National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Sequoia and Kings Canyon National Parks California Phenology Project 2013-2014 Annual Report

Resources Management and Science

ON THE COVER

Photos: Upper left: Greenleaf manzanita in flower; Upper right: Greenleaf manzanita fruits; Lower left: Blue oak acorns; Lower right: Ranger taking observations of California buckeye phenology; Center: Mountain pride in flower.

All photographs were taken by Division of Interpretation staff, Sequoia National Park

Sequoia and Kings Canyon National Parks California Phenology Project 2013-2014 Annual Report

Resources Management and Science

March 2015

Liz Ballenger
National Park Service, Sequoia and Kings Canyon National Parks
Resources Management and Science
47050 Generals Highway
Three Rivers, California, 93271

Contents

Figures

Tables

Page

Acknowledgements

This project was possible with support from the National Park Service Climate Response Program and leadership of the California Phenology Project and USA National Phenology Network. Thanks especially to Kathy Gerst and her staff for their efforts with data management and guidance with data summary and interpretation, and to Dr. Susan Mazer at the University of California at Santa Barbara for leading countless training workshops and ensuring the scientific rigor of the California Phenology Project. Special thanks to Sylvia Haultain, Plant Ecologist and Denise Robertson, Sequoia District Interpreter for their ongoing leadership and advocacy of this project at Sequoia and Kings Canyon National Park, and to Ann Huber for carrying the torch of this project through its first several years. The information gained from this project is used by the Foothills Education Staff in the SPROUTS module of the Rangers in the Classroom program, and they have been tireless ambassadors of the project. Most of all, thanks go to the many individuals who spent hours collecting phenology observations at Sequoia and Kings Canyon National Parks, including Barbie Alexander, Dani Crawford, Veronica Cueva, Kelly Evans, Lynne Firpo, Ann Huber, Vladimir Kovalenko, Erik Meyer, Brianne Permar, Shelley Quaid, Christann Roy, Ari Sarzotti, Alysia Schmidt, Don Seale, Lena Silerio, David Sodeburg, Joel Vogt and the students from Sequoia High School. This project would not have been possible without their diligent efforts, attention to detail and enthusiasm for contributing information that will help answer questions surrounding how plants respond to climate change.

,

Introduction

Phenology is the study of seasonal changes or events in plants and animals such as flowering, leaf drop, insect emergence, and animal migration. Long-term studies have shown that phenological phases are sensitive to changes in environmental variation and climate. Climate-driven changes in the timing of plant and animal seasonal events can have far-reaching ecological effects such as changes in primary productivity, species interactions, resource availability, and population growth.

Sequoia and Kings Canyon National Parks (SEKI) is currently one of seven national parks in California that participate in the California Phenology Project (CPP). With funding from the National Park Service (NPS) Climate Change Response Program, the CPP was formed in 2010 to provide tools and protocols to be used for long-term plant phenology monitoring with an emphasis on public participation and education across parks in California. SEKI participates in the CPP effort to advance public understanding of phenology and its relationship with climate with a variety of outreach efforts, and also in scientific understanding of current phenological events by monitoring plants in the field. The scope of this annual report is limited to the activities and results of the monitoring component of the California Phenology Project in SEKI.

The main objective of this report is to provide information on the amount of data collected (effort) and general patterns in phenological activity observed at SEKI from January 2013 to December 2014, lessons learned, and recommendations for the future. Trend analyses and other analyses investigating links between changes in phenology and changes in climate are generally not included in park-specific annual reports. Because this annual report presents two years of monitoring data, comparison between years and broad observations of possible relationships between phenology, temperature and precipitation are included.

Methods

A brief overview of methods is summarized here. For a complete account of methods and materials please refer to the California Phenological Monitoring Guide: Sequoia and Kings Canyon National Parks. Information on CPP-wide protocols, including site selection, field methods, data management, and data analysis are described in the California Phenology Project (CPP) Plant Phenology Monitoring Protocol. A collection of phenological monitoring resources that provide additional information about methods, including phenophase definition sheets, species accounts, and sample datasheets are available from the California Phenology Project at www.usanpn.org/cpp/.

Monitoring Locations, Sites, and Frequency

There are two plant phenology monitoring locations at Sequoia National Park: the Foothills Visitor Center (FHVC) and the Lower Kaweah Air Quality Monitoring site (LKAQ). These locations were chosen primarily because the target plants are easily accessible, they are co-located with weather stations, and they occur at two different elevation zones in the park. FHVC is located in blue oak woodlands at 1,700 ft and LKAQ is located in an opening in mixed conifer forest at approximately 6,000 ft.

Fourteen blue oak (*Quercus douglasii*) and seven California buckeye (*Aesculus californica*) trees are monitored at the Foothills Visitor Center location, and are divided among four sites (Sites 1-4) located near the visitor center. Phenological monitoring at FHVC began in January 2013 and is conducted year-round by NPS Interpretive Ranger staff or interns. Monitoring occurs frequently at this site (often twice per week), due to its ease of accessibility and involvement from multiple staffing sources.

Ten greenleaf manzanitas *(Arctostaphylos patula)* and ten mountain pride plants *(Penstemon newberryi)* are monitored at one site at the Lower Kaweah Air Quality Monitoring station (LKAQ). Phenological monitoring at LKAQ began in January 2013 and is conducted year-round by National Park Service air quality staff on their weekly visits to service the station. Snow cover or staff time constraints occasionally hamper monitoring at this site, however.

Data Summaries

Step-by-step methods for annual data summaries are described in the CPP Protocol's SOP 10: Data Summary, Analysis and Reporting. For phenology data, this protocol guided summary efforts, with some streamlining made possible with new summary spreadsheets available for download from https://www.usanpn.org/results/data. Original protocol calculates phenophase duration based on the number of days between the first date any monitored individual exhibits a phenophase and the last date any monitored individual exhibits a phenophase in a given year. This does not account for large gaps in phenophases that may happen in multiple discrete periods during the year (such as spring and fall flowering), however. Therefore, one modification made for this report was to examine the summary spreadsheets for date gaps in each phenophase >30 days across all monitored individuals. Gaps >30 days were subtracted from phenophase duration and noted in the summary tables with additional phenophase dates.

Another modification was to calculate mean first observed dates and durations for each phenophase. First observed, or onset date of a phenophase, is of particular interest when climate change scenarios predict changes in phenology timing. Summary methods using only SOP 10 could result in first observed date being determined by a single individual beginning a phenophase far ahead of the rest of the monitored individuals. Therefore, mean first observed dates and mean duration dates should better reflect phenology onset dates for the whole population. Mean first observed dates and durations were calculated for each phenophase using those individuals exhibiting the phenophase at any time during the monitoring period.

For climate summaries, additional data sources not referenced in SOP 10 were utilized, and are described here. Monthly average temperature and total precipitation data for 2013-2014 were downloaded from NOAA's National Climatic Data Center at http://www.ncdc.noaa.gov. This website also provided 30-year normal data, available at http://www.ncdc.noaa.gov/cdo-web/datatools/normals. For Foothills Visitor Center (FHVC), data from the nearby Ash Mountain, CA weather station was used. For Lower Kaweah Air Quality station (LKAQ), data from the Grant Grove, CA weather station was used. Using weather data from the LKAQ site was not possible because those data are currently only available for April-November each year. Weather data is available from Lodgepole, which is geographically closer to LKAQ, but because Lodgepole is in a cold-air sink, Grant Grove is a better surrogate for conditions in the Lower Kaweah / Giant Forest area. Monthly average temperatures at Grant Grove station are usually within a degree of the monthly averages for LKAQ.

Results

Annual Climate Summary

For the Foothills Visitor Center (FHVC), spring-summer temperatures (March-July) in 2013 were 2.8-4.4°F warmer compared with the 30 year normal (Table 1). All 2014 monthly averages were higher than the 30 year normal, with the most notable departures being January (8.9°F warmer), March (5.5°F warmer), and October-December (approximately 4°F warmer).

Table 1. Temperature summary table for Ash Mountain, CA to represent conditions at the Foothills Visitor Center (FHVC). Departure from 30-year normal is based on years 1981-2010.

	2013		2014	
	Average Temp. (°F)	Departure from 30-yr Normal	Average Temp. (°F)	Departure from 30-yr Normal
Jan	46.8	-0.1	55.8	8.9
Feb	48.2	-1.5	53.4	3.7
Mar	56.1	3.0	58.6	5.5
Apr	61.2	4.0	60.3	3.1
May	68.9	2.8	67.6	1.5
Jun	79.2	4.4	77.4	2.6
Jul	86.2	4.2	85.1	3.1
Aug	81.0	-0.2	83.1	1.9
Sep	75.6	0.3	79.0	3.7
Oct	64.6	-0.6	69.3	4.1
Nov	56.5	2.9	57.6	4.0
Dec	48.9	2.2	50.9	4.2
Annual	**64.4**	**1.8**	**66.5**	**3.8**

At the elevation of FHVC, precipitation is predominately in the form of rain that falls in the winter and spring (November-April), and summers are typically dry. 2013 was a very dry year, with nearly all months less than 35% of normal precipitation, and several months with no precipitation (August-September, Table 2). This dry period extended into 2014, with very little precipitation until April. Later in 2014, more months had equal to or higher than normal precipitation, but there were several very dry months with less than 10% of normal precipitation (March, June, and October). Overall, both years would be considered very dry, with total annual precipitation 24% of normal in 2013 and 52% of normal in 2014.

Table 2. Precipitation summary table for the Foothills Visitor Center (FHVC) monitoring location at Ash Mountain, Sequoia National Park. Departure from 30 year normal is based on years 1981-2010.

	2013			**2014**		
	Total Precip. (in)	Departure from 30-yr Normal	% of 30-yr Normal	Total Precip (in)	Departure from 30-yr Normal	% of 30-yr Normal
Jan	1.81	-3.09	37%	0.70	-4.2	14%
Feb	1.38	-3.45	29%	1.73	-3.1	36%
Mar	0.98	-3.35	23%	0.35	-4.0	8%
Apr	0.54	-2.07	21%	2.77	0.2	106%
May	0.37	-0.75	33%	1.06	-0.1	95%
Jun	0.00	-0.40	0%	0.00	-0.4	0%
Jul	0.24	0.13	218%	0.06	-0.1	55%
Aug	0.00	-0.03	0%	0.03	0.0	100%
Sep	0.00	-0.44	0%	0.70	0.3	159%
Oct	0.00	-1.44	0%	0.00	-1.4	0%
Nov	0.53	-2.38	18%	1.96	-1.0	67%
Dec	0.59	-3.40	15%	4.85	0.9	122%
Annual	**6.44**	**-20.67**	**24%**	**14.21**	**-12.9**	**52%**

Similar in pattern to Foothills Visitor Center, the spring-summer (March-April) average monthly temperatures for Lower Kaweah Air Quality station in 2013 (using data from Grant Grove as an estimate for conditions at LKAQ) were approximately 2-5°F warmer than the 30 year normal record (Table 3). November and December 2013 were 2°F warmer than normal, whereas January 2013 was 2°F colder. In 2014, nearly all monthly temperatures were above average, with the most notable being January (9°F warmer than normal).

Table 3. Temperature summary table for Grant Grove (GG), Kings Canyon National Park as a surrogate for Lower Kaweah Air Quality Station (LKAQ). Departure from 30-year normal is based on years 1981-2010.

	2013		2014	
	Average Temp. (°F)	Departure from 30-yr Normal	Average Temp. (°F)	Departure from 30-yr Normal
Jan	33.3	-2.1	44.4	9.0
Feb	33.8	-1.3	39.4	4.3
Mar	41.9	5.0	40.8	3.9
Apr	43.3	2.6	43.0	2.3
May	50.4	1.8	50.0	1.4
Jun	61.7	4.3	60.4	3.0
Jul	68.5	3.8	67.3	2.6
Aug	64.0	-0.3	63.3	-1.0
Sep	59.7	1.1	61.3	2.7
Oct	48.6	-1.3	54.7	4.8
Nov	42.8	2.0	43.9	3.1
Dec	37.4	2.0	36.0	0.6
Annual	**48.8**	**1.5**	**50.4**	**3.1**

Lower Kaweah Air Quality Station precipitation, represented by Grant Grove weather data (Table 4), had below normal total annual precipitation for both 2013 and 2014 (25% and 67% of the 30 year normal, respectively). Similar in pattern to FHVC, the winter and spring months in 2013 were very dry (7-30% of normal), and this continued into the early part of 2014. July and August, 2013 were wetter than normal (139% and 162% of 30 year normal). 2014 had several months with no precipitation (June, August, and October), and January was also very dry (18% of normal).

Table 4. Precipitation summary table for the Lower Kaweah Air Quality (LKAQ) monitoring location, using data from Grant Grove, Kings Canyon National Park as a surrogate. Departure from 30 year normal is based on years 1981-2010.

	2013			2014		
	Total Precip. (in)	Departure from 30-yr Normal	% of 30-yr Normal	Total Precip (in)	Departure from 30-yr Normal	% of 30-yr Normal
Jan	2.32	-5.49	30%	1.42	-6.39	18%
Feb	1.21	-6.12	17%	3.99	-3.34	54%
Mar	1.72	-4.95	26%	5.62	-1.05	84%
Apr	0.89	-2.76	24%	5.13	1.48	141%
May	0.46	-1.14	29%	1.43	-0.17	89%
Jun	0.00	-0.53	0%	0.00	-0.53	0%
Jul	0.32	0.09	139%	0.39	0.16	170%
Aug	0.21	0.08	162%	0.00	-0.13	0%
Sep	0.21	-0.69	23%	0.90	0.00	100%
Oct	1.82	-0.65	74%	0.00	-2.47	0%
Nov	0.29	-3.98	7%	3.33	-0.94	78%
Dec	0.92	-5.75	14%	6.25	-0.42	94%
Annual	**10.37**	**-31.89**	**25%**	**28.46**	**-13.80**	**67%**

Monitoring Effort

Monitoring occurred more frequently both years at FHVC, particularly during the growing season of February-August (Table 5). LKAQ generally maintained weekly visit intervals, although half of the months in 2014 had one visit missed, resulting in a larger gap between visits for these months. Most of these gaps were during fall and winter months when the plants are less active, so the gaps should have less impact on the monitoring data. The government shutdown in October 2013 caused a 3-week gap in monitoring at both sites, affecting potential late-season phenology observations such as ripening fruits or leaf drop. In addition, several additional weeks of data were missing for FHVC in 2013, resulting in a continuous data gap from 9/14- 11/8 that year. Observations of individual plants were missing for a few dates at each site (Appendix A), but were sporadic enough that effect on phenology data summaries was minor.

Table 5. Monitoring effort (visits) in 2013 and 2014 for Foothills Visitor Center (FHVC) and Lower Kaweah Air Quality Monitoring (LKAQ). Total number of plants monitored was 21 at FHVC and 20 at LKAQ.

2013	FHVC #Days Between Visits		LKAQ #Days Between Visits	
	Maximum	Mean	Maximum	Mean
January	16	5.4	6	6.0
February	8	3.5	6	6.0
March	7	4.0	6	6.0
April	5	3.0	6	6.0
May	6	3.0	6	6.0
June	7	3.7	6	6.0
July	3	2.4	6	6.0
August	7	5.0	6	6.0
September	56 (includes Oct)	30.5	7	6.0
October	No visits		27	9.5
November	6	4.4	6	6.0
December	7	7.0	13	8.3
Total 2013 visits	**63**		**46**	
Total observation records	**13,861**		**5,740**	
2014	**FHVC #Days Between Visits**		**LKAQ #Days Between Visits**	
	Maximum	**Mean**	**Maximum**	**Mean**
January	9	6.0	13	8.3
February	3	2.5	13	8.3
March	4	1.5	13	10.7
April	4	1.0	13	8.3
May	6	1.5	6	6.0
June	5	1.6	13	7.8
July	6	2.7	6	6.0
August	4	1.2	6	6.0
September	6	1.9	6	6.0
October	10	3.9	12	7.5
November	14	8.7	7	6.5
December	10	5.5	No visits	
Total 2014 visits	**111**		**40**	
Total observation records	**24,105**		**4,298**	

Phenophase Activity

Phenophase activity dates and duration times are shown in tables for each species. “First” or “first observed” and “last” or “last observed” dates are the first and last dates with a positive observation in any individual for the corresponding phenophase. “Duration” or “days” is simply a count of the number of days between the first and last observation dates. In cases where there was a gap > 30 days between any individuals exhibiting a phenophase, more than one first and last observed date will be listed. Mean first observed date uses the earliest first observed date for each individual, but mean values were calculated using only those individuals exhibiting a particular phenophase any time that year.

It is important to note that observation dates do not precisely capture the onset or cessation of a phenophase, particularly if there has been a large gap between observations. Phenophases may have actually begun or ended during gaps in monitoring visits, and not specifically on the date they were observed. This is a particular problem if first or last observed dates border a gap in the monitoring data, such as the 3-week gap from the government shutdown in 2013.

The USA-NPN visualization tool used in the previous annual report (2012) https://www.usanpn.org/nn/connect/visualizations, provided simple overviews of observed phenological activity at a site, park, or region. Unfortunately at the time of this writing, the visualization tool is unavailable, with a new version being released later in 2015.

Blue oak (*Quercus douglasii*)

Several phenophases had breaks in occurrence greater than 30 days, such as colored leaves in 2013 (Table 6). Phenophases active on the first visit each year (such as 2013 breaking leaf buds, colored leaves, falling leaves) likely initiated earlier than the first observed date in Table 8. For those phenophases, duration estimates are probably underestimates, and could be made more accurate by including data from 2012. Due to the nearly two months of data gap in 2013 (9/14-11/8), it is possible that additional observations for fruits and ripe fruits were missed, since those phenophases were still active on the 9/13/13 observation date.

Table 6. *Quercus douglasii* phenophase activity for 2013 and 2014 (n=14). Note: Mean values only include those individuals exhibiting a phenophase.

Year 2013	Blue oak (*Quercus douglasii)*					
Phenophase	**First Observed**	**Last Observed**	**Duration (Days)**	**Mean First Observed**	**Mean Duration (Days)**	**Notes**
Breaking leaf buds	1/2/2013*	3/20/2013	78	2/13/2013	13	
Increasing leaf size	1/2/2013*	3/26/2013	84	2/11/2013	29	
Leaves	1/2/2013*	12/14/2013**	347	1/7/2013	300	
Colored leaves	1/2/2013* 6/4/2013	2/3/2013 12/14/2013**	33 194	2/28/2013	191	No observations 2/4 - 6/3
Falling leaves	1/2/2013* 6/11/2013	1/29/2013 11/25/2013	28 168	3/13/2013	83	No observations 1/30 - 6/10
Flowers or flower buds	3/23/2013	4/16/2013	25	3/31/2013	12	
Open flowers	4/1/2013	4/16/2013	16	4/3/2013	7	
Pollen release	4/1/2013	4/7/2013	7	4/3/2013	5	
Fruits	5/28/2013 11/22/2013	9/13/2013*** 11/22/2013	109 1	6/30/2013	58	No observations 9/14 - 11/21 1 tree with fruits 11/22
Ripe fruits	9/7/2013	9/13/2013***	7	9/10/2013	4	1 tree with ripe fruits 9/7, and 1 tree with ripe fruits 9/13
Recent fruit or seed drop	11/22/2013	11/22/2013	1	11/22/2013	1	One tree observed with phenophase

Year 2014 Blue oak (*Quercus douglasii)*						
Phenophase	**First Observed**	**Last Observed**	**Duration (Days)**	**Mean First Observed**	**Mean Duration (Days)**	**Notes**
Breaking leaf buds	2/16/2014	4/6/2014	50	2/28/2014	18	
Increasing leaf size	2/2/2014	7/1/2014	150	3/5/2014	64	
Leaves	1/5/2014*	12/31/2014**	361	1/5/2014	353	
Colored leaves	3/11/2014	12/31/2014**	296	4/5/2014	222	
Falling leaves	3/24/2014	12/31/2014**	283	5/11/2014	146	
Flowers or flower buds	2/23/2014	6/10/2014	108	3/22/2014	14	
Open flowers	3/11/2014 9/22/2014	5/22/2014 9/22/2014	73 1	3/31/2014	3	None 4/23 - 9/21 (1 tree observed 9/22)
Pollen release	3/11/2014 9/17/2014	4/22/2014 9/17/2014	43 1	5/12/2014	2	None 4/23 - 9/16 (One tree observed 9/17)
Fruits	3/2/2014	9/10/2014	193	4/1/2014	20	
Ripe fruits	5/8/2014 8/25/2014	5/15/2014 8/25/2014	8 1	5/8/2014	2	None 5/16 - 8/24 (One tree observed 8/25)
Recent fruit or seed drop	8/25/2014	8/25/2014	1	8/25/2014	1	One tree observed with phenophase
*Phenophase in progress on first observation date **Phenophase in progress on last observation date ***Observation date borders the 9/14/13 - 11/8/13 data gap.						

For most phenophases, there was a wide variation each year in first observed dates among trees, as shown by standard deviation error bars in Figure 1. That said, leaf-related phenophases began much earlier on average in 2013 compared to 2014. Most striking was colored leaves and falling leaves, which started 6-8 weeks earlier in 2013. Mean first observed dates for flowers and open flowers were within a few days of each other when comparing 2013 and 2014 observations, but fruits and ripe fruits were observed 3-4 months earlier on average in 2014.

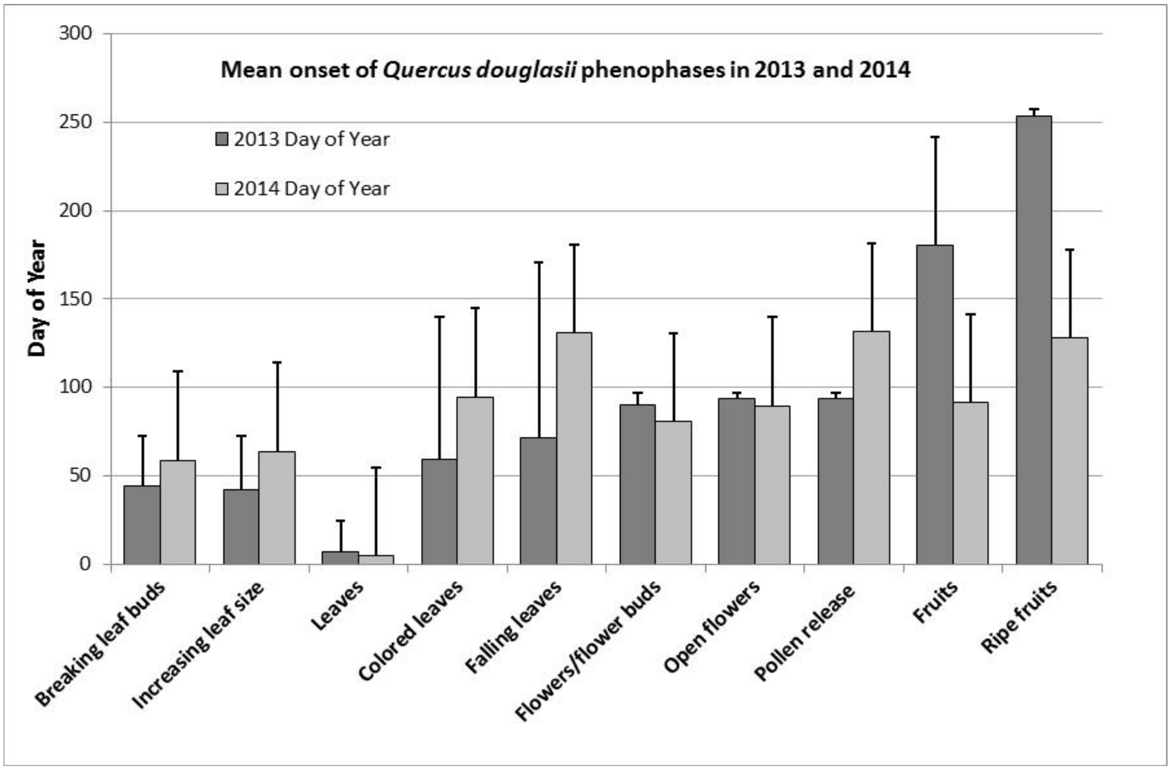

Figure 1. Mean onset day of year for *Quercus douglasii* phenophases in 2013 and 2014 (n=14), with error bars representing standard deviation. Recent seed drop not shown.

Reproduction: blue oak

Fruiting phenophase occurred in more trees and with a longer duration in 2014 compared with 2013 (Fig. 2 and Fig 3). Nearly half of trees (6 out of 14) showed no evidence of reproduction in 2013 (Fig. 2), including no flowering (data not shown). All trees bore flowers and fruit in 2014 (Fig. 3), although only 8 of the 14 trees monitored had ripe fruit observed. The greatest fruiting intensity was seen on one tree in 2013; however only two trees (oak #452 and oak #458) had observations of ripe fruit that year.

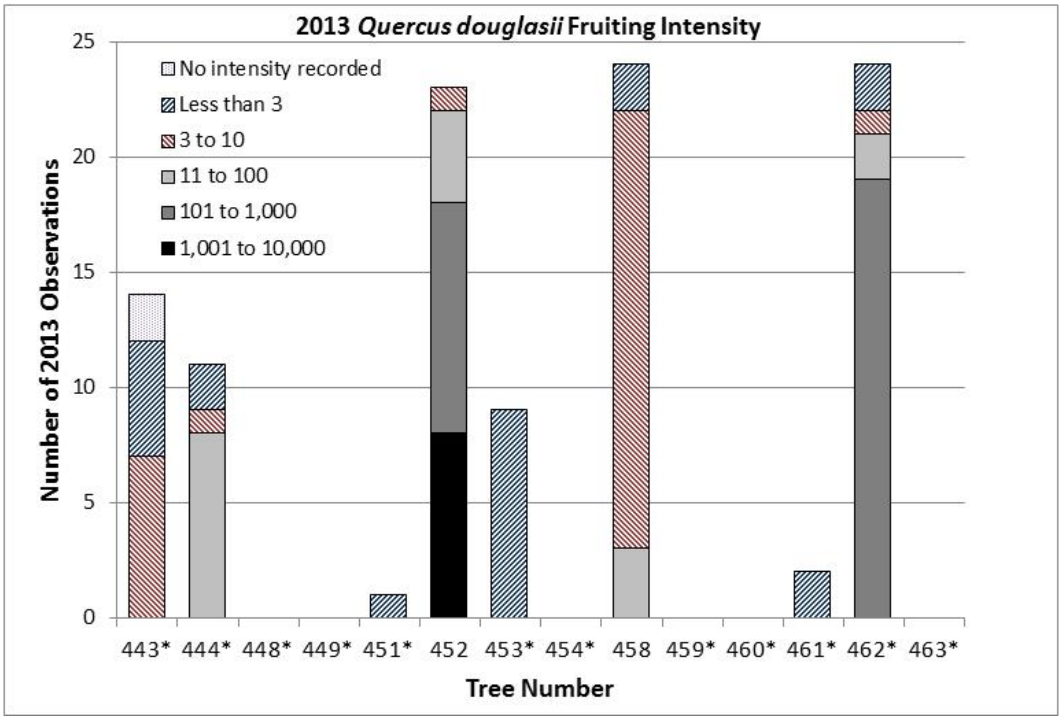

Figure 2. *Quercus douglasii* fruiting activity of individual trees in 2013. *Indicates trees with no observations of ripe fruit.

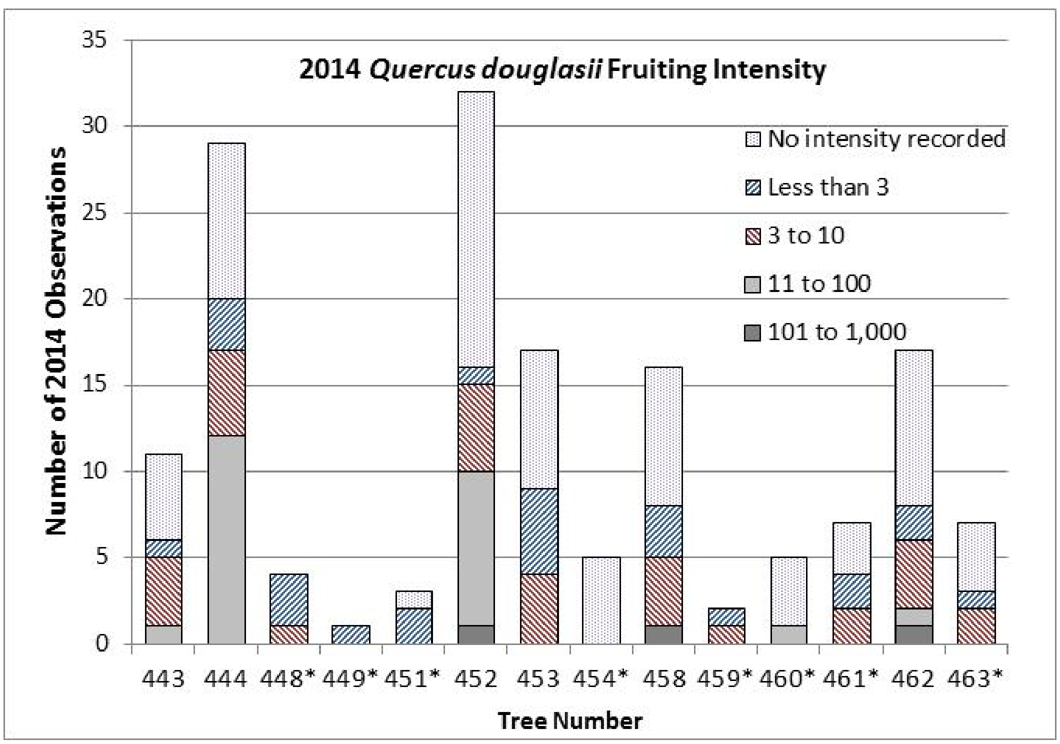

Figure 3. *Quercus douglasii* fruiting activity of individual trees in 2014. *Indicates trees with no observations of ripe fruit.

Leaves: blue oak

Although *Quercus douglasii* is a deciduous species, leaves were seen year-round (Table 7), since at least one tree had at least some leaves throughout the monitoring period. However, all trees were completely leafless during some portion of the 2013 monitoring period, and half the trees (7 of 14) were leafless at some point in 2014. Canopy cover varied among individuals, but overall trees spent a longer proportion of the monitoring period with greater than 50% canopy cover in 2014 compared with 2013 (Fig. 4 and Fig. 5).

Table 7. *Quercus douglasii* 2013 and 2014 estimated duration of leaves phenophase for each tree monitored (n=14), sorted from smallest to largest for 2013 values. Mean and standard deviation are shown at the bottom of each column.

	Total #Days with Leaves	
Tree ID#	**2013**	**2014**
443	278	355
451*	280	361
460	285	355
461	288	311
463	288	329
459	288	355
453	288	356
452*	296	361
449*	301	361
458*	301	361
448*	305	361
444	326	347
462*	326	361
454*	347	361
Mean, ±SD	**300, ±20**	**353, ±15**

*Indicates trees with observations of no leaves in 2014
(All trees had observations with no leaves in 2013)

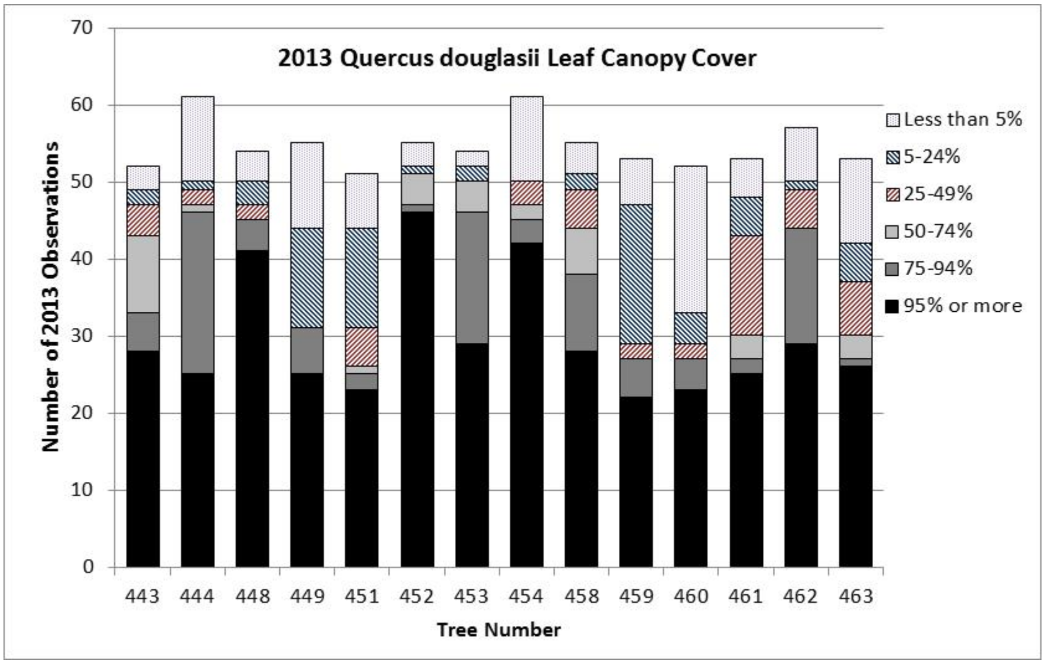

Figure 4. *Quercus douglasii* phenophase intensity for leaves in 2013.

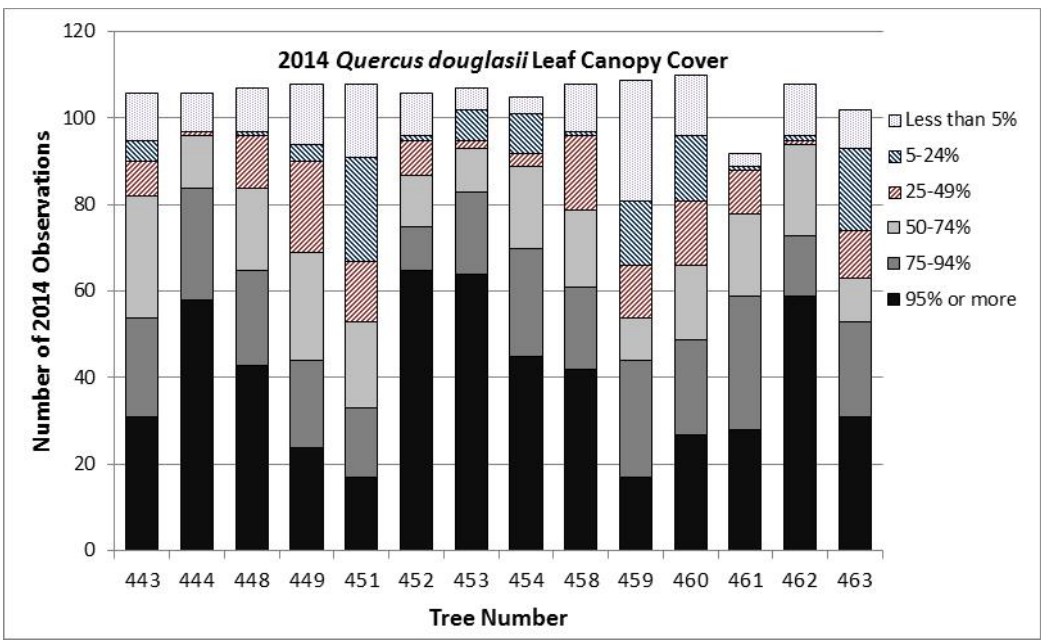

Figure 5. *Quercus douglasii* phenophase intensity for leaves in 2014.

California buckeye (Aesculus californica)

No phenophase was active on the first date of monitoring either year, so obserations for onset of leaf emergence in individual trees (February 3, 2013 and January 20, 2014) are accurate to within a few days (Table 8). On average, leaves appeared two weeks earlier in 2014 compared with 2013. Activity periods for all phenophases except flowers or flower buds were continuous (not sporadic) in 2013, in contrast to 2014 with half of the 10 phenophases being more sporadic. Most noteworthy in 2014 was a second flush in the fall of 2014, when leaf-related phenophases were observed after not being seen for several months. It is curious that the second period of breaking leaf buds was observed after the second period of leaves and colored leaves in 2014 and that no increasing leaf size was noted for fall 2014. It is possible that breaking buds and increasing leaf size happened rapidly, between observation dates, such that they were not noted on the individuals producing leaves in the fall of 2014.

Table 8. *Aesculus californica* phenophase activity for 2013 and 2014 (n=7). Mean values are calculated only using individuals that exhibit a phenophase.

Year 2013 California buckeye (*Aesculus californica*)						
Phenophase	**First Observed**	**Last Observed**	**Duration (Days)**	**Mean First Observed**	**Mean Duration (Days)**	**Notes**
Breaking leaf buds	2/3/2013	3/10/2013	36	2/17/2013	12	
Increasing leaf size	2/3/2013	4/7/2013	64	2/19/2013	39	
Leaves	2/3/2013	8/6/2013	185	2/19/2013	142	
Colored leaves	5/3/2013	8/6/2013	96	5/9/2013	64	
Falling leaves	5/7/2013	8/17/2013	103	5/19/2013	33	
Flowers or flower buds	3/23/2013 8/17/2013	5/28/2013 8/17/2013	67 1	3/25/2013	67	None observed from 5/29 - 8/16, then one tree with flowers 8/17
Open flowers	5/7/2013	6/11/2013	36	5/9/2013	22	
Fruits	5/21/2013	11/30/2013	194	5/21/2013	131	
Ripe fruits	11/9/13*	11/30/2013	22	11/9/2013*	20	
Recent fruit or seed drop	11/9/13*	11/30/2013	22	11/9/2013*	18	
*Observation date follows the 2013 gap in data collection (i.e., phenophase likely active during observation gap)						
Year 2014 California buckeye (*Aesculus californica*)						
Phenophase	**First Observed**	**Last Observed**	**Duratio n (Days)**	**Mean First Observed**	**Mean Duration (Days)**	**Notes**
Breaking leaf buds	1/20/2014 10/3/2014	4/1/2014 11/6/2014	72 35	2/2/2014	29	None observed 4/2 - 10/2 (2nd flush in Oct)
Increasing leaf size	1/20/2014	6/3/2014	135	2/7/2014	77	
Leaves	1/20/2014 9/1/2014	7/28/2014 9/4/2014	190 4	2/7/2014	131	None observed 7/29 - 8/31
Colored leaves	4/14/2014 9/4/2014	6/30/2014 9/4/2014	78 1	4/19/2014	38	None observed 7/1 - 9/3, then one tree on 9/4 observed
Falling leaves	2/13/2014 4/14/2014	3/6/2014 10/27/2014	22 197	3/3/2014	84	None observed 3/7 - 4/13

Flowers or flower buds	3/6/2014	7/16/2014	133	3/10/2014	74	
Open flowers	4/13/2014	6/4/2014	53	4/15/2014	34	
Fruits	5/1/2014	11/20/2014	204	5/23/2014	85	
Ripe fruits	10/6/2014	11/20/2014	46	10/12/14	15	
Recent fruit or seed drop	8/22/2014 11/13/2014	8/22/2014 12/5/2014	1 23	11/9/2014	7	None observed 8/23 - 11/12 (one tree observed 8/22)

First observed dates (onset dates), were earlier for most phenophases in 2014 compared with 2013 (Fig. 6). Leaf-related phenophases were approximately two weeks earlier in 2014, colored leaves was nearly one month earlier, and falling leaves was over two months earlier. Most reproductive phenophases happened earlier in 2014 as well, with open flowers and ripe fruits appearing one month earlier than in 2013. Unripe fruits were observed on nearly the same date both years, however, and the 2013 observation of ripe fruits may not be accurate due to the data gap from 9/14 to 11/8 in 2013. Ripe fruits may have appeared earlier than 11/9/13 and gone undetected.

There was little variation among individuals for most phenophase onset dates, as evidenced by small standard deviations in Figure 6. In fact, 2013 first observations for fruit and ripe fruit phenophases occurred on the same date for all individuals.

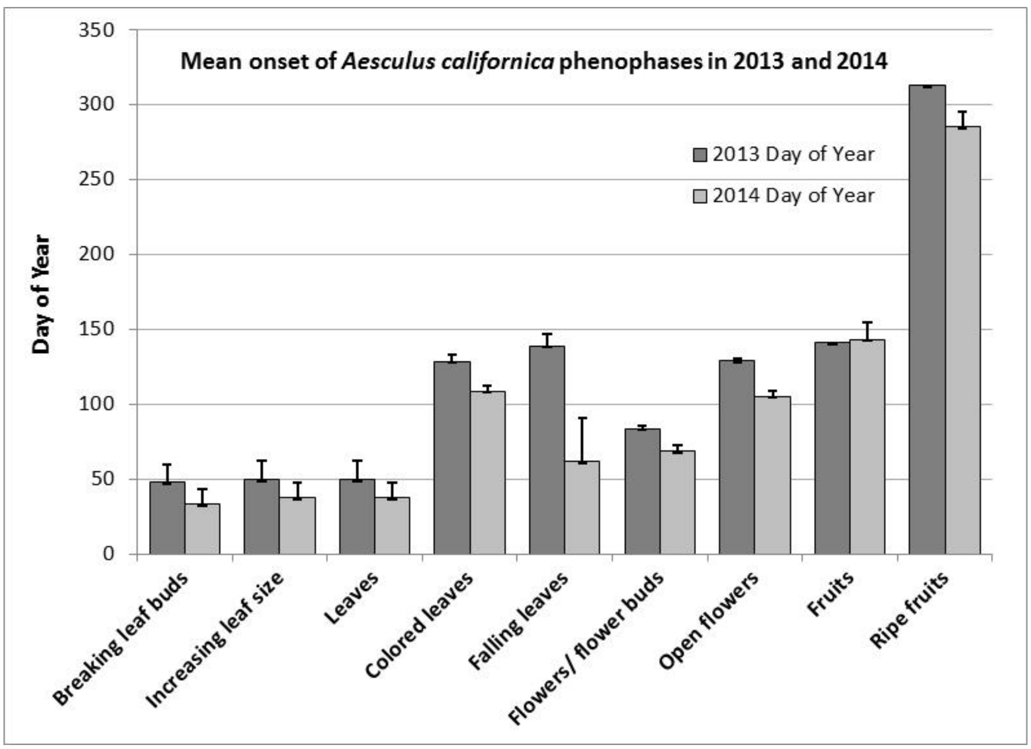

Figure 6. Mean first observed day of year for *Aesculus californica* phenophases in 2013 and 2014 (n=7), with error bars representing standard deviation. Recent seed drop not shown.

Reproduction: California buckeye
All buckeye trees produced fruits both years, but less than half the trees (3 of 7) both years had ripe fruit observations (Fig. 7 and Fig. 8). Observation for ripe fruit may have been missed in 2013, however, due to the data gap of 9/14-11/8. Overall, 2014 appeared to be a better fruiting year, with two trees (#447 and #450) producing over 1,000 fruits per tree, and all but one tree producing over 10,000 fruits (Fig. 8).

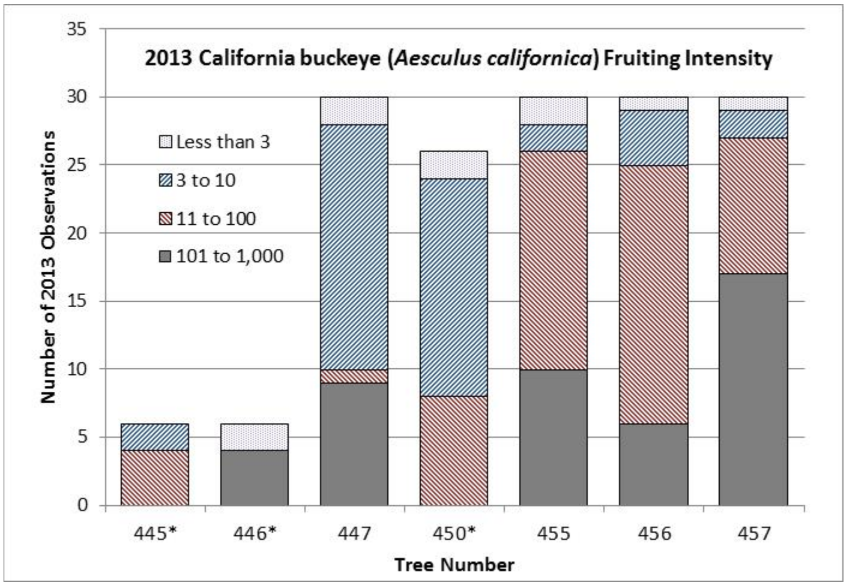

Figure 7. Fruiting intensity for *Aesculus californica* trees in 2013. *Indicates trees with no observations of ripe fruit.

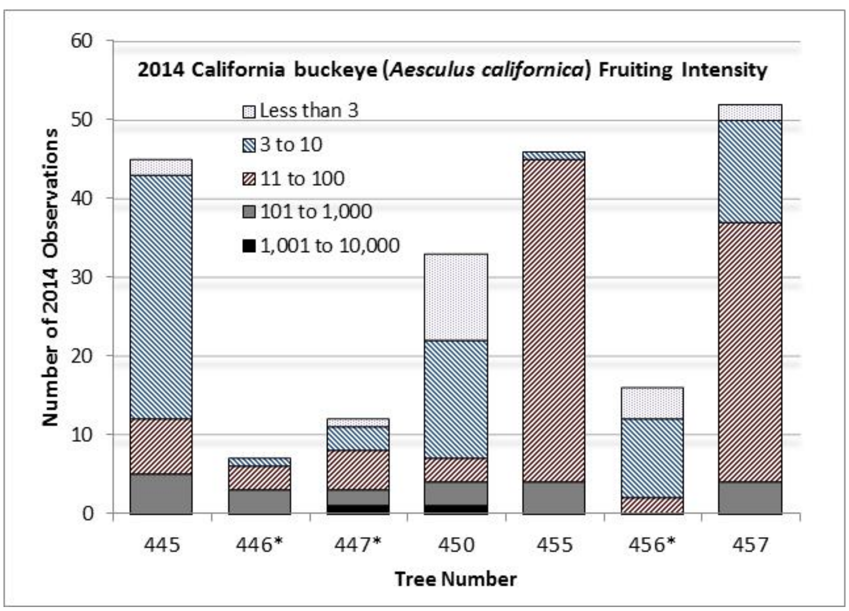

Figure 8. Fruiting intensity for *Aesculus californica* trees in 2014. *Indicates trees with no observations of ripe fruit.

Leaves: California buckeye

California buckeye is a deciduous tree that loses its leaves during the heat of summer. Many of the monitored trees retained leaves less than half the year (Table 9). Leaf retention (number of days with leaves) varied between 102 and 183 days per year, and individuals with shorter leaf retention times in 2013 had shorter time with leaves in 2014 as well. Buckeye #447, which had the longest leaf retention time in 2013, dropped its leaves 45 days earlier in 2014, however.

Table 9. *Aesculus califonica* 2013 and 2014 duration estimates of the leaves phenophase for each tree monitored (n=7), sorted by increasing values for 2013.Mean and standard deviation shown at the bottom of each column.

	Total #Days with Leaves	
Tree ID#	**2013**	**2014**
445	102	114
446	102	108
450	131	122
456	144	145
457	154	126
455	178	162
447	183	138
Mean, ±SD	**142, ±33**	**131, ±19**

Proportion of time spent with 95% or more canopy cover was lower in 2013 compared to 2014 (Fig. 9 and Fig. 10). Conversely, most trees in 2013 spent a relatively long proportion of time with less than 5% canopy cover. Table 9 shows a second flush of leaves occurring in 2014, and this likely increased the total number of observations for trees with greater than 95% canopy cover that year.

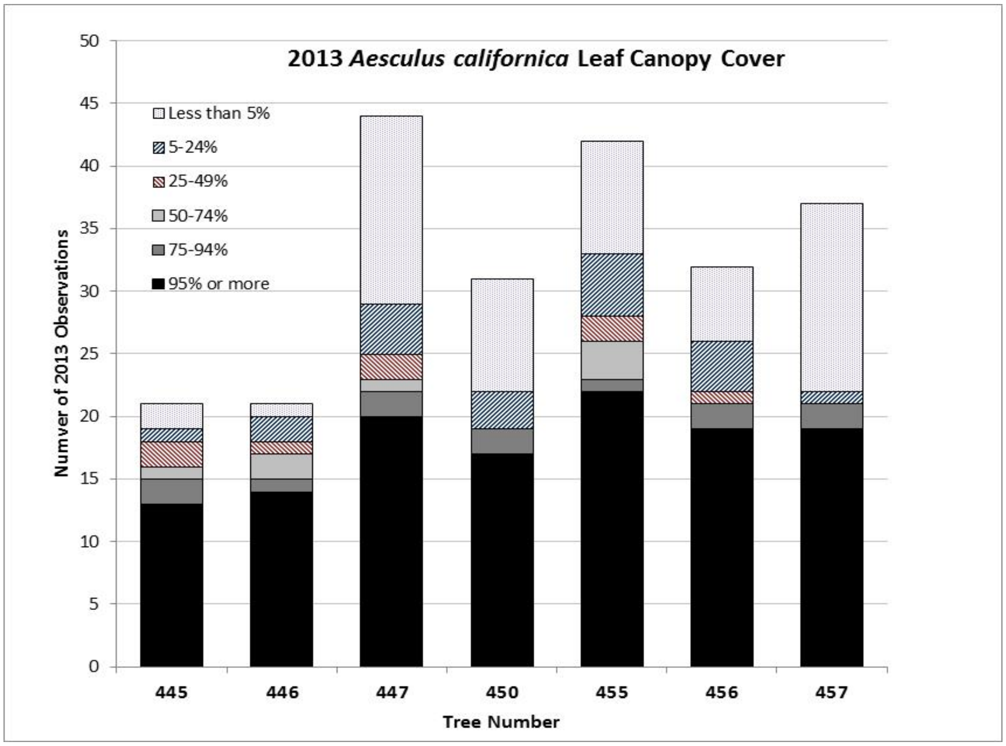

Figure 9. *Aesculus californica* phenophase intensity for leaves in 2013.

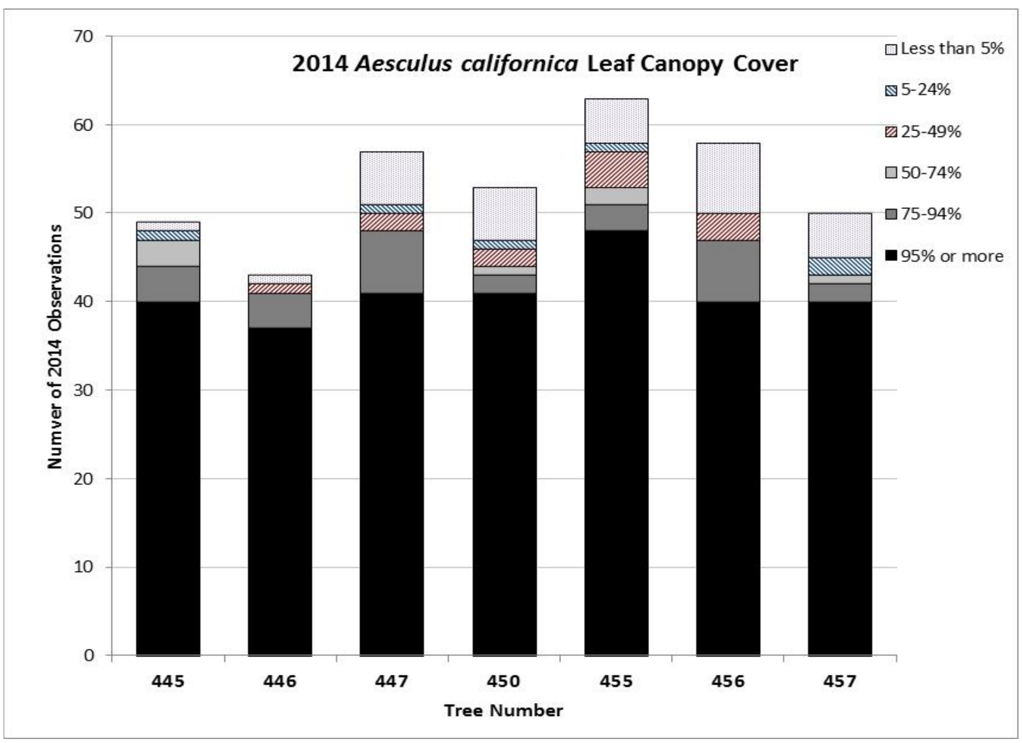

Figure 10. *Aesculus californica* phenophase intensity for leaves in 2014.

Greenleaf manzanita (*Arctostaphylos patula*)

Observed phenophases were sporadic in 2013 and 2014 for greenleaf manzanita (i.e., had breaks >30 days), with the exception of breaking leaf buds, flowers/ flower buds, and open flowers (Table 10). The wide variation among individuals in first observed dates (indicated by error bars in Fig. 11) increases uncertainty in comparing data between years. That said, mean first observed dates appeared similar in 2013 and 2014, with the exception of flowers/ flower buds (earlier in 2013), fruits and ripe fruits (later in 2013). The fruiting dates for manzanita are affected by early-year observations of the previous year's fruits, since fruits that appear viable from last year are included in observations. This makes it difficult to accurately determine the onset of current year fruiting.

Mean durations for all fruiting and flowering phenophases appeared considerably longer in 2014 compared to 2013 (Table 10).

Table 10. *Arctostaphylos patula* phenophase activity for 2013 and 2014 (n=10). Mean values are calculated only using individuals that exhibit a phenophase.

Year 2013	**Greenleaf manzanita (*Arctostaphylos patula)***					
Phenophase	**First Observed**	**Last Observed**	**Duration (Days)**	**Mean First Observed**	**Mean Duration (Days)**	**Notes**
Breaking leaf buds	5/21/2013	7/2/2013	43	5/28/2013	30	
Young leaves	2/26/2013 5/21/2013	3/5/2013 8/6/2013	8 78	5/26/2013	40	None observed from 3/6 to 5/20
Flowers or flower buds	2/26/2013	5/21/2013	85	2/27/2013	73	
Open flowers	3/19/2013	5/21/2013	64	4/4/2013	37	
Fruits	2/5/2013 4/30/2013	2/5/2013 12/31/13*	1 246	4/27/2013	240	None observed from 2/6 - 4/29
Ripe fruits	2/5/2013 3/5/2013 7/10/2013	12/31/13* 3/5/2013 12/31/13*	330 1 175	7/3/2013	166	None observed from 2/6 - 3/4 and 3/6 - 7/9
Recent fruit or seed drop	8/13/2013 11/5/2013	9/9/2013 12/31/13*	28 57	9/15/2013	57	None observed from 9/10 - 11/4
Year 2014	**Greenleaf manzanita (*Arctostaphylos patula)***					
Phenophase	**First Observed**	**Last Observed**	**Duration (Days)**	**Mean First Observed**	**Mean Duration (Days)**	**Notes**
Breaking leaf buds	5/27/2014	6/24/2014	29	6/2/2014	21	
Young leaves	2/25/2014 8/12/2014 10/14/2014	7/8/2014 8/12/2014 11/25/2014*	134 1 43	3/22/2014	107	No young leaves 7/9 to 8/11 and 8/13 to 10/13 All individuals with young leaves on 8/12
Flowers or flower buds	3/25/2014	5/20/2014	57	4/2/2014	25	
Open flowers	3/25/2014	5/20/2014	57	4/3/2014	24	
Fruits	1/7/2014* 9/17/2014	7/28/2014 11/25/14*	203 70	1/7/2014	125	None observed from 7/29 - 9/16

Ripe fruits	1/7/2014* 7/22/2014 8/18/2014	4/21/2014 7/22/2014 11/25/14*	105 1 100	1/7/2014	102	None observed from 4/22 - 7/21 and 7/23 - 8/17 One shrub with fruits on 7/22
Recent fruit or seed drop	1/7/2014*	4/8/2014	92	1/23/2014	35	
*Phenophase active on first monitoring date for the year **Phenophase active on last monitoring date for the year						

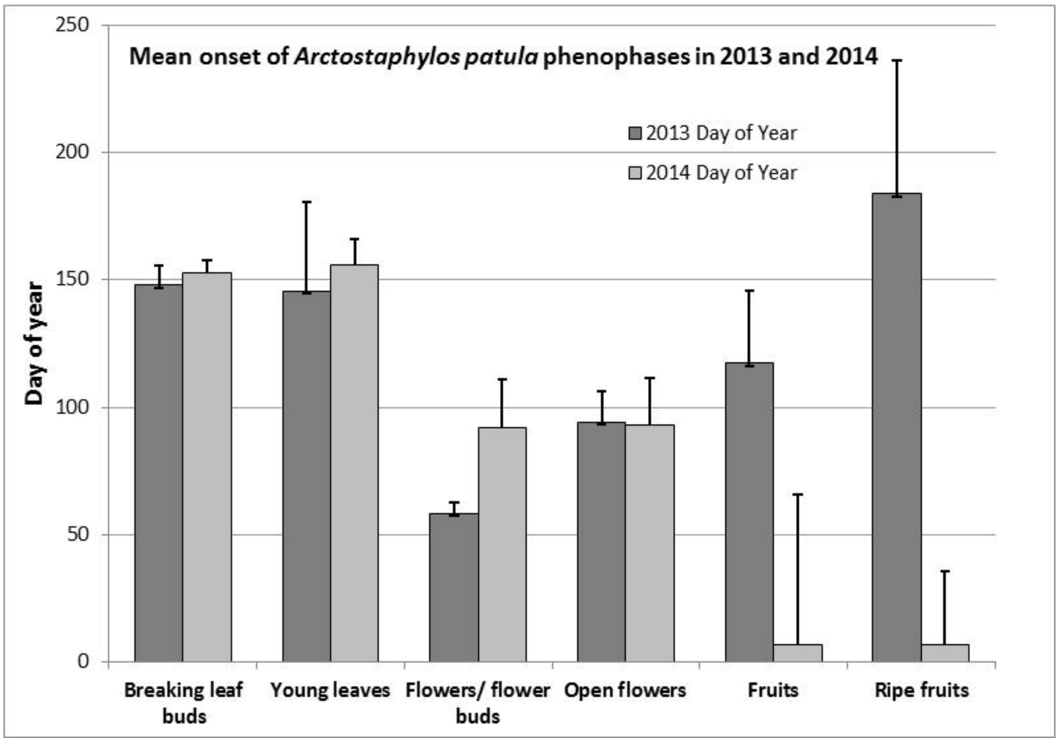

Figure 11. Mean onset day of year for *Arctostaphylos patula* phenophases in 2013 and 2014 (n=10), with error bars representing standard deviation. Recent seed drop not shown.

All manzanita shrubs bore fruit in 2013 (Fig. 12) and 2014 (Fig. 13), and ripe fruit was observed on all shrubs. Fruiting duration appeared shorter in 2014, as indicated by the lower number of 2014 observations with fruit for nearly all shrubs (the exception being manzanita #634, which had over 25 observations with fruit in 2014). More fruits were produced on all shrubs in 2013, as indicated by intensity categories of >10,000 fruits (1 shrub) and 1,001 to 10,000 fruits (7 shrubs). These categories were not recorded for any shrubs in 2014.

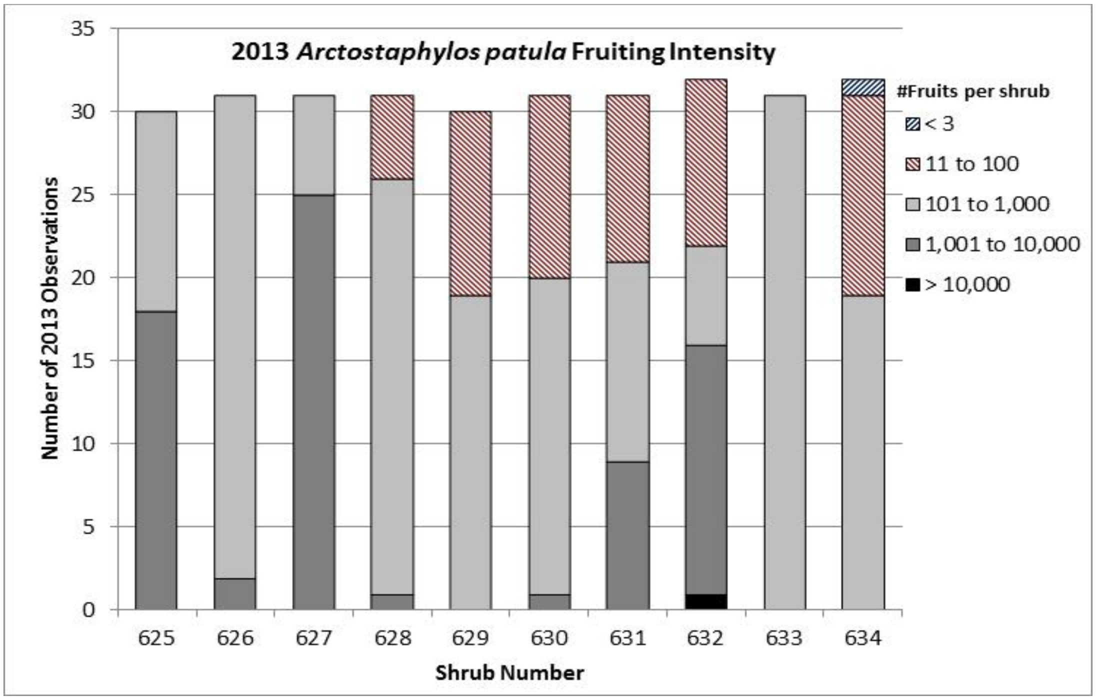

Figure 12. Fruiting intensity for *Arctostaphylos patula* shrubs in 2013.

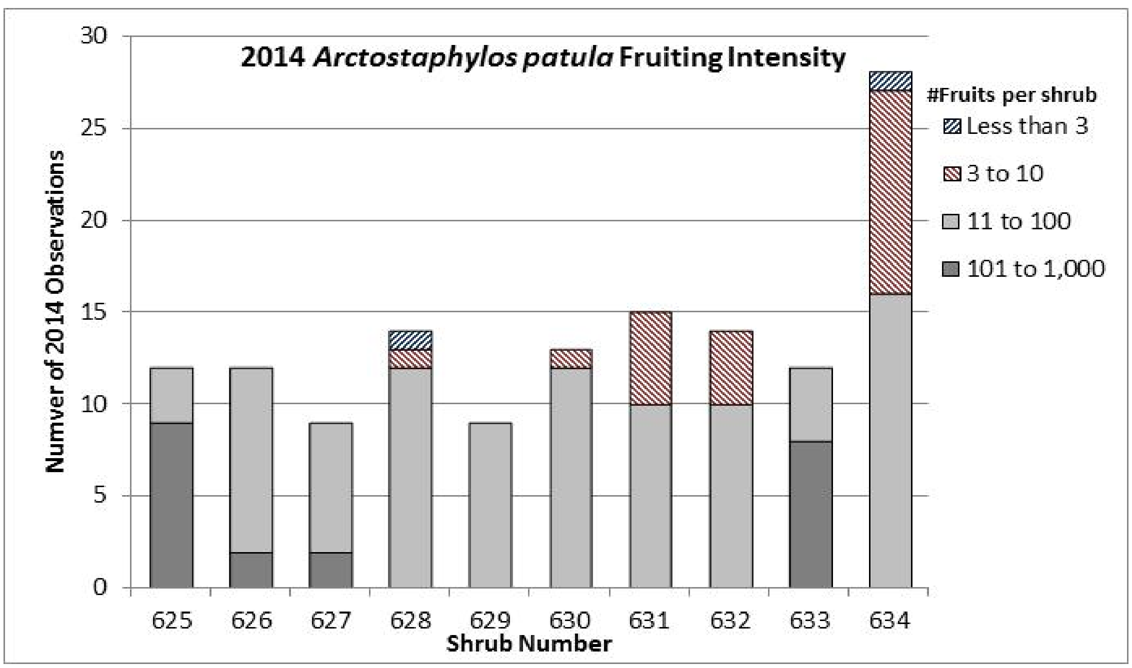

Figure 13. Fruiting intensity for *Arctostaphylos patula* shrubs in 2014.

Mountain pride (*Penstemon newberryi*)

Phenophase activity for mountain pride shrubs was continuous for all phenophases with the exception of fruiting in 2013 and young leaves in 2014 (Table 11). "Fruits" and "Ripe fruits" in 2013 likely included capsules from the previous year that appeared viable to observers in February and March, and were perhaps overlooked by January 2013 observers. This led to a much earlier average onset date for fruits and ripe fruits (Fig 14), which likely does not accurately depict the onset of current year fruiting for 2013.

Flowers opened on some shrubs earlier in 2014 vs. 2013 (Table 11), but the average onset date for open flowers for 2014 was only 3 days earlier than 2013. Many individuals exhibited the same phenophase onset date, as shown by the small error bars in Figure 14.

Table 11. *Penstemon newberryi* phenophase activity for 2013 and 2014 (n=10). Mean values are calculated only using individuals that exhibit a phenophase.

Year 2013 Mountain pride (*Penstemon newberryi*)						
Phenophase	**First Observed**	**Last Observed**	**Duration (Days)**	**Mean First Observed**	**Mean Duration (Days)**	**Notes**
Young leaves	3/19/2013	7/23/2013	127	4/6/2013	100	
Flowers or flower buds	4/30/2013	6/18/2013	50	5/4/2013	40	
Open flowers	5/21/2013	6/18/2013	29	5/25/2013	19	
Fruits	2/5/2013 6/4/2013	3/26/2013 12/17/2013	30 197	2/5/2013	155	None observed 3/27 - 6/3
Ripe fruits	2/5/2013 7/9/2013	3/26/2013 12/17/2013	50 162	2/5/2013	126	None observed 3/27 - 7/8
Year 2014 Mountain pride (*Penstemon newberryi*))						
Phenophase	**First Observed**	**Last Observed**	**Duration (Days)**	**Mean First Observed**	**Mean Duration (Days)**	**Notes**
Young leaves	2/25/2014 8/12/2014 10/14/2014	7/8/2014 8/12/2014 11/25/2014*	134 1 43	3/22/2014	107	No young leaves 7/9 to 8/11 and 8/13 to 10/13 All individuals with young leaves on 8/12
Flowers or flower buds	5/6/2014	6/24/2014	50	5/9/2014	40	
Open flowers	5/6/2014	6/24/2014	50	5/21/2014	25	
Fruits	6/10/2014	11/25/2014*	169	6/10/2014	134	
Ripe fruits	7/22/2014	11/25/2014*	127	7/15/2014	86	
*Phenophase active during last observation of the year.						

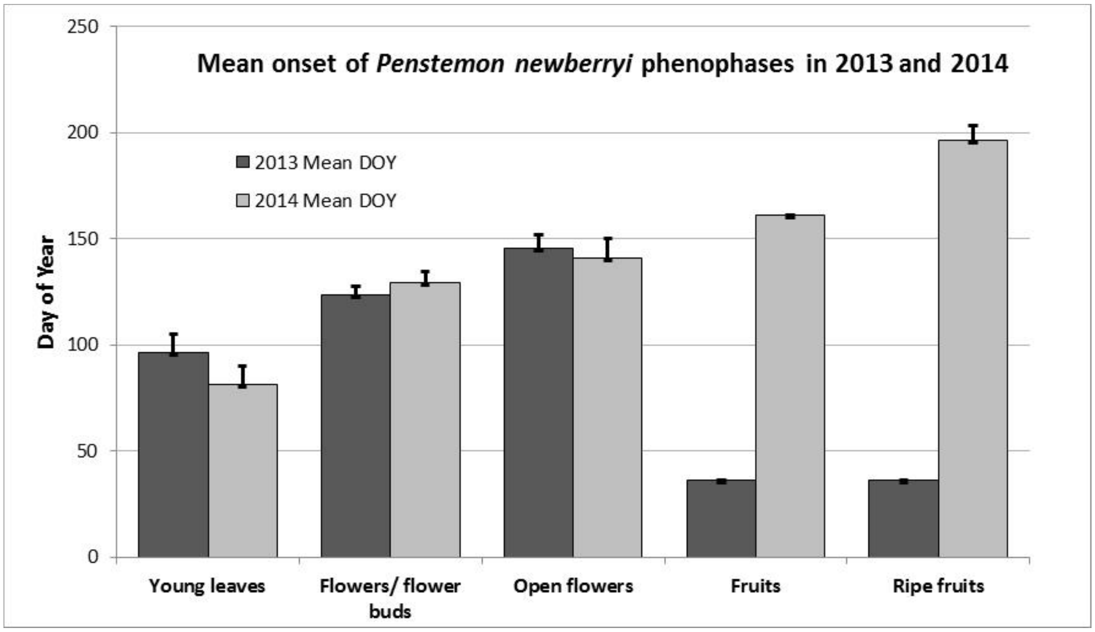

Figure 14. Mean onset day of year for *Penstemon newberryi* phenophases in 2013 and 2014 (n=10), with error bars representing standard deviation.

All shrubs bore fruit in 2013, but with lower intensity than 2014 (Fig. 15 and Fig. 16), since the 1,001-10,000 category was not observed in 2013. That said, shrub #641 did not bear fruit in 2014, nor did it flower (flowering data not shown).

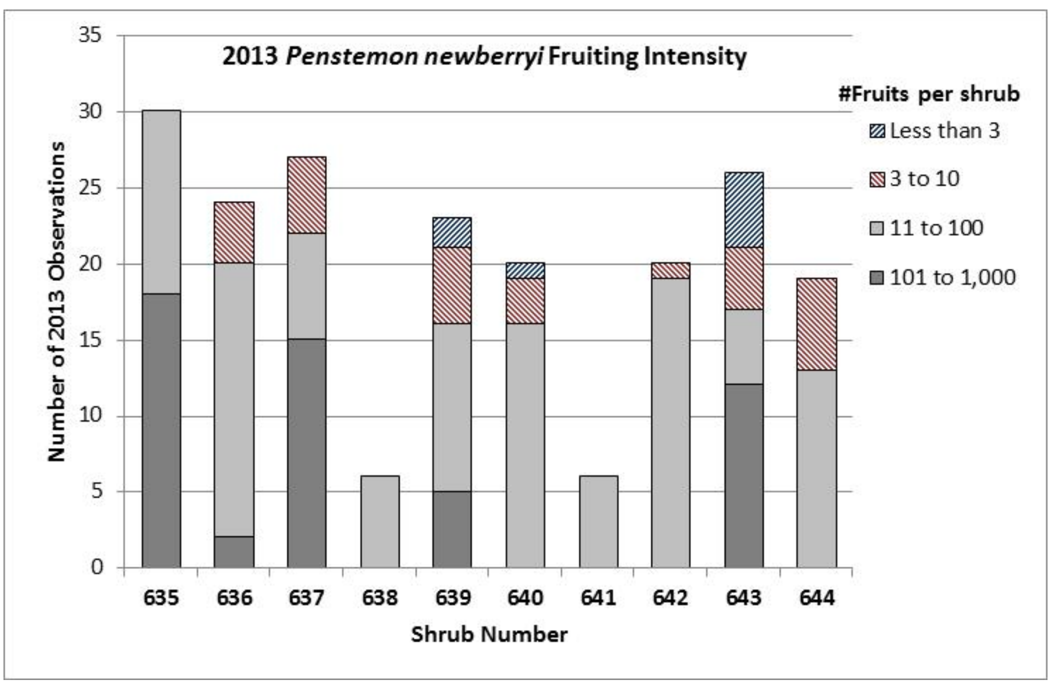

Figure 15. Fruiting intensity for *Penstemon newberryi* shrubs in 2013.

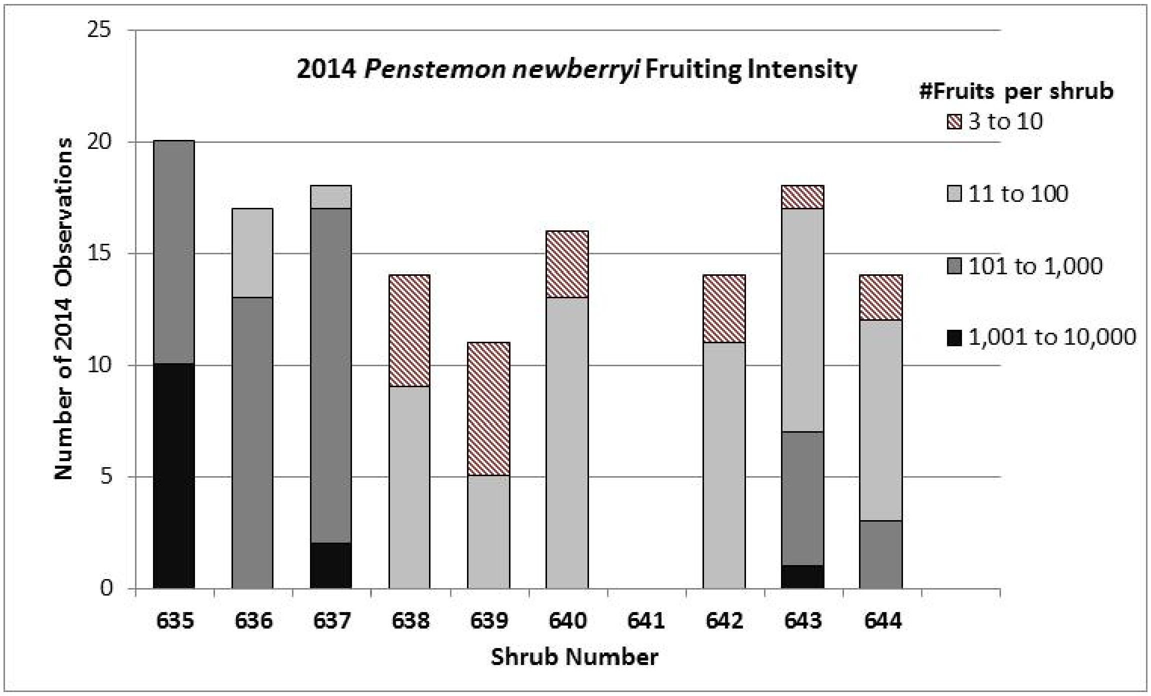

Figure 16. Fruiting intensity for *Penstemon newberryi* shrubs in 2014.

Discussion

Results Interpretation

Weather for the monitoring sites in 2013 and 2014 was overall warmer and drier compared to long-term records of average temperature and precipitation. At Foothills Visitor Center (FHVC), weather station records indicate that March-July both years was several degrees warmer than normal, and records from Grant Grove (GG), used as a surrogate for weather at Lower Kaweah Air Quality station (LKAQ), showed similar patterns. January 2014 was 9°F warmer at both sites, and above average temperatures continued through that summer. While both years were much drier than the 30 year normal, a pronounced lack of rain marked the period of August 2013 through March 2014 at FHVC, particularly unusual over the winter when this area should receive most of its yearly precipitation. This drought period was somewhat less extreme in the mountains, as Grant Grove had a greater proportion of normal precipitation during that time. Several pulses of precipitation provided slight relief from drought, including episodes in July-August of 2013 (both areas), August-September of 2014 (FHVC), July 2014 (GG) and September 2014 (GG).

Although detailed analysis correlating climate and phenophase data is outside the scope of this annual report, potential relationships are noted for each species in the following sections. In addition, information or observations about individual trees and shrubs and other potential sources to explain patterns in the data are discussed below.

Blue oak (*Quercus douglasii*)

Blue oaks are fall and drought-deciduous trees that may retain leaves year-round on moist sites (Pavlik et al. 1991). During extremely dry years, blue oaks may respond to soil moisture stress by dropping their leaves in the summer. Tracking leaf canopy fullness for this species could be used as a potential indicator of soil moisture stress or availability. One of the most striking differences between 2013 and 2014 observations for blue oak was that all the trees were completely leafless at some point during 2013, whereas only half the trees (7 of 14) lost all their leaves in 2014. Blue oaks retained leaves 53 days longer on average in 2014. In addition, colored and falling leaves occurred at least two months earlier in 2013 on average. 2013 was a drier year than 2014, and this likely caused more extensive and faster leaf drop. In contrast, the pulses of moisture in the second half of 2014 may have contributed to greater leaf retention. It will be interesting to compare these patterns with additional years of data to see how closely activity patterns in the leaf-related phenophases track year-to-year changes in weather and over the longer-term, changes in climate.

Fruits and fruit ripening, in contrast, were later in 2013 compared with 2014. It should be noted, however that the sample size in 2013 for trees producing acorns was smaller (8 of 14) compared with 2014 (n=14), and that only two trees were observed with ripe fruit in 2013. It is possible that additional ripe fruit would have been observed in 2013 had the gap in data collection from 9/14-11/8 not occurred. The fact remains, however, that only slightly over half the trees attempted reproduction in 2013, so the additional trees reproducing in 2014 may be individuals that generally bloom earlier than the rest.

Apart from weather influences, fruiting variables such as intensity (number of fruits observed per tree) is likely strongly related to tree size and vigor. For example, oak #452 is a large, robust tree and produced the most "intense" acorn crop observed in 2013 (1,000-10,000 fruits), as well as the most acorn observations in 2014. It also was one of only two trees in 2013 observed with ripe acorns. In contrast, oaks #448 and #449 are saplings that likely have underdeveloped root systems, and are more quickly affected by drought periods. These two trees produced no acorns in 2013, very few in 2014, and had no observations of ripe acorns. Additional years of data collection to investigate patterns correlating acorn production to tree size or vigor (using variable such as leaf canopy cover), as well as climate variables would contribute valuable information to our understanding of factors influencing blue oak reproduction.

California buckeye (*Aesculus californica*)

The general seasonal patterns in phenophase activity observed for monitored California buckeye trees observed in 2013 and 2014 are typical for this species. Like the other species monitored at SEKI, additional years of monitoring will be helpful to discern relationships between phenophase activity and weather conditions (and, over the long-term, climate). Since the leaves, flowers, and fruit phenophases for this species are obvious in appearance and stand out over the year in very distinct periods, this may be an ideal species to track responses to climate.

In contrast to observations between years in blue oak, leaf-related phenophases in buckeye trees occurred earlier in 2014 compared to 2013, although the difference was less dramatic (approximately 2 weeks earlier, on average). The warm temperatures in January 2014 (9°F above normal) likely contributed to earlier leaf development that year. It is unclear why leaves became colored and dropped sooner in 2014 compared to 2013, although it appears that a second flush of leaves occurred in fall 2014, likely precipitated by the above-average rainfall events in August and September that year. This second flush probably led to the higher proportion of observations for full leaf canopy (>95% cover) recorded in 2014. There was greater variation among individuals in 2013 for leaf retention, with 2 of the 7 trees monitored retaining their leaves much longer than the others; this likely skewed the average value for leaf retention that year and thus did not accurately reflect the patterns for leaf drop of the larger population.

Differences between years and individuals for reproductive phenophases in the California buckeye trees was not as dramatic as in the blue oaks. All individuals flowered and produced fruits both years, and of the three trees each year not observed with ripe fruit, only one of them (#446) was common to both years. Again, due to the data gap in 2013 (9/14-11/8), additional fruit may have ripened and dropped before it could be observed on 11/9/13. Despite this, trees produced overall more fruit in 2014 compared with 2013, although potential reasons for this are not obvious in the weather data from FHVC.

Greenleaf manzanita (*Arctostaphylos patula*)

According to past monitoring efforts (late 2011- 2012), Greenleaf manzanita phenophases can be tricky to identify, particularly with regard to young leaves (can be confused with small adult leaves) and fruits (which often remain on the shrub through winter into the next year). Datasheets and some phenophase definitions were customized in 2013 to mitigate these issues, but including fruit from previous years in observations makes it difficult to interpret timing of fruiting phenophases. This was the case for 2014 fruit and ripe fruit phenophases that were observed on the first monitoring date for 2014 and thus skewed the mean onset date for those phenophases.

Phenophases were also more sporadic (with breaks >30 days for any individual exhibiting a phenophase) in this species than in others monitored at SEKI, which further complicates interpretation of phenophase onset dates and duration.

Although there was high variation among individuals, leaf emergence and flower buds were observed slightly earlier (approximately 1 week) in 2013. Because observations at this site only occur every 7 days, this difference between years could be an artifact of the monitoring interval. The duration in flowering appeared longer in 2014 by 2-4 weeks, however. This area received average to above average precipitation in April, May and June 2014 (compared with less than 30% average for those months in 2013), and this may have increased the length of flowering time for shrubs in 2014.

Mountain pride (*Penstemon newberryi*)

Although mountain pride phenophases are generally easier to observe, there may have been difficulty with definitions for fruiting phenophases that led to inconsistencies in the data. Most notable was the 2/5/13 observation of fruits and ripe fruits that were obviously last year's fruits but were not noted by observers earlier in 2013. As of 2013, fruiting definitions for this species include viable fruits from the previous year, but this makes it very difficult to determine dates and durations for current year fruit production.

Flowering seems to be a less confusing phenophase for observation, so the observations of open flowers on average 3 weeks earlier in 2014 than 2013 likely represents a real pattern. Young leaves also appeared earlier in 2014. January was exceptionally warm in 2014 (9°F above normal), with continued above average temperatures by several degrees through July. This likely pushed leaf and flowering phenophases earlier in 2014 for mountain pride shrubs.

Fruiting intensity was higher in 2014 (evidenced by observations of shrubs with >1,000 fruits), but one of the lesser-fruiting shrubs from 2013 (#641) did not produce any fruit in 2014. Shrub #641 may be one of the smaller shrubs in the monitored population, thus accounting for its barrenness. Because fruits are first forming in early June, the precipitation events in April-May 2014 may have boosted fruit production that year.

Lessons Learned / Recommendations

The two most obvious factors that affect quality of the dataset are accuracy of defining/observing phenophases for each species and monitoring interval/ data gaps. Although there were improvements in tailoring phenophase definitions to better reflect species-specific characteristics for 2013-2014, there is still some subjectivity in quantifying certain phenophases, so good training and calibration among observers is essential. This is particularly true for intensity variables such as leaf canopy cover, percent of flowers open or ripe fruit. Phenophases like breaking leaf buds, young leaves, or colored leaves could also be interpreted differently by different observers. Frequent check-ins between the phenology project manager and lead monitors is recommended, and an annual training/ refresher for lead monitors in early spring at each site would be highly beneficial. Because flowering and leaf emergence seem less confusing for monitors to observe, future data analyses to correlate phenophase timing with climate variables may choose to focus on these phenophases.

The change in phenophase definition for fruits and ripe fruits at LKAQ in 2013 (to include viable-appearing fruits from previous years) may have made monitoring easier for observers, but it made data for these phenophases nearly impossible to interpret. If timing and duration of fruit development is of interest, then perhaps an “immature fruit” category could be defined and added. Otherwise, unless there is a gap in fruit retention (where last year’s fruit drops before this year’s fruit forms), observations for current year fruit formation will be completely lost.

Gaps occurred in this dataset for various reasons, with variable potential impacts on analysis depending on the timing of the gap. Most obviously, the government shutdown in October, 2013 caused a 3-week gap in data at both sites, but for FHVC, an additional two weeks before and one week after the shutdown was also missing. Luckily, this data gap encompasses a less active period the monitored species, so it likely only affected interpretation of ripe fruit and recent seed drop phenophases. More troubling (because they seem preventable) are the sporadic missing observations for individual trees/ shrubs in the database. For example, there were observations in the dataset for a tree where “pollen release” was marked yes but “flowers/ flower buds” was marked no. Other instances occurred where intensity fields were left blank when a phenophase was marked yes. Most troubling were instances where all phenophases were left blank for a specific tree/ shrub on a particular date when the rest of the trees were monitored. If data collection is paperless, then QA/QC built into the electronic database should prompt the user of such mistakes while they can still be easily corrected.

For LKAQ, one visit per month was missed for half of the months in 2014, and two of them occurred during phenologically active months (March-April). Because phenology monitoring is a collateral duty for air quality monitoring staff at this location, their primary duties must take precedent at the occasional expense of collecting phenology data. If volunteers or other park resources could be found, it would be ideal if monitoring frequency could increase at this station during times that phenophases were expected to begin or end, to more closely capture onset or ending dates.

Finally, the new National Phenology Network data summaries available online were extremely useful for interpreting phenophases, particularly phenophase duration. They do not, however, automatically detect sporadic phenophases such as flowering that occurs in both spring and fall. An automated flag for phenophases occurrence more than once per season with a break greater than 1 month apart would be useful for this purpose.

Education and Outreach

The phenological monitoring program at Sequoia and Kings Canyon is a collaborative effort between the Division of Interpretation and the Division of Resources Management and Science. Phenological monitoring is a powerful way to involve students, visitors, and park staff in collecting data that provides a direct link to understanding climate and its influence on plants and animals. For this reason, phenology has been selected as a component of the parks' Climate Change interpretation program. Below is a brief summary of selected outreach efforts conducted by the Sequoia District Interpretive staff during 2013 and 2014.

During the summer of 2013, the Lead Education Technician, Kelly Evans, supervised a phenology intern, Russell Doughty, who was funded by the Climate Change Youth Initiative. During his internship, he developed'PhenoLapse', an online educational tool to illustrate the phenophases of a California buckeye tree in the foothills. This interactive tool combines daily photos taken of one of the buckeye trees in the study with the park's weather station data to convey the concepts of phenology to students and the general public. The tool engages users by allowing them to view photos of any day in 2011-12 with respective weather data, or allowing them to play the entire year's sequence to quickly see the phenophases. The intern also developed a 7th grade lesson plan that incorporates the PhenoLapse tool into an interactive science lab project that meets California state curriculum standards. Russell also wrote and uploaded the Phenology section of SEKI's education web pages, which explain what phenological monitoring is happening at the park and how anyone can get involved in monitoring species.

In 2014, two phenology volunteers and two phenology interns monitored the 22 plants at the Foothills Visitor Center site along with periodic monitoring by rangers. Funding for the interns was provided through the California Phenology Project and administered through a cooperative agreement with Dr. Susan Mazer at the University of California at Santa Barbara. Dani Crawford hired and supervised the two interns to monitor and work on outreach and public facilitated dialogue in the park.

Through the Rangers in the Classroom program, SPROUTS (Student Phenologists Researching Oaks to Understand Trees and Science) engages 5th and 6th grade students in recording and observing phenological events of oak species in their school yard. The SPROUTS program provides students with a hands-on learning opportunity using phenological monitoring and citizen science. SPROUTS was presented to over 150 students in 6 classes throughout academic year 2013-2014.

Location of project components

All data is entered online via Nature's Notebook (https://www.usanpn.org/natures_notebook) and is stored in the USA-NPN's National Phenology Database, available for download at https://www.usanpn.org/results/data.

Files associated with phenological monitoring at the Foothill's Visitor Center are located at: S:\INTP\Foothills operations\12 Phenology

Files associated with the plant ecology program, included downloaded data and reports are located at: J:\seki\park_programs\share_docs\Vegetation\Plant Ecology Program\California Phenology Project

A monitoring binder is stored at each monitoring location. Monitoring binders contain:

- Datasheets
- Phenophase definition sheets and species accounts
- SEKI Monitoring Guide

For this 2013-2014 data summary, Excel spreadsheets with pivot tables and graphs can be found at J:\seki\park_programs\share_docs\Vegetation\Plant Ecology Program\California Phenology Project\2013-2014 Data.

This report, with electronic title "2013-2014 SEKI Phenological Monitoring Annual Report.docx" is located at: J:\seki\park_programs\share_docs\Vegetation\Plant Ecology Program\California Phenology Project\Monitoring reports

Literature Cited

Pavlik, Bruce M.; Muick, Pamela C.; Johnson, Sharon G.; Popper, Marjorie. 1991. Oaks of California. Los Olivos, CA: Cachuma Press, Inc. 184 p.

Appendix A. Data gaps in Observation Dates

For mountain pride (*Penstemon newberryi*), observations for all shrubs were missing on the following 2014 dates: 2/4, 2/11, 10/7, 10/21, 10/28. Otherwise, all *Penstemon newberryi* observations were complete. The following tables summarize missing dates for individuals of other monitored species.

Table A-1. Blue oak (Quercus douglasii) missing 2013-2014 observation dates for individual trees. Total number of monitoring dates was 63 in 2013, and 111 in 2014.

Tree Number													
443	444	448	449	451	452	453	454	458	459	460	461	462	463
2013 Dates													
				6/4/13*		5/10/13* 5/14/13*	5/7/13	5/7/13	5/7/13	5/7/13	5/7/13	5/7/13 11/25/13	5/7/13
2014 Dates													
5/6/2014 6/30/2014	3/27/14 5/6/14 8/11/14	3/24/14 3/27/14 3/31/14 4/20/14	10/24/14 10/30/14	3/23/14 10/3/14 10/24/14 10/30/14	3/27/14 4/14/14 5/6/14 6/13/14 10/24/14	5/6/14 6/13/14 7/28/14	7/1/14 7/28/14 9/14/14 10/24/14 10/30/14	3/25/14 10/6/14 10/10/14			3/11/14* 8/10/14 8/25/14 9/1/14 9/15/14 10/3/14 10/10/14	4/4/14 11/20/14 12/17/14	12/10/14

*Leaves phenophase only collected on this date

Table A-2. California buckeye (*Aesculus californica*) missing 2013-2014 observation dates for individual trees. Total number of monitoring dates was 63 in 2013, and 111 in 2014.

Tree Number						
445	**446**	**447**	**450**	**455**	**456**	**457**
2013 dates						
4/30/2013 5/3/2013 5/7/2013	4/30/2013 5/3/2013 5/7/2013			5/7/2013	5/7/2013 7/12/2013	5/7/2013 7/26/2013
2014 dates						
5/6/2014 6/30/2014	3/20/2014 5/6/2014 5/25/2014 9/29/2014 10/27/2014 12/17/2014	5/6/2014 5/8/2014	9/10/2014	10/24/2014 10/30/2014 11/20/2014 12/17/2014	6/3/2014 10/24/2014 10/30/2014	10/24/2014

Table A-3. Greenleaf manzanita (*Arctostaphylos patula*) missing 2013-2014 observation dates for individual shrubs. Total number of monitoring dates was 46 in 2013, and 40 in 2014.

Shrub Number									
625	**626**	**627**	**628**	**629**	**630**	**631**	**632**	**633**	**634**
2013 dates									
		10/30/13	10/30/13	10/30/13	10/30/13	10/30/13	10/30/13	10/30/13	10/30/13
2014 dates									
10/28/14	10/21/14 10/28/14	10/21/14 10/28/14	10/21/14 10/28/14	10/21/14 10/28/14	10/21/14 10/28/14	10/21/14 10/28/14	10/21/14 10/28/14	10/21/14	10/21/14