Schiedea obovata

Scientific name: *Schiedea obovata* Sherff
Hawaiian name: None
Family: Caryophyllaceae
Federal status: Listed Endangered October 29, 1991
Requirements for MIP Stability

- 3 Population Units (PU)
- 100 reproducing individuals in each PU
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Description and biology

Habit- Suberect or ascending, branched shrubs 3-10 dm tall, glabrous throughout except for the leaf margins.

Leaves- Leaves opposite; blades 4-11 cm long, (1.5-6.8) cm wide, thick and somewhat fleshy, light green becoming yellowish white toward the base and at the apex (youngest yellowish white, sometimes purple tinged), elliptic to broadly elliptic, sometimes obovate or oblanceolate, with 3 principal veins, sometimes also with an inconspicuous looping pair of veins near the margins, margins serrulate, the teeth with antrorsely hooked hairs ca. 0.1-0.2 mm long, apex mucronate; petioles 1-3 (-3.8) cm long, yellowish white.

Flowers- Inflorescence pseudoaxillary, with 22-33 flowers, somewhat congested; bracts much smaller than uppermost leaves, usually curled and twisted, lowest pair to 1.4 cm long; peduncles (2-) 5-25 mm long, not elongating much in fruit, the internodes of the lateral inflorescence branches 2-10 mm long; pedicels thinner, 15-30 mm long, elongating mostly just prior to anthesis. Flowers apparently adapted for bird pollination, pendent. Sepals (4-6), often variable on the same plant, 7-8.4 mm long, 5.5-6 mm wide, enlarging to 9-12 mm long and 8-9 mm wide in fruit, white adaxially, the outer ones oblong-elliptic, pale green abaxially, inner ones elliptic to obovate, greenish white with a green midrib, the apex broadly obtuse and usually retuse, the outer ones sometimes with a subapical minute mucro, becoming dark purple and fleshy as fruit matures. Stamens (8-12); filaments 4.4-5 mm long, subequal; anthers 1.9-2.65 mm long, pale reddish purple at anthesis, changing to a darker reddish purple, the pollen gray. Nectary ring bright green, the flap-like extensions weakly connate at the base, thin, translucent, 2.2-2.5 mm long, irregularly 2-toothed to subentire. Styles (4-8), often variable in number on the same plant (Modified from Wagner *et al.* 2005).

Fruit- Capsules 9-12 mm long, ovoid to subglobose.

Seeds- Seeds 1.2-1.5 mm long.

Distribution- Oahu, formerly nearly throughout the Waianae Mountains, now restricted to the north end of the Waianae Mountains; rare and scattered on ridges and slopes in diverse mesic forest; 550-800 m.

Pollination and dispersal- Passerine birds have been suspected pollinators due to nectar concentration and amount (Weller et al. 1998), but no birds have been observed visiting this species (Weisenberger 2012). The fleshy dark purple sepals surrounding the mature capsules of the two species (*S. obovata* and

S. trinervis) are unique in the Caryophyllaceae and may have attracted birds as dispersal agents. As the fruit matures, the calyx lobes persist and become purple and fleshy. This 'false berry' is very likely to attract fruit-eating birds that may disperse the species' seeds (Carlquist 1970).

Taxonomic background: There are 34 endemic species in the endemic genus *Schiedea.* All species have been shown to have arrived from one single colonization. The name *Schiedea obovata* was changed from *Alsinidendron obovatum* after molecular and morphological data from Wagner *et al*. (2005), concluded that *Alsinidendron* formed a monophyletic group within *Schiedea*. *Alsinidendron* has since been subsumed into the Hawaiian endemic genus *Schiedea*. *Schiedea obovata* is differentiated from the closely related *S. trinervis* by its more congested inflorescence, flowers that open fully during anthesis and have greater nectar production, and thicker leaves, the young ones whitish green. It grows in mesic forests at lower elevations than *S. trinervis*. The congestion in the inflorescence of *S. obovata* appears to be primarily due to the reduction of the internodes of the lateral inflorescence branches and to the delayed elongation of the pedicels until just prior to anthesis.

Table 1. Historic Collections of *Schiedea obovata* on Oahu

Area	Year	Collector	Pop. Reference Code
Palehua	1911	Forbes	
Palehua	1927	Degener Horner	
Palehua	1929	Russ	
Palehua	1929	St John	
Palehua	1931	Degener Park	
Pahole	1932	Degener	PAH-A
Palehua	1933	Judd	
Palehua	1933	Russ	
Palehua	1934	Wilder	
Pahole	1934	Onouye	PAH-A
Pahole	1934	St John	
Palehua	1937	Fosberg	
Palehua	1938	Skottsberg	
Palehua	1946	Kerr	
Palehua	1950	Hatheway et al 87	
Pahole	1973	Nagata & Obata	PAH-C
Pahole	1975	Herbst & Obata	
Makaleha	1978	Gagne & Gagne	LEH-B
Pahole	1987	Perlman & Obata	PAH-A
Pahole	1987	Perlman	PAH-A
Mokuleia	1908-1920	Forbes	
Kaluaa	1978	Takeuchi	
Keawapilau	1980s	Welton	PIL-A

Table 2. Reproductive Biology of *S. obovata*

	Observed Phenology			**Reproductive Biology**		**Seeds**	
Population Unit	**Flower**	**Immature Fruit**	**Mature Fruit**	**Breeding System**	**Suspected Pollinator**	**Average # Per Fruit (viable)**	**Dormancy**
Kahanahaiki to Pahole	Jan-Sept	Jan-Oct	Jan-Dec	Hermaphroditic	Bird or None	~100 ± 15[¥]	None*
Keawapilau to West Makaleha	Jan-Dec	March-Dec	Jan-Dec	Hermaphroditic	Bird or None	80±10	None*
Makaha	Jan-June	April-June	April-Dec	Hermaphroditic	Bird or None	48± 3	None*

*Some collections have delayed initial germination for approximately six months. A physiological mechanism to prevent germination until cooler, wetter winter months may be present. This delay has been documented occasionally across all populations and collections. There is substantial variation among length of time until initial germination between individual plants within the same collection and between different collections of the same plant. Delayed germination may be mechanism for preventing germination during the hottest months immediately following dispersal.

[¥] Some collections of mature fruit have lower numbers of seeds per fruit; likely because fruit are picked after most seeds have dispersed.

Breeding System: Hermaphroditic (facultative autogamy) (Weller et al. 1998) with high selfing rates and very little pollinator visitation (Weisenberger 2012).

Fruit collection: Peak collection time is spring (April-May).

Plant morphology and habitat

Figure 1. Outplanting of immature plants

Figure 2. Immature and Mature fruit

Figure 3. Mature plant variation in leaf morphology

Figure 4. Immature and mature fruit on plant with typical leaf morphology

Figure 5. Mature fruit and seed

Figure 6. Open flower with perianth removed

Figure 7. Seedling recruitment in a dense mat

Figure 8. Immature and mature fruit

Figure 9. Flower development

Figure 10. Flower with purple pollen

Table 3. Habitat characteristics

PU	Population Reference Code	Elevation (feet)	Slope	Topography	Aspect	Annual Ave. Max. Temp. (F)*	Average Annual Rainfall (mm)*/**
Kahanahaiki to Pahole	MMR-A *in situ*	1880	Vertical	Upper Slope	N	77	1561/ 1334
Kahanahaiki to Pahole	MMR-G reintro	2000	Moderate	Upper Slope	N	77	1531/ 1320
Kahanahaiki to Pahole	PAH-A *in situ*	2297	Steep	Upper Slope	N	75.2	1766/ 1505
Kahanahaiki to Pahole	PAH-C *in situ*	2100	Steep	Upper Slope	N	75.2	1667/ 1425
Kahanahaiki to Pahole	PAH-D reintro	2250	Moderate	Upper Slope	N	75.2	1667/ 1425
Keawapilau to West Makaleha	PIL-A *in situ*	2149	Moderate	Upper Slope	N	75.2	1781/ 1556
Keawapilau to West Makaleha	PIL-B *in situ*	2240	Moderate	Upper Slope	NE	75.2	1880/ 1612
Keawapilau to West Makaleha	PIL-C reintro	2500	Moderate & Steep	Upper Slope & Crest	N	75.2	1880/ 1612
Keawapilau to West Makaleha	LEH-A *in situ*	2598	Steep & Vertical	Upper Slope	N	73.4	2022/ 1765
Keawapilau to West Makaleha	LEH-B *in situ*	2500	Moderate & Steep	Upper Slope	E	75.2	1962/ 1651
Keawapilau to West Makaleha	LEH-C reintro	2760	Steep	Upper Slope & Crest	NE	73.4	2023/ 1766
Makaha	MAK-A reintro	2600	Moderate & Steep	Upper Slope	N	75.2	1921/ 1638

Information was compiled from Army Natural Resource Program - Oahu (OANRP) observation forms, GIS data, PRISM Climate Group. *PRISM. 2018. Prism Climate Group. Oregon State University. http://prism.oregonstate.edu. **Giambelluca TW, Chen Q, Frazier AG, Price JP, Chen Y-L, Chu P-S, Eischeid J., and Delparte, D. 2011. The Rainfall Atlas of Hawaiʻi. http://rainfall.geography.hawaii.edu.

Table 4. Associated species table, species are listed in order of abundance as observed by the Army natural resource program on Oahu (OANRP). Six digit codes used for species names.

PU	Population Reference Code	Canopy	Understory
Kahanahaiki to Pahole	MMR-G reintro	AcaKoa, PsyOdo, MetPol, SchTer, PsiCat, SanFre, AntPla, DioHil	AlyOli, MicStr, MepExa, DiaSan, CarWah, VioCha, OplHir, DooKun, HedTer, ConBon, MelMin, AspKau, PhlAur, AspNid, CocTri, RauSan, ChaMul, ReySan, DieFal, LanCam, PepTet, AspHor, BleApp
Kahanahaiki to Pahole	PAH-D reintro	AcaKoa, MetPol, PsyOdo, ChaTom, Schter, PsyMar, AntPla, Psicat	FreArb, Psicat, Alyste, DooKun, CibCha, Coplon, PsyOdo, Clihir, AntPla, Oplhir, Bleapp, Rubros
Kahanahaiki to Pahole	PAH-E reintro	SchTer, MetPol, LepTem, PsiCat, DodVis, PsyOdo	DiaSan, CliHir, MelMin, LanCam, MicStr, AlyOli, CocTri
Keawapilau to West Makaleha	PIL-A *in situ*	MetPol, MelPed, GreRob, AntPla, WikOah, PsyMar, PsiCat	NepExa, AlyOli, PasCon, OplHir, DiaSan, BidTor, DryGla, BleApp, HedTer, AspHor, PleAur, CliHir, SchNut, CyaLon
Keawapilau to West Makaleha	PIL-B *in situ*	MetPol, AcaKoa, AntPla, SchTer, GreRob, PsiCat	CarWah, MicStr, RubRos, CliHir, BleApp, DooKun
Keawapilau to West Makaleha	PIL-C reintro	MetPol, AcaKoa, PsiCat, SchTer, PsyOdo, NesSan, SyzCum, GreRob	DodVis, BleApp, DooKun, MelMin, LepTam, DicLin, StaDic, MicStr, RubRos, CarWah, BidTor, AlyOli, CopFol, NepCor, NepExaHaw, OxaCor, PsiCat, ElaPal, PsiNud, CreCre, PanNep, CliHir, CocTri, HedTer, WikOah, LanCam, ConBon
Keawapilau to West Makaleha	LEH-A *in situ*	AntPla, PsiCat, MetPol, GreRob	DipPin, AlyOli, CliHir, OdoChi, RubRos, DooKun
Keawapilau to West Makaleha	LEH-B *in situ*	MetPol, PsiCat, AcaKoa, SchTer	MelMin, BidTor, AlyOli, AgeAde, DodVis, PanNep, CarWah
Keawapilau to West Makaleha	LEH-C reintro	PsiCat, MetPol, CopFol, MelClu, ScaGau, AntPla, DodVis	RubArg, BleApp, MelMin, StaDic, RubRos, CliHir, ChrPar, MetPol, PriKaa, PitGla, DicLin, PsiCat, NepMul, MelClu, AntPla, DipSan, PepMem, WikOah, FreArb

Map removed to protect rare resources

Figure 11. Map of current *Schiedea obovata* locations

Map removed to protect rare resources

Figure 12. Map of historic *Schiedea obovata* locations

Current status:

The known population units of *S. obovata* in the Waianae Mountains totals 917 plants, consisting of mature and immature plants, and seedlings (Table 5). This is an approximately 3% increase in the total plants from 2017. About 60% of this total is represented by *in situ* plants, and the remaining 40% from reintroduced populations. Currently, no PU has more than 100 reproducing individuals required to meet stabilization goals. While the total number of mature plants in the Keawapilau to West Makaleha PU and the Kahanahaiki to Pahole had previously been over 100 individuals, more recent declines, a lack of seedling development, and a reduction in immature plant survival has led to a decrease in overall plant numbers in these PU. The threat of fire is highest for the Makaha and Pahole PUs. Future outplantings will be needed to meet the stabilization goals for the number of reproducing individuals, as currently there are no PUs that meet the minimum number of reproducing individuals, despite slug control at two populations in the Keawapilau to West Makaleha PU, and at the lone population in the Makaha PU.

Table 5. Current population size and structure for all populations of *S. obovata*.

PU	Population Reference Code	Mature Plants	Immature Plants	Seedlings
Kahanahaiki to Pahole	MMR-G reintro	84	167	200
Kahanahaiki to Pahole	PAH-D Reintro	3	0	0
Kahanahaiki to Pahole	PAH-E reintro	4	0	0
Keawapilau to West Makaleha	PIL-A *in situ*	1	0	0
Keawapilau to West Makaleha	PIL-B *in situ*	3	306	2
Keawapilau to West Makaleha	PIL-C reintro	6	1	0
Keawapilau to West Makaleha	LEH-A *in situ*	2	2	0
Keawapilau to West Makaleha	LEH-B *in situ*	6	100	3
Keawapilau to West Makaleha	LEH-C reintro	7	0	0
Makaha	MAK-A reintro	20	0	0
Totals for all populations		136	576	205

Population Units: Three Manage for Stability Population Units (MFS PU) are required for this taxon as it is found in the Makua Action Area. All PUs are MFS, as there are no Genetic Storage Population Units.

Table 6. Stabilization Goal Status, Yes/No/Partial refers to whether threat is mitigated.

	PU Stability Target	MU Threat Control					Genetic Storage
Population Unit	**100 reproducing plants**	**Ungulate**	**Slugs**	**Rodent**	**Fire**	**Weeds**	**% Completed**
Kahanahaiki to Pahole	No	Yes	No	Partial	No	Yes	100%
Keawapilau to West Makaleha	No	Yes	Partial	Partial	No	Yes	100%
Makaha	No	Yes	Yes	Yes	No	Yes	N/A

Population Unit Kahanahaiki to Pahole

The Army natural resource program on Oahu (OANRP) began to outplant *S. obovata* into the Kahanahaiki to Pahole PU in 1999. A seedling was recently observed in the original outplanting site after years of no management in the area, which indicates the seedbank can persist long after reintroduced plants perish. The original outplantings were immature plants grown from seed, collected from the remaining *in situ* plants (MMR-A, PAH-C, LEH-A, PIL-B) and from seed collected from living collection plants (PAH-A and PIL-A). The Kahanahaiki to Pahole PU currently consists of three reintroduction sites that are monitored regularly, and have had fluctuating numbers of seedlings and immature plants. One site is in Kahanahaiki (MMR-G, Fig. 13), and two sites in Pahole (PAH-D and PAH-E, Figs. 14 and 15).

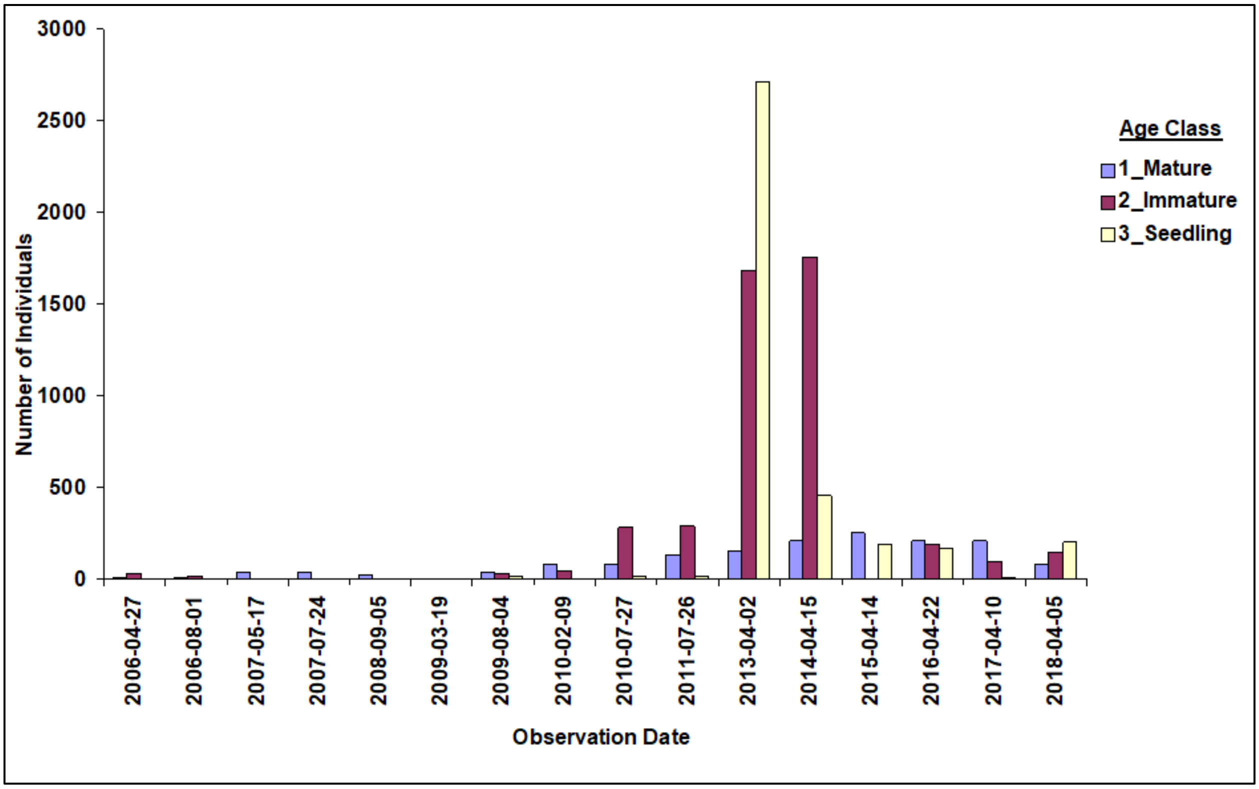

Figure 13. Schobo MMR-G reintroduction site population structure for seedlings, immature, and mature plants

Planting at the MMR-G site began in 2006 and outplants yielded mature plants within a few years. There was an increase in recruitment observed between 2010 and 2014, perhaps due to more open canopy in parts of the reintroduction area. Since 2013, many seedlings and immature plants have died, and the total number of plants have declined (Fig.13). The population size has not changed much over the past three years, with approximately 450 total plants. However, the population structure has changed from a majority mature plants to a majority seedling age class. This single population accounts for over 95% of the total plants in the Kahanahaiki to Pahole PU.

Planting at the PAH-D site began in 2003 and outplants yielded mature plants within a few years. The most recent outplanting was in 2011 but since then the population has been in steep decline, with only four mature plants remaining (Fig. 14). Similar population trends have been observed for PAH-E as well, with the most recent ouplanting in 2013, and currently only three mature plants remaining (Fig. 15). Increased weed encroachment and invasive canopy that limited light levels was the likely cause of decline.

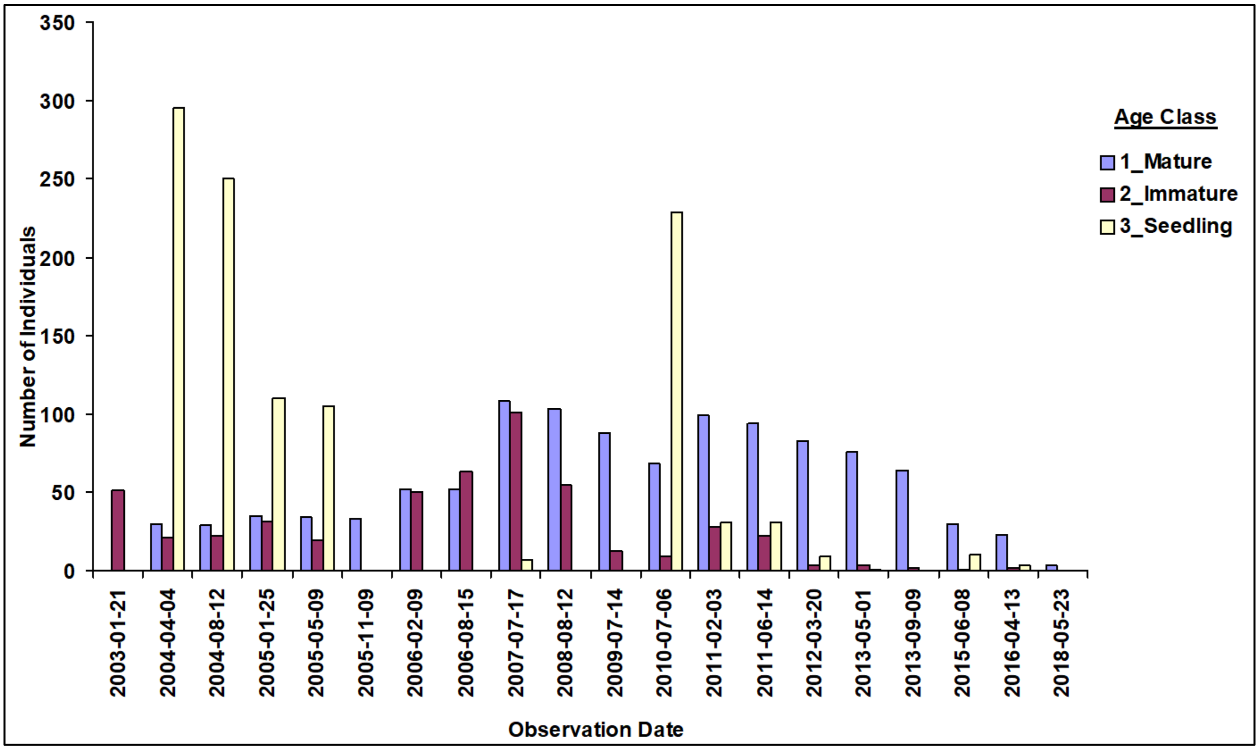

Figure 14. Schobo PAH-D reintroduction site population structure for seedlings, immature, and mature plants

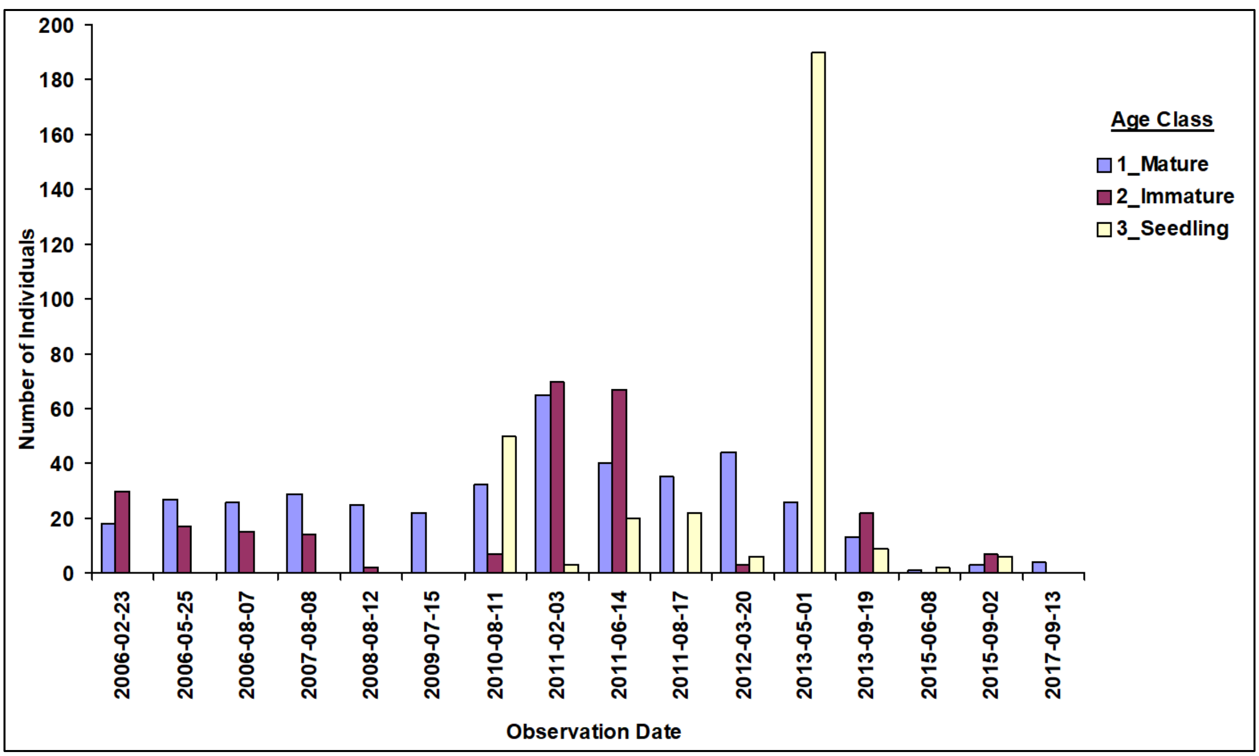

Figure 15. Schobo PAH-E reintroduction population structure for seedlings, immature, and mature plants

Population Unit Keawapilau to West Makaleha

Plants at the LEH-B population site in the Keawapilau to West Makaleha PU have been monitored regularly and typically take one to two years to mature and survive for one to two years after maturation. The majority of plants die in less than 5 years, while some have survived longer. This stresses the importance of regeneration through the seed bank for this species. Outplanting sites may need to be initiated with a large number of outplants in order to establish a seedbank that can replace the short-lived outplants within 5 years of planting.

Two *in situ* populations (LEH-B and PIL-B) in the Keawapilau to West Makaleha PU account for over 95% of the total plants in this PU (Figs. 16 and 18). The LEH-B population had a large increase in immature plants and seedlings between 2010 and 2014, with over 2000 plants observed during monitoring (Fig. 16). However, this PU has not reached the stability goal to maintain ≥100 mature plants since 2012. These numbers have since declined, with only 25 total mature plants in the PU as of the most recent monitoring. Additionally, the reintroduction site PIL-C has had a similar decline in total plants, despite slug control at the site (Fig. 19). The PIL-B (Fig.18) population currently has the highest number of immature plants amongst all populations in this PU, with over 300 immature plants present, followed by the LEH-B site with over 100 immature plants. One other reintroduction site, PIL-C, was attempted in this PU, but has had a recent decline in population (Fig. 19). This was observed in both reintroduction sites in the PU.

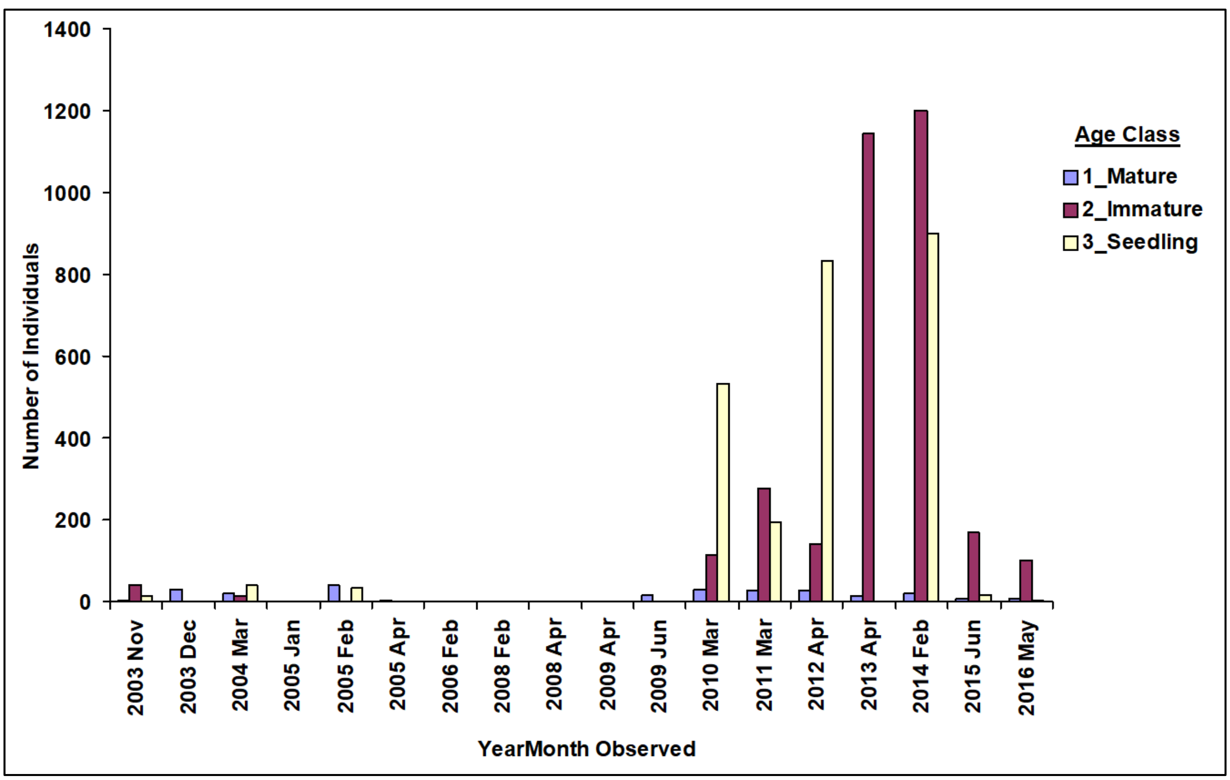

Figure 16. Schobo LEH-B *in situ* site population structure for seedlings, immature, and mature plants

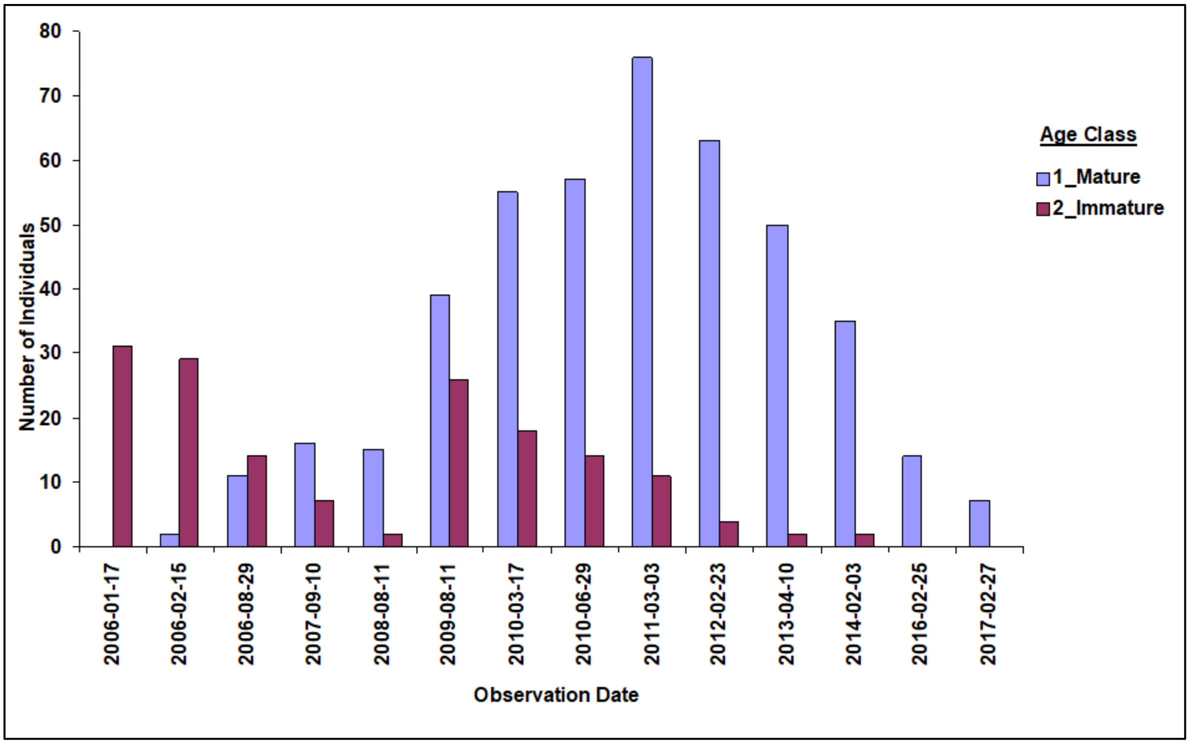

Figure 17. Schobo LEH-C reintroduction site population structure for seedlings, immature, and mature plants

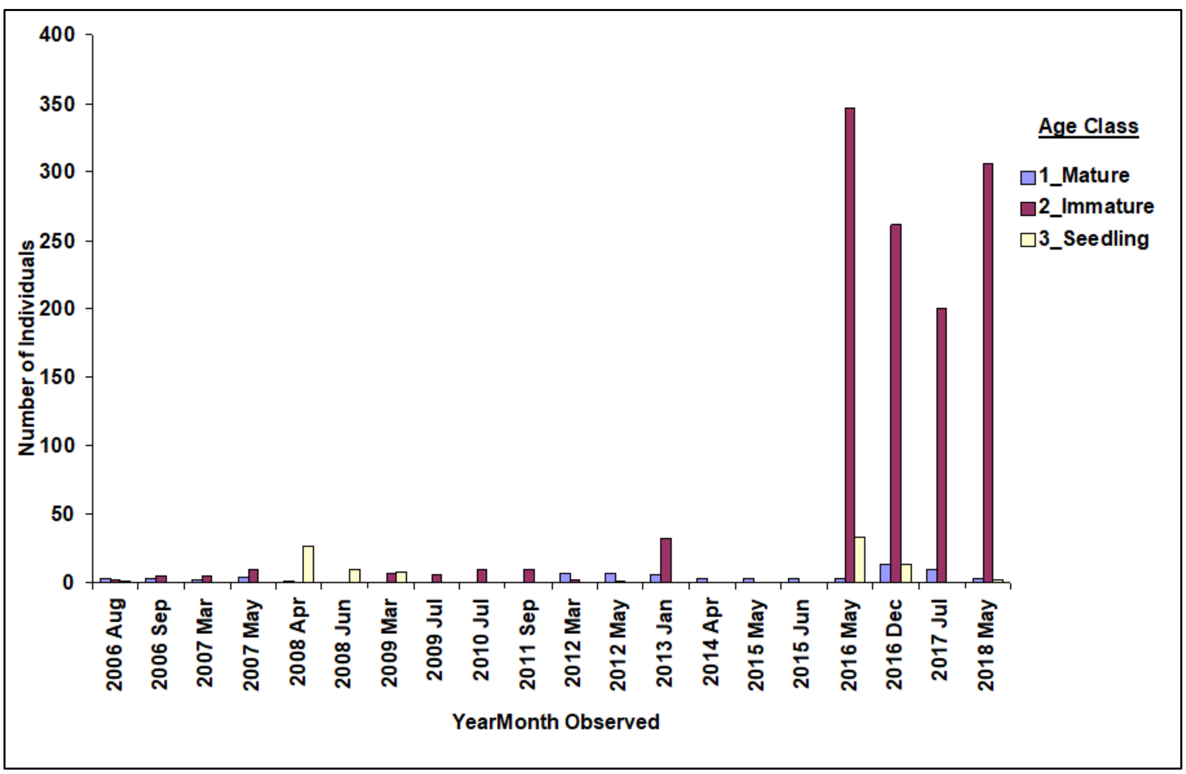

Figure 18. Schobo PIL-B *in situ* site population structure for seedlings, immature, and mature plants

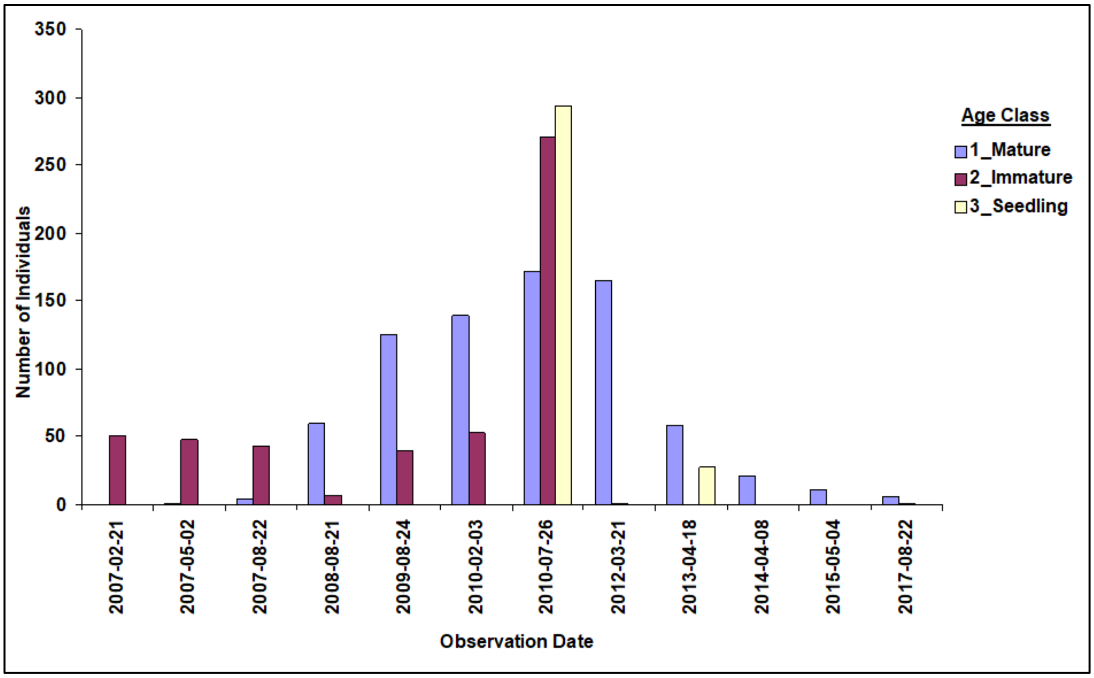

Figure 19. Schobo PIL-C population structure for seedlings, immature, and mature plants

Population Unit Makaha

The Makaha reintroduction site MAK-A was established in 2014 with 200 individuals planted (Fig. 20). These plants matured over the following two years, but have since declined to just 20 mature plants, and sparse recruitment of seedlings observed. It is likely the outplanting site conditions in this area are too wet and the surrounding habitat too dense for seedling recruitment.

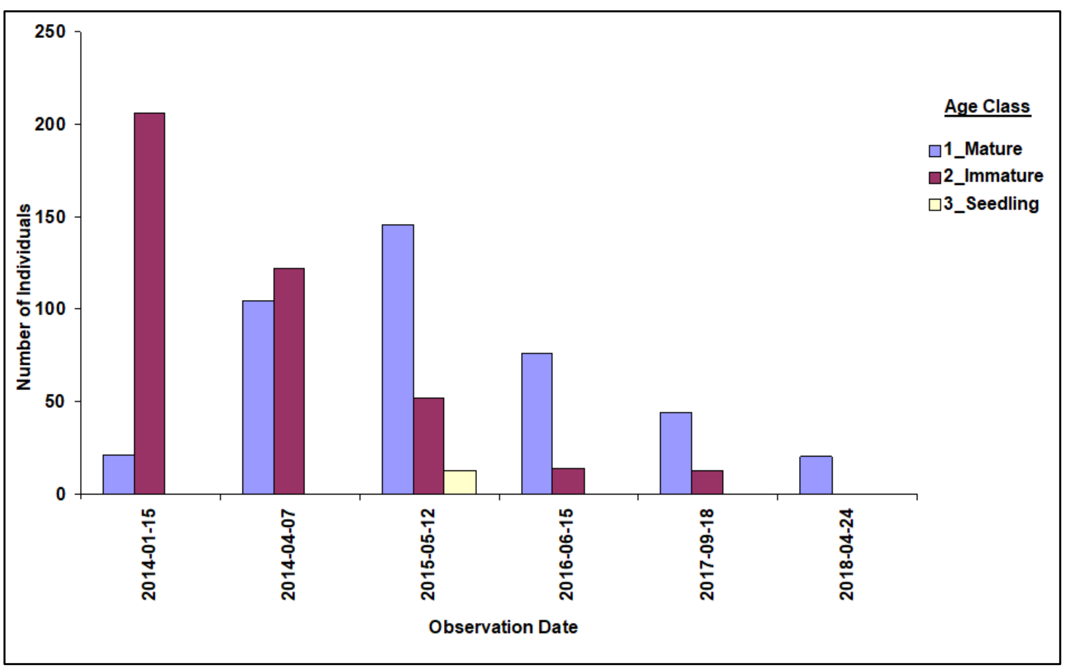

Figure 20. Schobo MAK-A population structure for seedlings, immature, and mature plants

Outplanting considerations from 2003 MIP: *S. obovata* was classified as *Alsinidendron obovatum* in 2003. "Since *A. obovatum* is a naturally selfing plant (Weller pers. comm. 2000) plants from different stocks should not be mixed together during outplantings. *A. trinerve*, like *A. obovatum*, is an endangered plant. The ranges of these two species do not overlap geographically. *A. trinerve* is known only from the sides of Kaala and on the ridge between Kaala and Puu Kalena to the south. The two *Alsinidendron* also occur in different habitats. *A. trinerve* occurs in wetter forests and at higher elevation than *A. obovatum*. *A. obovatum* should not be introduced within the range or habitat of *A. trinerve*. In many cases *A. obovatum* is located in the same drainages as its relative. *S. nuttallii, S. pentamera*, and *S. kaalae*. Natural hybridization between species of *Schiedea* has been documented in the Waianae Mountains. Although hybridization between species of *Schiedea* and *Alsinidendron* have yet to be found in nature or created experimentally, the possibility of hybridization between the two exists, so *Alsinidendron* should not be outplanted near *Schiedea* species. Due to the large gap between northern plants and possibly extirpated southern plants, it is presumed that the southern plants are, or were, genetically distinct. If rediscovered, the southern stock should be preserved separately from the northern stocks. Northern stocks should not be planted in the southern Waianae Mountains as long as there remains some chance that southern plants still persist. Outplanting lines have been drawn limiting the outplanting of the northern and southern stocks to their respective ends of the mountain range."

Current Outplanting considerations and plan: There have been ten outplantings sites of *S. obovata*. Six outplanting sites in the Kahanahaiki to Pahole PU, three in the Keawapilau to West Makaleha PU, and one in the Makaha PU. The first outplanting site was established in 1999 in the Pahole PU. The number of individuals to be planted at each site was previously determined by factoring in the survivorship of previous plantings and the number of mature recruits produced by the surviving outplants. Previous outplanting data has shown that approximately 400 outplants are needed to produce 100 mature plants within 5 years. However, longer term monitoring of outplanting sites has shown more complex factors related to site establishment, in addition to the total number of outplants attempted. An experimental site was established in 2009 in Kahanahaiki. The experimental site included over 500 outplants, and had over 90% survival after one year, however, survival was less than 10% after five years. The number of outplants attempted does not always equate to stable populations. It should be noted that outplants for this experimental site were also relatively small (less than 10cm tall).

Additional factors such as changing site conditions, plant size, threats from slugs and rats, and associated species present in outplanting sites are factors that should be prioritized in future outplantings. Previous research on the effects of precipitation and herbivory on *S. obovata* showed that plant size was directly related to outplanting survival and fruiting (Bailic-Murphy and Gaoue 2018). Small plants less than 8cm were most susceptible to drought, and also benefit the most from molluscicide treatment. This research concluded that early stage plant vitality has the greatest impact on population dynamics, and establishment of outplants is critical to population structure. Future outplantings should be established near the best current sites, with slug and rat control, and larger size plants used for initial outplanting.

Previous studies determined the fitness of outplants grown from seed produced by outcrossing and selfing the available stocks of *S. obovata* (Weisenberger 2012). These studies showed that the relative fitness of plants increases when parents are from different populations. Mixed source reintroductions were implemented at the Makaha PU, while single source reintroductions were implemented in Kahanahaiki to Pahole and Keawapilau to West Makaleha PUs. The Makaha reintroduction had less than 10% survival within five years, and very little recruitment observed. While a mixed source populations were used for this reintroduction, similar poor results were observed for reintroduction sites from single source founders (Figs. 16, 18, and 19).

Reintroduction Plan

Priority for reintroductions will be to establish a new site in Makaha. The previous site in the Makaha II fence showed the lowest survival of any outplanting at five years with less than 10% overall survival and very low recruitment. The elevation at the current outplanting may be too high and a more suitable site will be scoped inside the Makaha I fence. As with all new outplanting sites, habitat and micro-site conditions that promote recruitment and stage class transitions to immature and mature plants should be prioritized. New outplanting sites should take into account the effects of climate change and drought, as well as weed control strategies, for long-term survival and reproduction. A site survey will be conducted in the Makaha, prioritizing the areas of Makai Gulch, Giant Ohia, and the area surrounding the *Hesperomannia oahuensis* MAK-A *in situ* site.

A majority of the plants encompassing the Kahanahaiki to Pahole PU are from a single population site, MMR-G. While this site does not meet the goal for reproducing individuals, there are robust numbers of immatures (167 plants) and seedlings (200 plants). This site will be monitored to see if these individual develop into mature plants over the next year or two, with additional outplants added to the site. An additional outplanting site will be established near the MMR-G site, and a site survey will be conducted near the Aunty Barbara area to determine the most suitable area. The Pahole outplanting sites in this PU were originally successful over the first five years following initial outplanting, but have recently declined. Additional plants will not be added to the Pahole sites and efforts will be focused on the additional site in Kahanahaiki, as this area benefits from better threat control and improved habitat resulting from common native reintroductions.

The Keawapilau to West Makaleha is similar to the Kahanahaiki to Pahole PU in that the majority of individuals are found in just one population, PIL-B. However, this is an in situ population, in contrast to the reintro site in Kahanahaiki. While this population has only three mature plants, there are over 300 immature individuals present. The population structure has fluctuated over the years, but has never met the goal for number of mature plants. This site will be monitored for any major changes in the number of immature plants, as well as the number of individuals developing into mature plants. Augmentation to this site will likely be needed in the future, and will be determined following the next monitoring.

The proposed outplanting sites are designed to meet the stability goal for the minimum number of reproducing individuals, as currently no PU contains 100 reproducing individuals. Future outplantings in the southern Waianae Mountains should be considered, considering the plants were last observed there in the 1970's.

Table 7. Current and proposed outplantings of *S. obovata* to meet stabilization goal of 100 reproducing individuals per PU.

Manage for Stability Population Units	Reintroduction Site(s)	Total Plants to be planted	Propagule Type	Propagule Population(s) Source	Plant Size	Year 2018-2019 # of plants	Year 2019-2020 # of plants	Year 2020 2021 # of plants
Kahanahaiki to Pahole	MMR-G	80	Immature plants	MMR-A	>10cm	0	40	40
Kahanahaiki to Pahole	MMR-I*	350	Immature plants	PAH-A	>10cm	100	150	100
Makaha	MAK-B*	350	Immature plants	Mixed source	>10cm	100	150	100
The propagule type for each planting will be immature plants grown from seeds collected from wild or outplanted plants. An asterisk (*) indicates outplantings that have not yet been initiated.								

Monitoring Plan

All extant *in situ* sites (LEH-A, LEH-B, PIL-B) will be monitored annually using the Hawaii Rare Plant Restoration Group (HRPRG) Monitoring Form to record population structure and the age class, reproductive status and vigor of all known plants. The sites will be searched for new seedlings and all new juvenile plants will be tagged as long as the health and safety of the plants and the site are not jeopardized. This monitoring data will serve to document the populations at the remaining sites to guide *in situ* threat management and genetic storage needs as these sites decline.

The managed reintroduction sites in all PUs will be monitored annually in the winter (January-March) using the HRPRG form to record population structure, age class, reproductive status and vigor. All outplants will be accounted for along with a total population census. Monitoring data will be updated to determine if replacement into mature class size is occurring and at what rate. This data will be used to guide future outplanting. The ratio of the total number of mature recruits over the total number of plants outplanted will be used to guide the number of outplants needed to establish 100 mature recruits.

Threats: The primary threat to *S. obovata* that were known at the time the Makua Implementation Plan (MIP) was finalized (2003) included feral pigs. All populations are currently in ungulate-free fenced areas, which are monitored for damage from treefall and potential ungulate ingress under fences due to erosion. Predation of plants and seedlings by rodents and slugs has been documented, and have had a negative effect on seedling survival and plant development. Rats are known to eat maturing fruit and slugs have been seen on seedlings. Rat and slug control has been initiated in many populations where native snails are absent, however, an increase in seedlings was not observed compared to sites not currently controlled for slugs. Various alien plant species threaten *S. obovata* by altering its habitat and competing with it for sunlight, moisture, nutrients, and growing space. Weed control is essential to improve habitat quality, which is beneficial to maintain reproducing populations and continued recruitment of immature plants. Fungal pathogens are not currently an issue with this species but should be noted if observed during annual monitoring. Selection of outplanting sites will be prioritized to include areas with current rat control and the absence of rare snails, so slug control can be implemented.

Genetic Storage Plan

Besides collections of fruit made for genetic storage and propagation, all other fruit has been left to mature on the plants. Fruit not eaten by rats was left to senesce and fall below the plants where germination has been observed. Fruit at some PUs have been hand-dispersed by OANRP staff while conducting work in the area via smearing fruits across various substrates, although results from these informal trials were limited to a few seedlings, and it was unclear if these were from fruit smears or natural germination of fruit falling to the ground. Conducting a formal trial using fruit smears will be beneficial to determine strategies for seedling recruitment.

Table 8. Action plan for maintaining genetic storage representation, and providing propagules for reintroductions

Propagule type used for meeting genetic storage goal	Source for propagules	Genetic Storage Method used to meet the goal	Proposed re-collection interval for seed storage	Seed storage testing ongoing	Plan for maintaining genetic storage
Seeds	Reintroductions	Seed Storage: -18C / 20% RH	≥20 years†	Yes	Single-source and Mixed Reintroductions
†Seeds in storage of this species have not shown a decline in viability. The viability tests are conducted every five years. Re-collection intervals will continually be extended until a decline in viability is detected.					

Future Management Considerations

All three PUs do not currently meet the MIP goals for minimum reproducing individuals. While at least one site in the Kahanahaiki to Pahole PU, as well as two sites in the Keawapilau to West Makaleha PU have over 100 immature plants, new outplanting sites near the current best performing sites will be established within these PUs. The effects of extreme weather events, fires, and long drought periods make individual sites susceptible to be being wiped out, while having plants spread across multiple sites within a PU give the species a better chance for long term survival.

In past years, recruitment following initial outplanting had been encouraging. However, more recently these recruits have failed to develop into mature plants and replenish the seed bank. This has led to decreases in both the mature and immature plant totals. The primary strategy for this taxon, in addition to outplanting, will be to focus on improving habitat through weed control, common outplantings, and threat control of rats and slugs. As recruitment has been sporadic for populations of *S. obovata*, and seedling survival limited, continued outplantings to maintain stable population numbers will be focused on two new sites where threat control and habitat improvement has already begun.

As all PUs currently meet the genetic storage requirement 100%. Collecting fruit from reintroduction sites will only be required as seed storage interval testing determines when seed collections expire. Makaha PU will require a new reintroduction in order to achieve goals for mature plant numbers. Survival and the development of immature plants to maturity will determine the timeline for outplanting sites in the

Keawapilau to West Makaleha and Kahanahaiki to Pahole PUs. Management efforts will also include monitoring as well as the feasibility of adding molluscicide to populations that do not show improved recruitment. OANRP will use results from *in situ* monitoring and current outplanting sites to finalize timeline, stock, and locations for future reintroductions. An assessment of plant growth and vigor will be used to determine if mixed stock outplantings are equally represented by each founder, or if founders from certain PUs show higher survival in each outplanting site. In order to establish reintroduction sites that become stable, the following should be considered to improve plant survival and reproduction:

Habitat site selection (large scale and micro-site locations): OANRP proposes selecting a new introduction site for the Makaha PU. Habitat and micro-site conditions with native understory that promote recruitment and stage class transitions to immature and mature plants should be prioritized. New outplanting sites should take into account the effects of fire risk, as well as weed control strategies, for long-term survival and reproduction. Potential habitat in the Southern Waianae Mountains should be considered for future outplanting sites as well.

Pollination and dispersal: OANRP could conduct pollinator observations using game cameras to determine what is potentially pollinating *S. obovata*, if certain sites have more visitation by pollinators than others, or if areas have more potential pollinators than others. Fruit set in most populations seems to be adequate for reproduction, given the high amount of seed per propagule, so perhaps focusing on rodent and slug control should be prioritized instead.

Threat Control: OANRP will focus on establishing outplanting sites in areas where threat control methods for rodents and slugs are implemented, and native snails are not present. A24 automatic rat traps have been an improvement in some areas as they require far less labor than previously used snap traps. All outplantings are contained in fences to control ungulates, have weed and rat control, and some receive slug control if rare native snails are not present. Increased rat control grids directly around outplanting sites may be necessary if natural recruitment and goals for population structure are not met.

References

Bialic-Murphy L and O.G. Gaoue. 2018. Low inter-annual precipitation has a greater negative effect than seedling herbivory on the population dynamics of a short-lived herb, *Schiedea obovata*. Ecology and Evolution **8**:176-184.

Ellshoff, Z. E., J. M. Yoshioka, J. E. Canfield, and D. R. Herbst. 1991. Endangered and threatened wildlife and plants; determination of endangered status for 26 plants from the Waianae Mountains, Island of Oahu, Hawaii. Federal Register **56**:55770-55786.

Giambelluca, T.W., Q. Chen, A. Frazier, J.Price, Y.L. Chen, P.S. Chen, J. Eischeid, and D. Delparte. 2011. The Rainfall Atlas of Hawaii. http://rainfall.geography.hawaii.edu. University of Hawaii, Honolulu.

Makua Implementation Team (MIT). 2003. Final Makua Implementation Plan. Prepared for the U.S. Army Garrison, Schofield Barracks, HI.

PRISM. 2018. Prism Climate Group. Oregon State University. http//prism.oregonstate.edu.

Wagner, W. L., S. G. Weller, and A. K. Sakai. 2005. Monograph of Schiedea (Caryophyllaceae - Alsinoideae. Systematic Botany Monographs **72**:1-169.

Weller, S. G., A. K. Sakai, A. E. Rankin, A. Golonka, B. Kutcher, and K. E. Ashby. 1998. Dioecy and the evolution of pollination systems in *Schiedea* and *Alsinidendron* (Caryophyllaceae: Alsinoideae) in the Hawaiian Islands. American Journal of Botany **85**:1377-1388.

Weisenberger, L. A. 2012. Inbreeding depression, outbreeding depression and heterosis in rare species in the genus Schiedea (Caryophyllaceae) on O`ahu. University of Hawai'i at Manoa, Honolulu.