Monitoring Plant Phenology Using Digital Repeat Photography

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Capturing Phenological Changes

- Repeated observations of plant phenology = important indicator of global change
- Difficult to capture plant phenological observations (leaf out, flowering, senescence) at high frequencies
- Easy to monitor climatic variables that modulate phenological changes
- What kind of system could monitor both at commensurate time scales? Repeat photo and climate monitoring system

Study Objectives

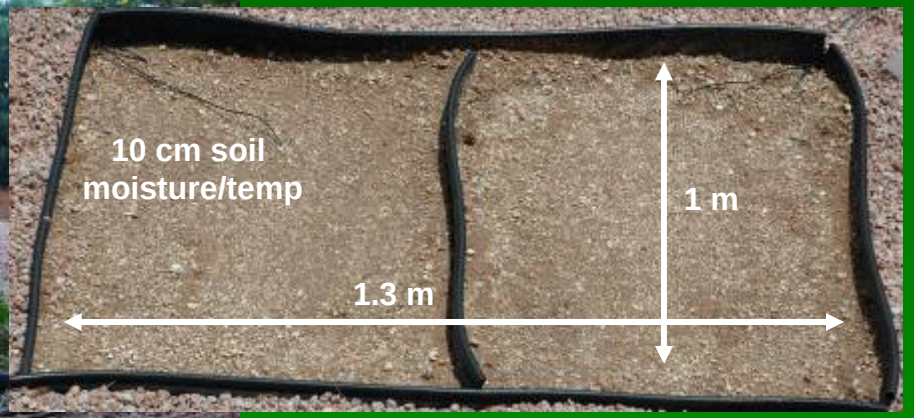
- Explore data types that can be captured from repeat photo series: qualitative, quantitative information
- Assess utility of greenness metric calculated from RGB camera
- Test system, image processing methods; make recommendations
- Ultimately: analyze pheno-climate relationships

System Design

- High-resolution digital camera (Nikon d70, 6.1 megapixels)
- Meteorological station: precipitation, solar radiation, temperature/relative humidity, soil moisture/temperature
- Laptop computer to control data collection

Study Design

Camera mounted indoors 2.6 m from plot



3008x2000 pixel TIFF image (~0.6 mm pixel resolution)

- Tested system from July-December 2006
- Monitor germination of native Sonoran Desert wildflower seed mix and site-specific meteorological conditions
- Collect hourly photos and meteorological observations

Phenology Plot 7/06 – 12/06

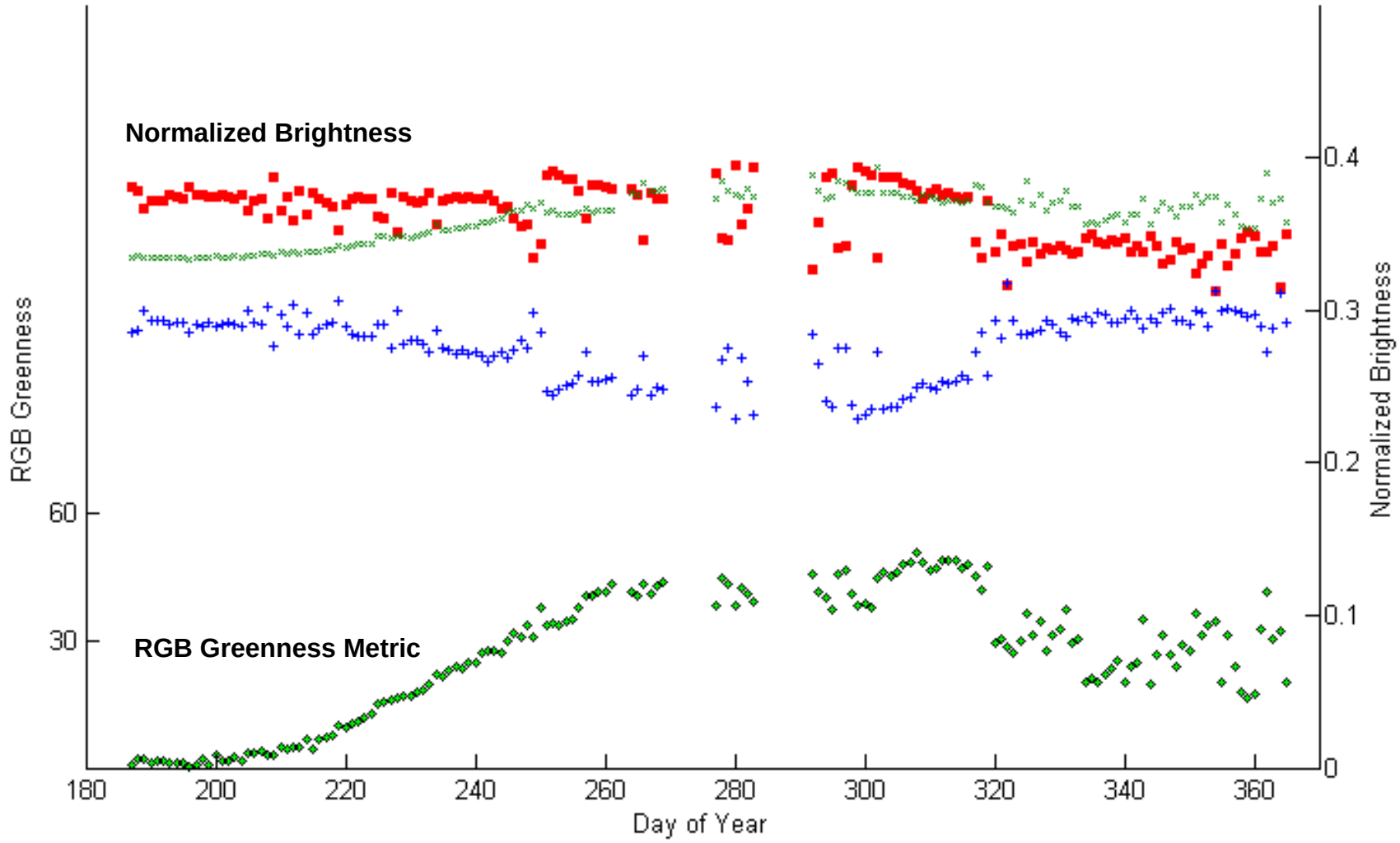
Analysis Methods

- Manually identify dates for key phenological events
- Calculate RGB greenness on brightness values for each daily photograph:

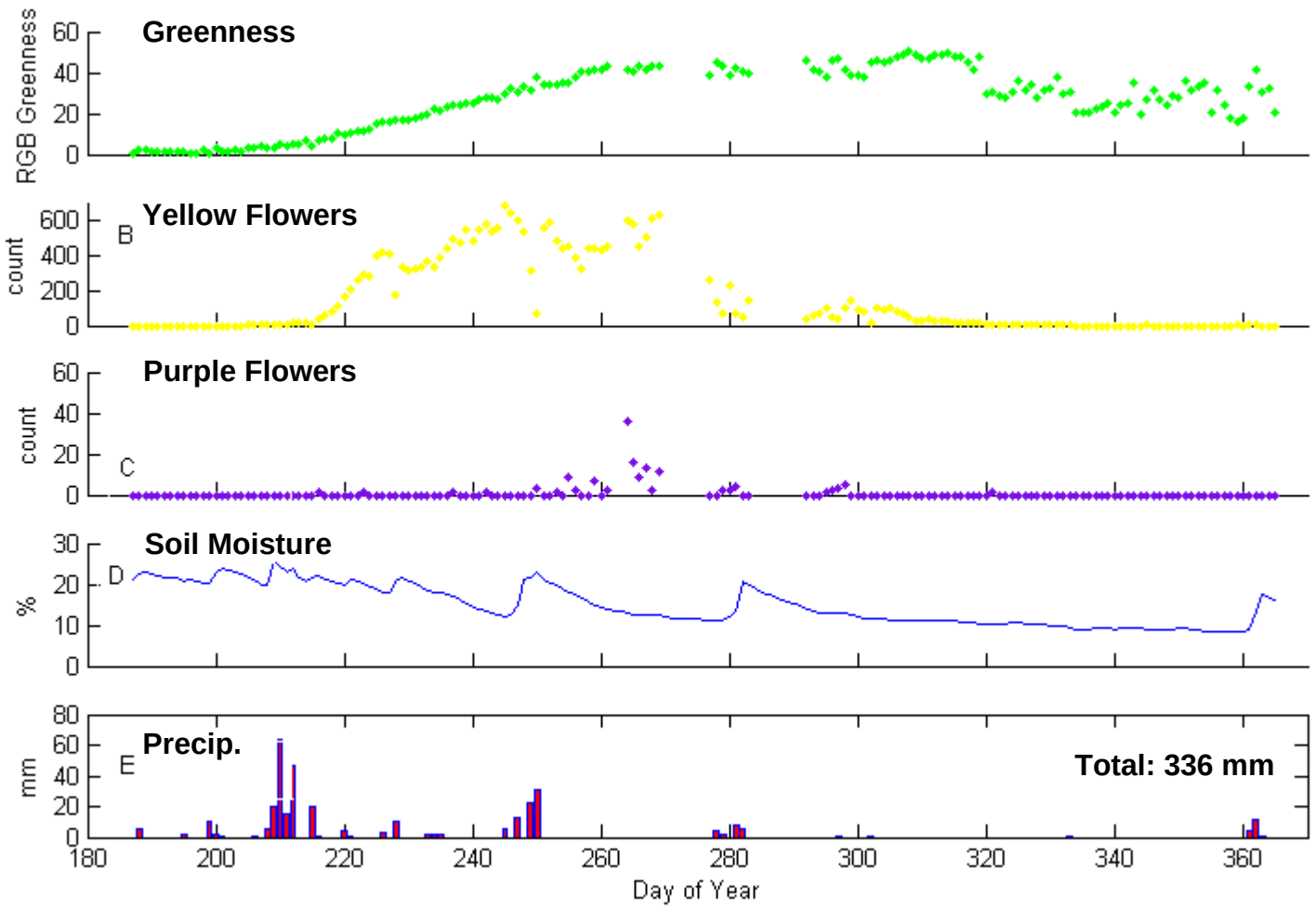
$$\left(\overline{x}_{green} - \overline{x}_{red}\right) + \left(\overline{x}_{green} - \overline{x}_{blue}\right)$$

- Perform automated counts of trailing windmills (purple) and manybristle cinchweed (yellow)
  - Matlab: rgb to hsv image, convert to binary, clean, majority, close, Euler number functions

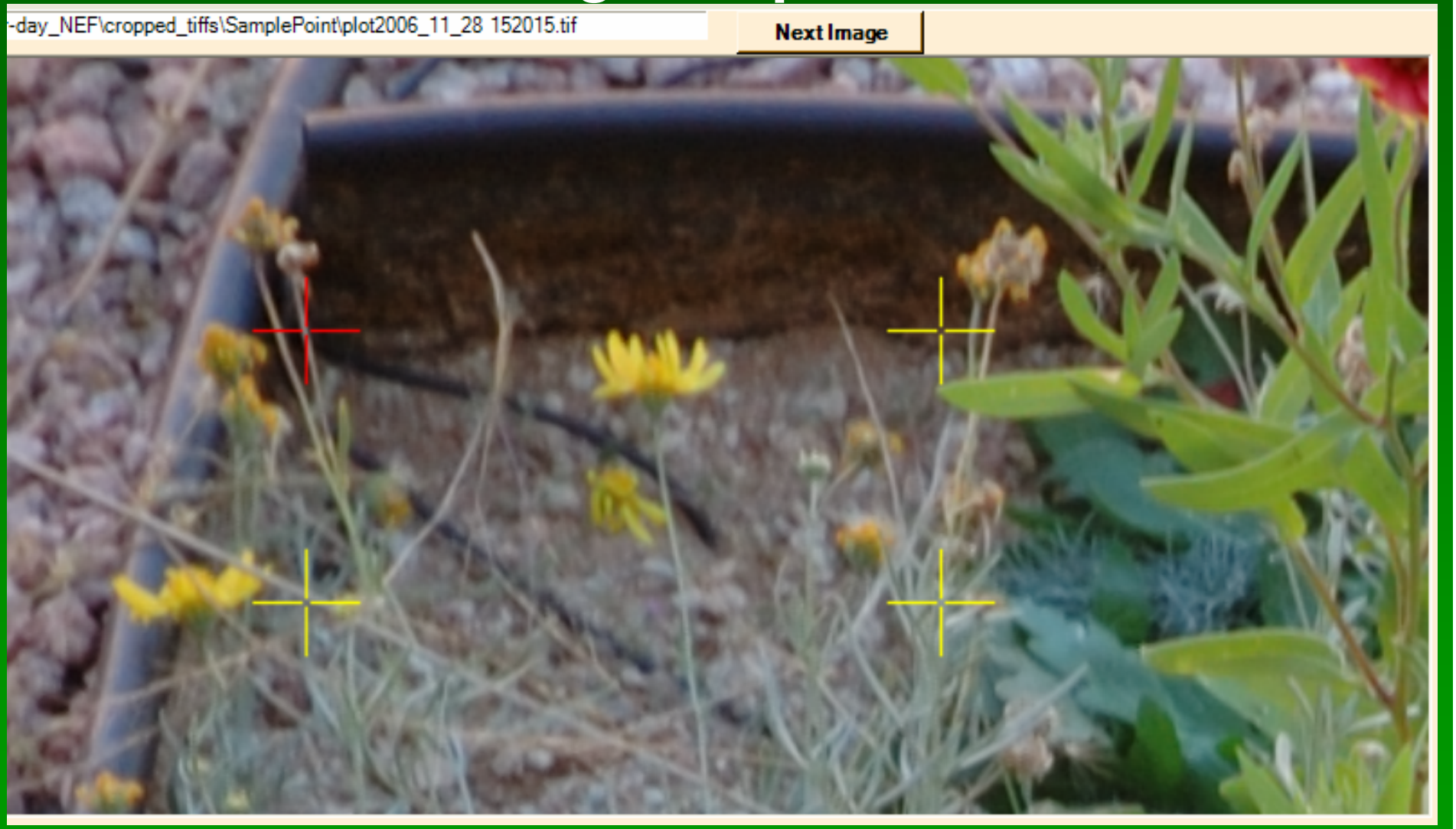
Brightness/Greenness



Phenometrics and Meteorological Data

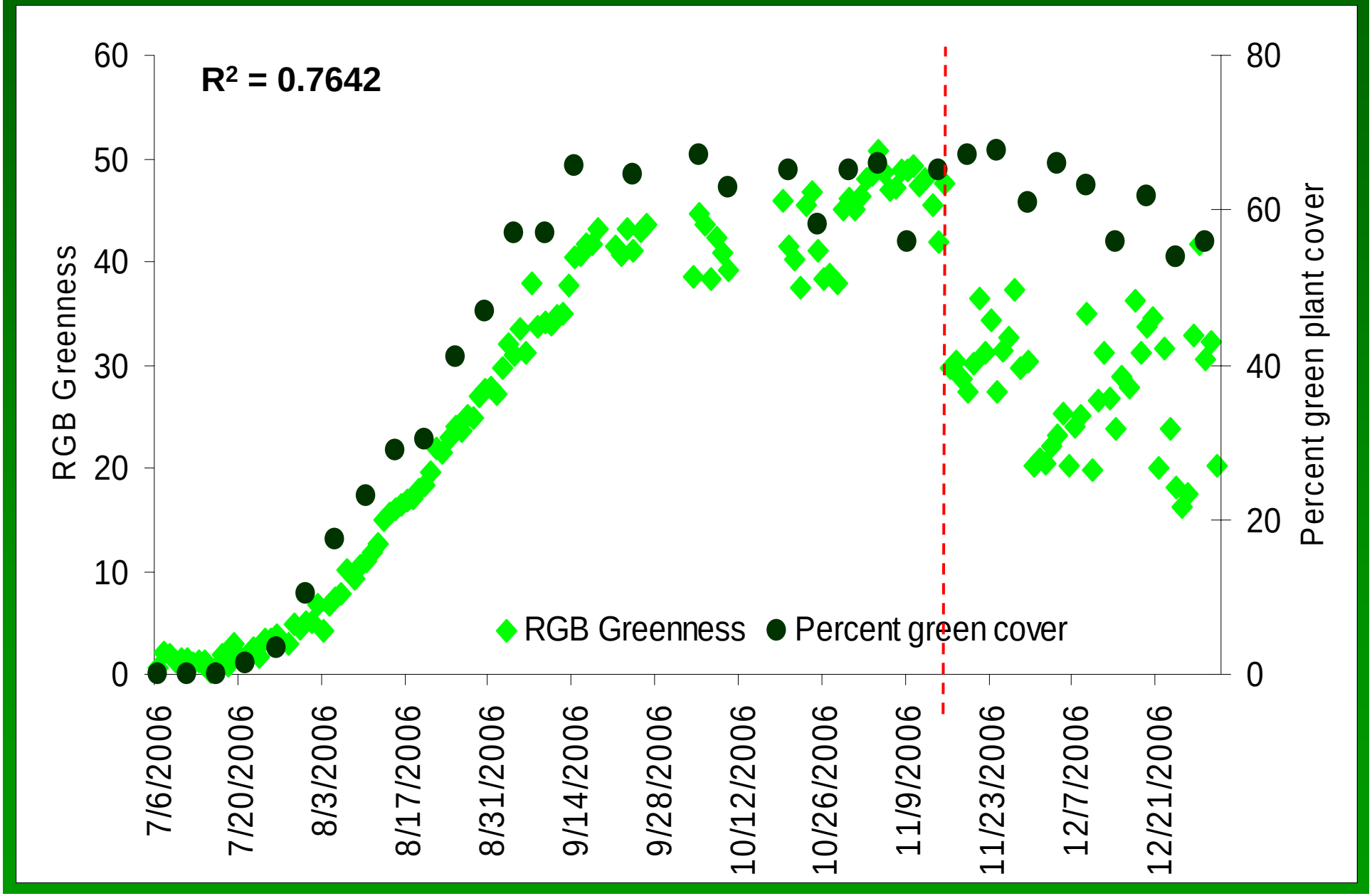


Greenness Validation:
Percent green plant cover



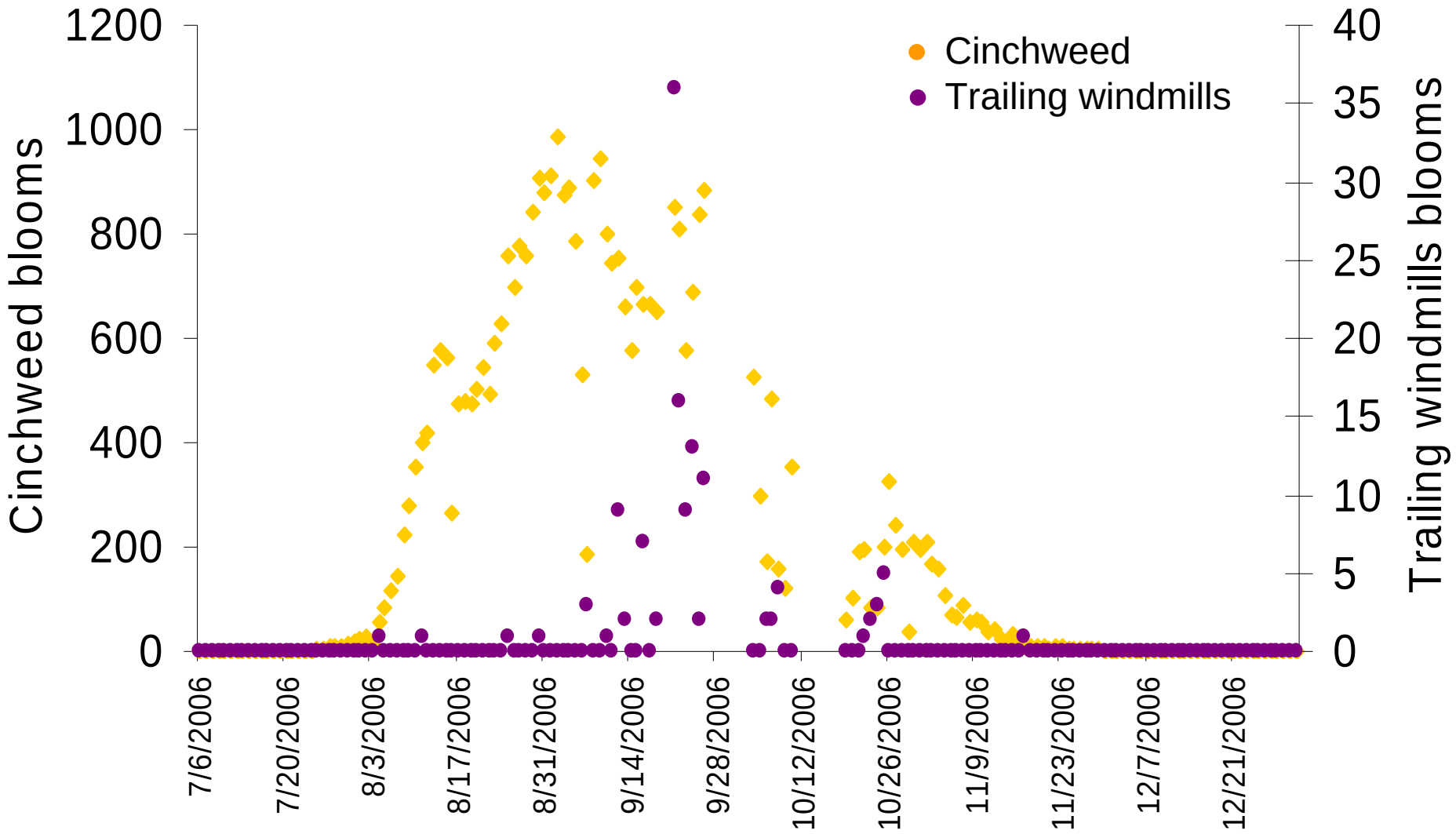
SamplePoint software v1.35 (Booth et al. 2006)
100 evenly-spaced points per image

Greenness Validation



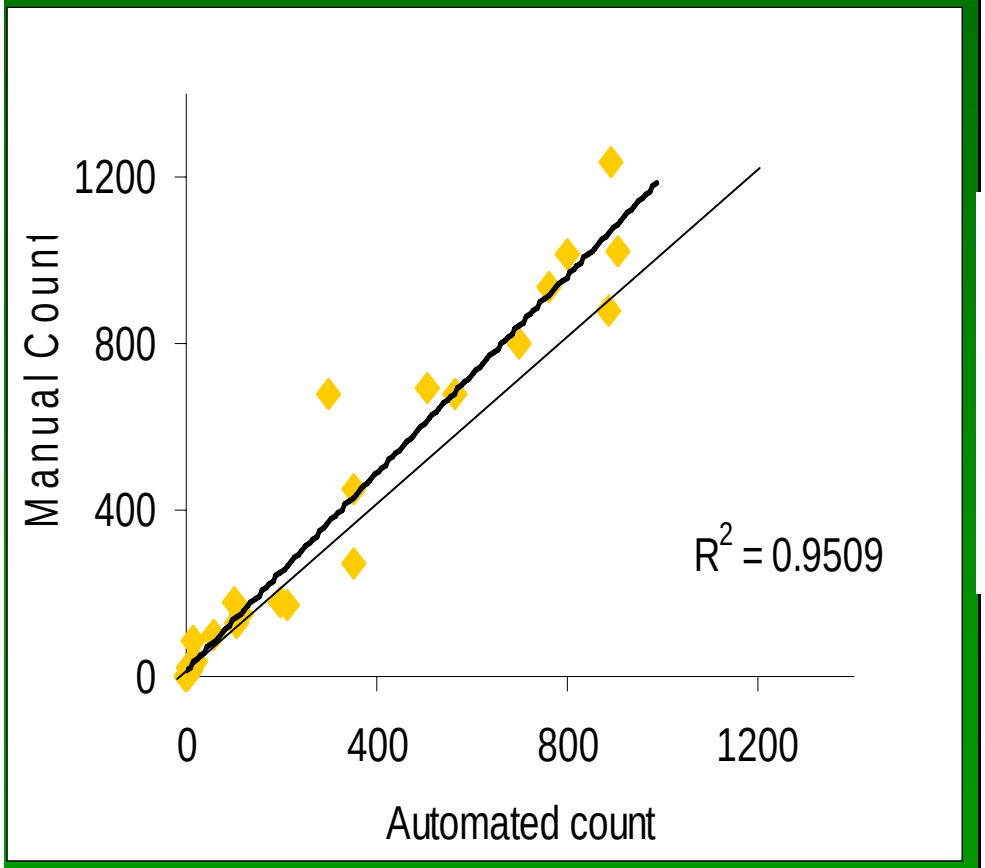
Flower Count Validation

Flower Counts

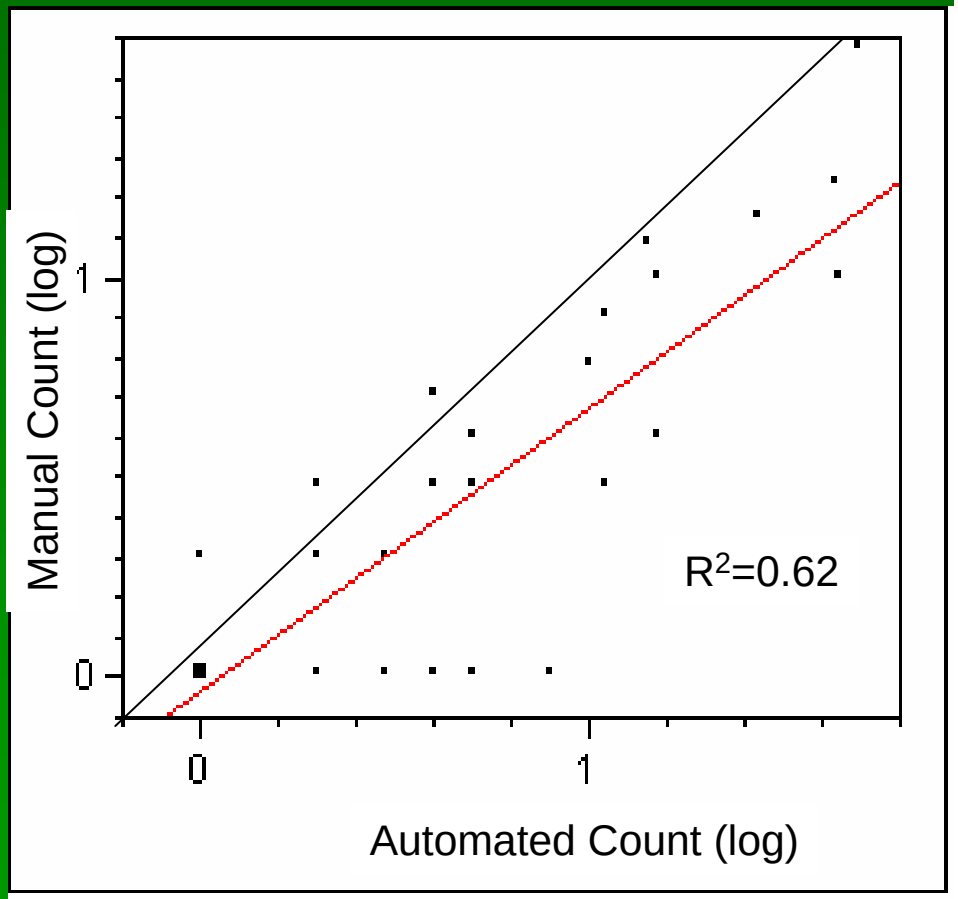


Flower Counting Algorithm Performance

Cinchweed (yellow) blooms



Trailing windmills (purple) blooms



Greenness, Flower Count Performance

- Greenness best in full-sun conditions
- Need algorithm to adjust full-shade photos
- Greenness from RGB – less info than NDVI; easier, less expensive to acquire
- Relative variations in flower counts represented very well; absolute numbers under-predicted

Conclusions

- Repeat photos relatively inexpensive, reliable; yield archive
- Traditional phenological events can be captured
- Method also yields quantitative information – potential applications in ground-truthing, model parameterization
- Photos + met data can be used with longer-term datasets to more precisely defining phenological triggers via predictive models
- Repeat photos = great public outreach value