



Banksy Crude Oils Modified Oil painting #12





VIRTUALFOREST.IO

TRACKING SEASONAL CHANGE
IN A VIRTUAL FOREST

EXPERIENCE THE FOREST

SCROLL THROUGH A YEAR

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<http://virtualforest.io/index.html>

Koen Hufkens

Using DIY technology to monitor forest phenology

	Ricoh Theta S	\$350
	Raspberry pi 2	\$36
	6-60V - 5V 3A UBEC	\$19
	24V POE injector	\$10
	APC surge protector	\$18
	200ft / 50m Cat5e cable	\$13
	8" glass globe lamp cover	\$35
	4" (10cm) PVC pipe	\$20
	4" (10cm) PVC coupler	\$2.5
	3.5" Wooden Fence post	\$5
	36" ground anchor	\$30
	3mm Plexiglass sheet	\$5
	1/4" stainless steel rod	\$1
	1/4" (coupling) nuts	\$1
	1/4" washers	\$1
	TOTAL	~\$550

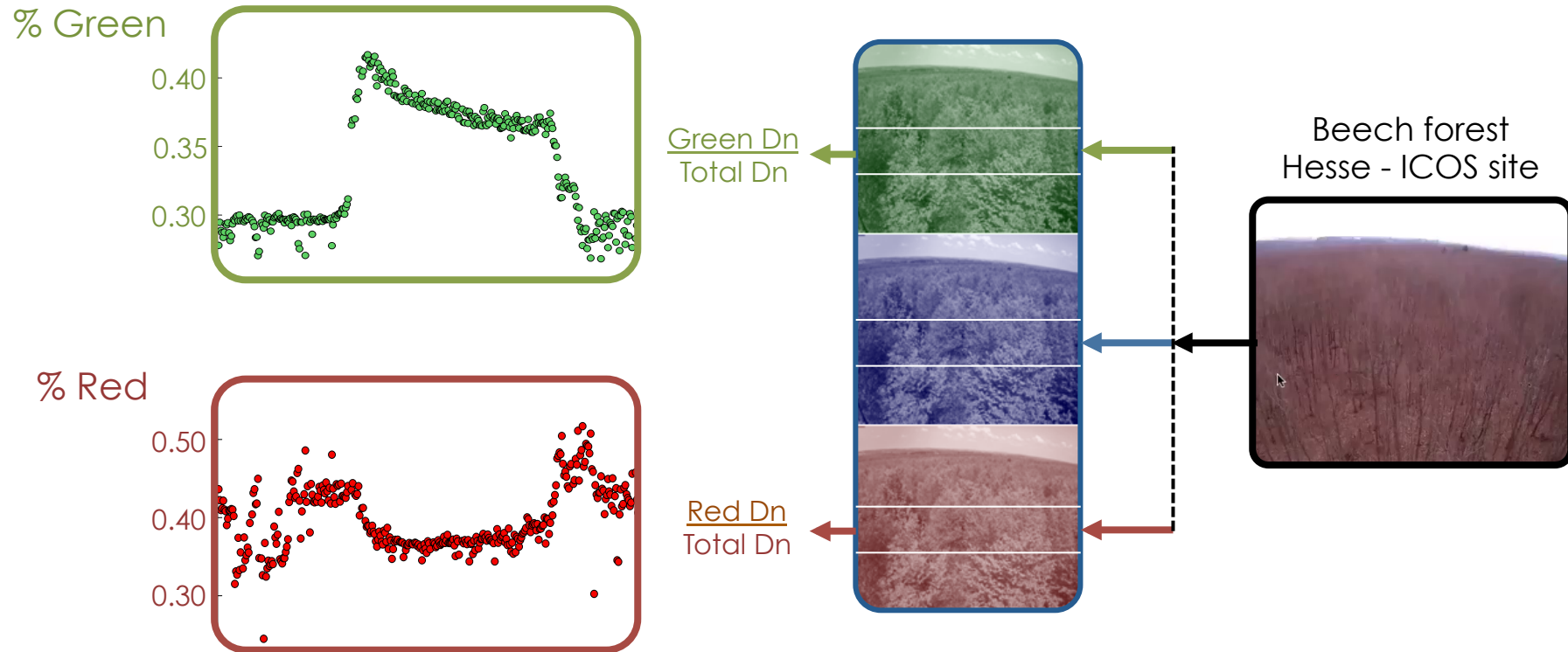


<http://virtualforest.io/faq.html>



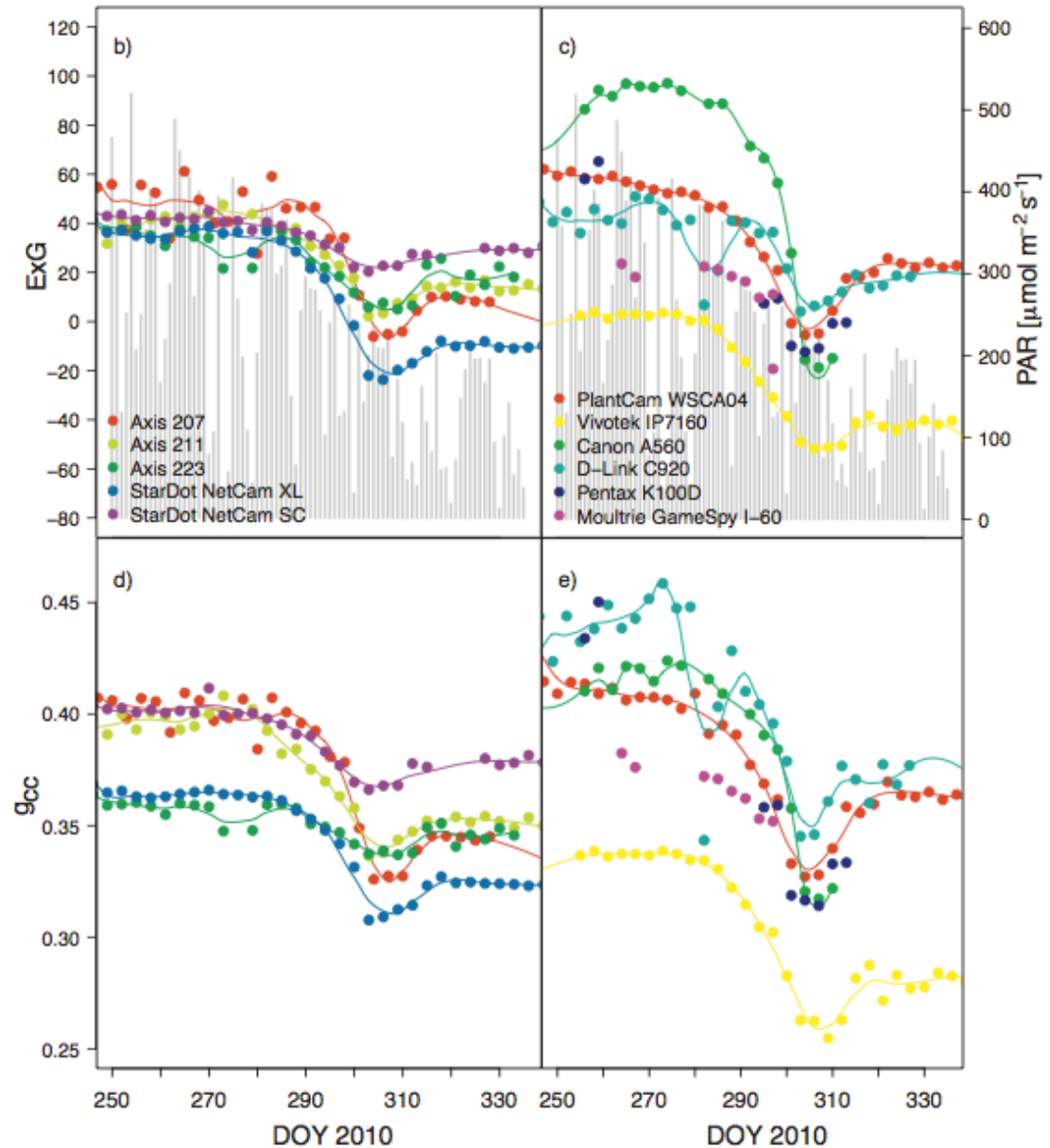
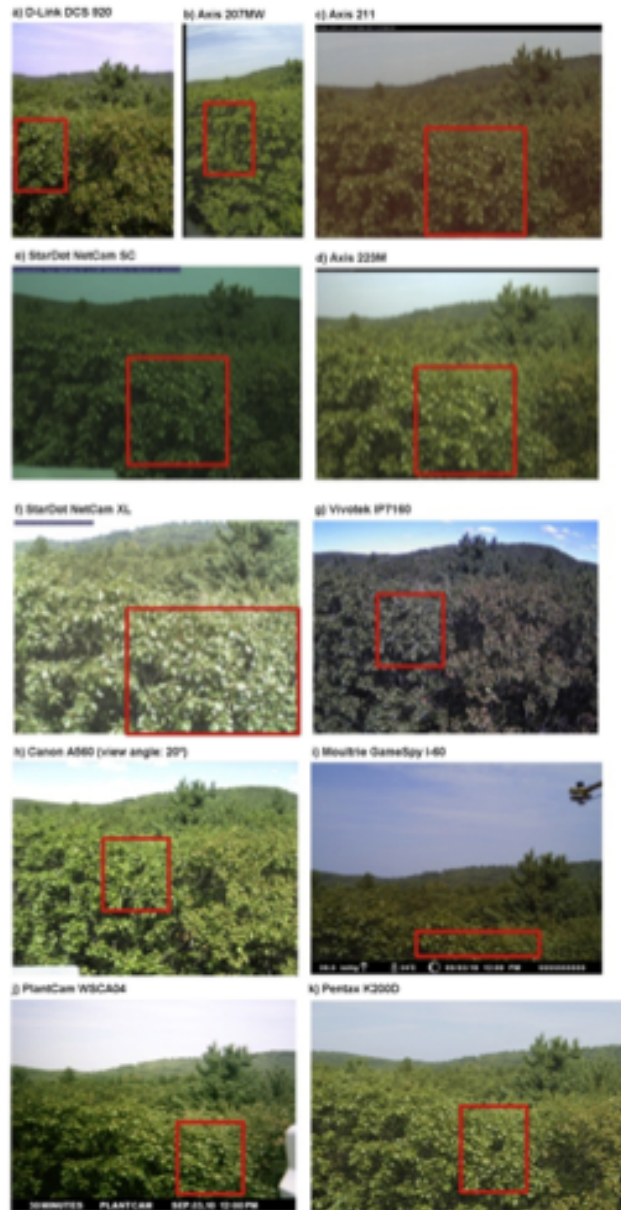
Google Cardboard
+
Open source code
Stored in Github

Digital cameras track the phenology of communities



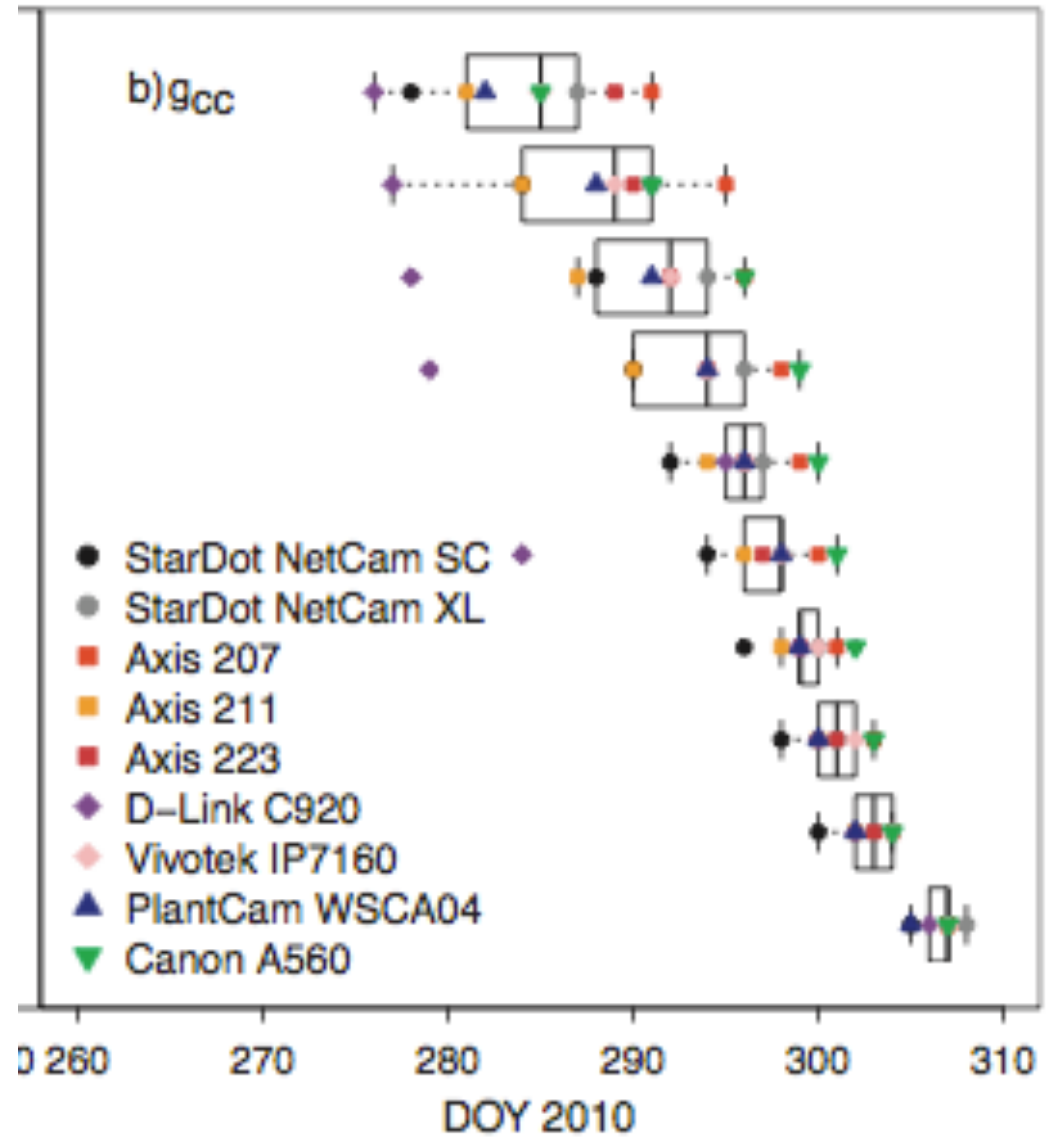
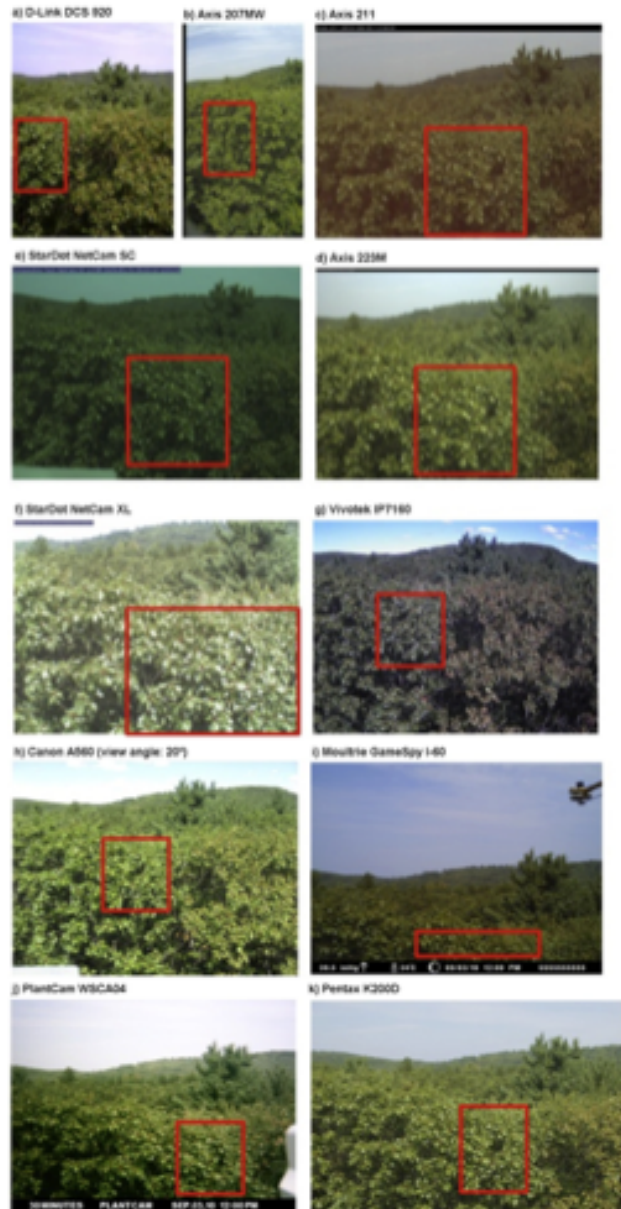
(Richardson et al., *Oecologia*, 2007)

Does it matter what type of camera I use?

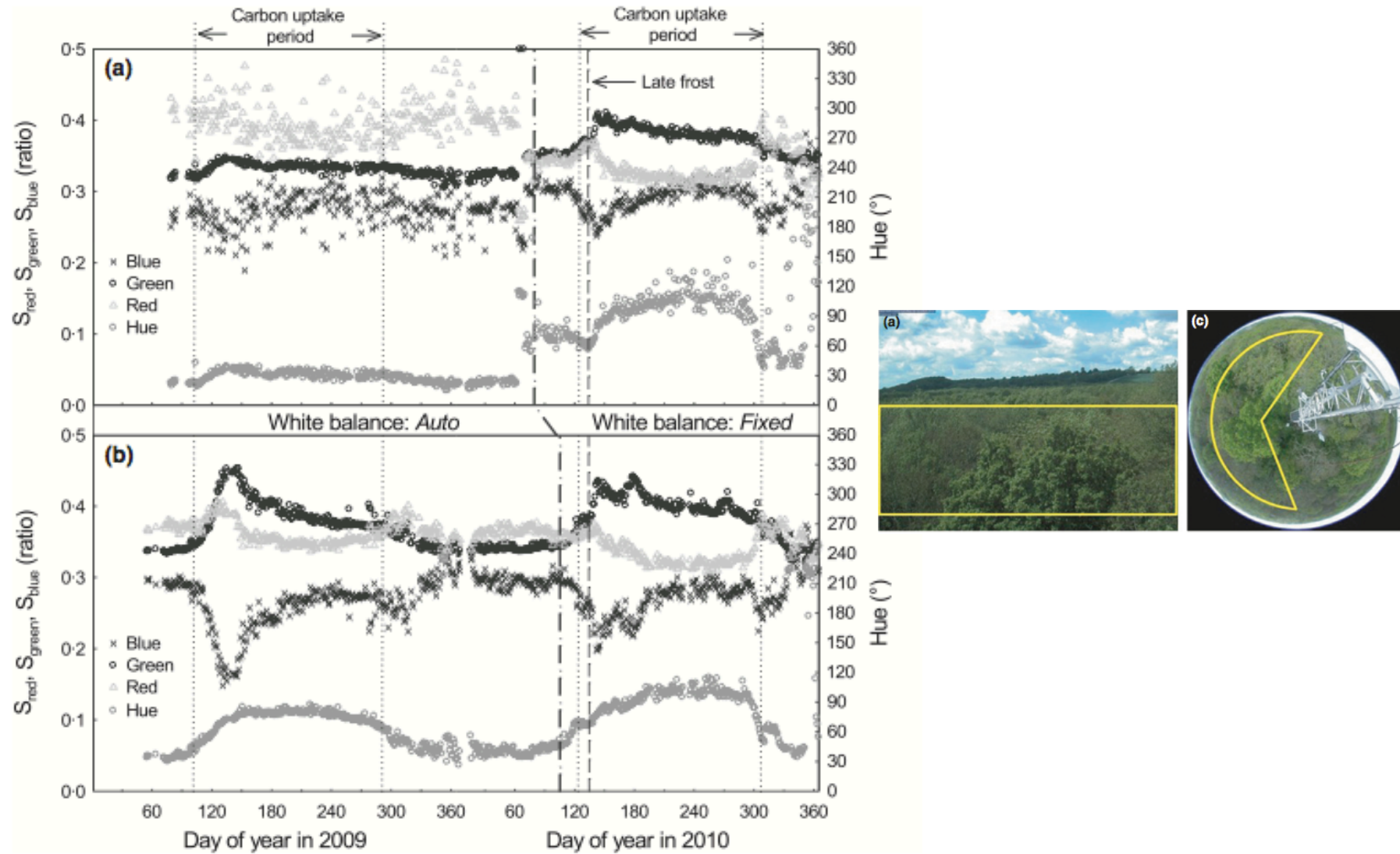


(Sonnentag et al., Agric.For.Met., 201?)

Does it matter what type of camera I use?

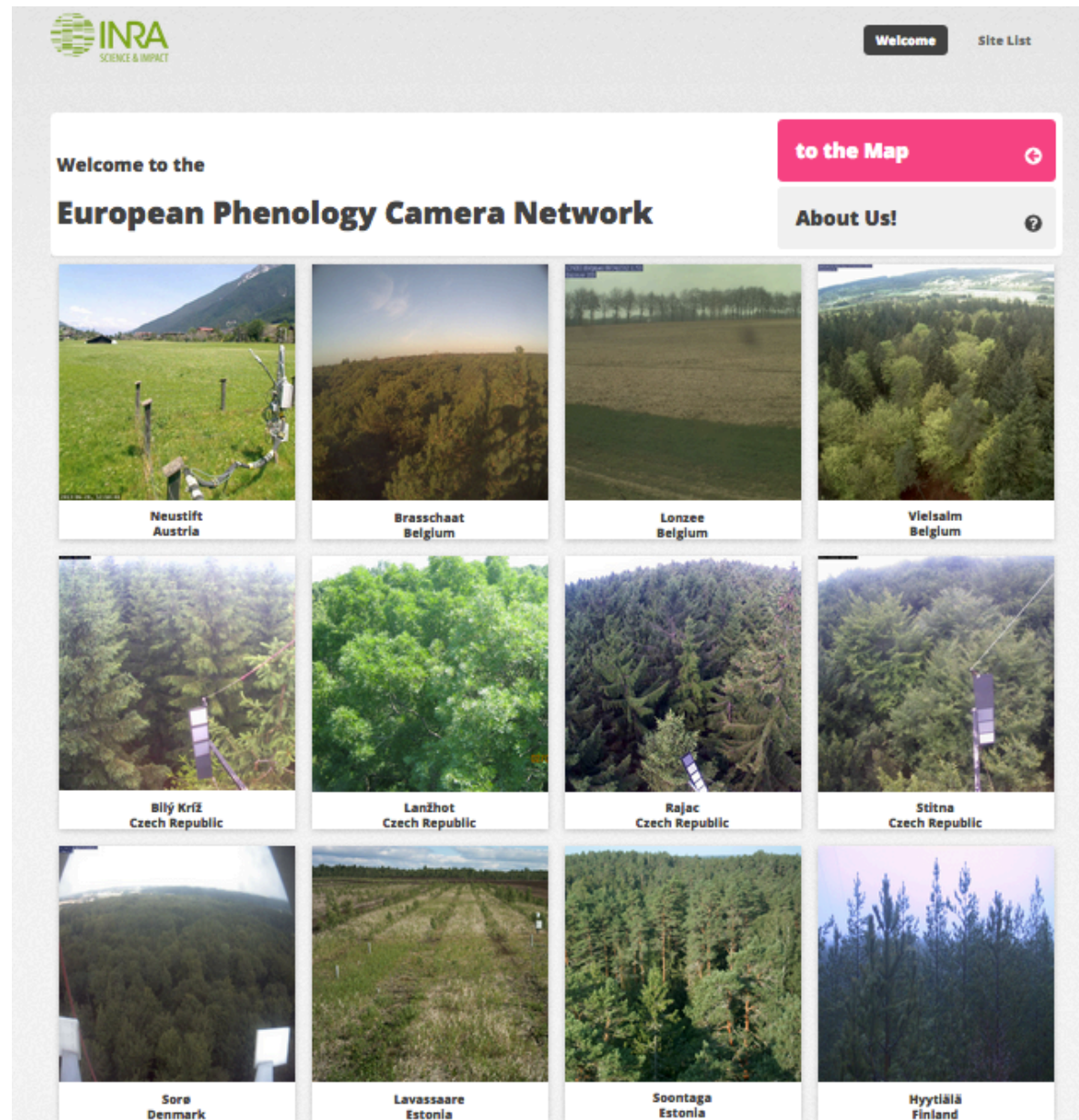


Common problems with colour balance settings



(Mizunuma et al., Functional Ecol, 2013)

Digital cameras networked to study ecosystem function



(Wingate et al., Biogeosciences., 2015)

Digital cameras networked to study ecosystem function

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EUROPHEN

The EuroPhen website serves as a portal to synthesise data from flux (or affiliated) sites across Europe where researchers have embraced the opportunity to establish automatic observations of phenological events by mounting digital cameras and recording digital repeat photography images of the vegetation throughout the seasons.

These digital repeat photography image time series increase our understanding of the feedbacks between the climate and seasonal vegetation growth. In depth references to publications can be found in our literature list.

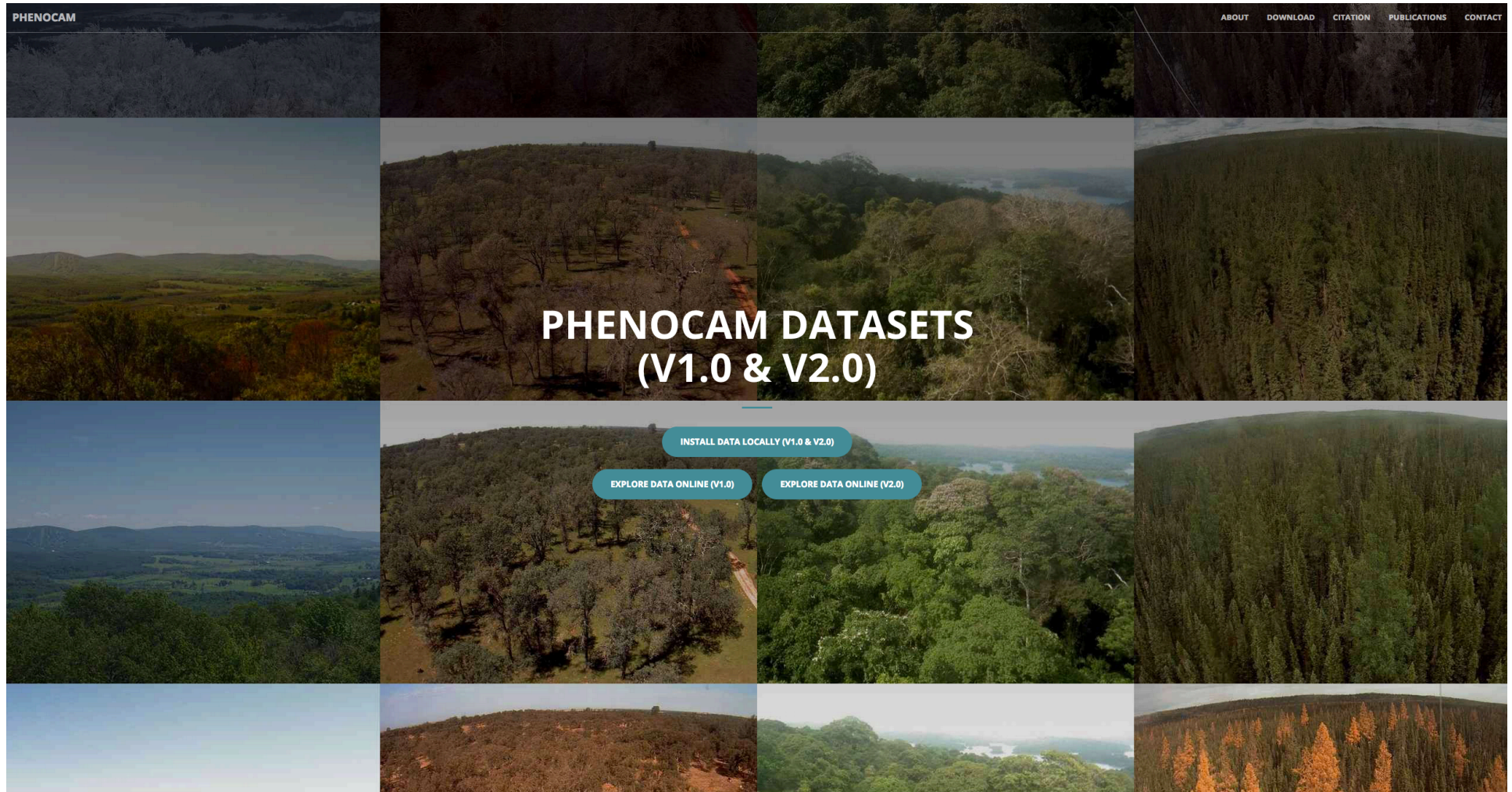
The EuroPhen network currently covers over 50 (flux) sites across Europe in various ecosystem types. If you want to contribute to our camera network please [do get in touch](#), so we can help you with the setup of a camera.



- Cropland
- Deciduous Broadleaf
- Deciduous Needleleaf
- Evergreen Broadleaf
- Evergreen Needleleaf
- Grassland
- Peatland

<http://europhen.org/>

Phenocam USA



<http://phenocam.us/>

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PhenoCam Dataset v1.0: Vegetation Phenology from Digital Camera Imagery, 2000-2015


A newer version exists.

Click the DOI link in the following citation for the latest version (as of 2019-09-04):

Syednasrollah, B., A.M. Young, K. Hufkens, T. Milliman, M.A. Friedl, S. Frolking, A.D. Richardson, M. Abraha, D.W. Allen, M. Apple, M.A. Arain, J. Baker, J.M. Baker, D. Baldocchi, C.J. Bernacchi, J. Bhattacharjee, P. Blanken, D.D. Bosch, R. Boughton, E.H. Boughton, R.F. Brown, D.M. Browning, N. Brunzell, S.P. Burns, M. Cavagna, H. Chu, P.E. Clark, B.J. Conrad, E. Cremonese, D. Debinski, A.R. Desai, R. Diaz-Delgado, L. Duchesne, A.L. Dunn, D.M. Eissenstat, T. El-Madany, D.S.S. Ellum, S.M. Ernest, A. Esposito, L. Fenstermaker, L.B. Flanagan, B. Forsythe, J. Gallagher, D. Gianelle, T. Griffis, P. Groffman, L. Gu, J. Guillemot, M. Halpin, P.J. Hanson, D. Hemming, A.A. Hove, E.R. Humphreys, A. Jaimes-Hernandez, A.A. Jaradat, J. Johnson, E. Keel, V.R. Kelly, J.W. Kirchner, P.B. Kirchner, M. Knapp, M. Krassovski, O. Langvall, G. Lanthier, G.I. Maire, E. Magliulo, T.A. Martin, B. McNeil, G.A. Meyer, M. Migliavacca, B.P. Mohanty, C.E. Moore, R. Mudd, J.W. Munger, Z.E. Murrell, Z. Nestic, H.S. Neufeld, T.L. O'Halloran, W. Oechel, A.C. Oishi, W.W. Oswald, T.D. Perkins, M.L. Reba, B. Rundquist, B.R. Runkle, E.S. Russell, E.J. Sadler, A. Saha, N.Z. Saliendra, L. Schmalbeck, M.D. Schwartz, R.L. Scott, E.M. Smith, O. Sonnentag, P. Stoy, S. Strachan, K. Suvocarev, J.E. Thom, R.Q. Thomas, A.K. Van den berg, R. Vargas, J. Verfaillie, C.S. Vogel, J.J. Walker, N. Webb, P. Wetzzel, S. Weyers, A.V. Whipple, T.G. Whitham, G. Wohlfahrt, J.D. Wood, S. Wolf, J. Yang, X. Yang, G. Yenni, Y. Zhang, Q. Zhang, and D. Zona. 2019. PhenoCam Dataset v2.0: Vegetation Phenology from Digital Camera Imagery, 2000-2018. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1674>

Overview

DOI	https://doi.org/10.3334/ORNLDAAC/1511
Version	1
Project	Vegetation
Published	2017-12-27
Updated	2017-12-27
Usage	251 downloads
Citations	4 publications cited this dataset

 [User Guide](#)

Description

This data set provides a time series of vegetation phenological observations for 133 sites across diverse ecosystems of North America and Europe from 2000-2015. The phenology data were derived from conventional visible-wavelength automated digital camera imagery collected through the PhenoCam Network at each site. From each acquired image, RGB (red, green, blue) color channel information was extracted and means and other statistics calculated for a region-of-interest (ROI) that delineates an area of specific vegetation type. From the high-frequency (typically, 30 minute) imagery collected over several years, time series characterizing vegetation color, including canopy greenness, plus greenness rising and greenness falling transition dates, were summarized over 1- and 3-day intervals.



Spatial Coverage

Bounding rectangle

N: 71.28
S: 9.15
E: 34.83
W: -158.61

Temporal Coverage

1999-11-16 to 2016-08-08

Other useful resources

Introduction to working with PhenoCam Images

Phenology—the study of how nature changes seasonally—is a core focus of research enabled by NEON data and infrastructure. NEON gathers phenological data at its field sites through various methods including field sampling of specific plants and insects, flyovers to collect remote sensing data and *in situ* phenocams that collect phenology image data. [These data are hosted by PhenoCam Network](#) and also accessible via the [NEON data portal](#) as NEON Data Products DP1.00033.001, DP1.00042.001, and DP1.20002.001.

The tutorials in this series were developed in close collaboration with [Phenocam Network scientists](#).

This series provides instruction on how to work with the photographs from the PhenoCam Network to extract the day you want for phenology or time-series analyses.

Learning Objectives

After completing the series, you will be able to:

- Access and download raw and processed data from the PhenoCam network
- Extract time-series data from any stack of digital images, including but not limited to the images of the PhenoCam network
- Quantitatively remove data obtained from bad weather conditions (such as presence fog and cloud, camera field of view shifts)
- Analyze the extracted time-series to address environmental questions

Things You'll Need To Complete This Series

Install R & Set up RStudio

To complete the tutorial series, you will need an updated version of R (version 3.4 or later) and, preferably, RStudio installed on your computer.


R is a programming language that specializes in statistical computing. It is a powerful tool for exploratory data analysis. To interact with R, we strongly recommend [RStudio](#), an interactive development environment (IDE).

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[FULL LIST OF EVENTS](#)


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OVERVIEW 

INTERACTING WITH THE PHENOCAM SERVER USING PHENOCAMAPI R PACKAGE 

DETECTING FOGGY IMAGES USING THE HAZER PACKAGE 

EXTRACTING TIMESERIES FROM IMAGES USING THE XROI R PACKAGE 

MODELING PHENOLOGY WITH THE R PACKAGE PHENOR 

Other useful resources



Int. Agrophys., 2018, 32, 677-687

doi: 10.1515/intag-2017-0050

INTERNATIONAL
Agrophysics

www.international-agrophysics.org

Assimilating phenology datasets automatically across ICOS ecosystem stations

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Matthias Peichl⁵, Bert Gielen⁶, Lukas Hörtnagl⁷, Kamel Soudani⁸, Dario Papale⁹, Corinna Rebmann¹⁰,
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⁷Institute of Agricultural Sciences, ETH Zurich, Universitätstrasse 2, 8092, Zurich, Switzerland

⁸Ecology Systematics and Evolution Laboratory, University Paris Sud, 91405, Orsay, France

⁹Department of Forest Science and Environment, University of Tuscia, Via Santa Maria in Gradi 4, 01100, Viterbo, Italy

¹⁰Department of Computational Hydrosystems, Helmholtz Centre for Environmental Research, Permoserstraße 15, 04318, Leipzig, Germany

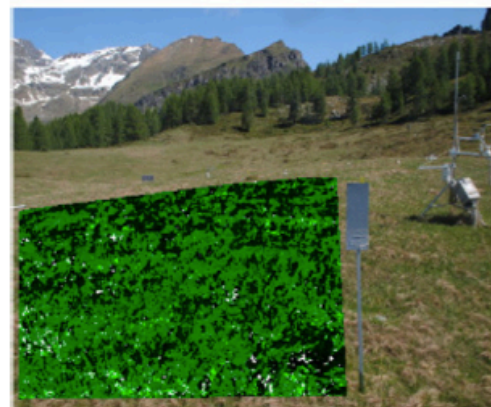
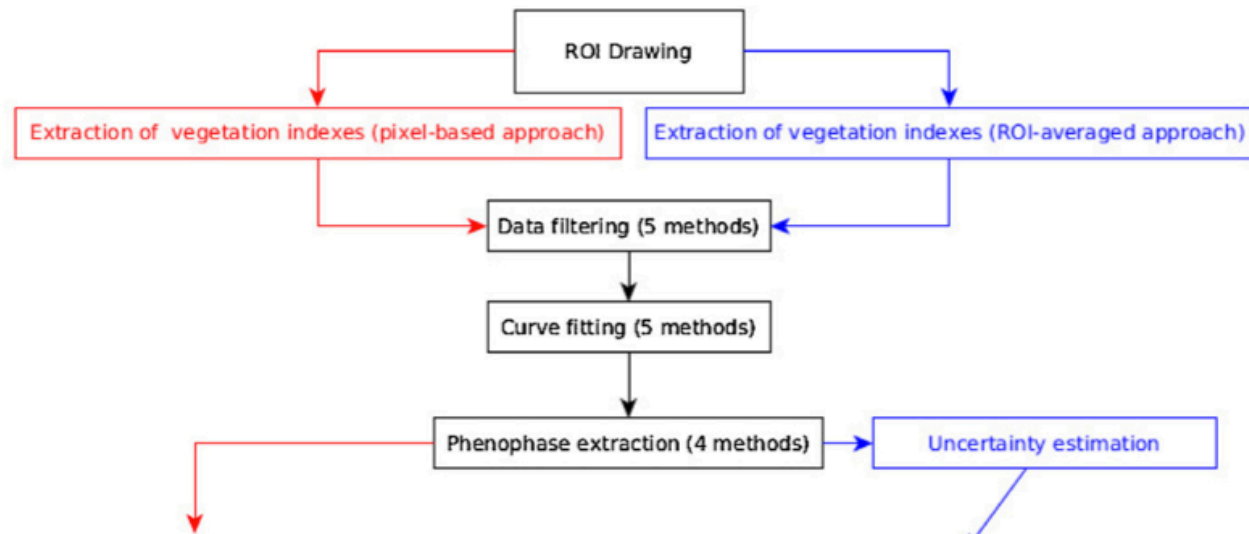
¹¹Research School of Biology, Australian National University, ACT 2601, Acton, Australia

Received June 29, 2018; accepted June 29, 2018

ICOS protocol



Estimating canopy phenology metrics using open source packages

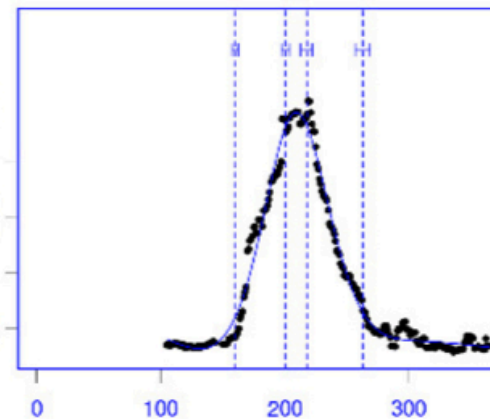


DOY

342
322
302
281
261
241

Green chromatic coordinate (G_{cc})

0.42
0.38
0.34



Time (DOY)

Phenopix

<http://r-forge.r-project.org/projects/phenopix/>

Comparing digital images visually against algorithms

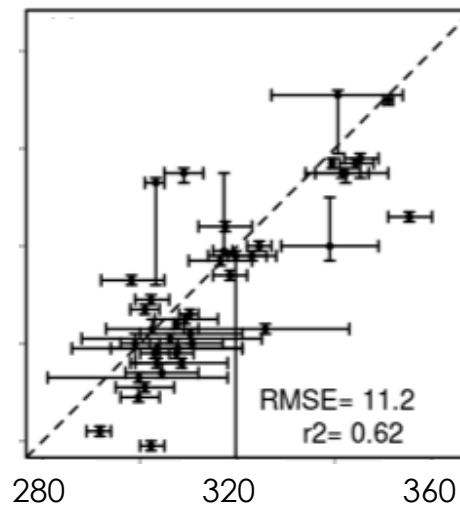
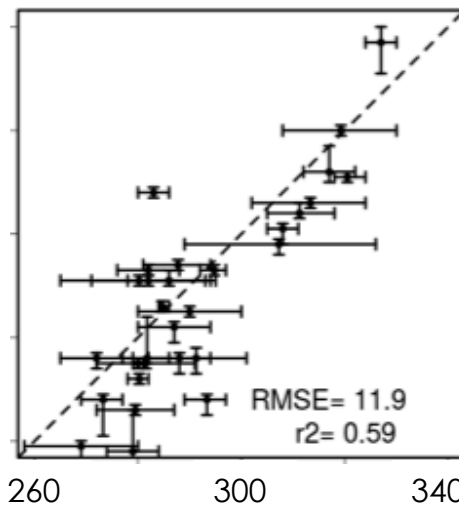
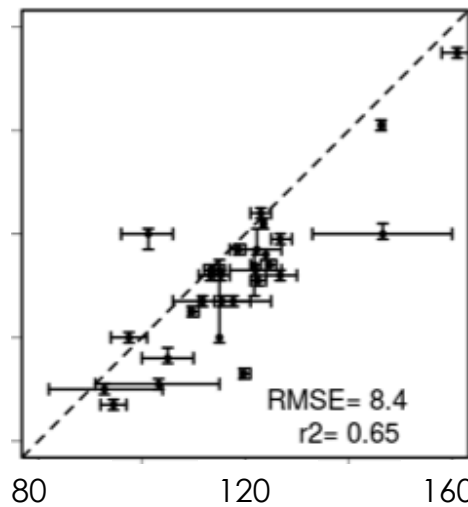


leaf
out
50% ROI

leaf
decolorisation
1st day non-green

leaf
fall
last day of non-green

piecewise
break
points
[doy]



visual
estimation
[doy]

(Wingate et al., Biogeosciences, 2015)

Cameras can track changes in ecology and land use

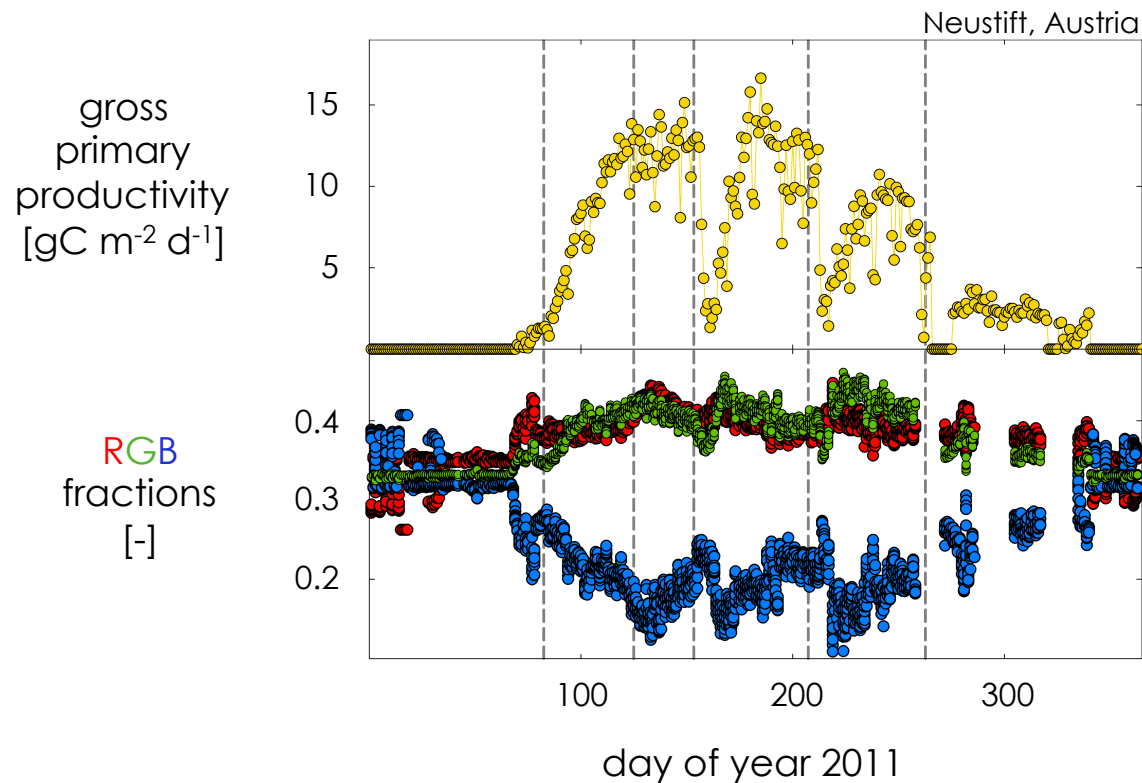
snow
melt

plants
flower

grass
long

meadow
mowed

grass
long



(Wingate et al., Biogeosciences., 2015)

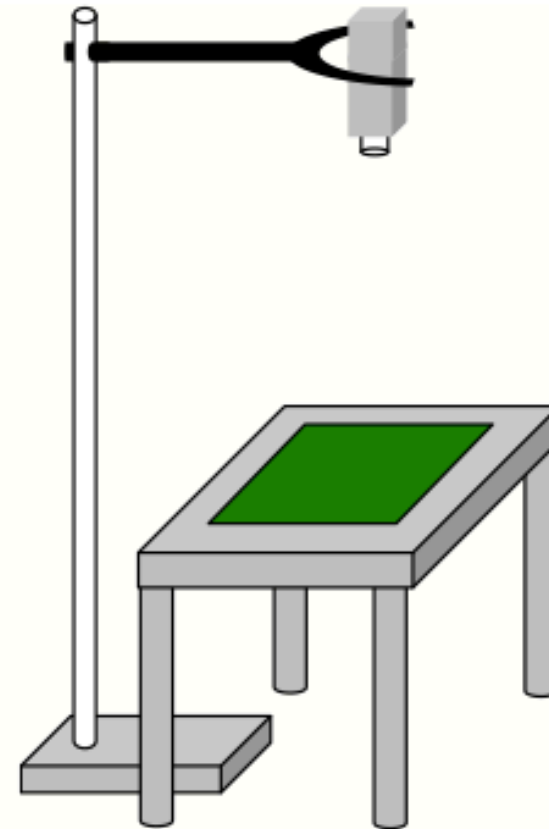
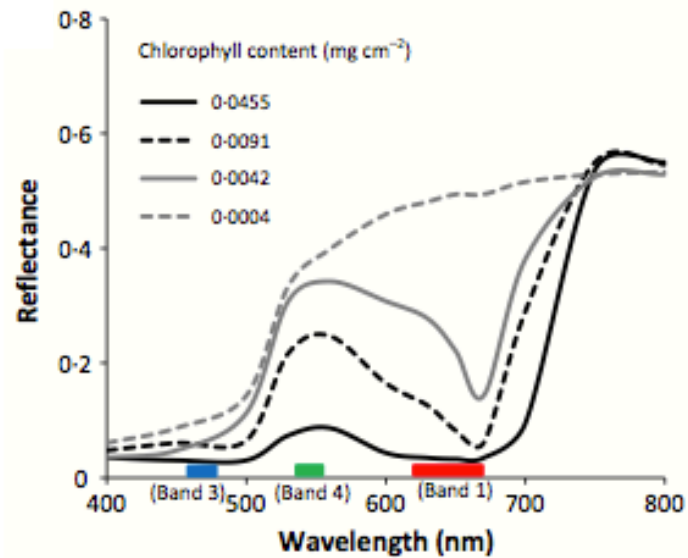
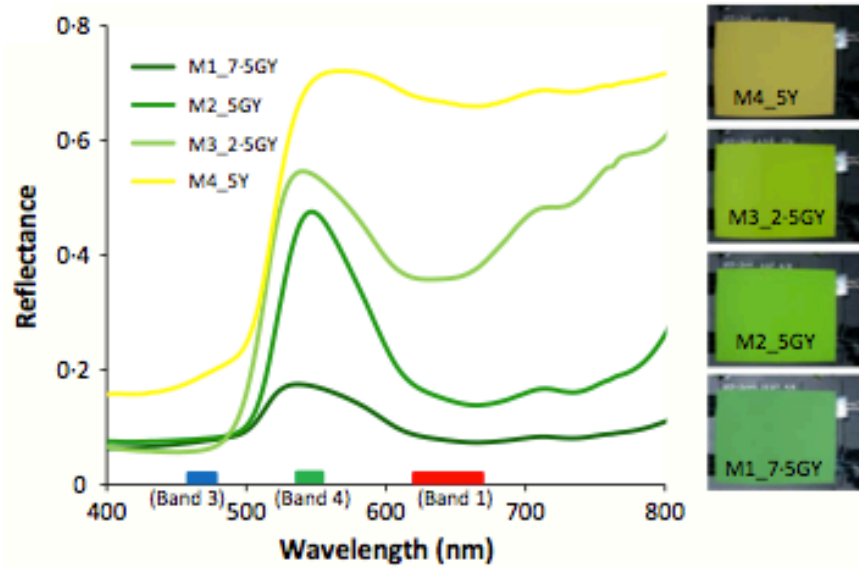
Pete the Maidenhair plant takes a selfie



Microbial Fuel Cells used to power camera

(London Zoo, 2019)

Digital cameras comparison with Munsell spectra



(Mizunuma et al., Method in Ecology and Evolution, 2014)