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Cypripedium fasciculatum monitoring in southern Oregon

2007 Progress Report

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PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization dedicated to natural resource conservation, research, and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.

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Figure 1. The namesake clustered flowers that characterize *Cypripedium fasciculatum,* "clustered lady's slipper."

This report summarizes population and demographic monitoring of *Cypripedium fasciculatum* (clustered lady's slipper) in the Medford District of the Bureau of the Land Management. *Cypripedium fasciculatum* (clustered lady's slipper) is a rare woodland orchid that occurs in coniferous forests. *Cypripedium fasciculatum* is found in scattered locations among several states in western North America. In Oregon, it occurs in the Blue Mountains in the northeastern part of the state and in the Klamath-Siskiyou and western Cascades ecoregions of Southwestern Oregon, where approximately 683 populations have been reported on federal land (Vance et. al., 2004).

Many questions remain about the habitat requirements of *C. fasciculatum*, in part because of its complex life history. *Cypripedium fasciculatum* is a long lived perennial that can enter dormancy for one or more years and then reemerge above-ground. Multiple aerial stems can arise from the rhizome of a single *C. fasciculatum* genetic individual creating some ambiguity as to identification of individual plants. These characteristics make it difficult to quickly assess the effects of environmental factors and disturbances on population dynamics.

Species status

Cypripedium fasciculatum is a U.S. Fish and Wildlife Species of Concern, a Bureau of Land Management Bureau Assessment organism in Oregon, Washington and California, a U.S. Forest Service Region 6 Sensitive species, and an Oregon State Department of Agriculture Candidate Species for listing on the state threatened and endangered list. It is on List 2 (threatened with extirpation) of the Oregon Natural Heritage Information Center (ONHIC, 2004).

Study goals and history

This project was initiated by Penelope Latham through the Cooperative Forestry Ecosystem Research Program (Latham and Tappeiner, 2000). The original goals were to:

- Assess the status and demographic structure of *C. fasciculatum* populations in southwest Oregon.
- Describe habitat characteristics and relationship of the species population characteristics to major environmental variables.
- Identify biological traits useful in monitoring.
- Evaluate the effects of thinning and ground disturbance on *C. fasciculatum* populations.

In 1998, 29 *C. fasciculatum* populations occurring on federal land in 5 environmental regions in southwest Oregon were selected for long-term demographic monitoring (Latham and Hibbs, 2001). A few of these sites had been monitored since 1996. A total of 892 *C. fasciculatum* plants were tagged and monitoring began for the majority of sites in 1999. Additional sites were added in subsequent years and the number of *C. fasciculatum* monitoring sites increased to 39. In 2003, the total was reduced back to 29. However, these were not the original 29 sites. In 2005, selected excavation within Wellington Butte #4, a site without emergent plants for the 4 previous years, revealed no living rhizomes. This population is presumed to be dead and monitoring has been discontinued. Currently 28 sites are monitored in 21 distinct geographical locations with a total of 1230 tagged plants in 234 plots and additional plots without tagged plants.

Initially, this project involved monitoring of three additional orchid species, *Allotropa virgata, Cypripedium montanum,* and *Goodyera oblongifolia*. *Goodyera oblongifolia* was included so that the life history and ecological characteristics of rare orchids could be compared with those of a relatively common orchid in the region. These aspects of the study were discontinued prior to 2003.

One of the goals of this project was to determine the species' response to thinning (Latham and Tappeiner, 2000). A relatively large and scattered population, Wellington Butte #3, was selected for a thinning treatment. Plans included manual litter removal by hand raking half of the plots in each thinning treatment (Latham and Tappeiner, 2000). Conventional thinning never occurred, but tree girdling and shrub removal treatments were conducted at the Wellington Butte #3 site in the spring of 2002. It is uncertain whether or not ground disturbance treatments occurred.

Another aspect of the study was to examine the response of *C. fasciculatum* to fire. The Round Prairie A and B sites were burned in 2000 after an understory thinning and the nearby Round Prairie C and D were left as unburned controls.

In 2003, the Medford BLM took-over the project which then included 29 sites. In 2004, the Medford BLM partnered with the Institute for Applied Ecology to continue the monitoring.

Objectives of this report

The primary objectives of this report are to document monitoring activities for this project in 2007 and summarize recommendations. The objectives of the 2007 field season were to:

- Relocate and resample permanent monitoring plots at 28 sites in southwestern Oregon.
- Enter all data collected from the current field season into a database to facilitate future analyses.
- Briefly summarize current findings of population status at the 28 sites.
- Recommend modifications to the monitoring protocol. In particular, determine through excavation whether plants that have been absent for several years are dormant or dead and examine a subset of demographic data to evaluate the number of years of absence after which plants may be considered dead.

METHODS

Overview of monitoring

Population monitoring has occurred at a total to 39 sites (Appendix B) in southwestern Oregon, and is currently conducted at 28 of these locations. In addition to population trend monitoring and collection of environmental data on site characteristics, experimental treatments have been conducted at a subset of the monitored populations.

Initially, monitoring at each site occurred in one to several 2x2 m permanent plots in which all plants were mapped, tagged and measured. Additional 2x2 m plots were added in subsequent years to include newly discovered plants as they arose. In the new plots, plants were counted, but not mapped or tagged. This has resulted in two types of plots at many of the sites, referred to here as "demography plots" and "count plots," respectively. Further, there are two sites at which only count plots were installed. Finally, at one site (Murphy Gulch), a large grid was established to census to whole population with several demography plots nested within it.

Study sites

The 28 sites that are currently monitored represent five different ecological regions in Southwest Oregon that were classified by temperature, precipitation and soil type (Latham and Hibbs, 2001). Medford BLM owns the majority of study sites, but 3 sites are on Rogue River-Siskiyou National Forest land (Table 1). Site elevations range from 354 meters to 1360 meters above sea level. In sites containing demography plots, the number of tagged plants ranges from 1 to 187 plants.

Location of monitoring sites

(information removed from public copies of this report)

Plot layout

Plot layout is identical for demography and count plots. Monitoring plots are 2x2 m^2, and are dissected into four 1 m^2 quadrants. White pin flags mark the location of plants in some plots, especially in count plots. Plot centers are marked with a metal curly-que often spray-painted orange. Plots are generally oriented with the top uphill and some plot maps have a specific azimuth documented. In the demography plots, individual *C. fasciculatum* stems have been marked with aluminum tags inscribed with a number unique to the population. Plants are located by the tag adjacent to their stem and by observing their relative position on a plot map. Stem tags have not been placed in a consistent cardinal direction from the stem; the proximity of plants in some areas prohibits this practice. Plot maps indicate the position of individual *C. fasciculatum* stems in a plot. The exact location of emergence can vary from year to year, but it is generally possible to identify and distinguish each individual plant. In this study, the protocol was to tag and track each individual stem, although it is possible for clusters of aerial stems to emerge from the same rhizome (Seevers and Lang, 1998).

If a stem recorded in previous years was absent and a tag was missing, it was not replaced. If a plant occurred in close proximity to, but outside of a plot border, it was recorded in the "0" quadrant (Figure 2) and the position was carefully mapped.

Table 1. *Cypripedium fasciculatum* monitoring sites and characteristics

Site name	Site #	Plants Tagged	Demographic Plots	Count Plots	Land Ownership	Elevation (meters)	Environmental Region	Notes
Alexander Gulch A	C-3A	115	10	6	Medford BLM	939	4	Seeding plot
Alexander Gulch B	C-3B	86	11	0	Medford BLM	927	4	Plot #s start at 3, seedling plot
Alexander Gulch C	C-3C	54	8	0	Medford BLM	927	4	Seeding plot
Brimstone	C-25	0	0	24	Medford BLM	500	1	
Emigrant Creek	C-4	48	4	0	Medford BLM	1098	5	
French Gulch	C-17	53	19	0	Rogue River-Siskiyou NF	720	4	
Keeler Creek	C-13	10	2	0	Medford BLM	500	4	
Logan- Bridgeview	C-27	0		6	Medford BLM	506	2	
Murphy Gulch	C-1	85	4	0	Medford BLM	790	3	140 cell grid
Pleasant Valley	C-9	38	6	0	Medford BLM	683	3	
Randecore Pass	C-18	42	2	0	Medford BLM	1195	5	
Round Prairie A	C-2A	20	8	0	Medford BLM	396	2	
Round Prairie B	C-2B	55	15	0	Medford BLM	365	2	
Round Prairie C	C-2C	57	14	0	Medford BLM	335	2	
Round Prairie D	C-2D	70	13	14	Medford BLM	335	2	
Sexton Mountain 2	C-7	37	7	0	Medford BLM	884	1	
Slick Rock	C-23	40	10	0	Medford BLM	762	3	
Soda Creek 2A	C-19A	1	1	0	Medford BLM	930	5	
Soda Creek 2B	C-19B	24	1	0	Medford BLM	945	5	
Soda Creek 3	C-32	61	13	6	Medford BLM	1042	5	
Sykes Creek	C-16	7	3	0	Medford BLM	610	3	
Tallowbox	C-5	16	3	0	Medford BLM	1360	4	
Taylor Creek	C-10	103	25	0	Rogue River-Siskiyou NF	369	1	Seeding plot
Taylor Ridge	C-24	6	3	0	Rogue River-Siskiyou NF	610	1	
Tyler Creek	C-31	2	1	0	Medford BLM	1042	5	
Wellington Butte #1	C-20	5	3	0	Medford BLM	1067	4	
Wellington Butte # 3	C-22	167	35	0	Medford BLM	927	4	
Whitehorse Park	C-6	28	9	0	Medford BLM	354	1	Seeding plot

Figure 2. Monitoring *Cypripedium fasciculatum*. 2 m^2 monitoring plots were divided into four 1 m^2 quadrants.

Information gathered

Demography plots -- Once an individual stem or its placement was located, its presence or absence was recorded. If it was present, the lengths of its leaves were measured and any flowers and/or undeveloped buds and capsules present were counted. Flower number was estimated by counting floral bracts. *Cypripedium fasciculatum* makes a bract that subtends each individual flower. Occasionally, a bract is made for a bud that does not fully mature, and these were called undeveloped buds in this study. Most of these undeveloped buds are so small that they either do not have a bract or the bract itself is so tiny that it would not be confused with a functional flower bract. Most undeveloped buds are small, translucent, whitish nubs at the center of the leaf axil. Sometimes they are larger and identifiable as flower buds, but one can usually tell by their lack of color, small size, and stage of development relative to other flowers in the population that they will not develop into mature flowers. Undeveloped buds can occur with or without functional flowers.

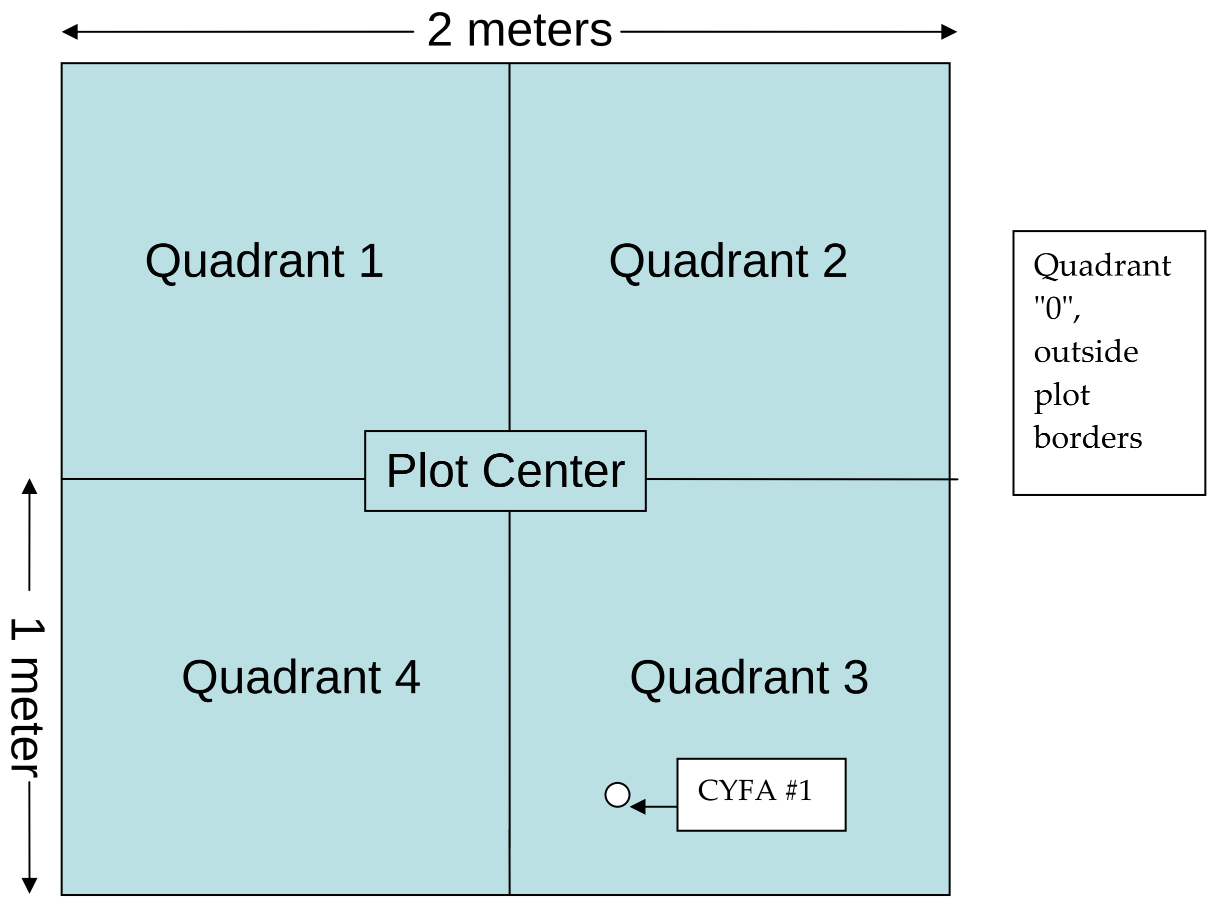

Figure 3. Diagram of demography and count plot layout. All plots are 2 x 2 m in size, and delineated into 1 m^2 quadrants. For demography plots, individual stems are mapped and tagged (see example in quadrant 3), and plants that occur adjacent to the plot but outside of quadrants 1-4, are considered to be in quadrant "0" and mapped accordingly. In count plots, the total number of flowering and vegetative stems are recorded but not mapped.

Litter depth, browsing, and the presence of "neighbors" (any other *C. fasciculatum* plants with stems within 2.54 centimeters) were noted. Litter depth was determined by inserting a thin metal stick (such as a pin flag) into the soil until the metal reached firm resistance indicating the presence of mineral soil. The depth of insertion was then recorded. Browsing was recorded in categories of 0-4, based on ocular estimation of the percentage of plant material that has been consumed. Browsing categories were defined as 0= none, 1 ≤5%, 2 =6-25%, 3 =26-50%, 4 =51-75%, 5 =75-100%.

Count plots -- In addition to the demographic plots, many sites also contain count plots (Table 1). Two sites, Brimstone and Logan-Bridgeview, consist entirely of count plots. Count plots are 2 m^2 plots that have an established plot center and defined perimeter like demography plots, but none of the individual plants are tagged. All *C. fasciculatum* stems in each size class were counted and the total number of flowers and fruits in each plot were also recorded. A database was created in 2005 for the summarization of count plot data from 2002-2006.

New plots and plants – Prior to 2004, additional count plots were set up when new *C. fasciculatum* plants were found in the general vicinity of a monitored population. In 2004, we altered this protocol so that new plots would only be set up if the newly discovered plants were within the perimeter of all existing plots. No new plots were set up in 2004 - 2006. As in previous years, plants that were found within close proximity of an established demography plot were mapped and recorded in association with the nearby plot in the "0" quadrant. Many new plants were found in 2004 at Wellington Butte #3 around and between Plots 14 and 15. There was not enough room to establish a new 2 m^2 plot between Plots 14 and 15, so the plants were all recorded as associated with one of the established demography plots. Additional new plants were found in this area in 2005 and 2006. These plants were tagged and monitored individually and may provide useful information about this apparently dynamic site.

Murphy Gulch grid -- One site, Murphy Gulch, contains a large 140 cell monitoring grid. A 20 x 28 m^2 rectangular area is divided into 140 2x2 m^2 cells. Plants in the cells were tallied by their vegetative or reproductive status, creating a census of the entire population. Nested within the grid are 4 demography plots in which individual plants were tagged and tracked, providing more detailed information for a subsample of the population. These 4 demography plots, presumably positioned to capture as many *C. fasciculatum* individuals as possible, are scattered within the grid area without alignment with the 2x2 m^2 grid cells.

Timing

Study populations were visited between from mid-May to late June 2007 to assess emergence, size, flowering status, fruit set, litter depth, and herbivory. In 2005, we changed our protocol and limited the visits to the majority of *C. fasciculatum* sites to just one visit during their fruiting stage, instead of visiting during both the flowering and fruiting stages. When flowers are senesced, a the number of flowers produced can be derived from the remaining floral bracts. Occasionally, a bract is formed for a bud that is subsequently aborted, but this can generally be delineated by size from bracts created for fertile flowers. Reducing the number of visits to each site increases the efficiency of data collection and minimizes monitoring effects on the steep slopes where *C. fasciculatum* is often found. To capture the phenological stage at which fruiting can be determined and leaves are still green, we started working at the lowest elevation sites and worked up the elevation gradient.

The occurrence of flowering and subsequent fruiting can vary by a few weeks from year to year. Therefore, the optimal time bracket to conduct visits must be reassessed each year.

Experimental treatments

To meet study goals of examining the response of this species to various forms of disturbance, experimental treatments were established at several field sites. These treatments included seeding, forest thinning, soil scraping to remove litter, and controlled burns (Table 2).

Table 2. Sites with experimental treatments conducted in this study.

Site name	Treatment(s)	Year implemented
Round Prairie (A-D)	Prescribed burn (and controls)	2000
Alexander Gulch (A-C)	Seeding	1999
White Horse Park	Seeding	1999
Taylor Creek	Seeding	1999
Wellington Butte #3	Tree girdling (and litter raking?)	2002
Murphy Gulch	Tree girdling	Unknown (prior to 2003)

Forest thinning – To evaluate the effects of forest thinning on *C. fasciculatum*, tree girdling was used to kill trees in *C. fasciculatum* habitat at Wellington Butte #3 and Murphy Gulch (Table 2). At Wellington Butte, this treatment also included shrub cutting (shrubs were cut at the base but their debris was left in place) and possibly litter raking. Tree girdling was only partly effective, killing some trees but not others. Raking of litter had been planned at this site (Latham and Tappeiner 2000), but no clear records of that treatment are available. However, in and around plot 14 and 15 the litter layer was observed to be very thin or non-existent during site visits in 2004 and 2005. No evaluation of the effects of this treatment on light conditions on the forest floor has been conducted to date. Plant responses to this treatment were measured by resampling the existing permanent demography plots at both sites and grid census plot at Murphy Gulch.

Prescribed burn – Two of four Round Prairie sites were burned in fall of 2000 and two were left as unburned controls after the entire site was thinned (at an unknown date). Fire intensity appeared to be moderate (Mark Mousseaux, *personal communication*). Plant responses to these treatments were measured by resampling the existing permanent demography and count plots at all four sites.

A small wildfire overlapping the Taylor Creek *C. fasciculatum* site burned through the area between our 2004 and 2005 visits. The area we perceived to be burned by the fire was drawn on existing site and plot maps. The fire burned through the southeast corner of the monitoring site, burning over one plot (15) and into 3 others (2, 12, and 13). A fireline was constructed through a fifth plot (16), scraping down to mineral soil and removing organic debris from a strip in the upper half of the plot and depositing it into the lower area. We identified the plants that were burned in the area and recorded the survival of burned and unburned plants.

Seeding plots -- Four sites, Alexander Gulch A, Alexander Gulch B, Alexander Gulch C, and Whitehorse Park, contained one seeding plot each. These plots are in a paired design in which one side was scraped to mineral soil prior to seeding and the other side was not. Seeds were put out in 1999 (seeding rate unknown) and the plots were checked every year for seedlings.

Evaluation of dormancy and mortality

Excavations -- In 2005, we excavated a limited number of tagged *C. fasciculatum* individuals that were non-emergent for many years to see if they were in elongated periods of dormancy or had died. To excavate plants, we gently dug beneath plant tags and searched for rhizomes. The periods of nonemergence ranged from 4 to 8 years. Four of these plants were in the Round Prairie complex that had been monitored since 1996 and were absent for 7-8 years. We also dug up 5 plants in the Wellington Butte #4 population that had been absent for 4-5 years. No *C. fasciculatum* were seen at this site since 2000.

Evaluation of dormancy vs. mortality with demographic data -- In addition to excavations, we evaluated the available demographic data for presence and absence of 1,267individuals extending back to 1999 (and data from Round Prairie A-D back to 1996 as well as Alexander Gulch A-C, Emigrant Creek, Murphy Gulch, and Tallowbox at which monitoring began in 1998) and calculated the probabilities that a previously absent *Cypripedium fasciculatum* stem would reemerge after one to six years of absence. In general, the longer the period of absence, the smaller the available sample size (Figure 9).

RESULTS

Overview

Across all plots (56 count plots and 230 demography plots), the mean number of stems per site has been stable, while flowering and fruit set have varied annually. The mean number of emergent stems per site in 2007 was 30.6 (Figure 4A), essentially identical to the 1999-2007 average of 31. The rate of flowering has been steadily rising from a low of 20% in 2002 to 56 % in 2007 (Figure 4B). Fruit set in 2007 was 38.4% in 2007 compared to the nine year average of 34.8% (Figure 4C).

Demography plots

Approximately one half (52%) of all plants tagged over the history of this study and currently monitored were present above ground in 2007 (675 plants out of 1309 tagged and currently monitored). Currently, it is unknown what proportion of the non-emergent plants were alive, but dormant below ground, or dead. In 2005 and 2007, a small subset of long dormant stems were excavated and all were determined to be dead.

Flowering and fruit set varied widely between populations, ranging from 0 to 100% for flowering and 15% to 80% for fruiting. Across all sites, 385 (57%) of the aerial stems flowered. Thirty-three percent of the flowers produced in 2007 matured into a fruit.

Environmental regions

The 26 sites containing demography plots have been categorized environmental regions (5) classified by soil type, precipitation, and temperature. One of the goals of this study was to determine if plant life history and characteristics differed between environmental regions. We found that there was a significantly lower proportion of reproductive individuals in environmental regions 2 (Illinois Valley up to Wilderville with the Round Prairie site) and region 3 (in the Evan's Creek Valley area with the Murphy Gulch site) (Bonferronni test for multiple comparisons, $P < 0.05$).

Demographic transitions

We calculated the average transition probabilities for all sites together and for Alexander Gulch and Murphy Gulch, the two sites that were large enough to have adequate sample size when analyzed separately. Across all sites, for three of the four stages (non-existant, reproductive, and vegetative) the highest probabilities were for plants remaining in a particular stage from one year to the next. In contrast, dormant plants were most likely to become vegetative (50%).

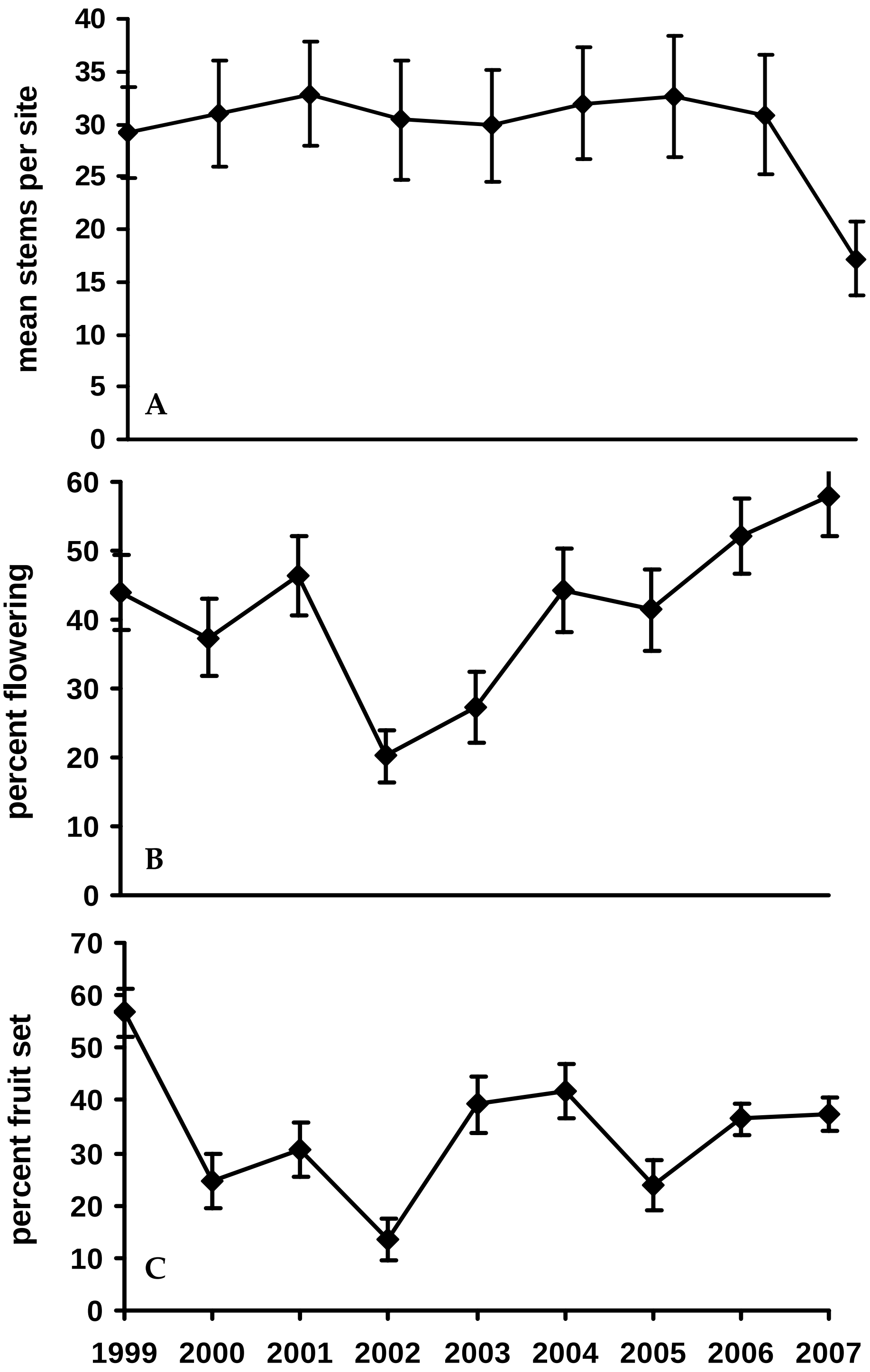

Figure 4. Mean number of stems (A), percent flowering (B) and percent of fruit set (C) for *Cypripedium fasciculatum* in all plots at all sites, 1999-2007. Points are means ±1 S.E.

Table 3. Summary of demographic information for *Cypripedium fasciculatum* averaged across all demographic plots, 1999-2007. Flowering percentages, flowers per plant and fruit percentages are means of site percentages. Twenty-six sites currently contain demography plots; plots and plants have been added within the course of the study.

Year	Total number tagged	Emergent	Flowering	Flowers	Fruits
1999	699	673 (96%)	264 (39%)	548 (2.1 per plant)	369 (67%)
2000	881	752 (85%)	229 (30%)	523 (2.3 per plant)	139 (27%)
2001	976	751 (80%)	308 (41%)	715 (2.3 per plant)	155 (22%)
2002	1097	652 (59%)	128 (20%)	244 (1.9 per plant)	42 (17%)
2003	1190	615 (52%)	214 (26%)	486 (2.3 per plant)	212 (36%)
2004	1227	671 (55%)	286 (42%)	687 (2.2 per plant)	286 (41%)
2005	1246	691 (55%)	304 (40%)	689 (1.9 per plant)	213 (35%)
2006	1262	675 (53%)	373 (55%)	1075 (2.9 per plant)	360 (34%)
2007	1309	675 (52%)	385 (55%)	1075 (2.8 per plant)	360 (33%)

The transition matrix for Alexander Gulch was fairly similar to the all-sites transition matrix. The only notable difference was that vegetative plants at Alexander Gulch were more than twice as likely to come back as reproductive stems the following year than vegetative stems in the all-sites matrix.

The transition matrix for Murphy Gulch was fairly different from both the all-sites and Alexander Gulch matrices. In particular, the probability of a reproductive stem entering one of the other stages was higher and vegetative stems were more likely to either become reproductive or non-existent.

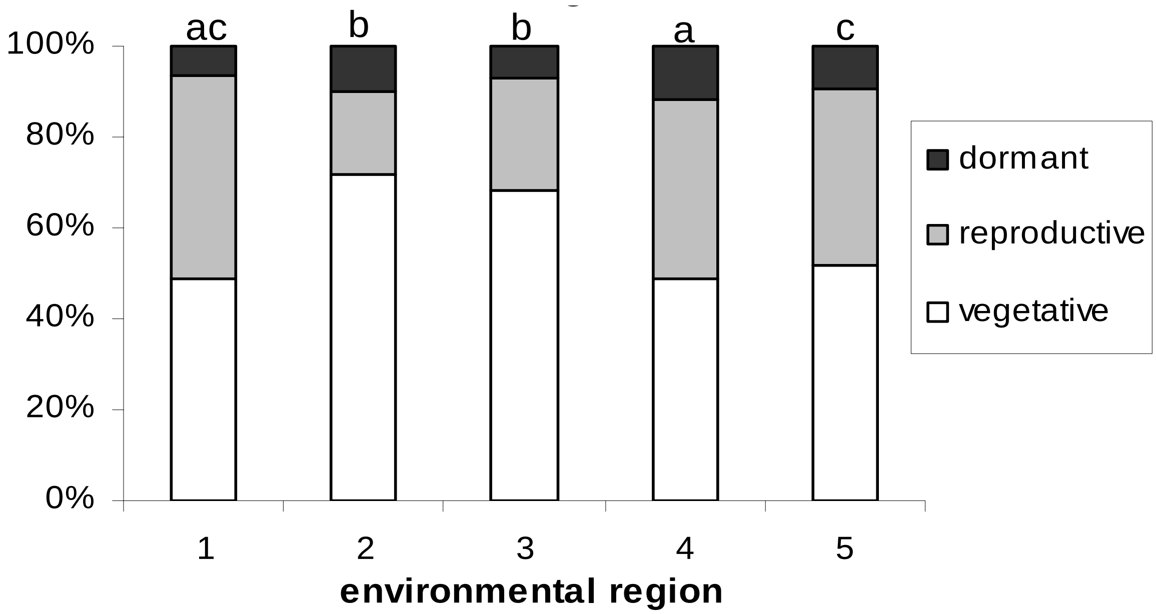

Figure 5. The relative proportion of the number of stems in each life history stage across the five environmental regions. Data is averaged from 1999-2005. Letters indicate a significant difference (P < *0.05*) in the proportion of reproductive stems using a Bonferroni test for multiple comparisons.

Table 4. Transition matrices for *Cypripedium fasciculatum* at all sites (26) averaged together, Alexander Gulch, and Wellington Butte #3. The top row of each matrix represents the number of dormant plants. Lower rows represent the probability of an individual in a given stage changing to another stage the flowing year. (D = dormant, N = non-existant, R = reproductive, V = vegetative)

Average stem transitions (± 1 SE) at all demography sites, from 1999 – 2005.

	D	N	R	V
D	0.321 (0.051)	0.000	0.075 (0.015)	0.076 (0.009)
N	0.000	0.793 (0.669)	0.046 (0.020)	0.157 (0.028)
R	0.175 (0.037)	0.045 (0.009)	0.695 (0.080)	0.132 (0.033)
V	0.504 (0.052)	0.162 (0.024)	0.184 (0.050)	0.636 (0.033)

Average stem transitions (± 1 SE) at Alexander Gulch, from 1999 – 2005.

	D	N	R	V
D	0.439 (0.076)	0.004 (0.000)	0.059 (0.021)	0.084 (0.045)
N	0.000	0.669 (0.059)	0.018 (0.012)	0.114 (0.029)
R	0.193 (0.056)	0.166 (0.007)	0.658 (0.110)	0.307 (0.082)
V	0.367 (0.043)	0.161 (0.059)	0.266 (0.059)	0.494 (0.041)

Average stem transitions (± 1 SE) Wellington Butte #3, from 1999 – 2005.

	D	N	R	V
D	0.417 (0.177)	0.000	0.278 (0.062)	0.101 (0.055)
N	0.000	0.047 (0.874)	0.125 (0.058)	0.278 (0.092)
R	0.377 (0.169)	0.077 (0.033)	0.336 (0.128)	0.368 (0.147)
V	0.207 (0.181)	0.049 (0.044)	0.261 (0.082)	0.052 (0.129)

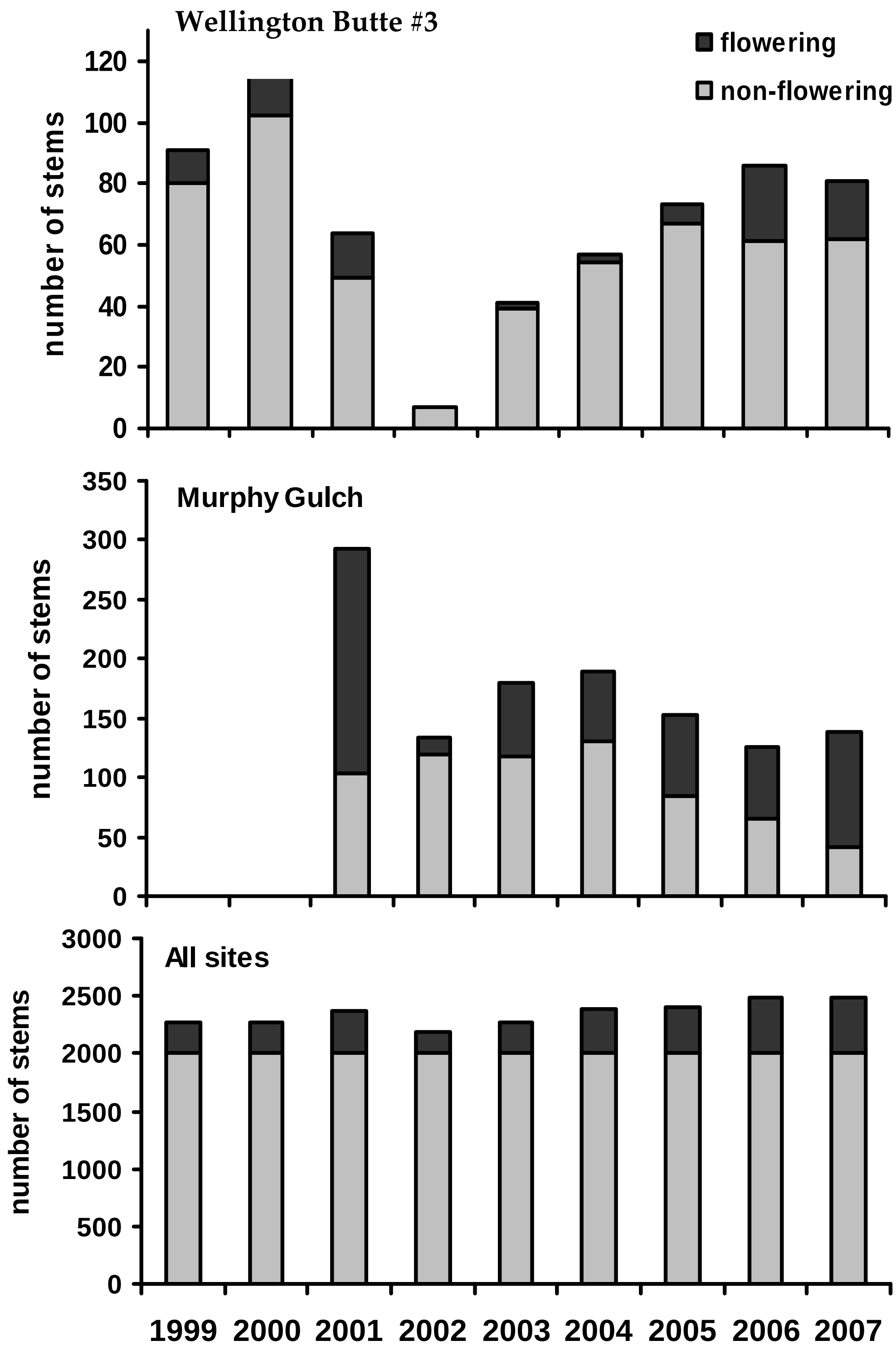

Figure 6. The number of total and flowering stems counted at Wellington Butte #3, Murphy Gulch, and all sites, from 1999 – 2007 (monitoring at Murphy Gulch was not initiated until 2001).

Experimental Treatments

Forest thinning -- The most significant treatment responses have been in Wellington Butte #3 and Murphy Gulch, the two sites where trees were girdled. Both sites experienced a significant decline in emergent stems in 2002 (Figure 6a, b), the year of treatment in Wellington Butte #3 and possibly Murphy Gulch. 2002 was a poor year for flowering and fruiting at all sites; however, the decline in the number of emergent stems was less severe at the other sites in this study (figure 6c).

The highest number of stems counted at Wellington Butte #3 was 117 in 2000. The population then declined dramatically to seven stems in 2002. The population then grew to 86 stems in 2006. In 2007, we counted five fewer stems than the previous year. The increase between 2002 and 2003 can largely be attributed to the 26 plants that came out of dormancy in that interval. However, in 2004 and 2005, very few plants came out of dormancy and new plants accounted for the population growth (22 in 2004 and 27 in 2005). Eight of the ten new stems in 2006 were found in the area in or around plots 14 and 15 in an area with little or no litter layer. A total of 52 new stems have been found in this area since 2002. In general, the proportion of the population new plants has been higher at Wellington Butte than the untreated sites (Figure 7). For example, in 2007, across all sites, 5% of the emerged stems were from new plants; in contrast 18% of the emerged stems at Wellington Butte were from new plants.

Murphy Gulch contains many dead or half dead madrone trees and manzanita bushes and there is a thick litter layer. Many of the madrones have been ringed in what appears to be an attempt to mimic a thinning that occurred at Wellington Butte #3 in 2002. A total of 139 *C. fasciculatum* plants (58 flowering and 81 vegetative) were found in the Murphy Gulch grid in 2007 (figure 6). After the population declined severely between 2001 and 2002, it seems to be fluctuating near a mean of 153 stems. The proportion of flowering plants (70%) was higher in 2007 than in any year since treatment in 2002.

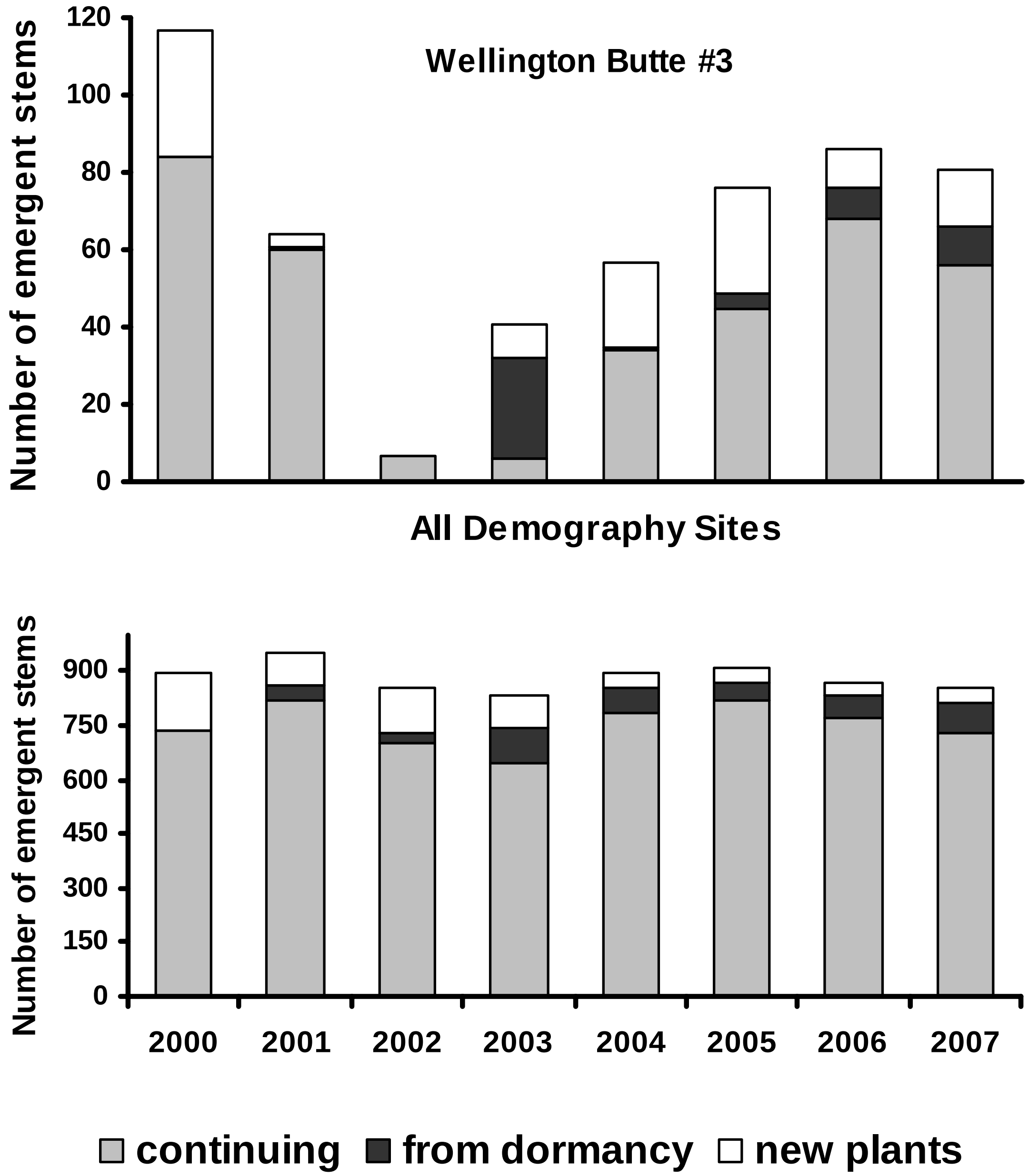

Figure 7. The number of emergent stems at Wellington Butte #3 and all demography sites that were either emergent stems the previous year ("continuing"), dormant the previous year, or newly plants in each year.

Prescribed burn -- Fire intensity at the Taylor Creek fire was sufficient to kill the above ground biomass of a *Lithocarpus densiflora* (tanoak) within the site (Figure 8). Three of the burned *C. fasciculatum* present in 2004 re-emerged in 2007, one less than in 2005. All three plants buried by fireline material also reappeared both years.

One *C. fasciculatum* stem was in the fireline and its rhizome may have been damaged during fireline construction. This stem has not re-emerged. The portion of the Taylor Creek population unaffected by the declined by 14% decline from 2004 to 2005, 13% decline from 2005 to 2006, and 11% from 2006 to 2007.

Figure 8. A tanoak tree burned and resprouting adjacent to Taylor Creek Plot 15. Photographed June 2005.

Seeding plots -- No *C. fasciculatum* plants were found in any of the seeding plots since before 2005.

Evaluation of dormancy and mortality

Excavations – We found no living rhizomes when we excavated plants that had been absent for four or more years in 2005, 2006, and 2007. All excavated plants were presumed to be dead, and their tags were removed to prevent confusion if new plants establish in the same location in future years.

Evaluation of dormancy vs. mortality with demographic data – A total of 28% of stems that went dormant for one year re-emerged the following year (Figure 9). The probability of re-emergence dropped to 10% after two years of absence, and to 4% after three years. Therefore, it appears that most plants that are absent for three or more years are dead, rather than dormant. This is consistent with the results of the excavations of long-absent plants reported above.

Discussion and Recommendations

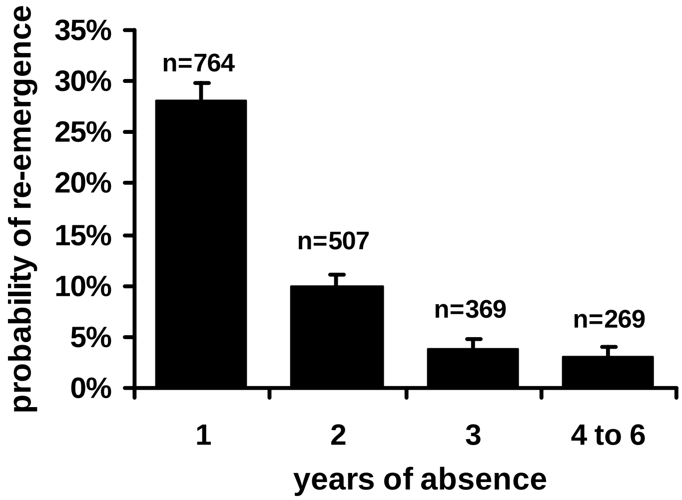

Figure 9. Probability of stems re-emerging above-ground after one or more years of absence. After 3 years of absence, over 95% of plants fail to re-appear and may be considered dead.

Averaged across all populations, the number of emergent *C. fasciculatum* stems is fairly stable from year-to-year. Flowering and fruit exhibit greater annual fluctuations. Over-all, flowering was higher in 2007 than in 2006, but the percent of fruit set was almost identical in the two years. Averages are strongly influenced by the two largest populations, Alexander Gulch A and Wellington Butte #3.

Two of the study's most dynamic populations were Wellington Butte #3 and Murphy Gulch, which both appeared to have experienced tree girdling treatments. The litter layer is thin at Wellington Butte #3, where the *C. fasciculatum* population is growing. In contrast, the litter layer is much thicker at Murphy Gulch, where the population is declining. These results suggest that litter inhibits germination and/or emergence of *C. fasciculatum*. germinating from seed establish better in mineral soil. However, in the seeding plots, there was no effect of removing litter from half of each plot (Anita Sedaghety, Medford BLM, *personal communication*). Thus, more information on the treatments that were applied to Wellington Butte #3 and Murphy Gulch or experimental litter removal in the future are required in order to determine the cause(s) of the population trends observed at these populations.

In 2008, we will conduct our final project analysis. In addition to summarizing data for each population, we will conduct analyses for trends over time, correlations with climatic and habitat variables, and re-run the population viability analyses.

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APPENDIX A. DEMOGRAPHY PLOT SUMMARIES 2003-2006.

	2003								2004							
	Stems present	No. flowering plants	No. of Flowers	No. of Capsule	% Fruit Set	% flowering	flowers/repro plant	capsules/repro. plant	Stems present	No. flowering plants	No. of Flowers	No. of Capsule	% Fruit Set	% flowering	flowers/repro plant	capsules/repro. plant
Alexander Gulch A	73	26	41	24	58.5	35.6	1.6	0.9	68	42	88	49	56	62	2.1	1.2
Alexander Gulch B	73	45	86	44	51.2	61.6	1.9	1.0	75	49	115	49	43	65	2.3	1.0
Alexander Gulch C	44	31	82	31	37.8	70.5	2.6	1.0	46	32	104	69	66	70	3.3	2.2
Emigrant Creek	29	14	28	2	7.1	48.3	2.0	0.1	31	18	38	11	29	58	2.1	0.6
French Gulch	29	7	13	4	30.8	24.1	1.9	0.6	29	8	13	4	31	28	1.6	0.5
Keeler Creek 1	2	0							2	0						
Murphy Gulch	13	3	3	0	0.0	23.1	1.0		11	2	3	0	0	18	1.5	0.0
Pleasant Valley	9	0							14	0						
Randecore Pass	19	10	14	1	7.1	52.6	1.4	0.1	20	10	19	0	0	50	1.9	0.0
Round Prairie A	12	4	9	6	66.7	33.3	2.3	1.5	11	3	7	2	29	27	2.3	0.7
Round Prairie B	19	5	10	4	40.0	26.3	2.0	0.8	23	11	22	12	55	48	2.0	1.1
Round Prairie C	19	0							26	3	4	4	100	0	1.3	1.3
Round Prairie D	40	8	11	2	18.2	0.2	1.4	0.3	43	12	25	9	36	0	2.1	0.8
Sexton Mountain 2	30	25	56	29	51.8	83.3	2.2	1.2	29	24	78	19	24	83	3.3	0.8
Slick Rock	26	5	11	8	72.7	19.2	2.2	1.6	31	9	21	5	24	29	2.3	0.6
Soda Creek 2A	1	0							1	1	2	2	100	1	2.0	2.0
Soda Creek 2B	13	11	50	44	88.0	84.6	4.5	4.0	19	18	68	16	24	95	3.8	0.9
Soda Creek 3	47	9	18	4	22.2	19.1	2.0	0.4	44	7	9	3	33	16	1.3	0.4
Sykes Creek	4	0							5	4	5	4	80	1	1.3	1.0
Tallowbox	6	0							11	0						
Taylor Creek 2	43	2	2	0	0.0	4.7	1.0		47	17	22	10	45	36	1.3	0.6
Taylor Ridge	4	2	7	0	0.0	0.5	3.5		4	3	8	2	25	1	2.7	0.7
Tyler Creek	2	0							1	1	0	0		1	0.0	0.0
Wellington Butte 1	2	0							3	0						
Wellington Butte 3	41	2	4	1	25.0	4.9	2.0	0.5	57	3	5	3	60	5	1.7	1.0
Wellington Butte 4	0								0							
Whitehorse Park	16	5	14	6	42.9	31.3	2.8	1.2	19	10	27	7	26	53	2.7	0.7
sum	616	214	459	210					670	287	683	280				
average	22.8	8.2	25.5	11.7	34.4	34.6	2.1	1.0	25	11	31	13	42	34	2.0	0.8

	2005								2006							
	Stems present	No. flowering plants	No. of Flowers	No. of Capsule	% Fruit Set	% flowering	flowers/repro plant	capsules/repro. plant	Stems present	No. flowering plants	No. of Flowers	No. of Capsule	% Fruit Set	% flowering	flowers/repro plant	capsules/repro. plant
Alexander Gulch A	85	52	129	67	52	61	2.5	1.3	86	58	198	60	30	67	3.4	1.0
Alexander Gulch B	74	52	138	34	25	70	2.7	0.7	75	53	180	44	24	71	3.4	0.8
Alexander Gulch C	49	36	117	53	45	73	3.3	1.5	46	35	132	55	42	76	3.8	1.6
Emigrant Creek	29	19	49	8	16	66	2.6	0.4	30	20	46	14	30	67	2.3	0.7
French Gulch	31	7	19	4	21	23	2.7	0.6	30	13	25	7	28	43	1.9	0.5
Keeler Creek 1	1	0							2	0				0		
Murphy Gulch	8	2	4	2	50	25	2.0	1.0	9	4	8	2	25	44	2.0	0.5
Pleasant Valley	13	1	1	0	0	0	1.0	0.0	11	2	2	1		0	1.0	0.5
Randecore Pass	22	10	22	2	9	45	2.2	0.2	26	14	33	5		54	2.4	0.4
Round Prairie A	10	4	10	3	30	40	2.5	0.8	6	4	8	5	63	67	2.0	1.3
Round Prairie B	24	13	28	7	25	54	2.2	0.5	25	13	33	11	33	52	2.5	0.8
Round Prairie C	26	3	8	0	0	0	2.7	0.0	23	8	14	5		0	1.8	0.6
Round Prairie D	47	14	22	8	36	0	1.6	0.6	37	17	36	18	50	0	2.1	1.1
Sexton Mountain 2	32	22	84	13	15	69	3.8	0.6	27	23	80	41	51	85	3.5	1.8
Slick Rock	27	13	35	4	11	48	2.7	0.3	23	15	56	13	23	65	3.7	0.9
Soda Creek 2A	1	0							1	0						
Soda Creek 2B	19	18	81	5	6	95	4.5	0.3	17	16	57	12	21	94	3.6	0.8
Soda Creek 3	44	6	24	2	8	14	4.0	0.3	45	10	28	13	46	22	2.8	1.3
Sykes Creek	4	2	3	2	67	1	1.5	1.0	4	3	5	4	80	1	1.7	1.3
Tallowbox	7	1	1	1	100	0	1.0	1.0	6	1	0	0		0	0.0	0.0
Taylor Creek 2	42	5	5	0	0	12	1.0	0.0	37	24	37	18	49	65	1.5	0.8
Taylor Ridge	4	4	10	0	0	1	2.5	0.0	4	3	15	4		1	5.0	1.3
Tyler Creek	1	1	2	0	0	1	2.0	0.0	1	1	3	1		1	3.0	1.0
Wellington Butte 1	2	0							2	0						
Wellington Butte 3	73	6	10	2	20	8	1.7	0.3	86	25	53	20	38	29	2.1	0.8
Wellington Butte 4	0					0										
Whitehorse Park	19	6	21	0	0.0	32	3.5	0.0	16	11	26	7	27	69	2.36	0.64
sum	616	214	459	210					670	287	683	280				
average	22.8	8.2	25.5	11.7	34.4	34.6	2.1	1.0	25	11	31	13	42	34	2.0	0.8

2007

	Stems present	No. flowering plants	No. of Flowers	No. of Capsule	% Fruit Set	% flowering
Alexander Gulch A	93	63	217	67	30.9	67.7
Alexander Gulch B	75	53	180	44	24.4	70.7
Alexander Gulch C	46	35	132	55	41.7	76.1
Brimstone	62	39	95	46	48.4	62.9
Emigrant Creek	30	20	46	14	30.4	66.7
French Gulch	30	13	25	7	28.0	43.3
Keeler Creek 1	2	0	0	0		
Logan-Bridgeview	55	34	98	18	18.4	61.8
Murphy Gulch	9	4	8	2	25.0	44.4
Pleasant Valley	11	2	2	1	50.0	18.2
Randecore Pass	26	14	33	5	15.2	53.8
Round Prairie A	6	4	8	5	62.5	66.7
Round Prairie B	25	13	33	11	33.3	52.0
Round Prairie C	23	8	14	5	35.7	34.8
Round Prairie D	70	28	56	24	42.9	40.0
Sexton Mountain 2	27	23	80	41	51.3	85.2
Slick Rock	23	15	56	13	23.2	65.2
Soda Creek 2A	1	0	0	0		
Soda Creek 2B	17	16	57	12	21.1	94.1
Soda Creek 3	78	21	48	19	39.6	26.9
Sykes Creek	4	3	5	4	80.0	75.0
Tallowbox	6	1	0	0		16.7
Taylor Creek 2	37	24	37	18	48.6	64.9
Taylor Ridge	4	3	15	4	26.7	75.0
Tyler Creek	1	1	3	1	33.3	100.0
Wellington Butte 1	2	0	0	0		
Wellington Butte 3	86	25	53	20	37.7	29.1
Wellington Butte 4						
Whitehorse Park	16	11	26	7	26.9	68.8
sum	865	473.00	1327.00	443.00		
average	31	16.89	47.39	15.82	36.5	58.4

APPENDIX B. MONITORING SITES

Site number	Site name	Ownership	Currently monitored?
C1	Murphy Gulch	BLM	Yes
C2A	Round Prairie A	BLM	Yes
C2B	Round Prairie B	BLM	Yes
C2C	Round Prairie C	BLM	Yes
C2D	Round Prairie D	BLM	Yes
C3A	Alexander Gulch A	BLM	Yes
C3B	Alexander Gulch B	BLM	Yes
C3C	Alexander Gulch C	BLM	Yes
C4	Emigrant Creek	BLM	Yes
C5	Tallowbox	BLM	Yes
C6	Whitehorse Park	BLM	Yes
C7	Sexton Mountain 2	BLM	Yes
C8	Lower Butte Creek	BLM	No
C9	Pleasant Valley	BLM	Yes
C10	Taylor Creek 2	USFS	Yes
C11	Blind Sam 1	BLM	No
C12	Waters Creek 2	BLM	No
C13	Keeler Creek 1	BLM	Yes
C14	Star Gulch 2	BLM	No
C15	Bunny Meadows	BLM	No
C16	Sykes Creek	BLM	Yes
C17	French Gulch	USFS	Yes
C18	Randecore Pass	BLM	Yes
C19A	Soda Creek 2A	BLM	Yes
C19B	Soda Creek 2B	BLM	Yes
C20	Wellington Butte 1	BLM	Yes
C21	Wellington Butte 2	BLM	No
C22	Wellington Butte 3	BLM	Yes
C23	Slick Rock	BLM	Yes
C24	Taylor Ridge	USFS	Yes
C25	Brimstone	BLM	Yes
C26	Wellington Butte 7	BLM	No
C27	Logan- Bridgeview	BLM	Yes
C28	Wellington Butte 5	BLM	No
C29	Wellington Butte 6	BLM	No
C30	Wellington Butte 4	BLM	No
C31	Tyler Creek	BLM	Yes
C32	Soda Creek 3	BLM	Yes
C33	Soda Creek 1	BLM	No