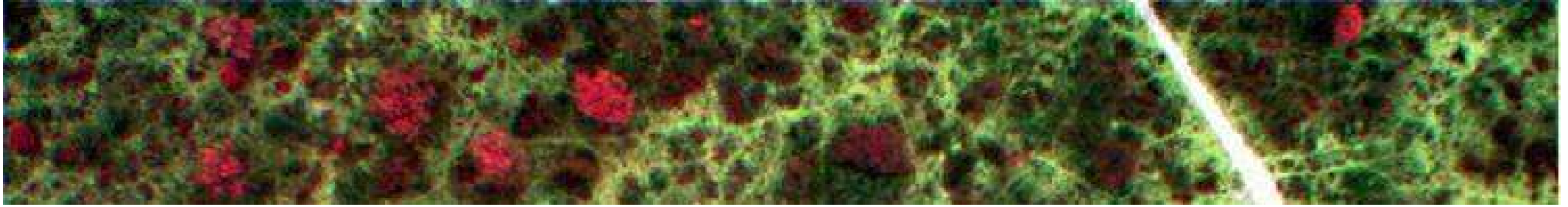


Early flushing trees

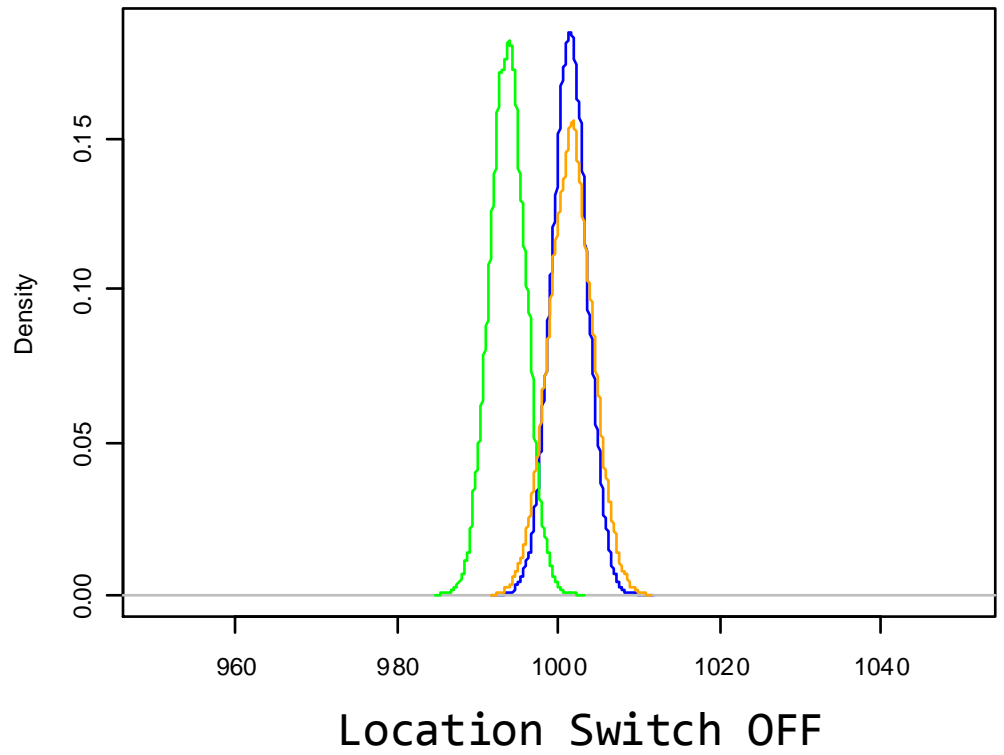
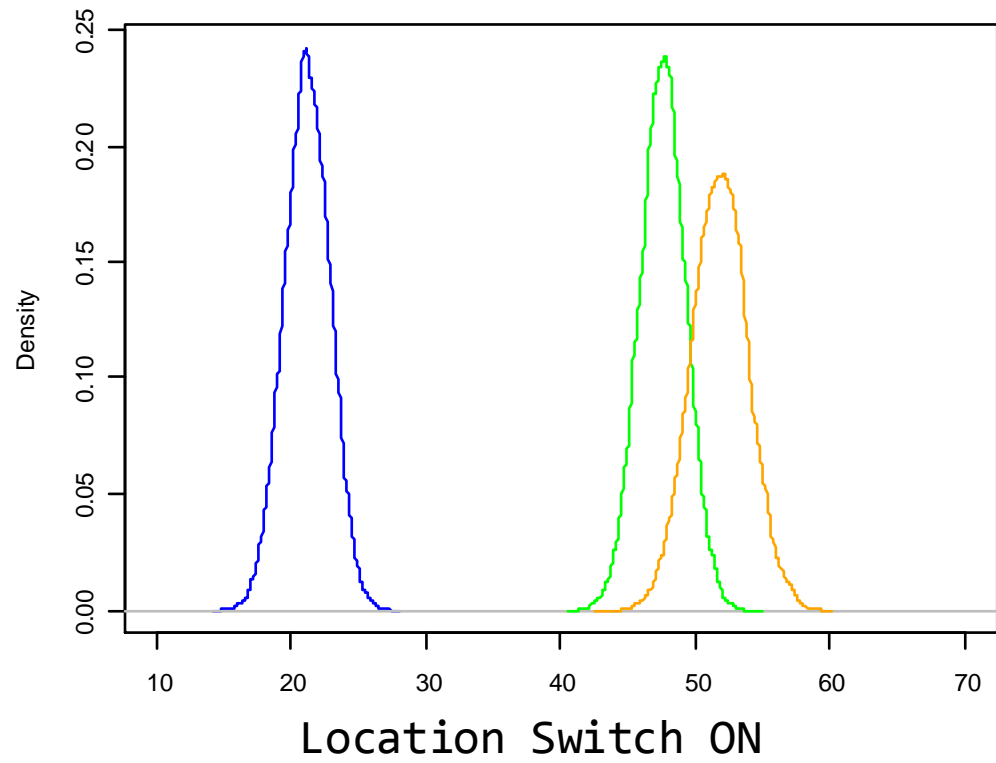
Late flushing trees

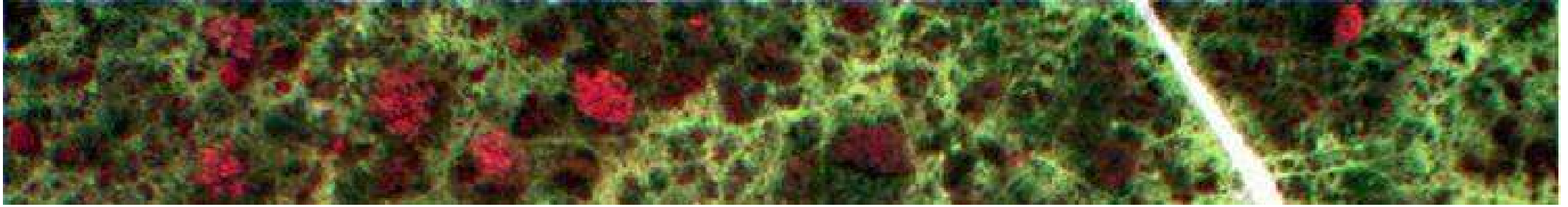
Grasses



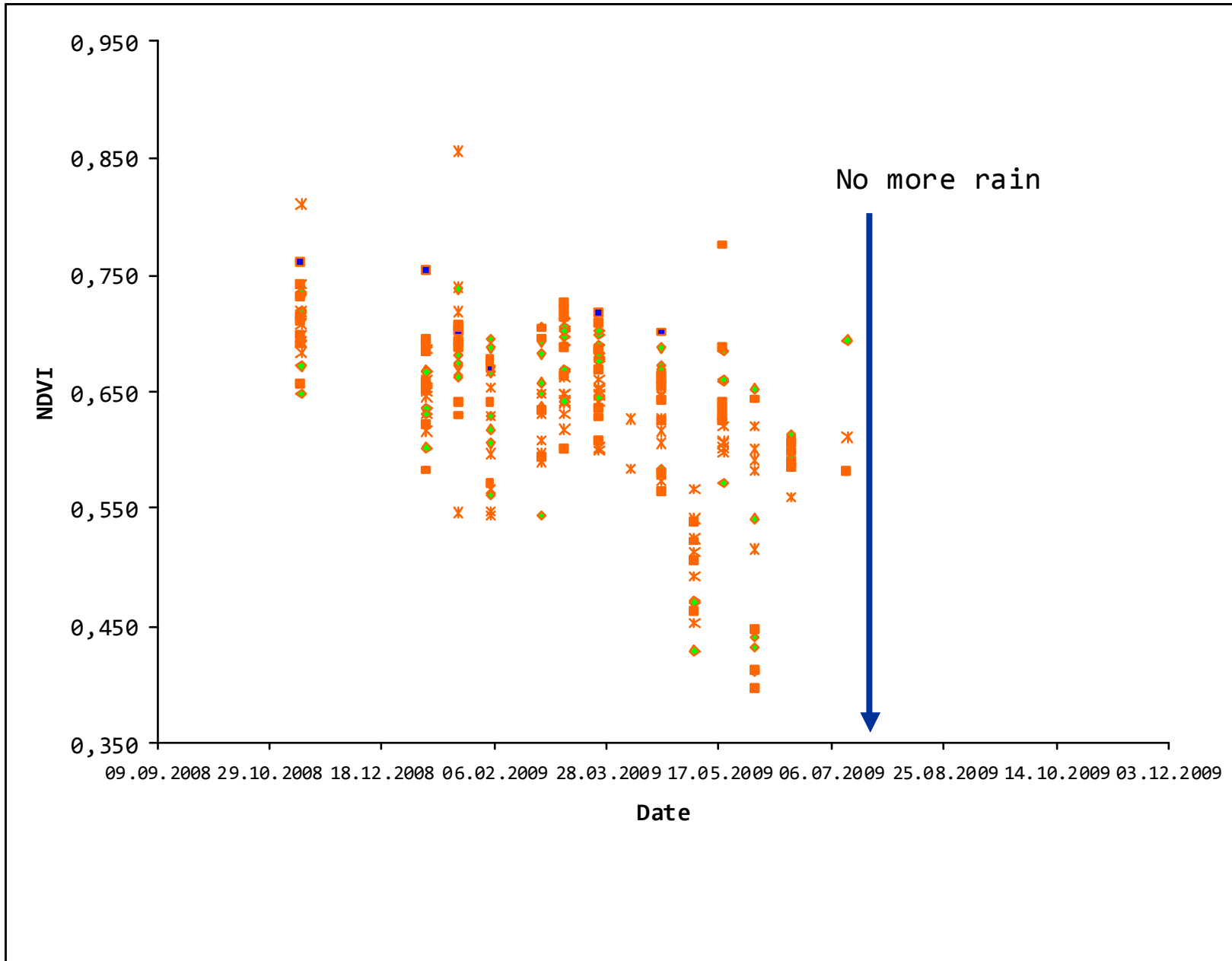


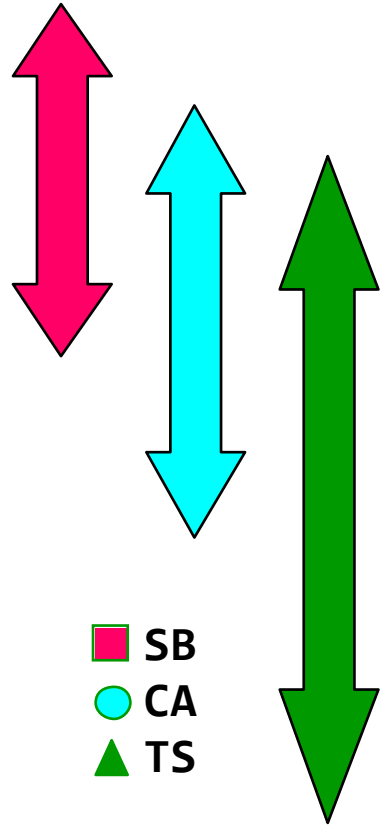
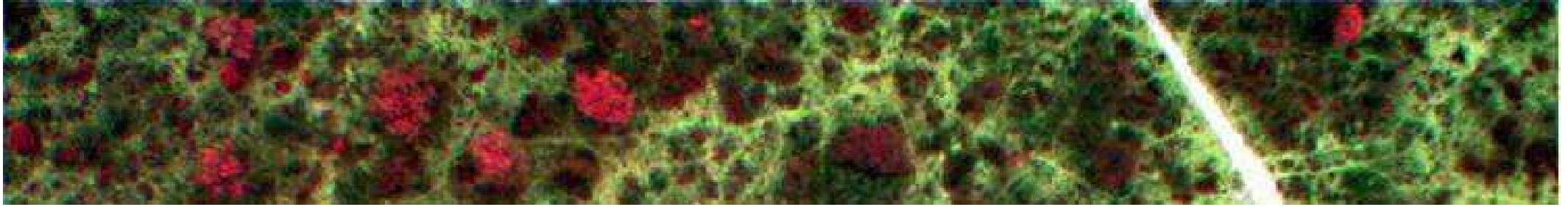
Early flushing trees
Late flushing trees
Grasses



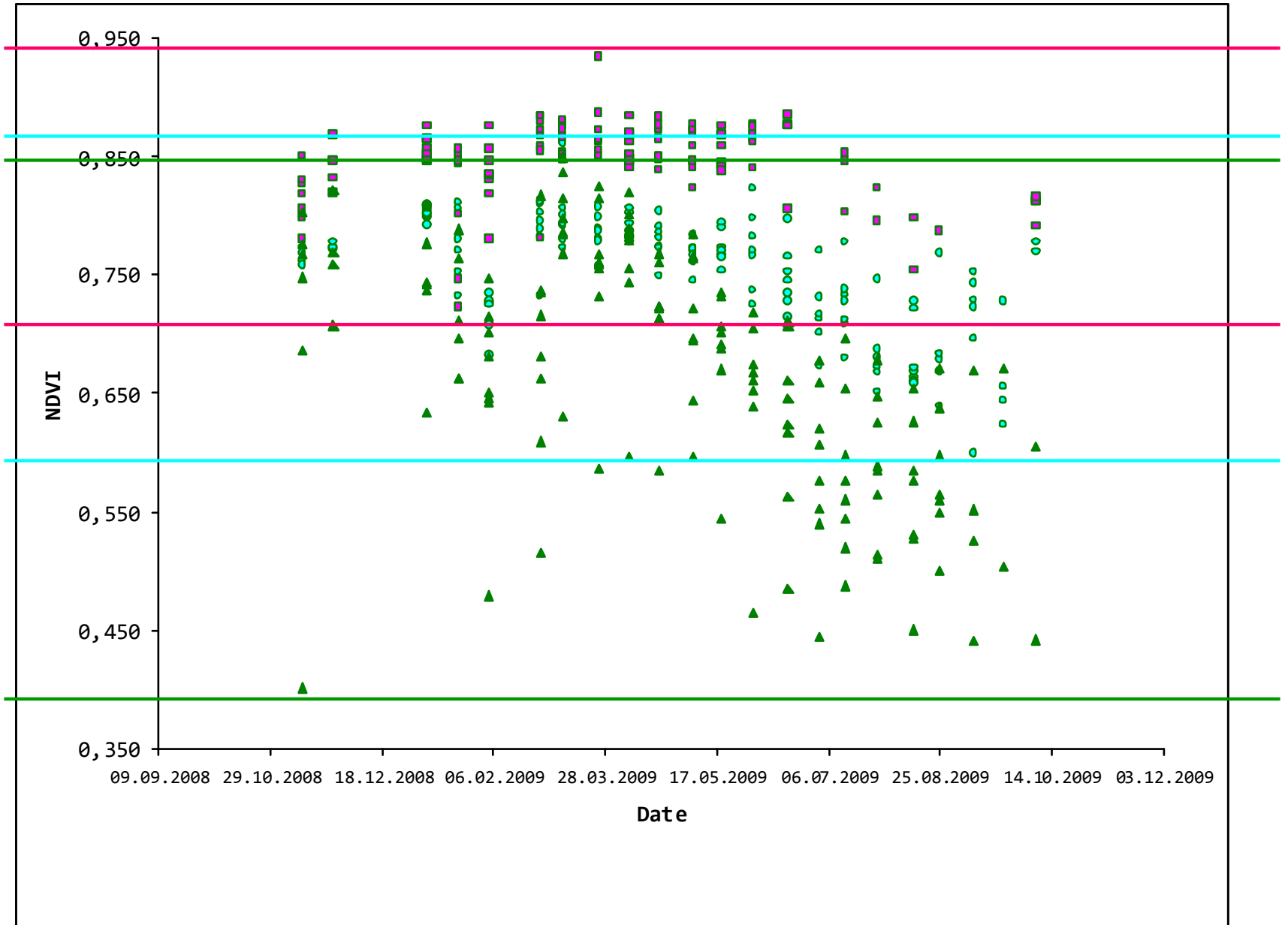


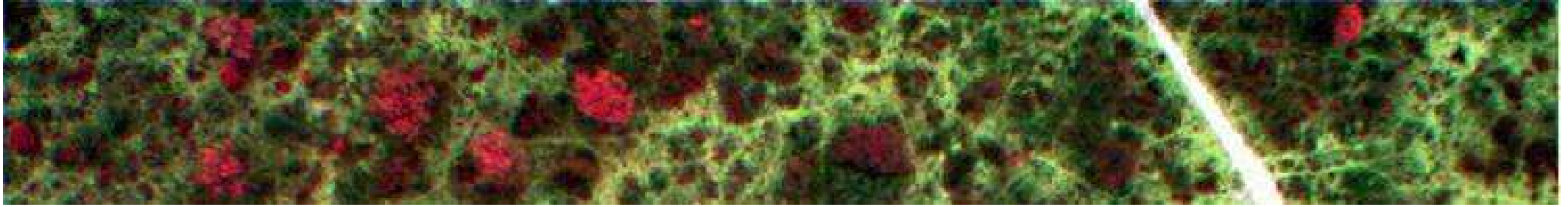
- ✕ BR
- ◇ ERA
- PA
- SC





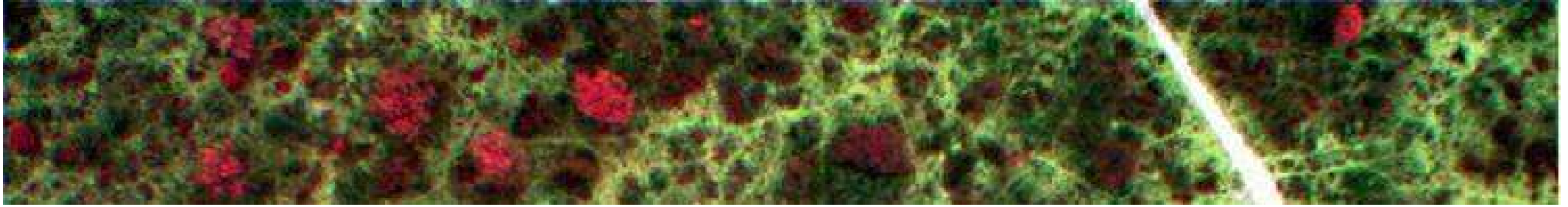
- SB
- CA
- TS





Summary:

- Three phenological syndromes:
 - Early flushing trees
 - Late flushing trees
 - Late flushing grasses
- Early flushing trees start flushing about 50mm before the grasses and late trees.
- Maximum NDVI values are higher in the late trees
- Grasses and trees show a very high variability at the leaf level
 - Exception: Marula (SB)
 - TS varied the most → densely cover with silver hairs
- SB → early flushing
- TS → late flushing
- CA → late flushing



THANKS to:

the Andrew Mellon Foundation

the Hermann-Willkomm-Stiftung

and to you for your attention!

GRACIAS!

Landscape and leaf-level phenological patterns of grasses and trees in an African savanna



Delgado-Cartay, M.D.^{1,3}, Combrick, H. J.^{2,4}, Higgins, S. I.^{1,5}, February, E. Z.⁶
¹Institut für Physische Geographie, Goethe Universität Frankfurt am Main, Germany
²TreeGrass Programme, Department of Botany, University of Cape Town, South Africa
³cartay@em.uni-frankfurt.de, ⁴henri@ge.co.za, ⁵higgins@em.uni-frankfurt.de, ⁶Edmund.February@uct.ac.za



Background:

Understanding of savanna leaf phenology is of great importance if we want to know the possible effects of climate change to the timing and duration of phenological cycles and their implications for human welfare.

A generalised phenology model for savannas should incorporate the different seasonal patterns of leaf display responses of grasses and trees. Several studies have addressed this question under the assumption that shoot growth in the woody component starts in the dry season, one to three months before the start of the rainy season, while the growth of the grass component is largely restricted to the rainy.

Contrary to this temporal niche separation hypothesis of grasses and trees, ongoing research on leaf phenology in savannas has shown that grasses and trees do not exhibit a clear temporal phenological separation. In our previous work, we have shown that three phenological syndromes exist in savannas: early-flushing trees, late-flushing trees and late-flushing grasses. In this work we present a complementary data set on savanna phenology.

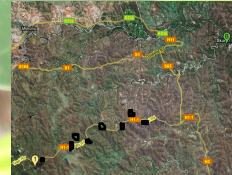
Our goals:
 to evaluate at-leaf-level seasonal phenological patterns of grasses and trees along a rainfall gradient in Kruger National Park,
 to identify tree species of the late and early flushing groups and,
 to compare patterns at the leaf-level with those observed at the landscape level.

Method:

We monitored NDVI along a rainfall gradient in the Kruger National Park. Weather stations at each site continuously register climate-related variables. We used high-spatial resolution, multispectral aerial photographs of savanna landscapes to derive seasonal NDVI time series and the partial contribution of trees and grasses to landscape greenness. Leaf-reflectance spectral data of dominant trees and grasses were collected at regular intervals during the growing season using a portable spectrometer (400-1100nm).

Monitored species:

- Trees:**
- *Combretum apiculatum* (CA)
 - *Sclerocarya birrea* (SB)
 - *Terminalia sericea* (TS)
- Grasses:**
- *Schmidtia pappopordoides* (SC)
 - *Brachiaria nigropedata* (BRA)
 - *Eragrostis rigidior* (ERA)
 - *Setaria spachelata* (SE)
 - *Panicum maximum* (PA)



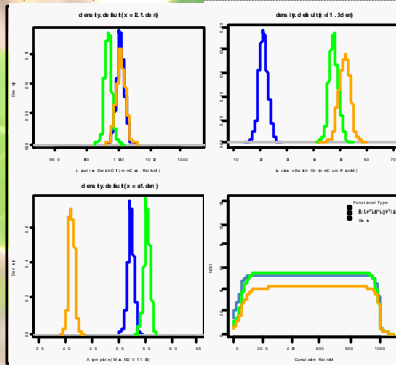
Site	Precipitation (mm/yr)
Site 1	40
Site 2	50
Site 3	57
Site 4	60
Site 5	67
Site 6	70
Site 7	77
Site 8	80



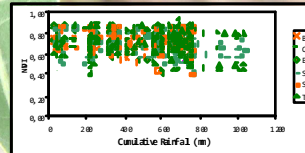
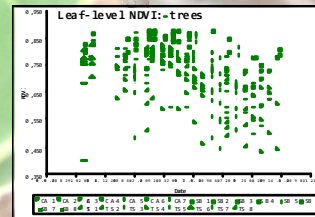
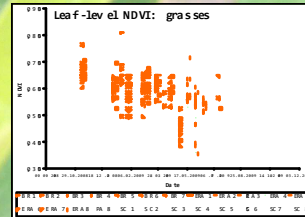
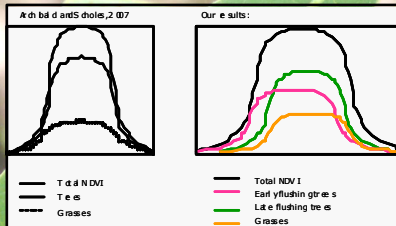
Environmental drivers of leaf phenology:

Possible candidates for the switch-on phase of leaf phenology are precipitation, soil moisture and temperature. Since all these variables (their cumulative values) are strongly correlated with one another ($r^2 \rightarrow 0.97$ for all pairs), we decided to analyse the NDVI with regard to the precipitation, which could also let us test the temporal niche hypothesis.

Bayesian modelling of NDVI course along the rainy season: top right and left and bottom left: parameters posterior probabilities; bottom right: fitted model



Testing the temporal niche hypothesis:



Summary:

- 1) Phenological patterns and their relation to (cumulative) precipitation have been accurately described by means of Bayesian analysis:
 - Early flushing trees start flushing about 50mm before the grasses and late trees, in many cases before the rains start, which indicates there might be another variable, independent of rainfall that allows for this early switch on.
 - Maximum NDVI values are higher in the late trees

2) NDVI patterns at the leaf level do not match with those observed at the landscape level. Moreover, leaf-NDVI is not correlated with precipitation (fig. at the left), indicating that cover patterns might play an important role in determining the landscape overall response.

3) Both, grasses and trees show a very high variability at the leaf level, with the only exception of the Marula tree (SB), which exhibits high, constant values along the year. TS varied the most, which is not surprising due to its leaves being often densely covered with silver hairs.

4) Identifying tree species belonging to one phenological pattern is challenging with the data available, and more studies are needed in this regard. However, one might think that SB could belong to the early flushing group due to the high NDVI values during the dry season.

Acknowledgments: to the Hermann Willkomm-Stiftung for funding travel costs for the meeting, and to the tree-grass program (UCT) for financial assistance and data collection.

References: Archibald and Scholes, 2007. Leaf green-up in a semi-arid African savanna - separating tree and grass responses to environmental cues. Journal of Vegetation Science 18: 583-594