Primary production drives eco-physiological cascades in African buffalo

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Primary production: eco-physiological cascades in African buffalo

Why Primary Production

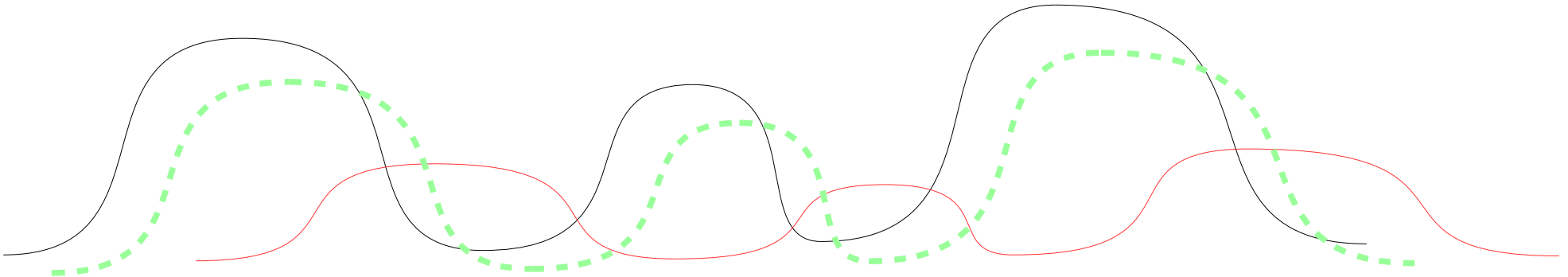
- Annual photosynthetic cycles are conspicuous from leaf to landscape level
- Introducing substantial temporal variability in the quality and quantity of forage plants

Image credit: http://www.geoforcxc.com/natural-systems/weather-and-climate/ecosystems/tropical-continental-climate/

Primary production: eco-physiological cascades in African buffalo

Why Primary Production

- Annual photosynthetic cycles are conspicuous from leaf to landscape level
- Introducing substantial temporal variability in the quality and quantity of forage plants
- Life histories and health of herbivores should be tightly coupled to seasonal phenological patterns
- Occurrence patterns of infectious diseases may be driven by the resulting fluctuations in animal immune status

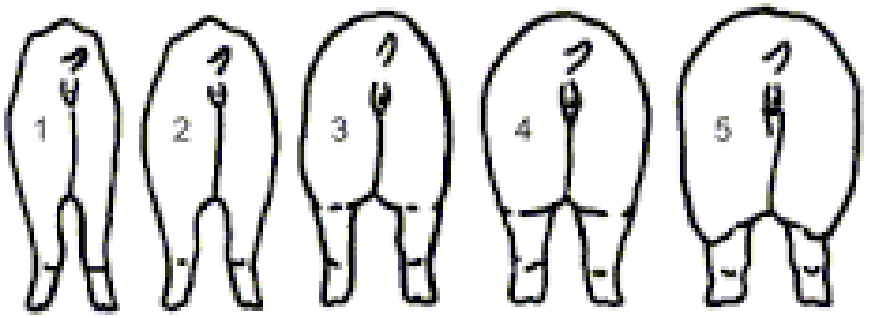


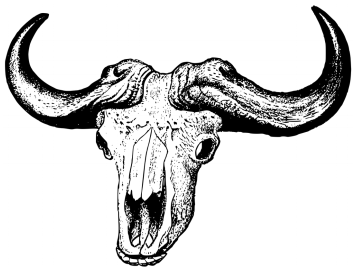
Primary production: eco-physiological cascades in African buffalo

Few datasets

- Few longitudinal datasets for ungulate consumers that combines:
  - Forage quality, along with
  - Physiological
  - Immunological
  - Disease outcomes

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$





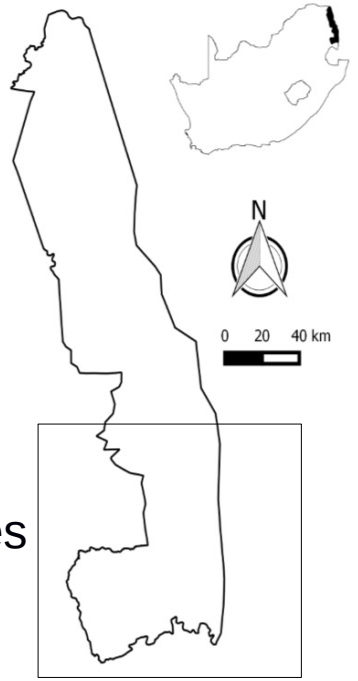
Study Site and Study Buffalo Population from the southern Kruger National Park

Study Population

- 200 Adult female African buffalo (*Syncerus caffer caffer*)
- 2008 to 2012
- Southern Kruger National Park
- Animals that died during the study period was replaced by a similarly aged animal
- 975 young (age 2-5 yr)

Sample Protocol

- 1112 samples
- 158 unique capture days
- Study animals relocated and immobilised every 6 months
- Faecal samples via rectal palpation
- Samples frozen @ -20°C until analyses



Presented Data: Datasets Used

Nutrition / Primary Production

- Faecal chlorophyll (Relative Value)
- Faecal nitrogen (%)
- NDVI (from MODIS products)

Physiological

- Body Condition Score (1-5)
- Cortizol (Stress hormone)
- Reproductive success ?

Immunological

- Dissease prevalance ?

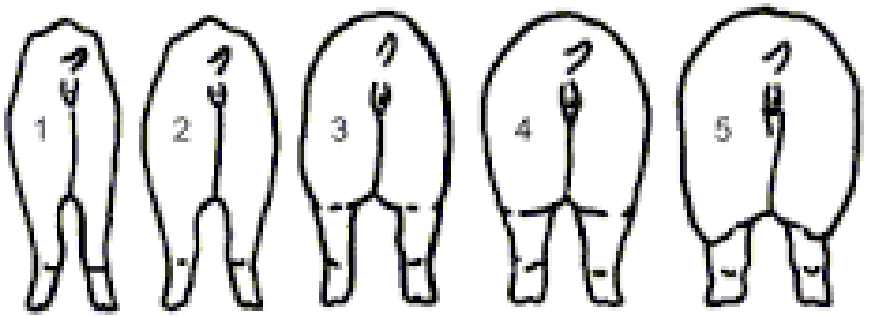
Discussion Points

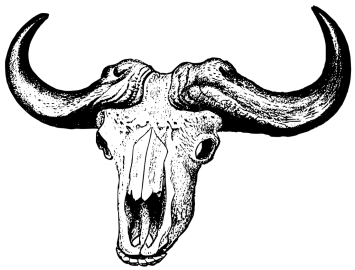
Feacal chlorophyll

Cascading effects

- Background to feacal chlorophyll
- Faecal chlorophyll, novel dietary metric for buffalo
- Faecal chlorophyll correlates tightly with faecal nitrogen
- African buffalo are highly sensitive to variation in primary production
- Cascading effects body condition
- Preliminary data on associations with animal physiology

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$





The Background to Faecal Chlorophyll

Ecological Applications, 19(5), 2009, pp. 1323–1335

Fecal chlorophyll describes the link between primary production and consumption in a terrestrial herbivore

DAVID CHRISTIANSON[1] AND SCOTT CREEL

Department of Ecology, Montana State University, Bozeman, Montana 59717 USA

Abstract. Spatiotemporal variation in primary productivity is known to have strong and far-reaching effects on herbivore ecology, but this relationship is often studied indirectly at broad scales, in part due to the difficulty in measuring selection for green biomass by

NRC Research Press

ARTICLE

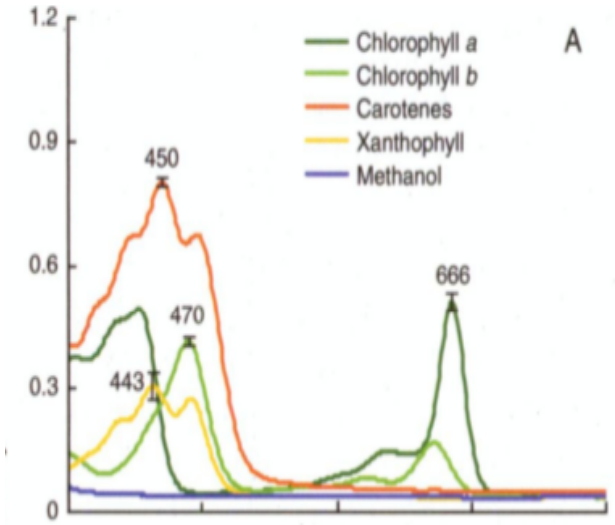
Photosynthetic pigments estimate diet quality in forage and feces of elk (*Cervus elaphus*)

D. Christianson and S. Creel

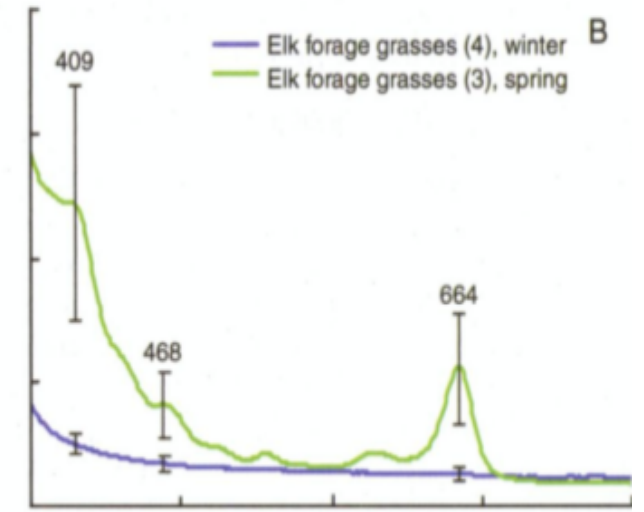
Abstract: Understanding the nutritional dynamics of herbivores living in highly seasonal landscapes remains a central challenge in foraging ecology with few tools available for describing variation in selection for dormant versus growing vegetation. Here, we tested whether the concentrations of photosynthetic pigments (chlorophylls and carotenoids) in forage and feces of elk (*Cervus elaphus* L., 1785) were correlated with other commonly used indices of forage quality (digestibility, energy content, neutral detergent fiber (NDF), and nitrogen content) and diet quality (fecal nitrogen, fecal NDF, and botanical composition of the diet).

The Background to Faecal Chlorophyll

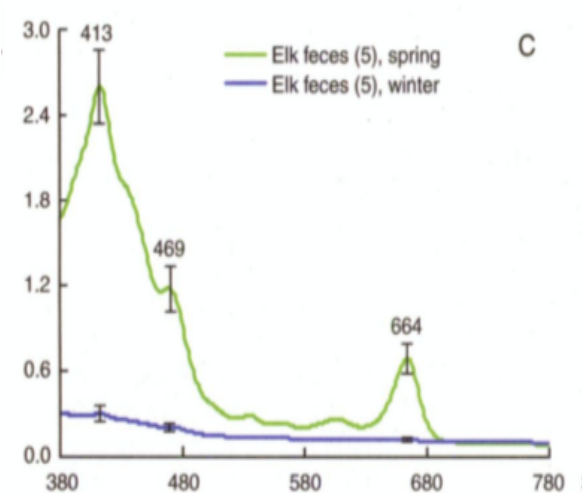
Pigments



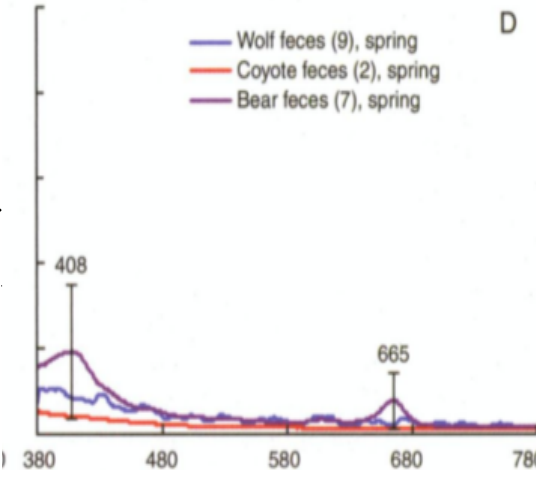
Forage Grasses



Ruminant Faeces



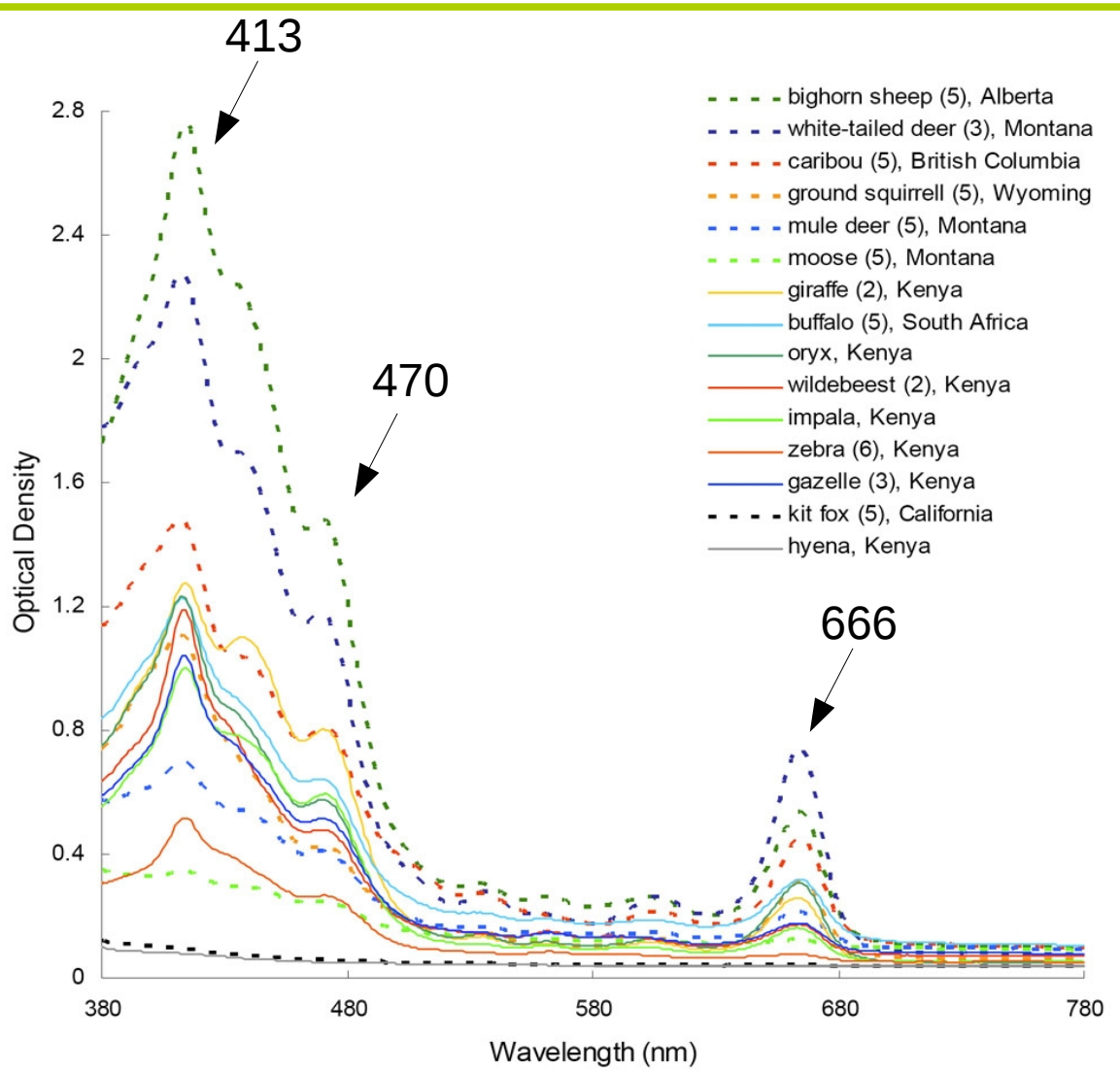
Predator Faeces



From Christianson & Creel 2009

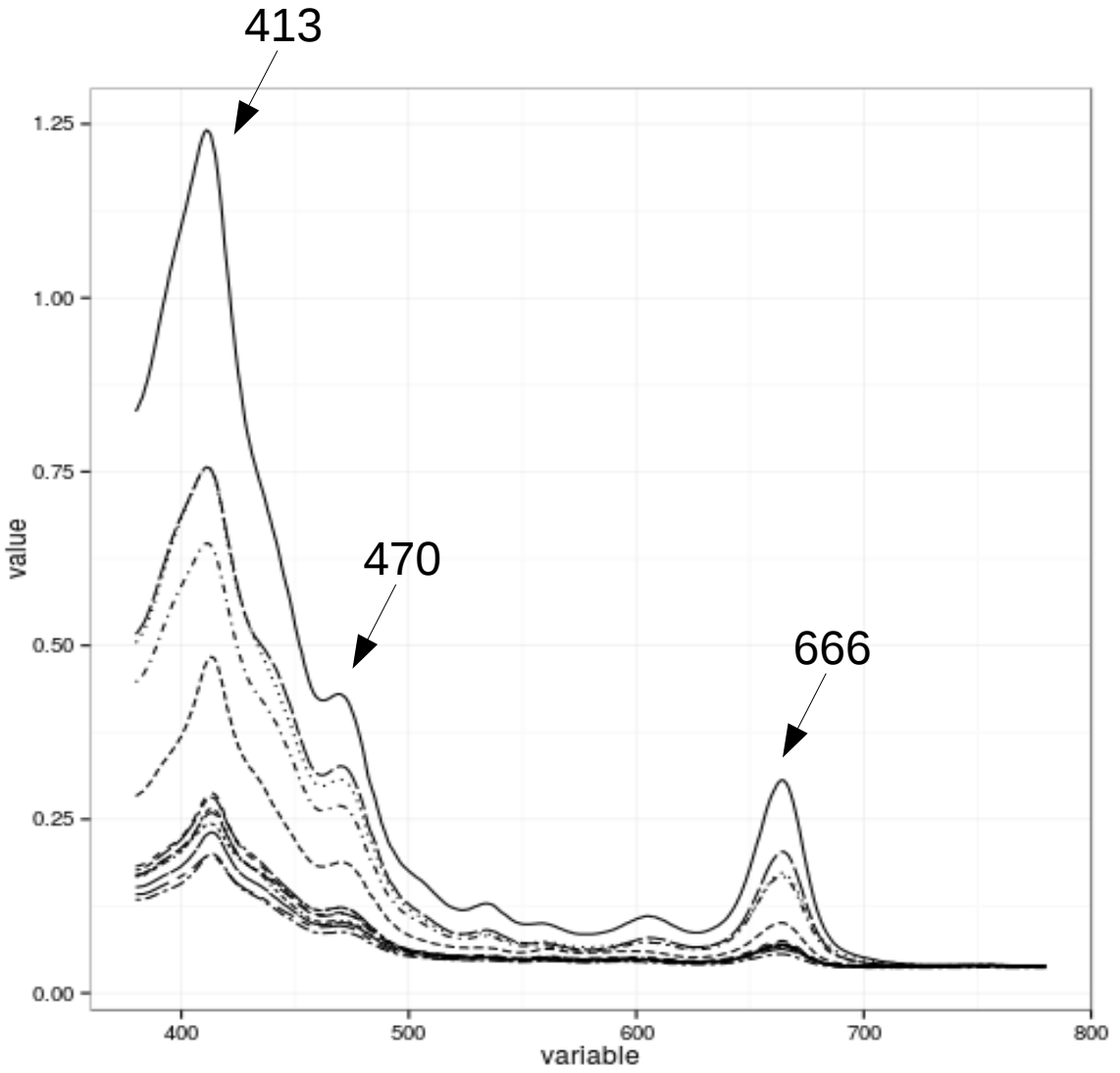
The Background to Faecal Chlorophyll

American and African ungulates
(Christianson & Creel 2009)



The Background to Faecal Chlorophyll

Full spectrum plots from Buffalo in KNP



Faecal Chlorophyll Extraction Technique

Extraction according to Christianson & Creel 2009

0.2 g Ground Faeces

6 ml 100% ethanol

Boiled for 15 Min in water bath

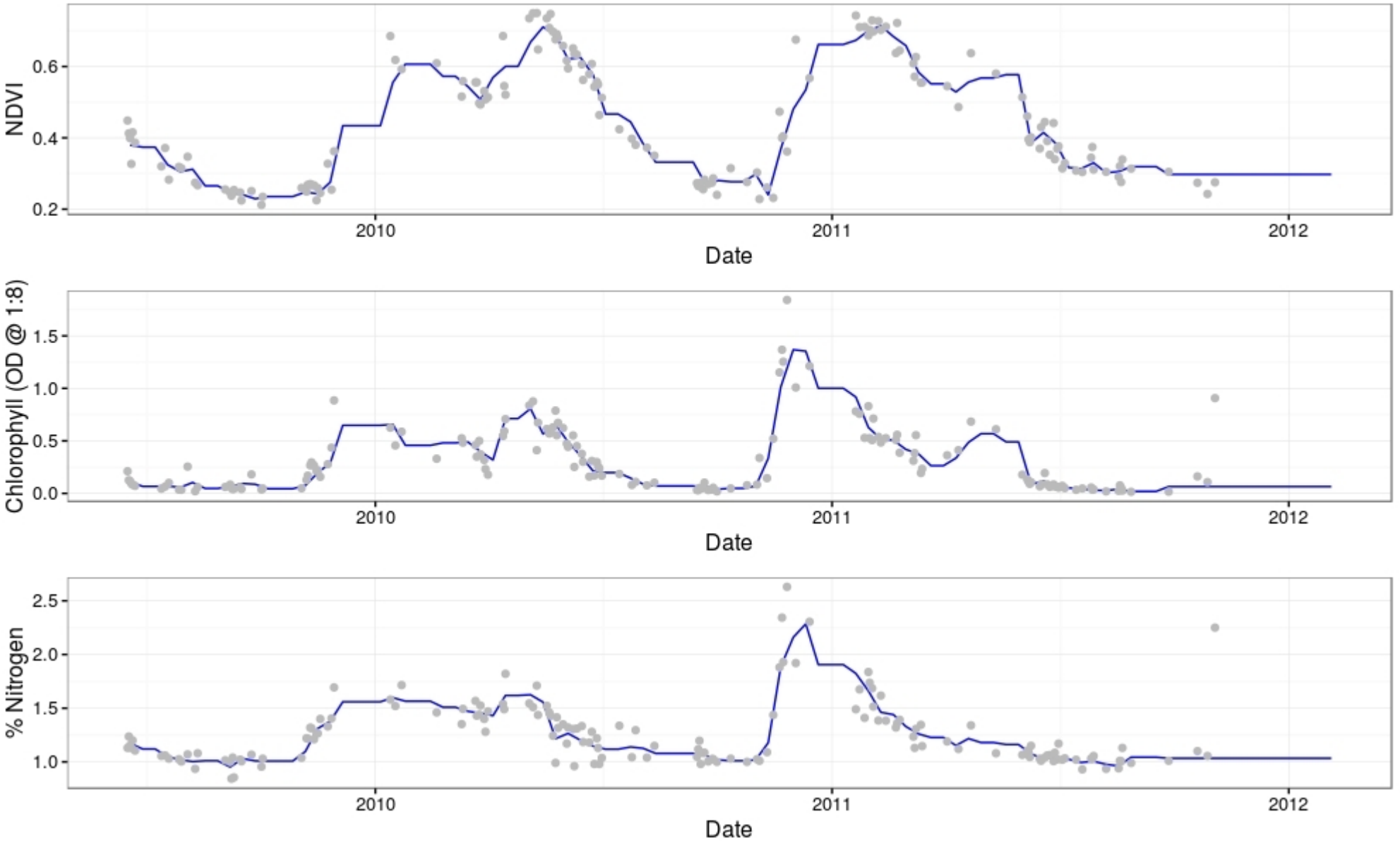
Pigmented supernatant Extracted and evaporated

Reconstituted in 1 ml 100% methanol

Diluted to optimal Concentration (1:8)

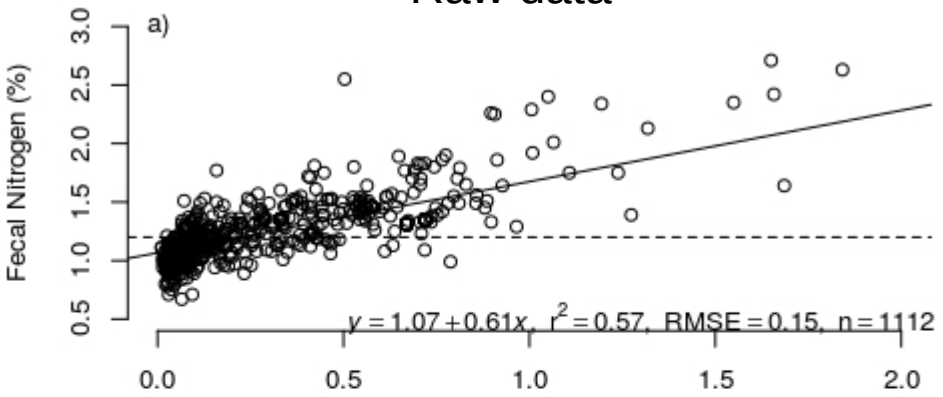
Optical Density Read @ 666 nm

Time Series

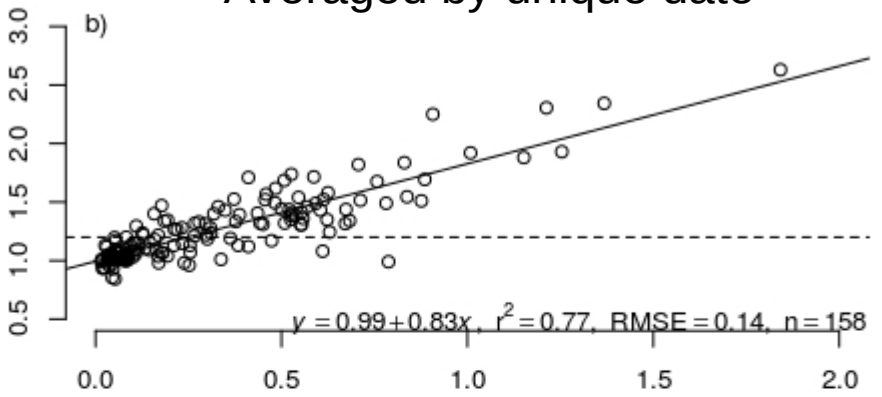

NDVI
0.6
0.4
0.2
2010
2011
2012
Date
Chlorophyll (OD @ 1:8)
1.5
1.0
0.5
0.0
2010
2011
2012
Date
% Nitrogen
2.5
2.0
1.5
1.0
2010
2011
2012
Date

Correlation between Faecal Nitrogen and Faecal Chlorophyll

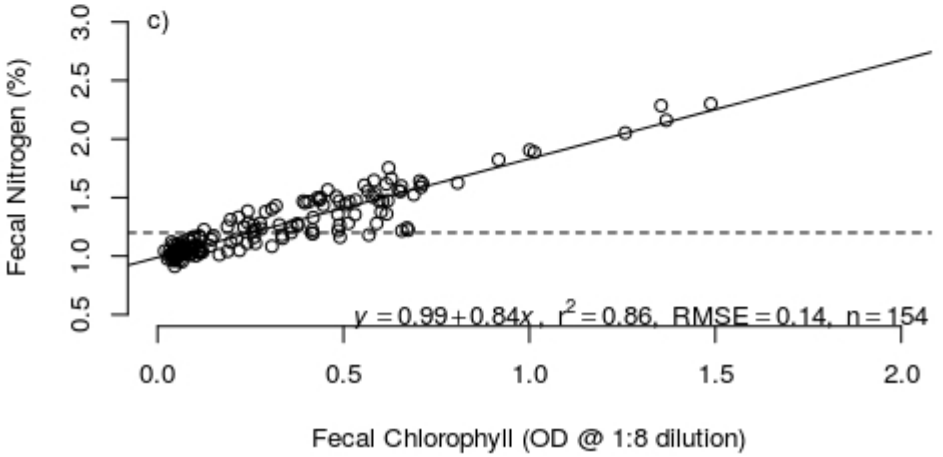
Raw data



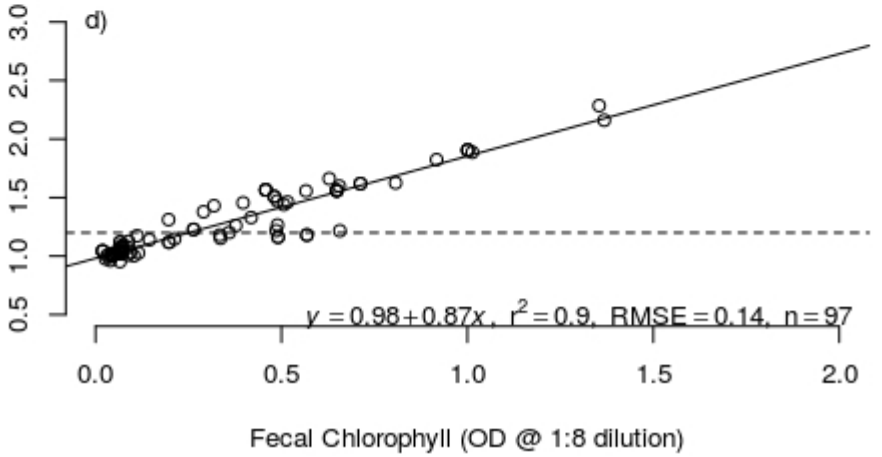
Averaged by unique date



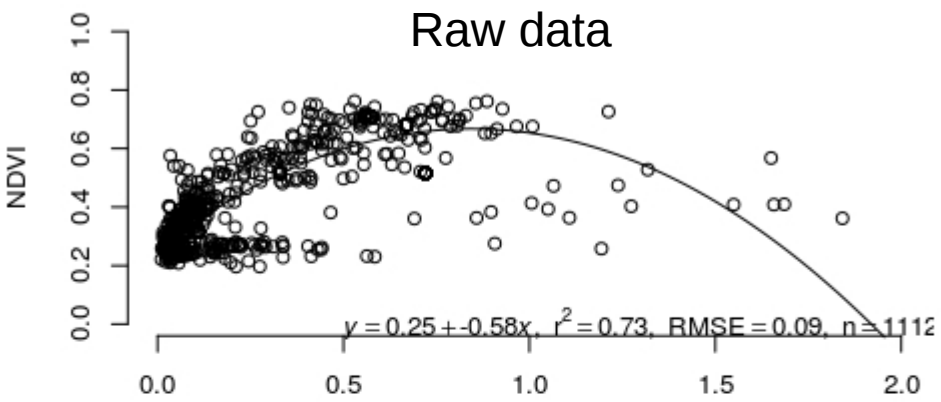
Running mean

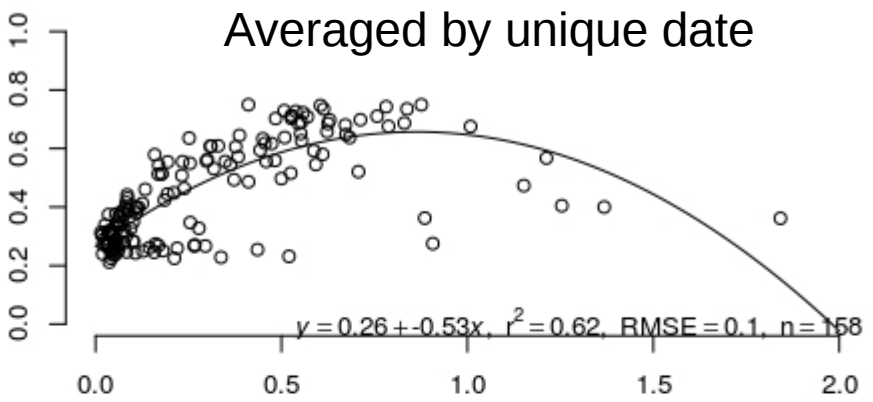


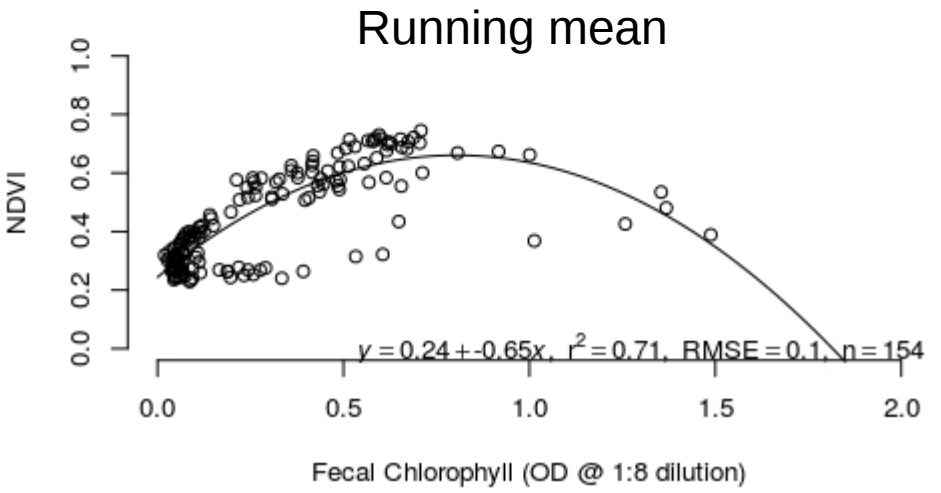
Re-sampled to NDVI interval

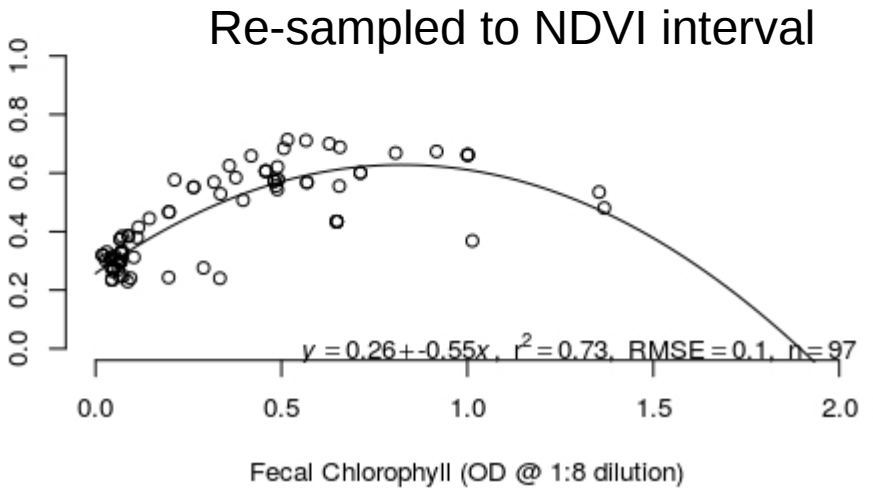


Correlation between NDVI and Faecal Chlorophyll

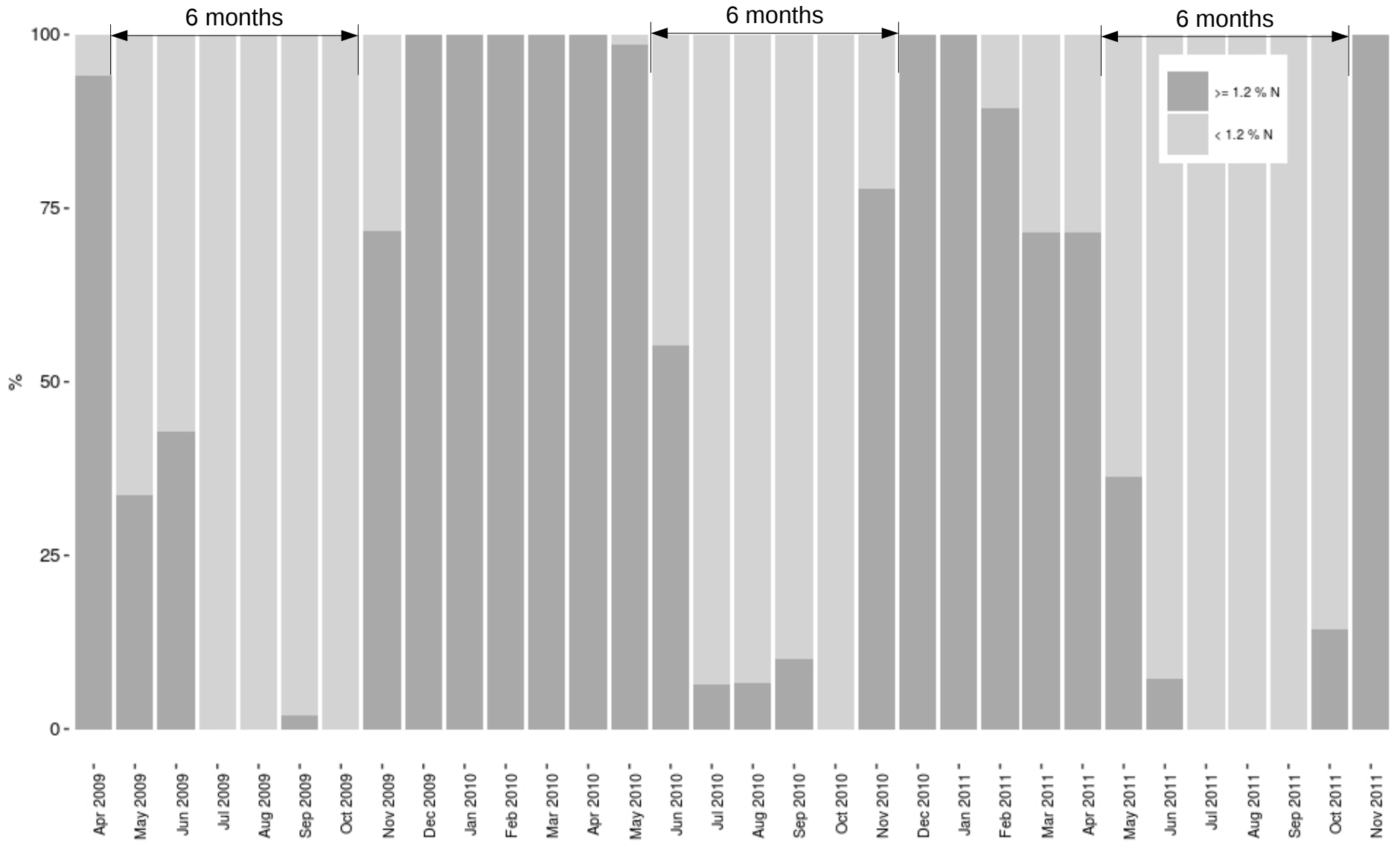




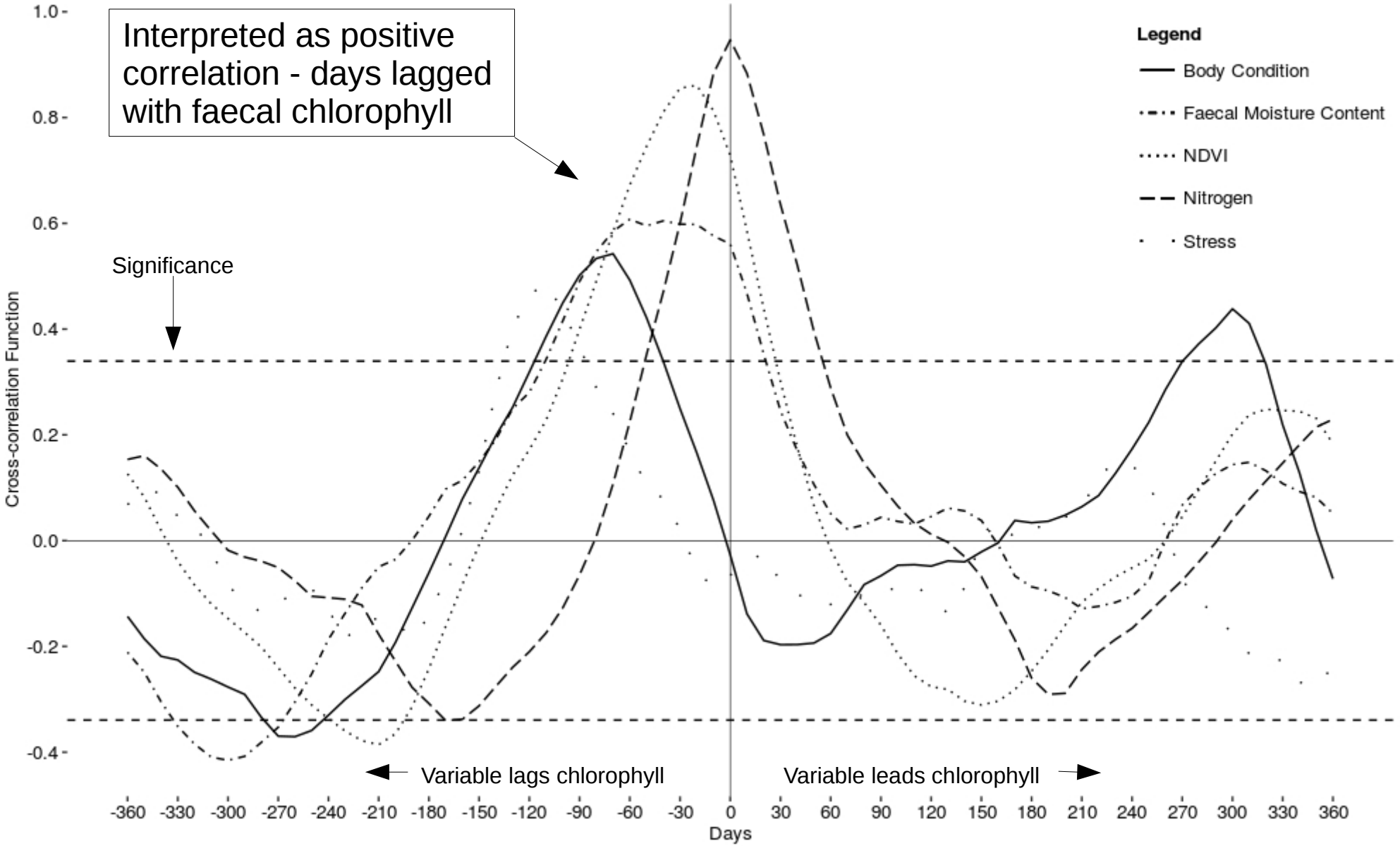




Nitrogen levels are below maintenance requirements during the dry season



Cross-correlation Functions with Faecal Chlorophyll



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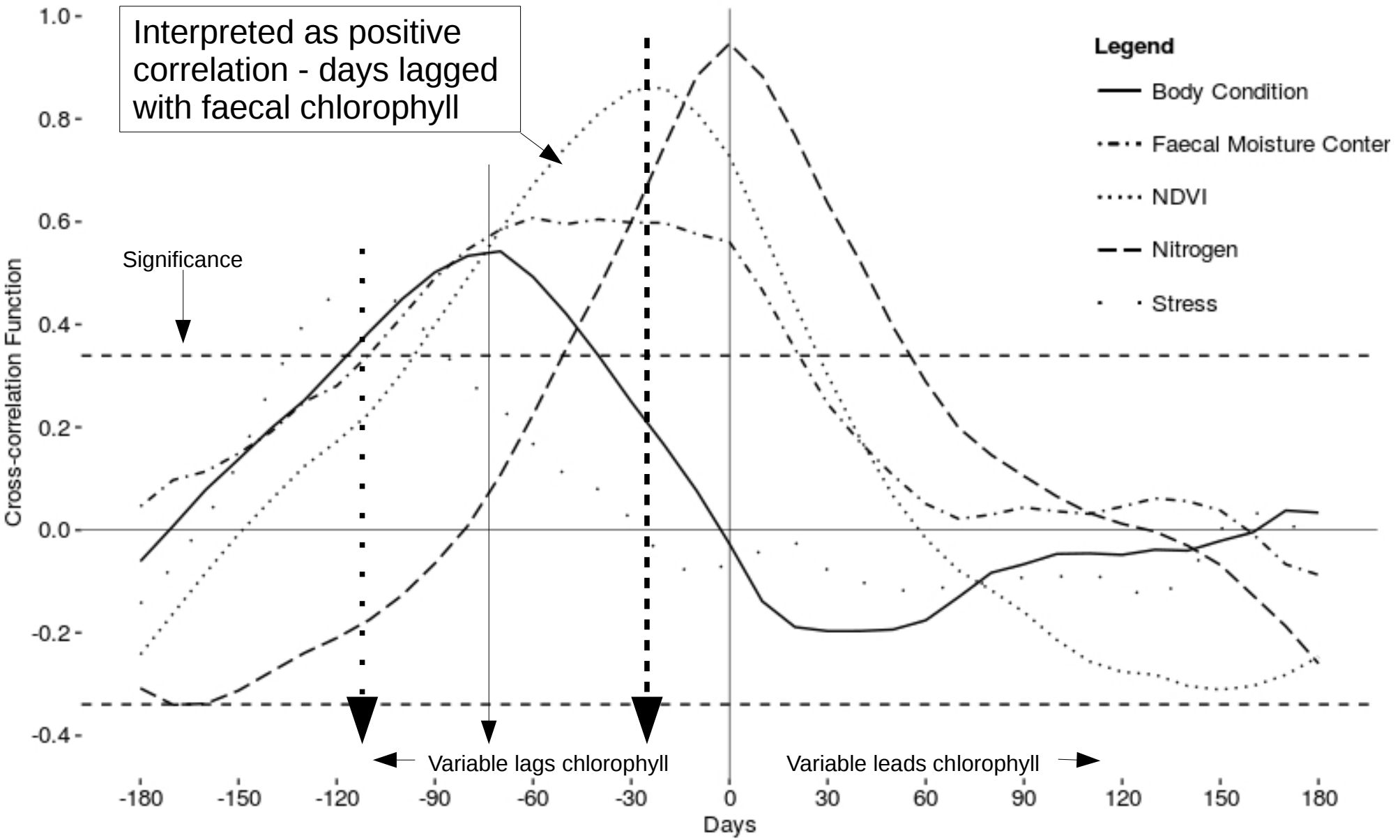
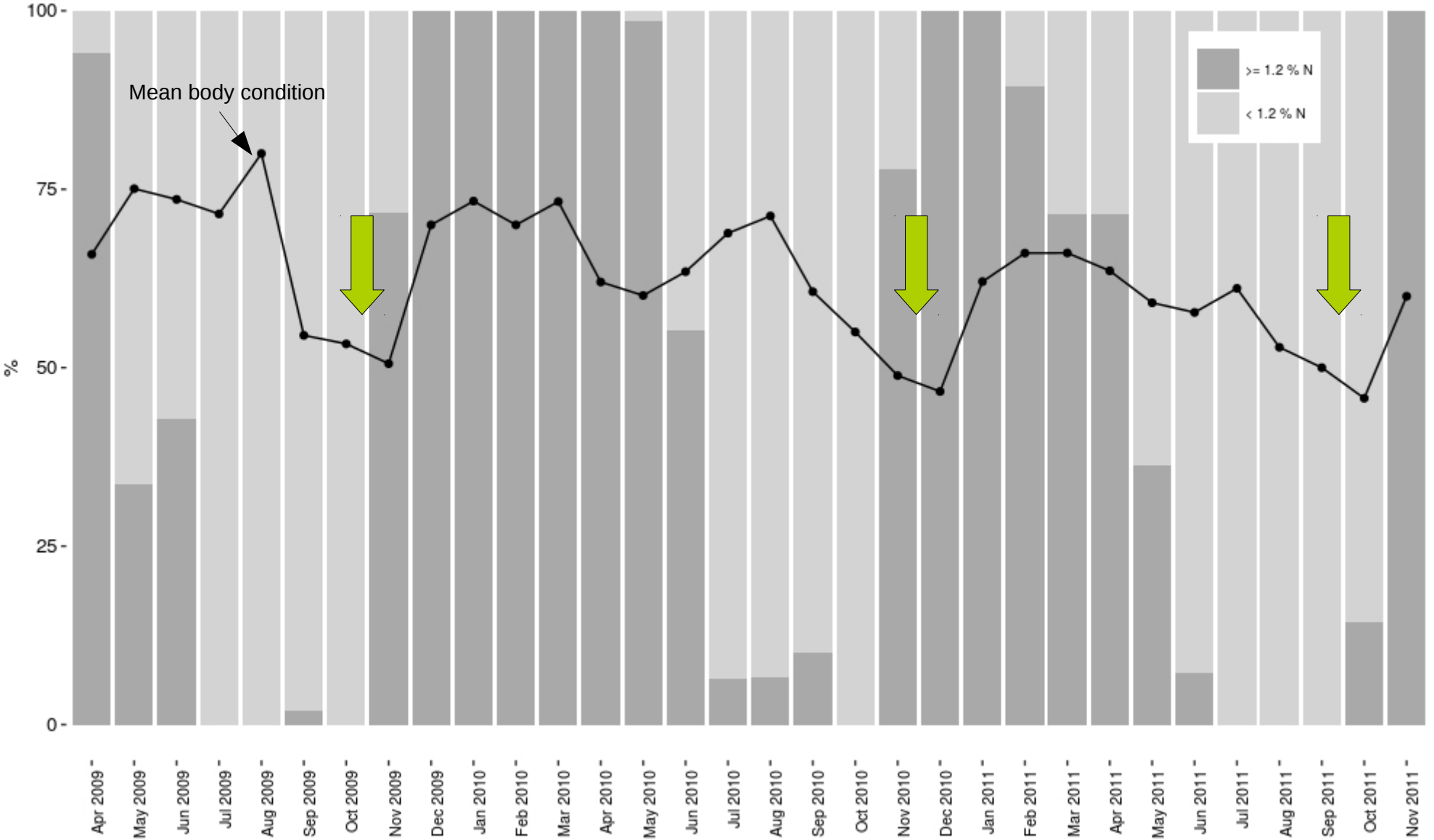


Mean Body Condition regulated by Nitrogen Levels



Primary Findings

Potein defficeint state

- Buffalo spend significant time in nutrient deficient state
- Kruger this is generally from July to October (4 months)
- Body condition takes 30 to 90 days to recover
- Buffalo can therefore spend 4 to 6 months in nutrient deficient state

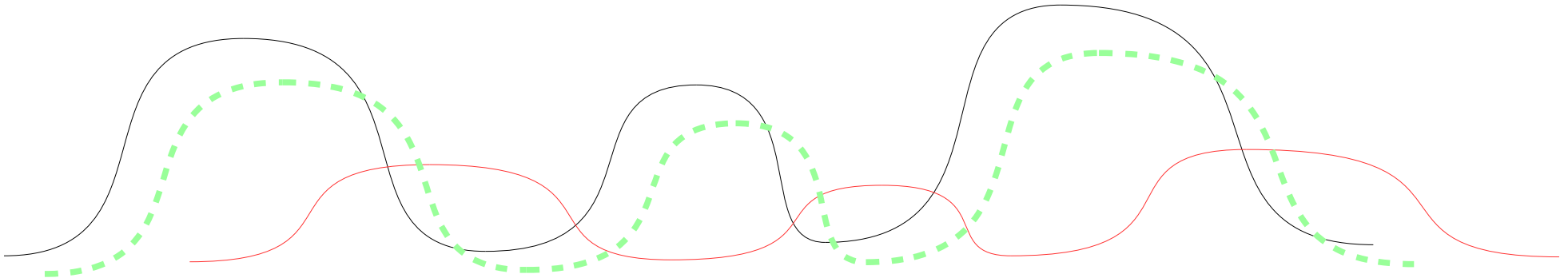
Highly selective

- Buffalo are very selective in late dry / early wet when compared to availability in the landscape
- Significant considering early tree NDVI signal
- Possible reasons:
  - Conditioning rumen (acidosis)
  - Offset nutrient state

Primary Findings

Strong explanatory variable

- Ecosystem primary production causes cascades in buffalo physiological condition
- These cascades may be the primary driver that influence immunity and susceptibility to disease and parasitism
- Future analysis will focus on making a connection with immune variables and burden of disease



Broader impact

Useful Tool

- Faecal chlorophyll correlates well with faecal nitrogen
- Faecal chlorophyll cheaper alternative to faecal nitrogen to monitor dietary quality
- Easy and fast
- Direct measure (compared to NDVI)
- Could be used to monitor when supplementary feeding is required
- Potential as a rangeland monitoring tool
- Potentially useful with GPS data (Key resources ?)

Implications

- Buffalo physiological state tightly linked to primary production
- Land managers should take note of the prolonged nutrient deficient state of buffalo
- Any changes to the system which may alter sward nutritional quality and / or
- prolong the interval between vegetative growth cycles can have major impact on buffalo immunity and disease dynamics

Questions