PRELIMINARY EVALUATION OF THE EFFECTS OF THE DIXIE FOREST FIRE ON THE EPHEMERAL GEOPHYTES, *DICENTRA UNIFLORA* AND *DICENTRA PAUCIFLORA* (PAPAVERACEAE) AT THREE LONG –TERM STUDY SITES IN BUTTE COUNTY, NORTHERN CALIFORNIA

HALKARD E. MACKEY, JR. Retired Environmental Scientist, littlebrownb@yahoo.com

SUMMARY

Forest fires and their intensity have increased in California in recent years (Fig. 1). Field studies (Table 1) from 2009 to 2023 of *Dicentra uniflora* Kellogg and *Dicentra pauciflora* S. Watson (Papaveraceae) in forests of southern Cascade Range, Northern California, provide preliminary information on the effects of forest fire on these ephemeral geophytes following the Dixie Fire in the summer of 2021. Emergence for both is linked closely to snowmelt, with emergence to senescence taking 5 to 6 weeks. Flowering to fruit maturation and seed production were within 3 weeks in *D. uniflora*, but flowering and seed production were rarer in *D. pauciflora*. *D. uniflora* produces both underground tubers and bulblets, while *D. pauciflora* produces rhizomes and bulblets. Below ground structures of *D. uniflora* develop in the shallow mineral soil below the overlying duff (if present) and are slightly deeper (2.5 to 4 cm) in the soil than the rhizomes and bulblets of *D. pauciflora* (1.5 to 2.5 cm). Data from ongoing studies at 3 locations in northeast Butte County (Fig. 2) permitted initial field surveys in spring of 2022 and 2023 to evaluate potential effects on both species of the fire at different locations of past studies from 2009 through the spring of 2021. Vegetational transects were re-established at Meadow and Summit from 2009 and 2010 and a new transect was established at Canopy in 2022 (Figs. 2 and 3). Scatter seed plots of *D. uniflora* were available (Fig. 4) and bulblet and rhizome plots were available for *D. pauciflora* to look at post fire effects (Table 1 and Fig. 5). The preliminary results varied and were probably also affected by a heavy snowfall year at both study sites during the winter of 2022-2023. Observations include some of the following: 1) both species may have had reduced flower production in 2022 (Table 2); 2) *D. pauciflora* had very good flower production at Canopy in 2023 (Table 2 and Fig. 6); 3) *D. uniflora* was apparently greatly reduced by the very intense fire at Summit with both reduction in flower and leaf production when compared to previous years (Table 2), as well as almost complete lost of the growth at the scattered seed plot (Fig. 7); 4) with the lost of duff at Summit, *D. uniflora* may have been reduced from erosional effects to the site; and 5) unburned or only moderately burned scattered seed plots of *D. uniflora* (Fig. 7) and bulblet and rhizomes plots of *D. pauciflora* survived the Dixie Fire (Table 3); 6) there was increase of flowering in 2023, especially of *D. pauciflora* at Canopy (Fig. 6), but it was not possible to determine if it was a result of an increase of snowfall in the winter of 2022-2023 or a slight increase in sunlight availability through a reduced canopy. Changes in the exposure of both species to reduced canopy cover could be beneficial, but erosion on unprotected sites could be detrimental, as was seen with *D. unifora* at Summit. Since both are linked closely to snowmelt, phenology may be shifted to earlier months if canopy lost results in earlier snowmelt. Both species have under ground structures a few centimeters in the soil and thus have the likelihood of surviving all but the most intense forest fires. Ongoing observations at our field transects and newly planted plots over the next several years may provide better indications of effects of fire on these ephemeral geophytes.

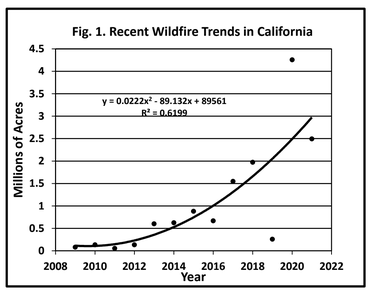


Table 1. Field Study Items for Post Dixie Fire Evaluations of *Dicentra uniflora* and *Dicentra pauciflora* in 2022 and 2023 in Northeastern Butte County, California. *Transects were re-established in 2022. **_Dicentra pauciflora_ is not present at Summit.

Dicentra uniflora		
2009/2010 Transects*	Meadow and Summit	Burned in 2021
2022 New Transect	Canopy	Burned in 2021
2021 Flower Counts	Summit	Burned in 2021
2021 Seed Counts	Not conducted	
2022 Seed Counts	Not conducted	Insufficient Flowering
2023 Seed Counts	Not conducted	No Flowering Occurred
2018 Scatter Seed Plot	Lower Meadow	Not Burned in 2021
2018 Scatter Seed Plot	Upper Meadow	Lightly Burned in 2021
2018 Scatter Seed Plot	Summit	Intensely Burned in 2021
Dicentra pauciflora		
2009 Transects	Meadow and Summit**	Burned in 2021 Not Counted in 2009 Counted in 2022/2023
2022 New Transect	Canopy	Burned in 2021 Counted in 2022/2023
2019 and 2021 Seed Counts	Canopy	Burned in 2021
2022 and 2023 Seed Counts	Canopy	After Dixie Fire in 2021
2009 Bulblet Plot	Lower Meadow	Burned in 2021 Counted in 2022/2023
2019 Bulblet Plot	Upper Meadow	Burned in 2021 Counted in 2022
2019 Rhizome Plot	Upper Meadow	Burned in 2021 Counted in 2022/2023

Table 2. Trends in numbers of fruits collected for seed counts or numbers of flowers marked at study sites for various years from 2018 through 2023 for *Dicentra uniflora* or *Dicentra pauciflora*. *Flowers counted only at two locations on Ridge, NE and E; four areas were sampled at Ridge, 2018 to 2021. **98 flowers were used in the ovule counts.

Year	2018	2019	2020	2021	2022	2023
Dicentra uniflora						
Ridge Total	112	88	55	79	27*	----
Lower Meadow	30	----	----	----	0	0
Upper Meadow	37	----	----	----	3	0
Summit	28	39	38	55	1	0
Dicentra pauciflora						
Canopy	----	26	----	105**	43	121

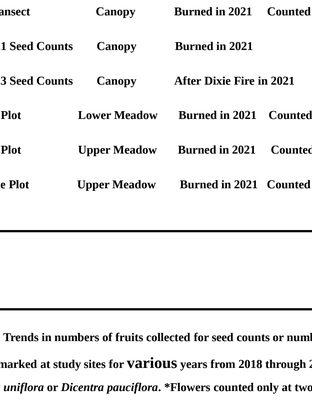


Fig. 6 . *Dicentra pauciflora* had very good flowering at Canopy in 2023

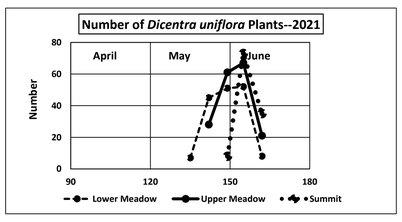
Table 3. Number of Leaves and Flowers from Bulblet and Rhizome Plantings of *Dicentra pauciflora* at Lower Meadow on 24 June 2009. *Planted 30 bulblets and 5 smooth rhizomes of *D. pauciflora*. **Early in the season, soon after snow melt. * Post Dixie Fire—Dixie Fire occurred here on 25 July 2021. See Pre- and Post Dixie Photography in Fig. 5, Below.**

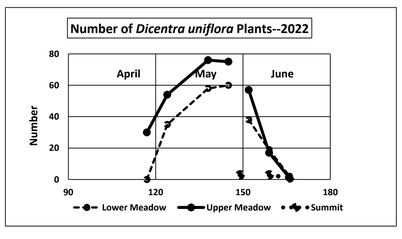
	Dicentra pauciflora	
	Leaves	Flowers
Date		
24 June 2009*	---	---
08 July 2010	33	0
06 May 2014**	22	0
28 June 2017	38	0
17 June 2019	42	1
26 May 2020	36	0
29 May 2021	45	0
01 June 2022***	46	0
08 June 2023	51	0

***Dicentra pauciflora* bulblet plot Pre Dixie Fire 2021**

***Dicentra pauciflora* bulblet plot Post Dixie Fire 2023**

Fig. 5 . The 2009 bulblet planting plot of *Dicentra pauciflora* survived burning by the Dixie Fire in July 2021





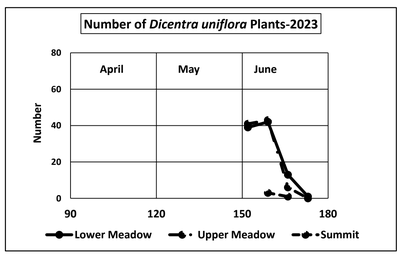


Fig. 7. Numbers of *Dicentra uniflora* plants observed in the scattered seed plots in Lower and Upper Meadow and in Summit and in the spring of 2021 before the Dixie Fire and in 2022 and 2023 after the Dixie Fire. Numbers of plants observed in 2021, 2022 and 2023 at Lower and Upper Meadow were little changed pre- and post-Dixie Fire. Numbers were greatly reduced at Summit in 2022 and 2023 following the Dixie Fire with almost no plants of *D. uniflora* found.

Fig. 3. The vegetational transects and plots for Lower Meadow were re-established in the spring of 2022. Locations of rocks and trees from the 2009 and 2010 photography were valuable in re-establishing the transects and plots. The transect at Summit was re-established in a similar manner. The transect at Canopy was a new transect established in 2022.

Lower Meadow in Woods Looking North Spring 2010

Lower Meadow in Opening Looking North Spring 2010

Lower Meadow in Woods Looking North Spring 2022

Lower Meadow in Opening Looking North Spring 2022

Canopy looking Southwest Spring 2022

Summit 2010 Looking East

Summit 2010 Looking West

Summit 2021 Looking East Post Dixie Fire

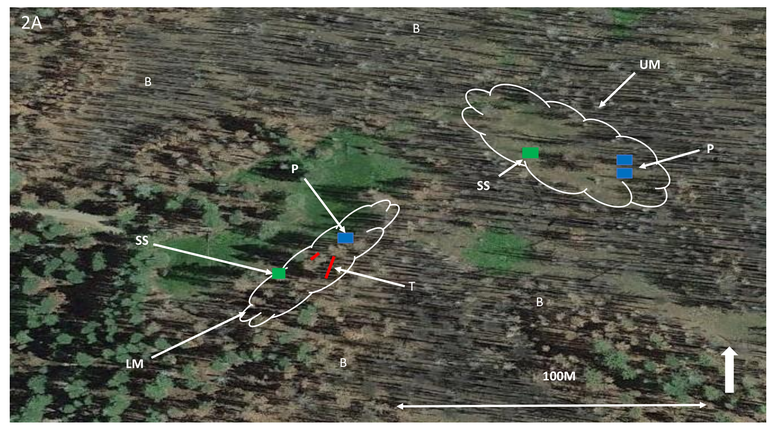
Summit 2021 Looking West Post Dixie Fire

Scatter Seed Plot Lower Meadow 03 October 2021

Scatter Seed Plot Upper Meadow 03 October 2021

Scatter Seed Plot Summit 03 October 2021

Fig. 4. Photography of 2018 scattered Seed plots of *Dicentra uniflora*. Lower Meadow plot was not burned. Upper Meadow was lightly burned. Summit was intensely burned. See Fig. 7 for counts of surviving plants in 2022 and 2023 post Dixie Fire.



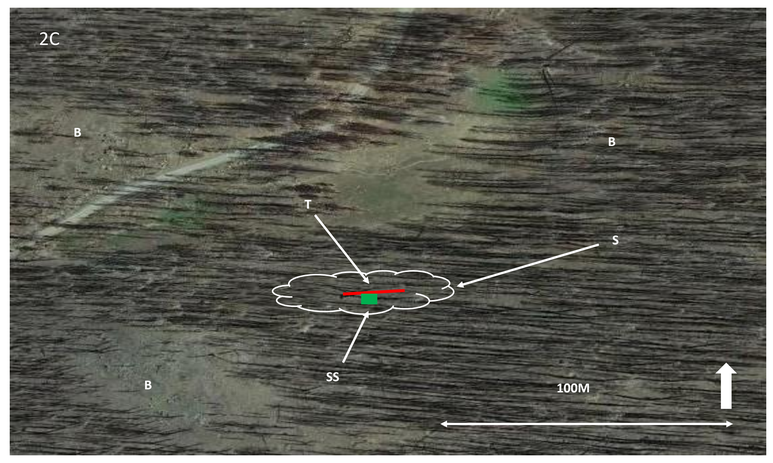


Fig. 2A. Meadow Study Site, 08 July 2022, Google Earth Imagery
Fig. 2B. Canopy Study Site, 08 July 2022, Google Earth Imagery
Fig. 2C. Summit Study Site, 08 July 2022, Google Earth Imagery

Fig. 2. Aerial imagery of study sites. Unburned areas appear primarily as green canopy or meadow and burned areas appear open with numerous shadows from standing dead trees. North arrow and scale are in lower righthand corners. Roads are not labelled. 2A. Meadow Study Site, 08 July 2022, Google Earth Imagery. The locations of Lower Meadow (LM) and Upper Meadow (UM) are shown along with the 2009 Transect (T) in Lower Meadow. The locations of the *D. uniflora* Scatter Seed Plots (SS) in Lower and Upper Meadow in 2018 are shown. The locations of the *D. pauciflora* bulblet plot (P) in Lower Meadow from 2009 and the rhizome (P) and bulblet (P) plots in Upper Meadow from 2019 are shown. Burned forests (B) to the south, east, and north of Meadow study sites are shown. Fig. 2B. Canopy Study Site (C), 08 July 2022, Google Earth Imagery. Canopy (C) study site extends 200 m east to west along US Forest Service Road 26N27 and 100 to 110 m north and south of the road. The imagery shows the location of the transect (T) established in 2022. Also seen are the extensive burned (B) areas from the Dixie Fire both to the north and south of Canopy and of the less affected collection areas adjacent to the US Forest Service Road. Fig. 2C. Summit Study Site (S), 08 July 2022, Google Earth Imagery. The location of the 2009 transect (T) which ran through the center of the Summit site is shown. Also, the location of the 2018 *D. uniflora* scatter seed plot (SS) is shown. The forest (B) surrounding the Summit site and the Summit site itself were extensively burned by the Dixie Fire.

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