Semi-automatic image analysis of spatiotemporal vegetation evolution in the Hühnerwasser catchment

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Brandenburg
University of Technology
Cottbus - Senftenberg

Goals

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Quantifying spatiotemporal behaviour of vegetation as an indicator for state transitions in early ecosystem development.

Develop an algorithm, as automatic as possible, that will allow to quantify spatial vegetation development, and study the spatial structure in time.

Study area

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- Hühnerwasser catchment, in Lower Lusatia, Germany.

- Post-mining area
- Initial ecosystem development
- Data available since September 2005.
- High resolution aerial images

https://www.b-tu.de/en/research-platform-chicken-creek

Approach

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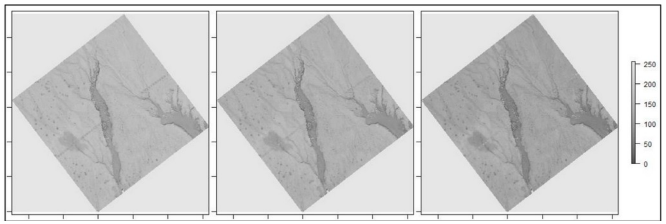
High-resolution aerial photography

Normalise colorspace for all photos (15 pictures from 2006 to 2015)

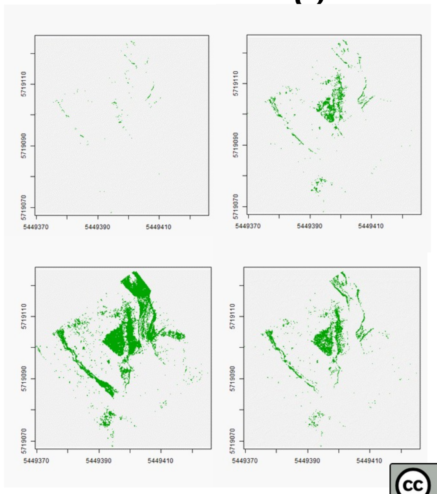
original

corrected

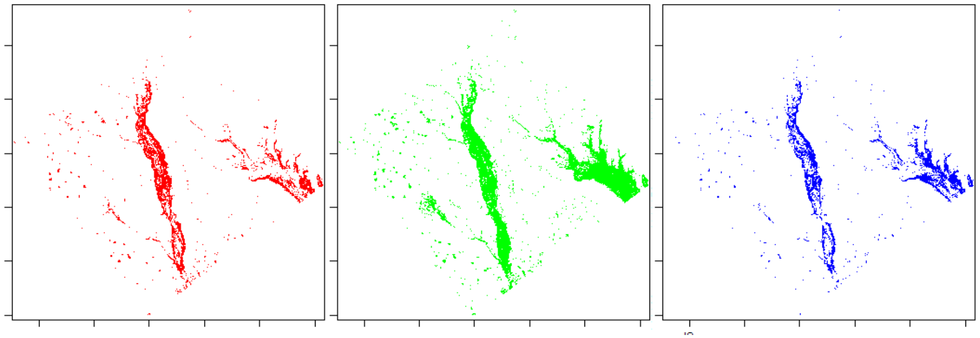
Separate RGB channels



Find good threshold (for each channel) to discriminate vegetation



Filter all channels into binary maps (vegetated/bare)



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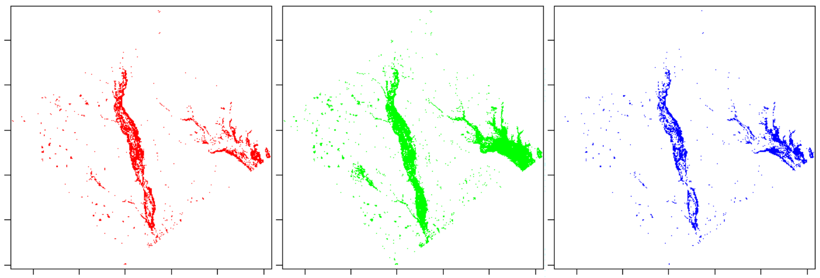
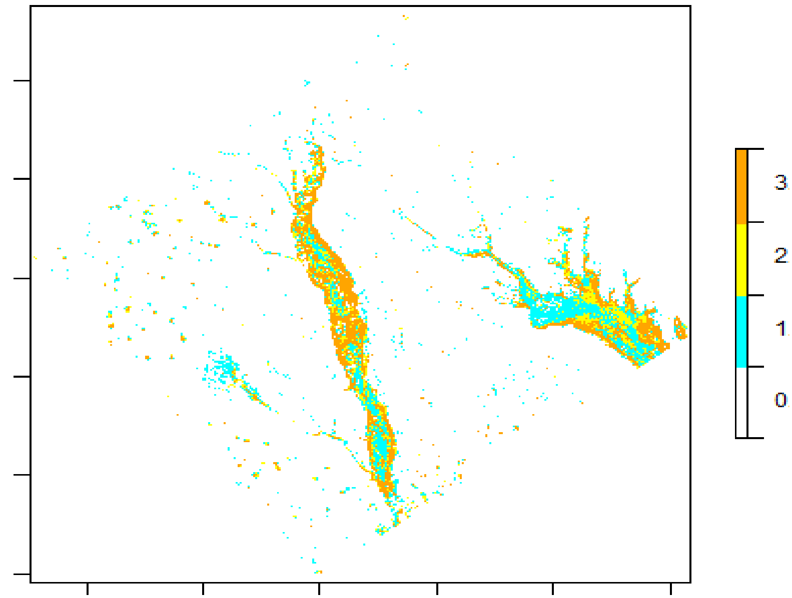
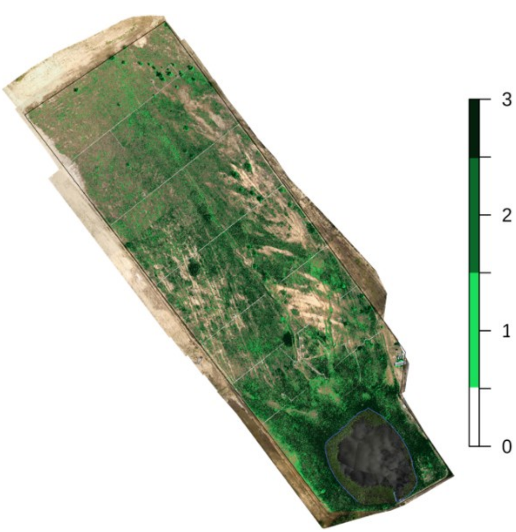
Filtered channels



Stack the channel binary maps, check overlaps



Construct vegetation maps



Algorithm implemented in R

Normalising colors

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- Problem: each aerial photography was taken under different natural lighting conditions (different day of the month, time of day, cloud cover, etc). We need to normalise colors so that we can use a single color threshold across the years.

Relative Luminescence (Stokes Equation):

$$Y = 0.2126R + 0.7152G + 0.0722B$$

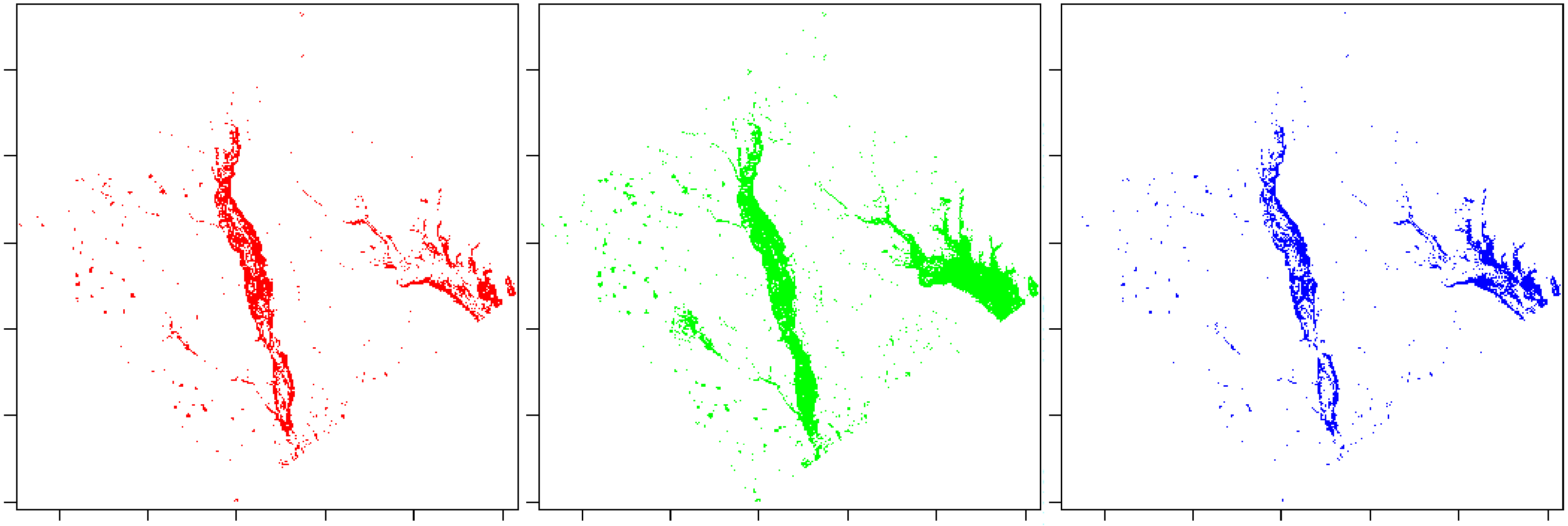
Averaged RGB values for soil/tile color

Luminescence factor

- The colors of the bare soil and concrete tiles present are taken as a reference
- The mean and standard deviation values of soil and tile samples (taken from a reference image) was used to correct **relative luminescence** (which relates to human eyesight)

Channel filtering

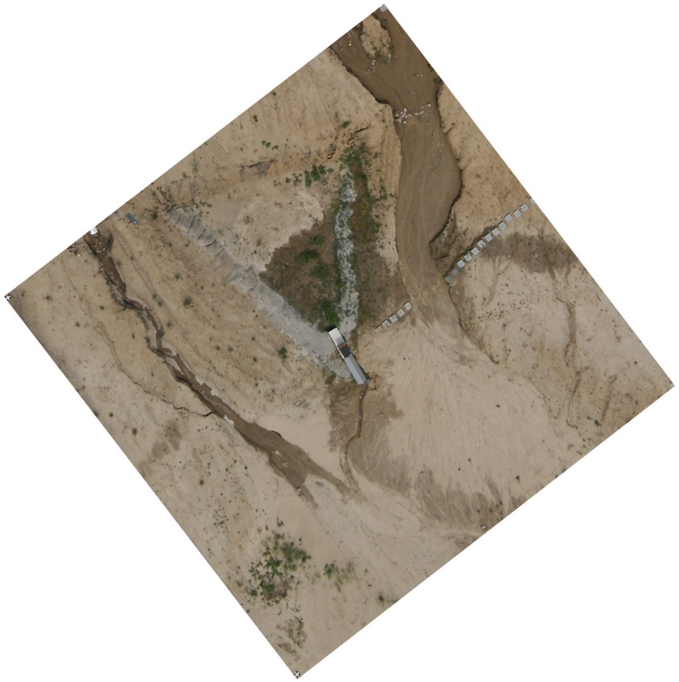
- Separate images into RGB channels
- Determine and set thresholds for each channel (configuration)
- Binarize images using a low pass filter



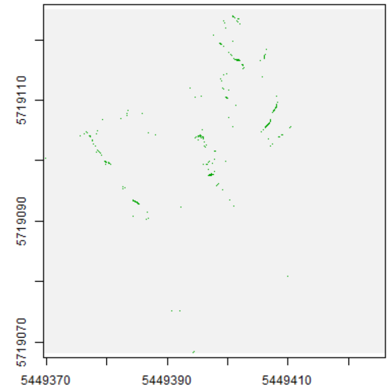
Red threshold = 100 | Green threshold = 100 | Blue threshold = 60

How to pick the thresholds?

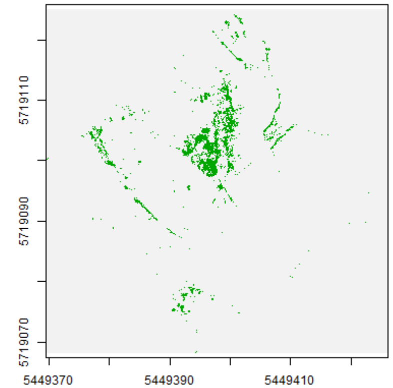
Visually: trial & error

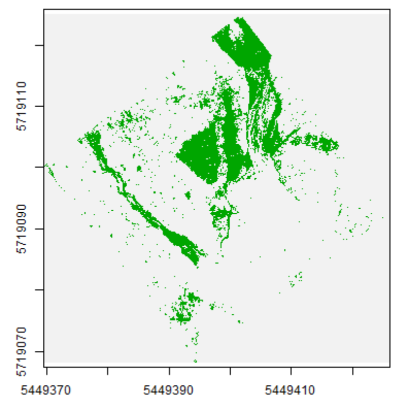


30-30-40

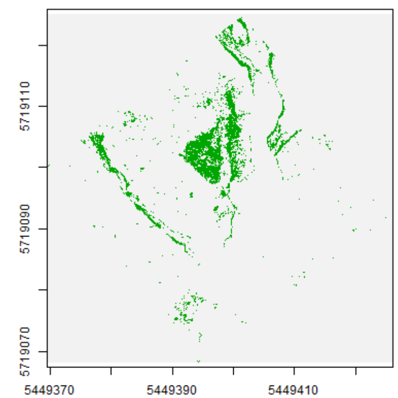


65-65-40

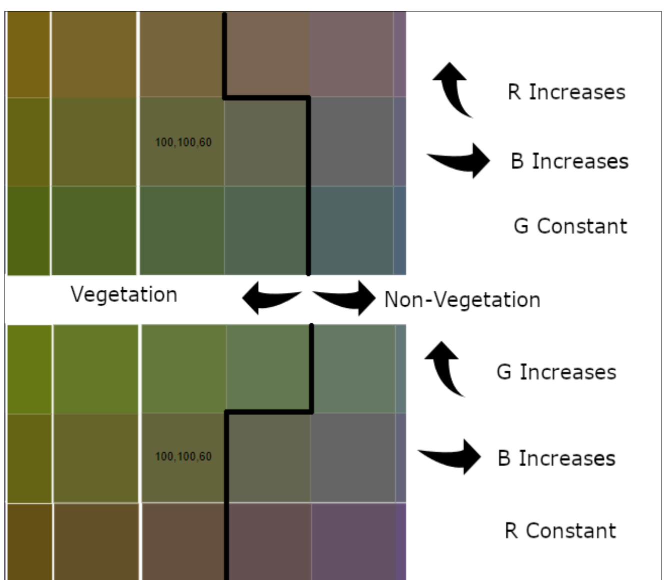




100-100-80



100-100-60



Based on reasonable color observations

Slow, subjective, not very automatic

How to pick the thresholds?

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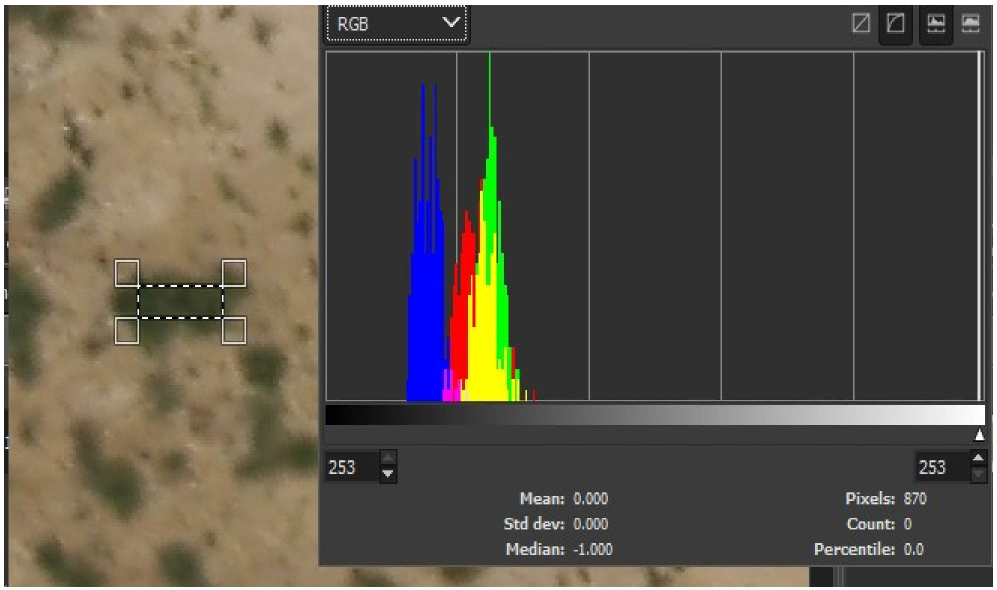
By analysing the histogram of vegetation patches versus the histogram of bare soil



Threshold	Visual Analysis	Histogram Analysis	
		Range	Mean
R	80-100	45-80	60
G	80-100	52-77	63
B	60-70	31-54	37-42

More objective, but we haven’t automated it yet. Goes in the direction of supervised classification. Further statistical properties of the patches could be used.

Putting it back together

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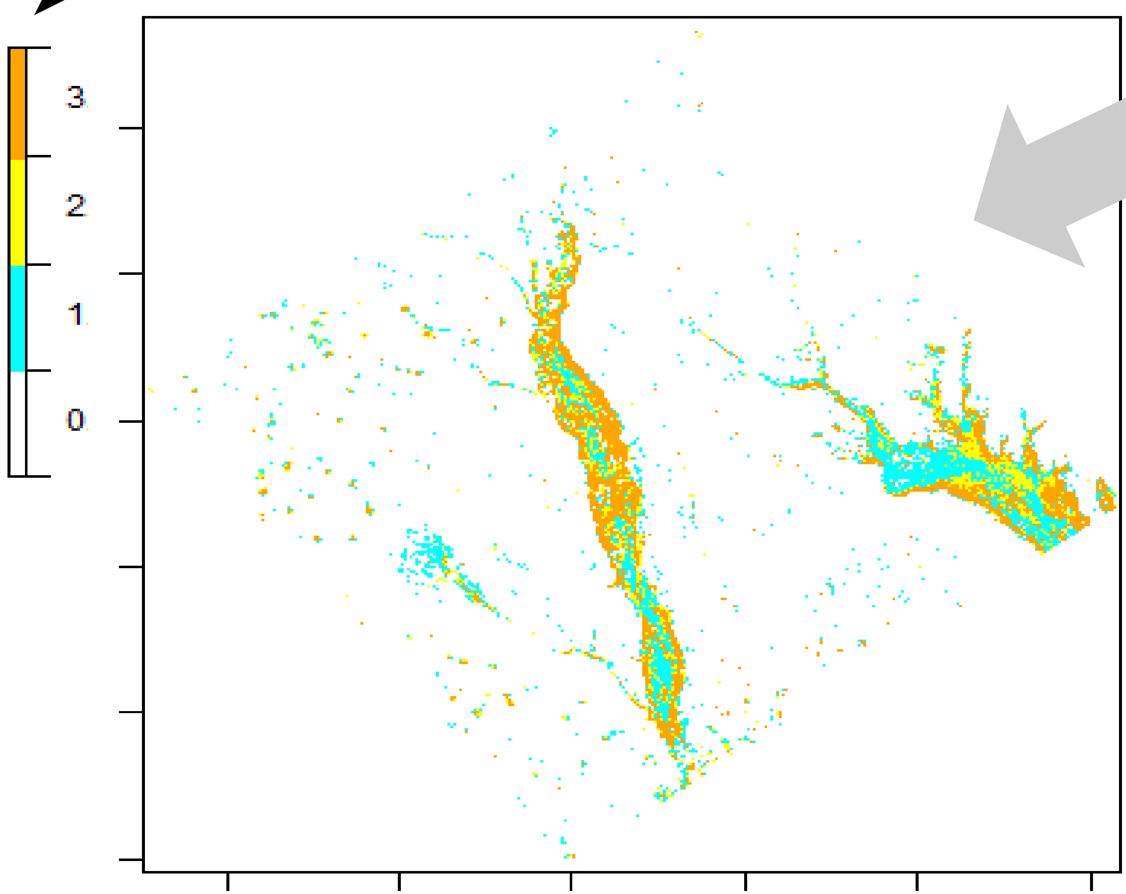
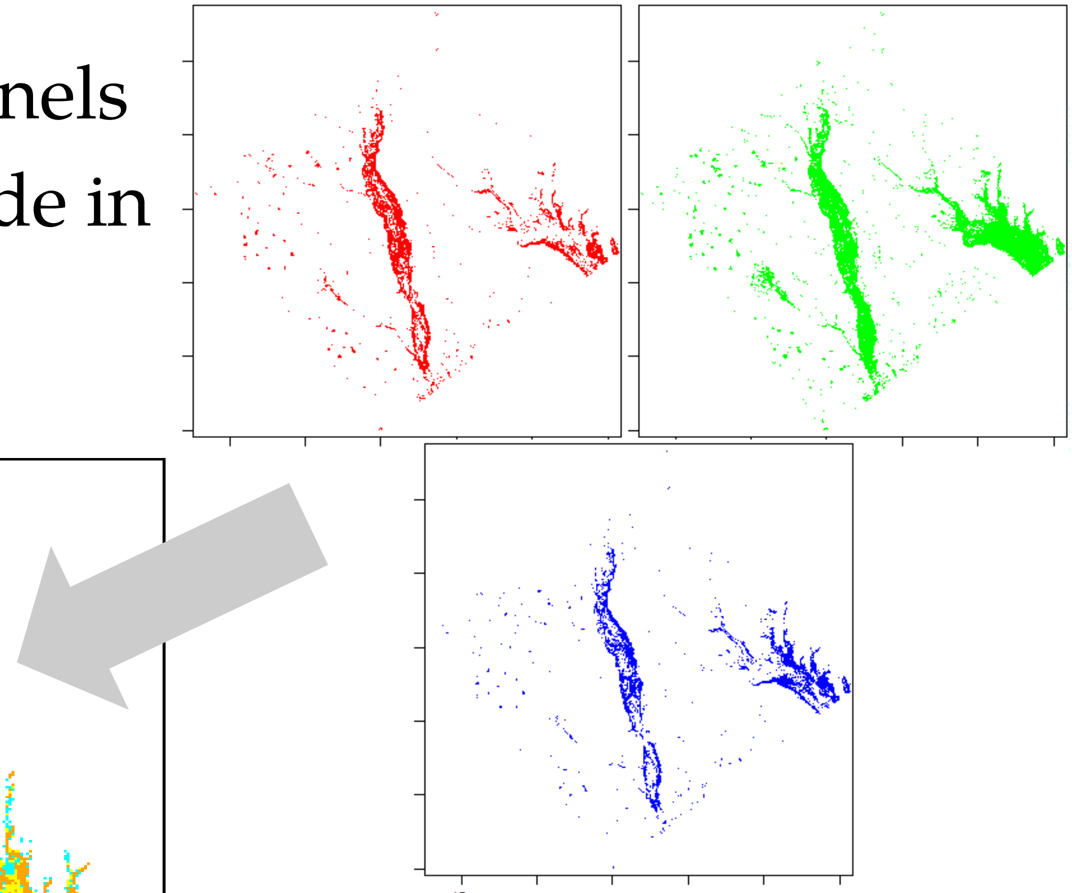
- Stack the filtered RGB channels
- How many channels coincide in classification of vegetation





The colors represent the number of channels detecting vegetation on the same pixel.

Validation

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Reference vegetation map obtained by manually digitising vegetation for two pictures

AC13

AC35

Validation

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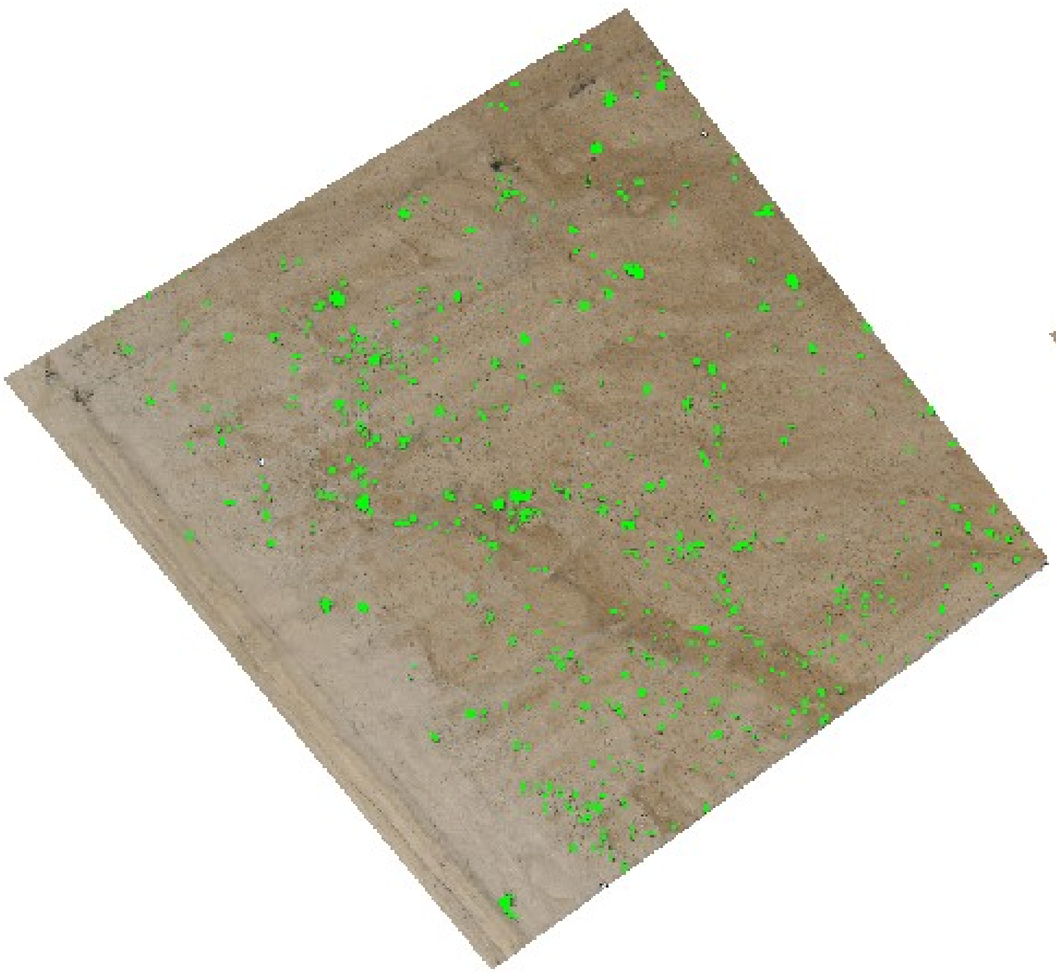
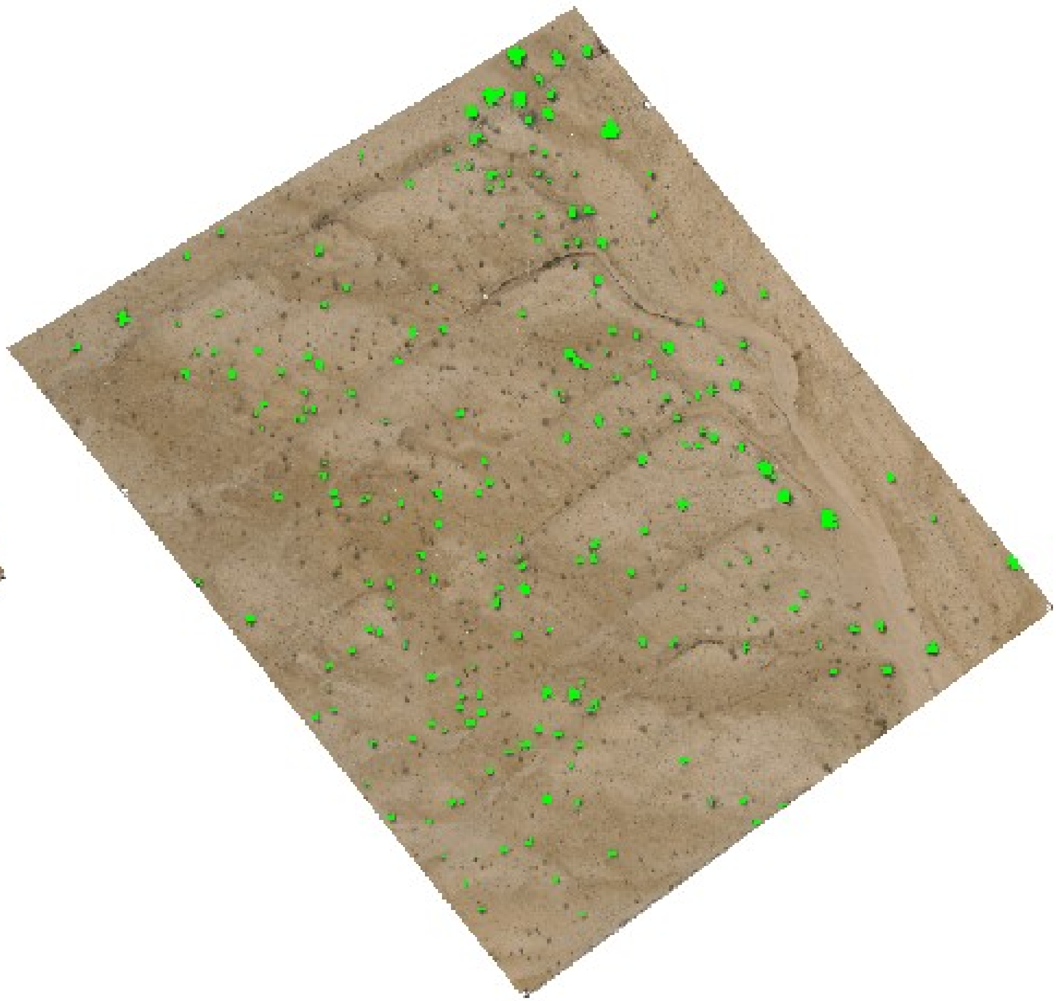
Reference vegetation map obtained by manually digitising vegetation for two pictures



AC13



AC35

Validation

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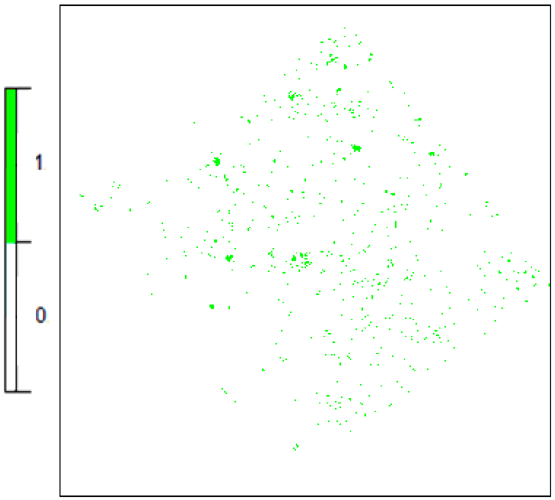
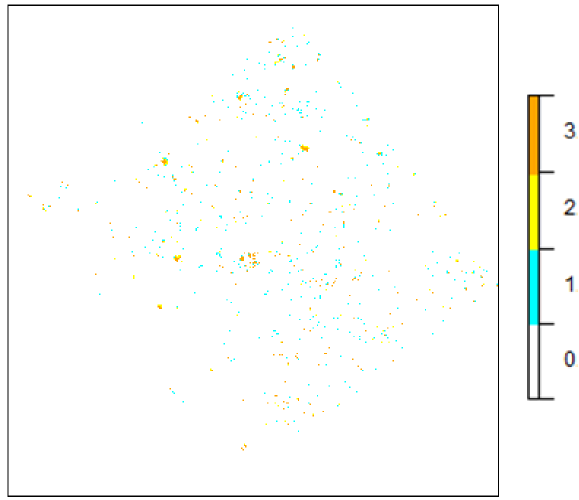
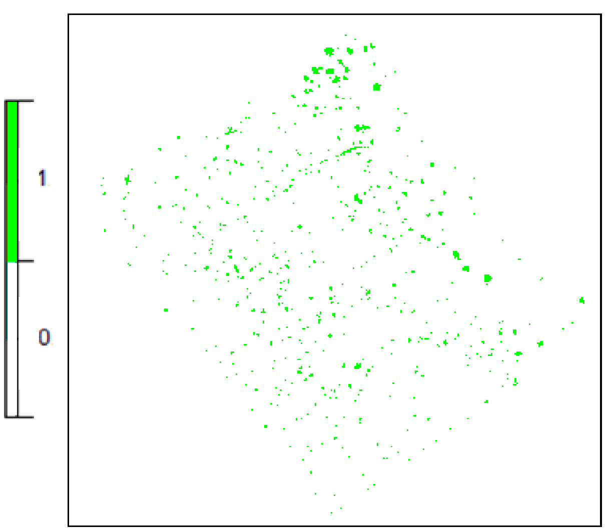
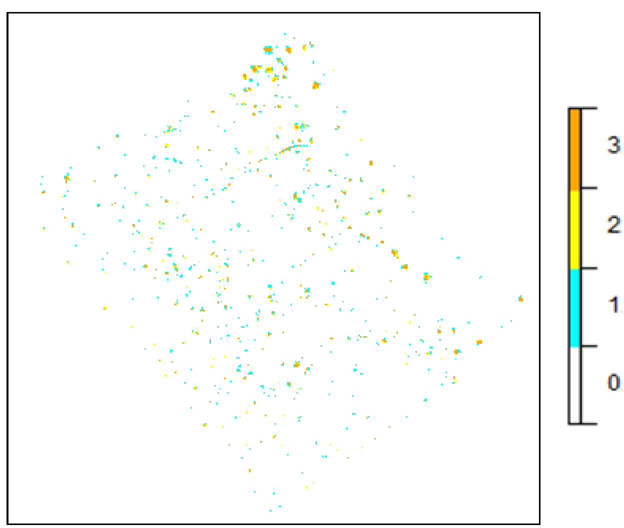
We then compare the reference (manual) binary map to combinations of the channel-filtered binary stack





AC13





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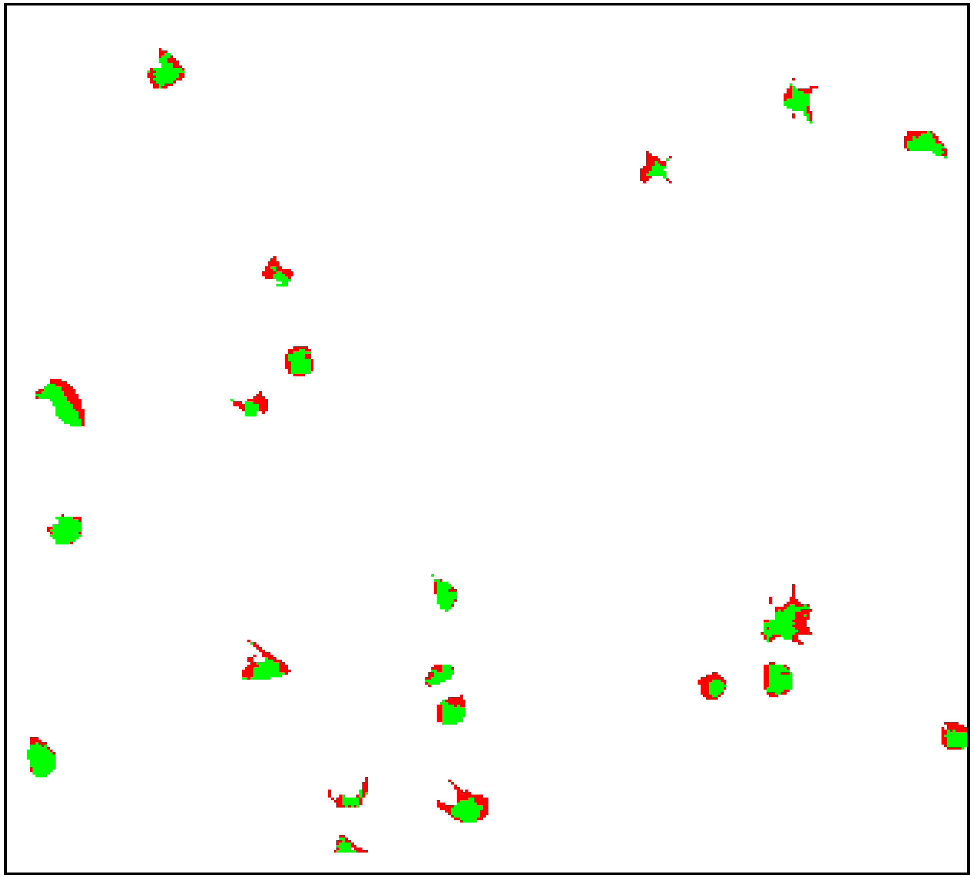
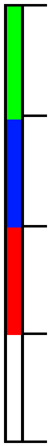
Zooming-in to get a better view



We use some metrics to evaluate

$$\varphi = \frac{A_{script} \cap A_{manual}}{A_{script} \cup A_{manual}} * 100\%$$



Both predict vegetation

Algorithm only predicts vegetation

Algorithm only predicts no vegetation

Both predict no vegetation

	Images	
	AC13	AC35
Manual Map - 1	42382	9709
RGB Processed - 10	711	0
Coincidence - 11	21165	19055
Coincidence Factor - φ	32.94%	66.25%

Algorithm captures the vegetation patches, but seems to underestimate their size

Further issues

Color thresholds assume vegetation is dark green and soil is brownish/white

Problem 1: shadows and dark soil detected as vegetation
Problem 2: non-green vegetation is detected as bare soil

Further issues

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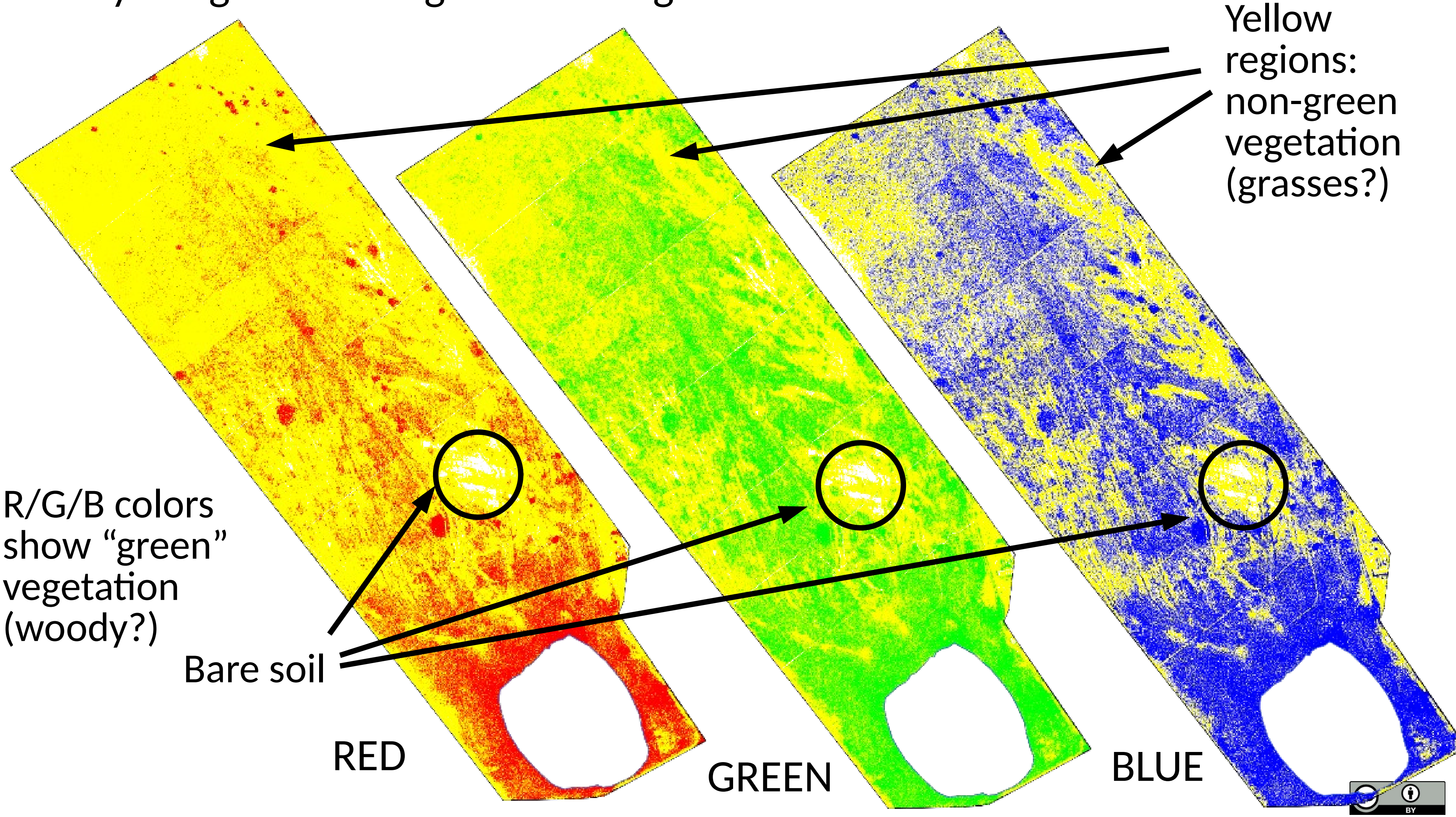
Solution: apply the same algorithm, but detect bare soil (with threshold determined from regions known to be soil), and compare the complement binary image to the vegetation image.



Application

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We can obtain spatial statistics during the initial ecosystem development

Date	% Vegetated area (woody)	% Vegetated area (herbaceous)	% Vegetated area (total)
22-09-06	0.3	19.02	19.32
14-06-07	2.1	23.47	25.57
10-07-08	0	71.11	71.11
10-09-09	28.53	37.83	66.36
26-07-10	56.28	16.33	72.61
03-09-10	63.9	20.44	84.34
29-06-11	17.18	73.41	90.59
16-09-11	18.84	72.23	91.07
08-07-12	21.06	58.36	79.42
04-09-12	30.64	60.41	91.05
16-07-14	22.4	54.13	76.53
16-09-14	25.94	61.4	87.34
22-07-15	30.02	60.17	90.19

Conclusions and outlook

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- Implemented a semi-automatic algorithm which allows to detect vegetation from aerial photography

- Need to automate thresholds a bit more

- Algorithm has potential to distinguish between green (woody?) and non-green (grassy?) vegetations, especially if comparing with ground truth or along time.

- The algorithm seems to underestimate patch size, but does capture the existence of a patch, which allows, for example to pursue point-pattern statistics, and evaluate changes of patterns in time.