# Introduction to Phenology Data

## *PhenoCam Data Graphing Ideas*

### Introduction

As mentioned in the Introduction to PhenoCam Data background guide, learning how to use graphs and computer technology to collate, summarize, and display data and to explore relationships between variables is an important skill for students to learn by grade 12. Now that you can download the Green Chromatic Coordinate (GCC) data from the phenocam website, there are a wide variety of ways to graph it. Here we'll explore a few graphing ideas that you can use in your educational setting with your learners.

**Estimated Time:**
One 60-90 minute class period

**Suggested Grade Level:**
Grades 5-9

**Materials:** Access to computers and the internet for research and downloading data

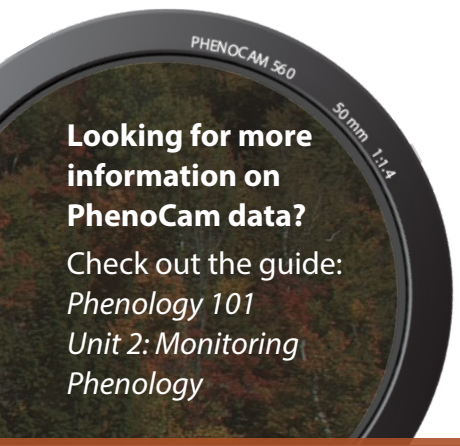
### Learning Outcomes

Students will be able to:

- Navigate the PhenoCam website and complete a chart recording latitude, longitude, elevation, terrain, urban-rural suburban classification, water features, and vegetation of eight diverse PhenoCam sites.
- Answer open-ended questions concerning the effects of climate change on plant phenology and ecosystem functions.

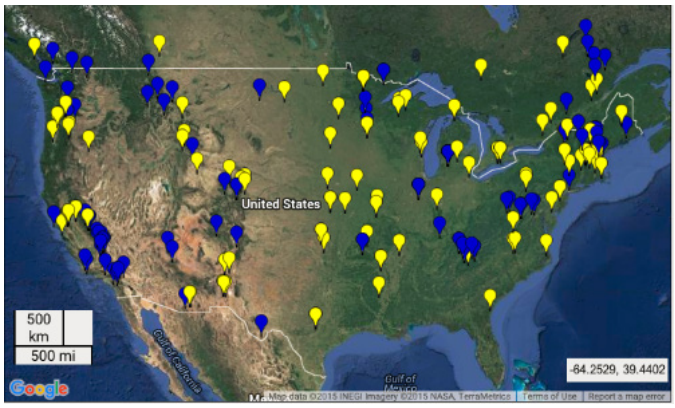
### Background Information

PhenoCam (phenocam.unh.edu) is a network of digital cameras that are used to record vegetation phenology in terms of seasonal changes in the greenness of the canopy. Cameras record digital images hourly over the course of a year at all the PhenoCam locations. The images are computer analyzed for color and generate a numerical value of canopy greenness which is then a part of a timeseries graph. Scientists can then identify major phenophases such as budburst from these graphs. The core sites include images of forest canopy, shrubs, grasslands, and cropland. There are urban, suburban, and rural sites.




**Looking for more information on PhenoCam data?**

Check out the guide:
*Phenology 101*
*Unit 2: Monitoring Phenology*

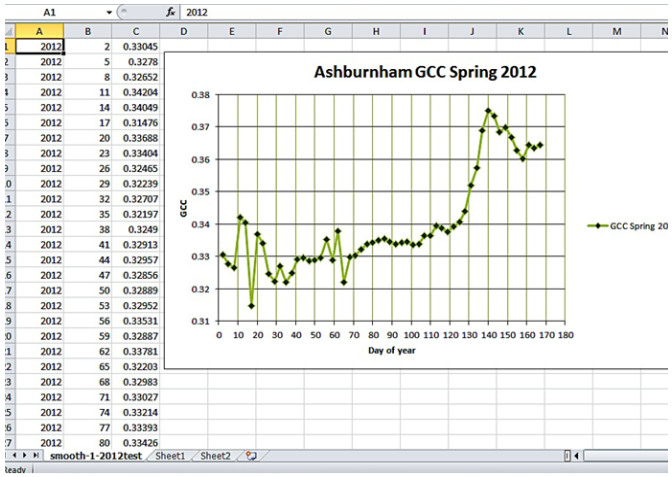



**Left:** Map of PhenoCam locations around North America. Yellow pins represent core sites. Blue pins show affiliated sites.

## Ideas for Graphing Phenophase Events

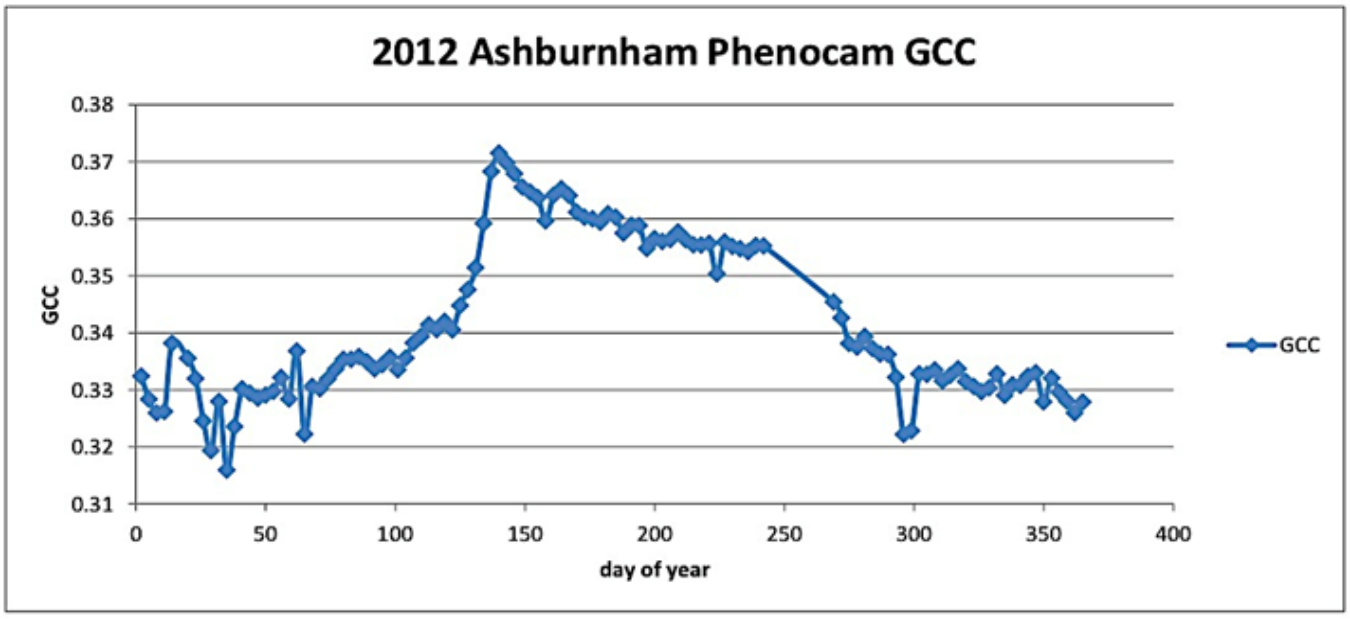
### Spring BudBurst

Students can start with a simple graph of Spring budburst. As the leaves emerge and start photosynthesizing, the chlorophyll pigments increase- resulting in increased green color.



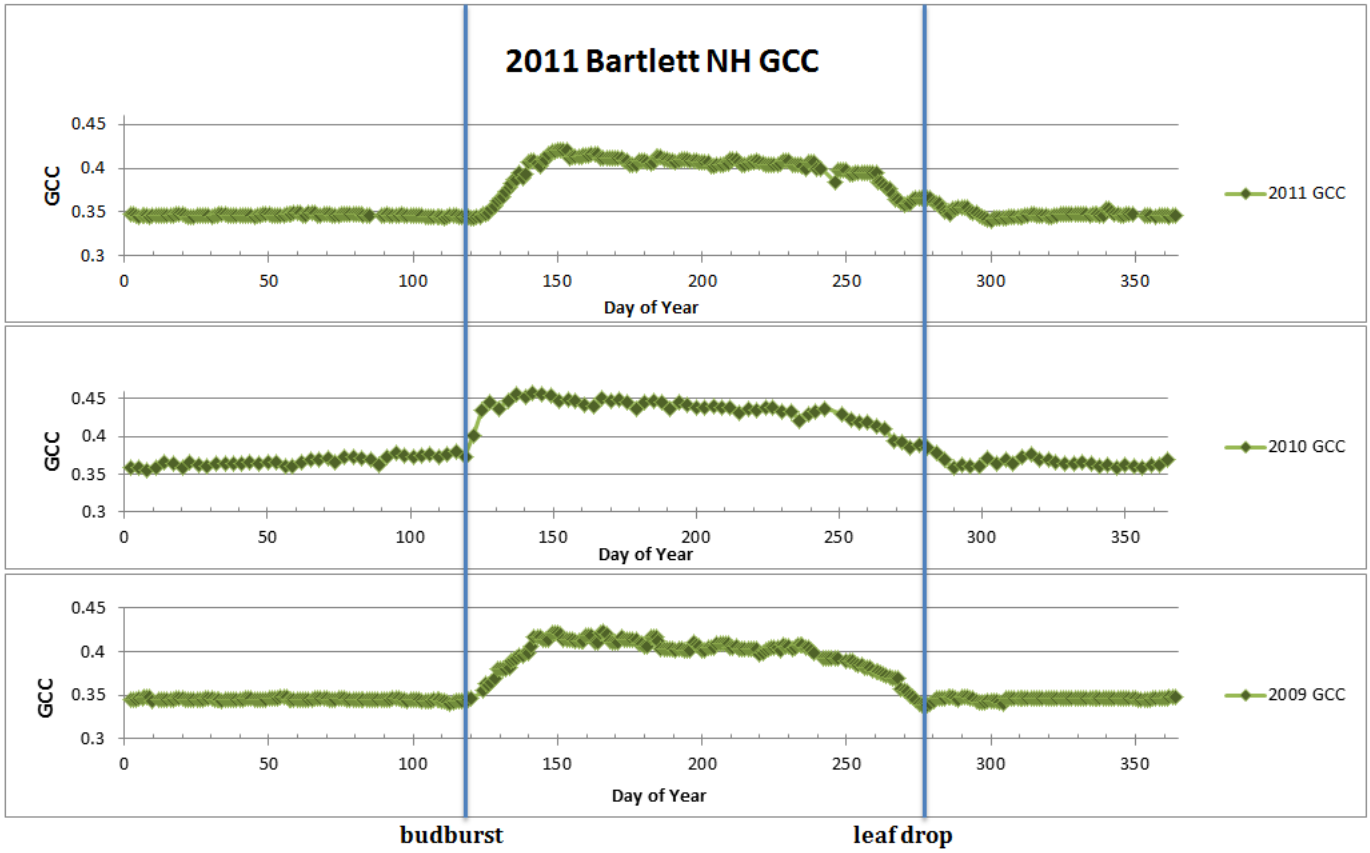


You can move on to a timeseries graph where your students can see the entire growing season. As you can see in the image below, chlorophyll decreases throughout the summer and dies off during senescence.



## Spring BudBurst (cont.)

These are the timeseries graphs for three years at the phenocam site in Bartlett, NH. The growing seasons of consecutive years at any site can be graphed and compared to see seasonal patterns. Which year had the earliest budburst? The latest?



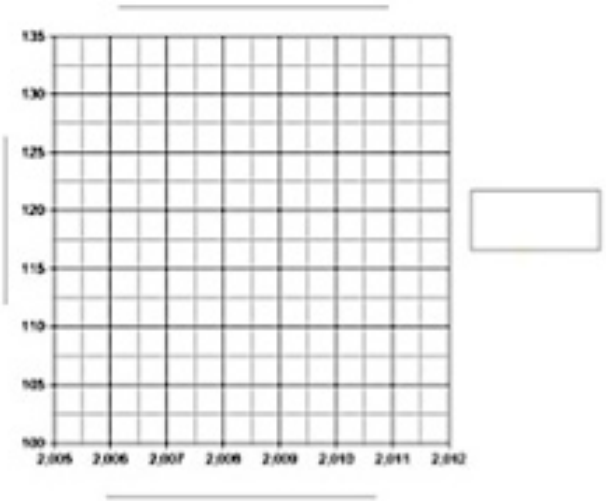

These graphs provide an excellent starting point for discussion about analyzing PhenoCam data. You might consider projecting the image then guiding students through analysis or creating a series of timeseries graphs that students can analyze as a group then present their findings to the class.

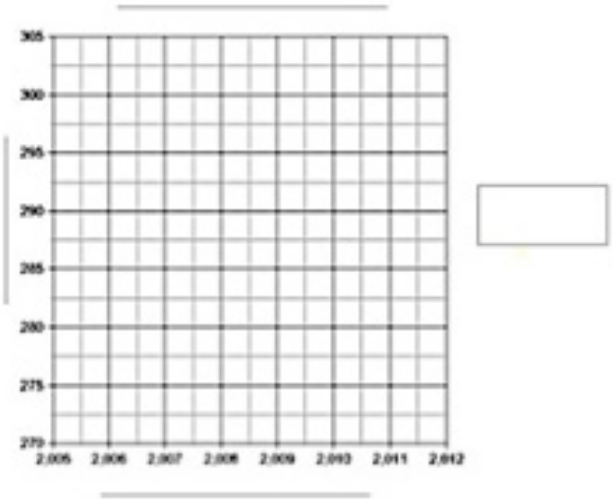
## Graphing by Hand

Students can use these graphs to determine budburst and maximum color change and leaf drop and graph them by hand. You can provide them with data to graph or have students download data from the PhenoCam website. They could compare budburst and leaf drop from different years or different locations. Below you'll find an example of a graphing worksheet students can use to graph their data by hand.

Name_____ Date_____

**Graph the day of year for budburst and leaf drop. Be sure to label the x and y axis, title your graph, and make a key.**



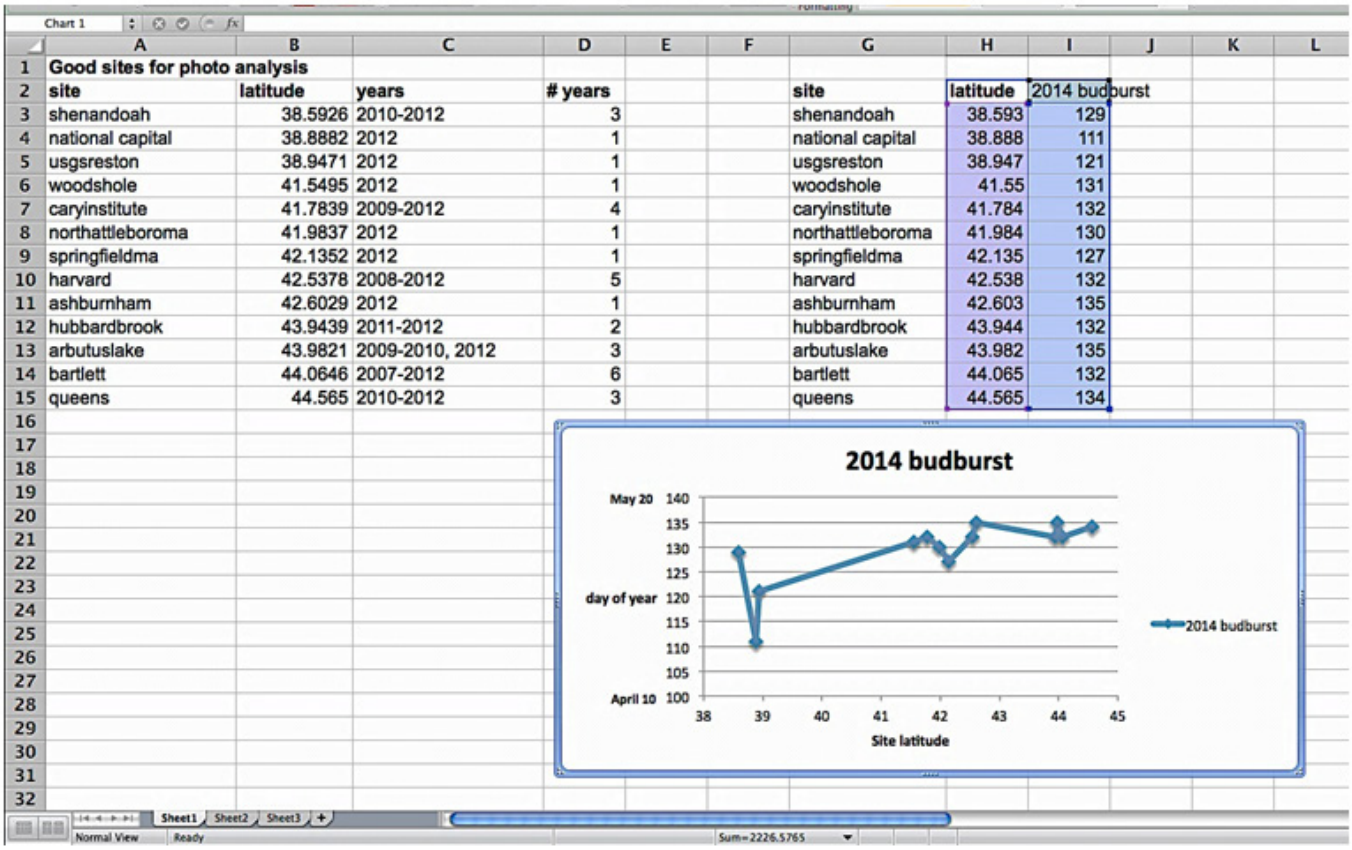

Do you see any trends over the years for budburst? Explain

Do you see any for color change and leaf drop? Explain

## Ideas for Graphing Locations

### Investigating Changes in Latitude

Phenological events at sites along a latitudinal gradient can be compared.



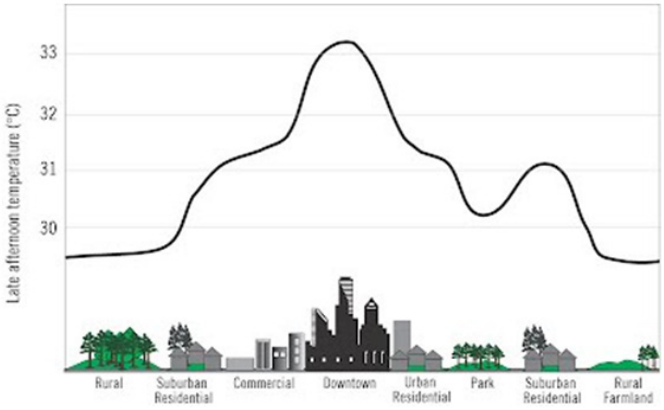
| | A | B | C | D | G | H | I |
|---|---|---|---|---|---|---|---|
| 1 | Good sites for photo analysis | | | | | | |
| 2 | site | latitude | years | # years | site | latitude | 2014 budburst |
| 3 | shenandoah | 38.5926 | 2010-2012 | 3 | shenandoah | 38.593 | 129 |
| 4 | national capital | 38.8882 | 2012 | 1 | national capital | 38.888 | 111 |
| 5 | usgsreston | 38.9471 | 2012 | 1 | usgsreston | 38.947 | 121 |
| 6 | woodshole | 41.5495 | 2012 | 1 | woodshole | 41.55 | 131 |
| 7 | caryinstitute | 41.7839 | 2009-2012 | 4 | caryinstitute | 41.784 | 132 |
| 8 | northattleboroma | 41.9837 | 2012 | 1 | northattleboroma | 41.984 | 130 |
| 9 | springfieldma | 42.1352 | 2012 | 1 | springfieldma | 42.135 | 127 |
| 10 | harvard | 42.5378 | 2008-2012 | 5 | harvard | 42.538 | 132 |
| 11 | ashburnham | 42.6029 | 2012 | 1 | ashburnham | 42.603 | 135 |
| 12 | hubbardbrook | 43.9439 | 2011-2012 | 2 | hubbardbrook | 43.944 | 132 |
| 13 | arbutuslake | 43.9821 | 2009-2010, 2012 | 3 | arbutuslake | 43.982 | 135 |
| 14 | bartlett | 44.0646 | 2007-2012 | 6 | bartlett | 44.065 | 132 |
| 15 | queens | 44.565 | 2010-2012 | 3 | queens | 44.565 | 134 |



What other factors might influence the timing of budburst?

## Urban Heat Island Effect

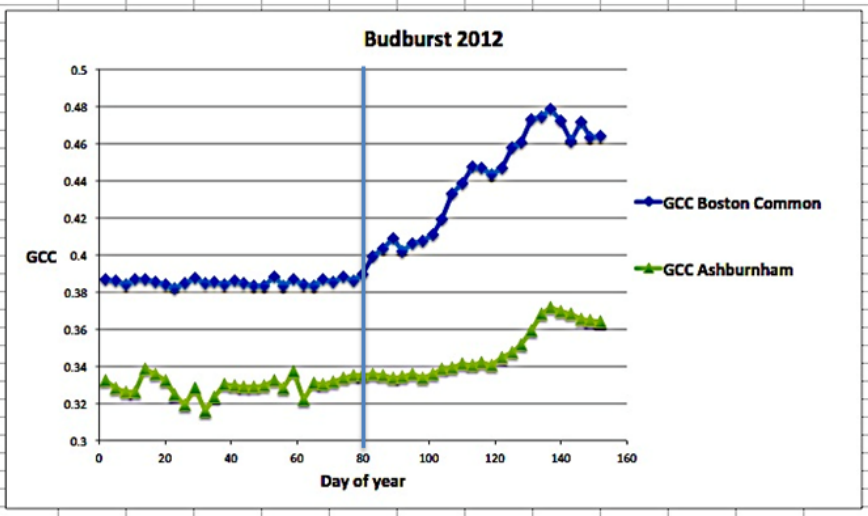
Compare an urban and a rural site at similar latitudes.




As developed areas expand, the amount of heat retained also grows. In turn the amount of air that is warmed, expands. This is process is sometimes referred to as the "Urban Heat Island Effect". This compounding warming effect in turn triggers variability in phenophase timing. A red maple (Acer rubrum) in a developed area, may experience initial stages of the leaves unfolding sooner than a red maple in an undeveloped area. On a smaller spatial scale, a red maple next to an asphalt road, may also flush sooner than a red maple that is close to the interior of a forest, or to a stream filled with cool running water.

For example, let's take a look at a graph of comparing GCC data for the Boston Common PhenoCam site (42.355° N) with the Asburnham PhenoCam site (42.603 ° N) which is located approximately 50 miles away.

| | A | B | C | D |
|---|---|---|---|---|
| 1 | | day of year | GCC Bostor | GCC Ashburnham |
| 2 | 2012 | 2 | 0.38685 | 0.3324 |
| 3 | 2012 | 5 | 0.38634 | 0.32834 |
| 4 | 2012 | 8 | 0.38407 | 0.32594 |
| 5 | 2012 | 11 | 0.38697 | 0.32616 |
| 6 | 2012 | 14 | 0.38654 | 0.33815 |
| 7 | 2012 | 17 | 0.3854 | 0.3355 |
| 8 | 2012 | 20 | 0.3837 | 0.33197 |
| 9 | 2012 | 23 | 0.38207 | 0.32454 |
| 10 | 2012 | 26 | 0.38486 | 0.31933 |
| 11 | 2012 | 29 | 0.38709 | 0.32794 |
| 12 | 2012 | 32 | 0.38445 | 0.31593 |
| 13 | 2012 | 35 | 0.38562 | 0.32353 |
| 14 | 2012 | 38 | 0.38416 | 0.33016 |
| 15 | 2012 | 41 | 0.38579 | 0.32941 |
| 16 | 2012 | 44 | 0.38439 | 0.32854 |
| 17 | 2012 | 47 | 0.38296 | 0.32904 |
| 18 | 2012 | 50 | 0.38295 | 0.32968 |
| 19 | 2012 | 53 | 0.38802 | 0.33215 |
| 20 | 2012 | 56 | 0.38346 | 0.32836 |
| 21 | 2012 | 59 | 0.38653 | 0.33681 |
| 22 | 2012 | 62 | 0.38425 | 0.32224 |
| 23 | 2012 | 65 | 0.38338 | 0.3306 |
| 24 | 2012 | 68 | 0.38648 | 0.33019 |
| 25 | 2012 | 71 | 0.38506 | 0.33188 |
| 26 | 2012 | 74 | 0.38831 | 0.33362 |
| 27 | 2012 | 77 | 0.3857 | 0.33532 |
| 28 | 2012 | 80 | 0.38971 | 0.3353 |
| 29 | 2012 | 83 | 0.39918 | 0.33583 |
| 30 | 2012 | 86 | 0.403 | 0.33491 |
| 31 | 2012 | 89 | 0.40864 | 0.33365 |
| 32 | 2012 | 92 | 0.40212 | 0.33438 |
| 33 | 2012 | 95 | 0.40574 | 0.33565 |
| 34 | 2012 | 98 | 0.40725 | 0.3335 |
| 35 | 2012 | 101 | 0.41102 | 0.33556 |
| 36 | 2012 | 104 | 0.41881 | 0.33819 |
| 37 | 2012 | 107 | 0.43309 | 0.3394 |
| 38 | 2012 | 110 | 0.43835 | 0.34139 |




What day does "green up" seem to begin (budburst)? At which site does budburst happen earlier?

What day does the green reach its peak?

What other differences can you see between these two graphs?