

## **2011 Haleakala Silversword Update**

### **Forest Starr and Kim Starr**

To learn more about the Haleakala Silversword or hinahina (*Argyroxiphium sandwicense* subsp. *macrocephalum*), and to keep a pulse on this park icon, each year the flowering silverswords are counted, and 11 silversword plots are monitored. Field work was done this year by Forest Starr, Kim Starr, and Paul Krushelnycky.

In short, it was a mid level year for flowering (565 blooms), and yet another year of decline (-5.5%) in the plots, which held 437 silverswords in 1982, and now only hold 86 in 2011, an 80% decline over 29 years. Anecdotally, similar levels of decline are being observed crater-wide.

Though there are still 10's of thousands of Haleakala Silverswords, there is currently a drastic decline of this species occurring in some of the most pristine and protected habitat in Hawaii, presumably from drought or other climate / environmental changes.

### **FLOWERING CENSUS**

The self-incompatible Haleakala silversword lives for many decades, flowers once, and then dies. The flowering census attempts to count all the flowering silverswords each year. The census was sporadically done from 1934 to 1962. Since 1969, the census has been done almost every year.

2011 was a medium flowering year, with 565 blooms, similar to last year's 520 blooms. The largest flowering year ever was 1991 with 6,632 blooms. The smallest was 1970 with 0 blooms. The flowering was spotty this year, with none on the West or South Rims, but large numbers on some of the cinder cones in the Central Crater.

The silverswords continue to bloom right on cue every summer (June - October), but the annual variation in numbers of blooms is quite dramatic, with no clear indication what triggers mass blooming events in this self-incompatible species, that requires other flowering plants nearby to produce viable seed. Thoughts on silversword bloom triggers have included ultraviolet levels, plant hormones, and precipitation, but to date no one has found a solid correlation, and what triggers silverswords to bloom remains a mystery. Recent thoughts have shifted towards looking at individual population flowering, rather than crater-wide flowering, but the silversword flowering trigger still remains a mystery.

### **PLOTS**

The 11 long-term silversword plots were established in 1982 and have been monitored almost every year since. They were established to document the predicted increase in silverswords after removal of goats from Haleakala Crater. However, they have actually stood witness to a severe decline in silversword numbers, presumably from drought or other environmental changes. The plots attempt to monitor a representative sample of the

silverswords by mapping individual silverswords, measuring live crown diameter of each silversword, and noting life history changes (seedlings, flowered, death).

### **Overall**

2011 was yet another year of decline, with the total number of live silverswords in the plots declining 5.5% (5 less plants) in the last year from 91 to 86. All 5 that died this year died without flowering. The total number of live silverswords in the plots has dropped by 80% (351) since 1982, from 437 to 86. This steep decline has occurred since an all time high of 488 silverswords in 1989, with 17 of the last 18 years showing decline.

### **Seedlings**

No new seedlings were recorded in the plots this year, nor the previous 4 years. In the past decade there have been 162 seedlings, of which 11 (6%) are still alive. Of the seedlings still alive, most are still small (<5 cm), though a couple are now quite large (25 and 38 cm). Seedling survival rates and current live crown diameters below:

2006 - 3 seedlings, 0 (0%) still alive.

2005 - 25 seedlings, 3 (12%) still alive, (1, 2, and 25 cm).

2004 - 127 seedlings, 8 (6%) still alive, (1, 1, 3, 3, 3, 4, 7, and 38 cm).

2001 - 5 seedlings, 0 (0%) still alive

2000 - 2 seedlings, 0 (0%) still alive.

### **Flowering**

No silverswords flowered in the plots this year. The most silverswords flowering in the plots was 22 in 2004.

### **Age**

30% (26 of 86) of the silverswords have been in the plots since 1982. In other words, almost a third of the plants alive in the plots are at least 29 years old. The smallest of these old silverswords is a mere 6 cm in diameter, the largest is 45 cm. The largest silversword in the plots measures 61 cm and has been in the plots since 1989.

### **Discussion**

No one knows what is causing the steep decline in silverswords, but what seems to be occurring is that silverswords begin shrinking (decrease in live crown diameter) and eventually shrink to zero (dead). The most obvious cause would seem to be lack of moisture. The past couple decades have held an inordinate number of dry years, including a string of driest years on record. However, local scale measurements of weather within silversword habitat at Haleakala during this period do not exist, and there have been silversword declines in wet years. Other environmental factors that have been proposed for the marked silversword decline include increased temperature, a more stable inversion layer, and a greater number of trade wind days.

### Flash Fry Phenomena

Below are images taken this year of a couple silverswords in the plots. Also included is the historical annual live diameter for each. Data from these example swords highlight a phenomena we are calling "flash fry" in which silverswords seem stable, but then all of a sudden die, without a perceived period of shrinking. Though not representative of all silverswords, these patterns are anecdotally evident crater-wide, and the long-term plot data provides a rare glimpse into the quantified life history of a subset of these.

#### Flash Fry, Small Silversword, 20 Years Old



There was a fair amount of death in the plots on Ka Moa o Pele this year. This particular sword was 20 years old, when it perished without flowering. It's old age is evidenced by the large petticoat of dead leaves at the base. Despite being two decades old, it was a mere 9 cm wide. Though we have seen silverswords slowly "shrink" in the past, in recent years we have witnessed silverswords "flash fry", where they seem to be holding steady and then just die. Not sure if this is heat related, drought, or something else, but the flash fry phenomena has seemed extra evident the last couple years, and is documented in the data below.

Annual Live Diameter (cm) - Silversword 90-17, Plot 8A - Ka Moa o Pele.  
Seedling (1990), ?, 1.5, ?, ?, ?, <5, 4, 5, 4, 3, 5, 6, 5, 7, 8, 9, 8, 8, 9, 9, Dead (2011)

#### Flash Fry, Large Silversword, >29 Years Old



Even more surprising than small silverswords dying are the large silverswords that are now "flash frying". This silversword from Ka Moa o Pele, which died this year, was 34 cm wide and at least 29 years old, as it was in the plots when they were established in 1982. As with the sword above, it wasn't growing much in recent years, but seemed stable and healthy last year, and then just up and died this year. Again it is assumed there is some environmental reason for these sudden deaths, presumably drought or heat, but to date a solid correlation has not been established.

Annual Live Diameter (cm) - Silversword 82-2, Plot 8B - Ka Moa o Pele.  
5-20 (1982), 5-20, 5-20, 5-20, 5-20, 5-20, ?, ?, >20, ?, 5-20, ?, ?, ?, >20, 22, 30, 25, 30, 28, 35, 29, 32, 34, 34, 34, 33, 32, 34, Dead (2011).

## **ADDITIONAL RESEARCH**

Given the dire news the plots seem to report, folks have questioned whether the 11 non-randomly selected plots are representative of the entire crater population, last estimated at 50,000 in 2001 (more detailed recent work shows this number was likely a 2-3x underestimate). Anecdotally there appears to be a lot of death beyond the plots, a walk along the Silversword Loop is pretty gut wrenching if you know what to look for. That said, populations along Sliding Sands and the Crater rims seem to be doing better.

In an attempt to determine whether all the silverswords are declining, or not, more detailed crater-wide mapping was started in 2010 by Forest Starr, Kim Starr, and Paul Krushelnycky, in collaboration with Lloyd Loope and HALE Vegetation Management. Initial findings seem to confirm the downward trends the long-term plots are reporting, though there are areas that seem to be not as bad off, such as higher elevations and areas with seeps. The methodology for this ramped up crater-wide monitoring is still undergoing optimization, but holds great promise for being able to keep a pulse on this park icon over a larger part of its range.

Along with ramped up silversword monitoring, a series of weather stations have been placed throughout the silversword range and maintained by Paul Krushelnycky. It is hoped this local scale weather data from within diverse silversword habitats will help elucidate correlations between silversword health and local environmental conditions.

Additionally, silversword drought tolerance studies have begun, looking at plants from across the silversword range to see if there are any genetic links to drought tolerance.

Much of this silversword work currently requires boots on the ground, but it is hoped someday some of these tasks can be accomplished through remote sensing. There are many reasons this would be desirable, though currently the technology isn't able to image the entire silversword range at the resolution necessary (<1 cm) at a reasonable cost.

## **DON DRAKE'S WORK**

Work by Don Drake and others (Cliff Morden, Chuck Chimera, Vickie Caraway, and Tim Motley), which is focused near the summit, is showing a similar short term decline over the past decade, but in stark contrast to the plots in the Central Crater, is showing a slight long term increase since 1993. The area Don et al. are tracking started with 118 plants in 1993, peaked at around 175 in 2001 and was back down to 133 this year.

During 2008 and 2009, there was no flowering and quite a few very small seedlings died. In 2010 there were 3 new seedlings, 3 plants flowered, and 9 plants died without flowering. This year (2011) there was 1 new seedling, 3 deaths (from among tiny plants) for a net loss of 2.

Don's results of a slow decline in the summit area over the past year are consistent with what we have found during ramped up monitoring of nearby areas over the same period.

## **SUMMARY**

The Haleakala Silversword remains an enigma, and seems increasingly imperiled despite high levels of protection. We get occasional insights into the biology and life history of this spectacular plant, but many questions remain unanswered. One of the biggest surprises is that most of the plots set up to showcase this conservation success seem to actually be documenting its demise in one of the most pristine and protected natural areas in Hawaii. Though it still hasn't been determined exactly why this is occurring, through expanded mapping, collaboration between a broad range of disciplines and individuals, and passage of time, we hope to better understand the status and trends of this park icon.

## **2011 SILVERSWORD IMAGE**

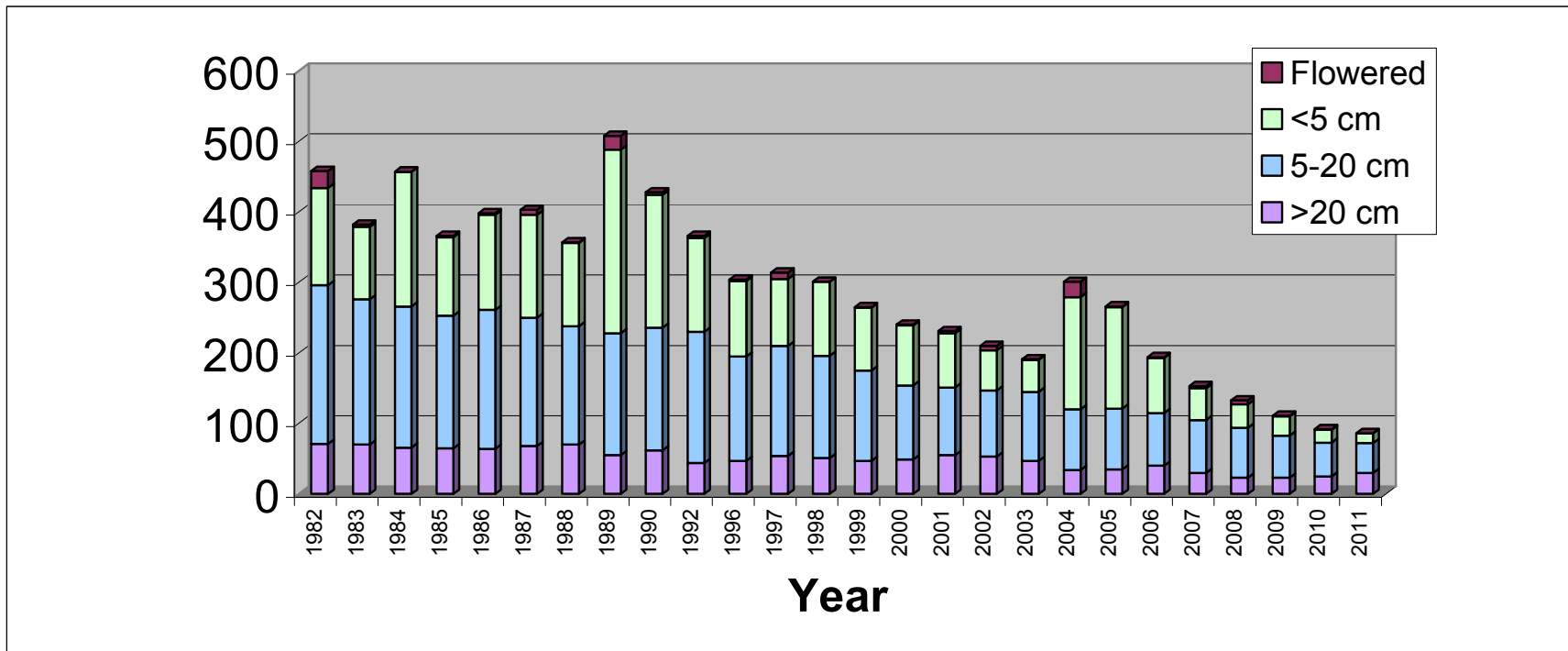
Though the silverswords are showing drastic decline over much of their range, there are still 10s of thousands of them, and this year 565 bloomed in an effort to keep the species going. This was one of the more aesthetic silversword blooms we came across this year. It was off Sliding Sands Trail, in the flats on the way to Kapalaoa.



## HALEAKALA SILVERSWORD ANNUAL PLOTS

### SILVERSWORD PLOTS SUMMARY (1982-2011)

Size	1982	1983	1984	1985	1986	1987	1988	1989	1990	1992	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<5 cm	138	103	191	111	135	146	118	260	188	133	107	95	105	89	85	77	57	45	159	144	78	45	33	27	18	14
5-20 cm	225	206	200	188	197	182	168	173	174	186	148	156	145	128	105	96	94	98	86	86	75	75	71	60	48	42
>20 cm	71	70	66	65	64	68	70	55	62	44	47	54	51	47	49	55	53	47	34	35	40	30	23	23	25	30
?	3	3	6	11	6	17	0	0	20	35	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flowered	24	3	0	2	2	7	1	20	4	3	2	9	0	1	1	3	6	1	22	1	1	3	6	1	1	0
Total #	461	385	463	377	404	420	357	508	448	401	312	314	301	265	240	231	210	191	301	266	194	153	133	111	92	86
Total Live	437	382	463	375	402	413	356	488	444	398	310	305	301	264	239	228	204	190	279	265	193	150	127	110	91	86



## ANNUAL HALEAKALA SILVERSWORD FLOWERING CENSUS 1934-2011

