

Native Plant Propagation
Midway Atoll National Wildlife Refuge

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I. Introduction

The purpose of this report is to provide effective and efficient ways of propagating native Hawaiian plants for future out-planting. This report will provide guidelines for nursery maintenance, general propagating and out-planting techniques, and specific information on propagating and out-planting native plant species known from Midway Atoll. The following report is intended to assist in future restoration efforts.

Plant names and descriptions were taken from: *The Manuals of the Flowering Plants of Hawai'i* by Warren L. Wagner, Derral R. Herbst and S. H. Sohmer (1990); *In Gardens of Hawai'i* by Marie Neal (1965); *Flowers of the Pacific Island Seashore* by W. Arthur Whistler. Drawings and photos were taken from: *The Manuals of the Flowering Plants of Hawai'i* by Warren L. Wagner, Derral R. Herbst and S. H. Sohmer (1990) and from *Plants of Midway Atoll* by Nanette W. H. Seto (date unknown). Propagation techniques and general horticulture information was contributed by: the authors, Kim Martz and Forest Starr; Richard Nakagawa, nursery manager, State Department of Land and Natural Resources on Maui; and Anna Palomino, nursery manager, Ho'olawa Farms Native Plants Nursery on Maui. Information was also gathered from: *Growing Native Hawaiian Plants* by Heidi Leianuenue Bornhorst (1996); *Propagation Techniques for Native Hawaiian plants* by Lilleeng-Rosenberger (date unknown); *Laysan Island Ecosystem Restoration Plan* by Marie Morin and Sheila Conant (1999); and *Plants of Midway Atoll* by Nanette W. H. Seto (date unknown). Distribution information was gathered from: *Report on a Botanical Survey of Midway Atoll, April 1-7, 1995* by Marie Bruegmann (1998) and from botanical surveys performed at Midway Atoll and other Northwestern Hawaiian Islands including French Frigate Shoals, Laysan, Lisianski, and Pearl and Hermes Atoll in 1999 by F. Starr and K. Martz.

The first section of this report will provide general information and guidelines for nursery maintenance. After this section, general propagation and out-planting methods are discussed. This section will be followed by one page descriptions of plants native to Midway Atoll. These descriptions include the plant's common name; scientific name; family; brief description; distribution in the world, Hawai'i, and Midway Atoll; potential out-planting sites; propagation and out-planting techniques; and information on pests and diseases. Attached are appendices which show illustrations of the native plants described in the species treatments, along with worksheets used to document relevant information concerning nursery, propagation and out-planting activities.

II. General Horticultural Information

The Fish and Wildlife Service nursery is located behind the Fish and Wildlife Service office. Organization, proper watering, and cleanliness are important factors to operating a successful nursery. Diseases and pests will have a tougher time establishing in a well kept environment. The following guidelines are given to help operate the nursery properly and efficiently.

Irrigation

Currently, the nursery's irrigation system is comprised of sprinkler heads which are manually operated. The sprinklers are misters and should be maintained so that they flow freely. Potted plants are watered daily, either in the morning or the evening. Cuttings like a very humid environment and need to be misted several times daily. In discussion are plans to lower the sprinkler heads to decrease drifting mist and deliver water to plants more efficiently. In addition, automatic timers would increase regularity and consistency of irrigation, decrease missed waterings, and decrease person hours spent on watering.

Potting Media

Potting media should be as sterile as possible and have excellent drainage when watered. The current mix is sand only. However, problems have been incurred and sterile potting media, such as Sunshine potting soil, will be used in a 2 to 1 or 3 to 1 potting soil to sand ratio in the future. Potting mix allows for better drainage, adds organic amendments, and resolves the problem of sand pouring out of pots.

Pests and Diseases

Pests and diseases can be prevented and controlled with diligence, cultural practices which reduce infestations, and overall cleanliness. Generally, healthy plants that are well cared for will be less susceptible to damage caused by diseases and pests. Plants should be in well drained potting media. Irrigation should work properly and plants should be watered regularly. Organic debris should be removed from the nursery, such as old leaves that have fallen or on the floor into pots, and disposed of properly. The following illustrates a few ways to combat some problems that occur in the nursery.

Mites: Mites are persistent, tiny red bugs that resemble spiders and live in a type of web under leaves. Mites have been observed infesting naupaka (*Scaevola sericea*). If the underside of the leaf looks dusty or webbed, the mites may already be there. They love dust but hate dampness. Turn your nozzle up and spray upward from the base of the plant to clean the underside of the foliage. Gently rub the leaves while power washing to help remove persistent mites. Increasing air flow around plants will also help to prevent mite infestations.

Aphids: Aphids are usually green or dark-colored and collect mainly on young growth and buds. Where they are very dense, put your hand behind the bud or branch to support it against the force of the water as you hose them off the plant: a little rubbing with your fingers will also help. Once on the ground, aphids rarely return to the plants. Aphids are often tended by ants. Decreasing the ant population will often lead to less aphids.

Plant eaters: Some damaging insects that can not be hosed off nursery plants can be rubbed off, squashed between your fingers, or picked off and discarded.

Other ways of combating pests and diseases include spraying plants with a soapy water solution. Be sure to rinse soapy solution off plants after a few hours. Sticky traps can be used to catch flying insects. Row covers physically prevent insects and birds from landing on plants. Currently, the nursery has several openings where pests can easily enter. There are plans to screen in the nursery to keep out critters such as beetles and canaries. Healthy plants and a clean environment are the best ways to prevent and control damage from pests and diseases.

Labeling

Plants in the nursery should be labeled properly to provide historical information about the plants. Labels should include the plant's name, either common, scientific, or both is best; date that the plant was collected and propagated; where the plant was collected; and method of propagation. It is not necessary to label every single plant. For a flat of plants in 3 ½" pots, label at least 3-4 plants. For plants in large pots, label the back row for the entire batch propagated on that particular date.

Documentation

Several worksheets exist to help keep track of relevant nursery activities. The information which is gathered will likely change over time as goals and needs change. Nursery activities that are currently documented include number of labor hours spent in the nursery, numbers of plants propagated, length of time from propagation to out-planting, and information relating to out-planting. Samples of these worksheets appear in the appendices of this report.

III. Propagation Techniques

Native plants can be propagated in several ways. Some methods of propagation include cuttings, seeds, digging up plants, and root divisions. Whatever method is used, plants should be collected in a manner that the main population is not injured or depleted beyond repair. Fresh material is best for propagation. Successful storage of plants and seeds varies. Viability at the end of any storage period is the result of the initial viability at harvest. Most dry seeds, such as 'emoloa (*Eragrostis variabilis*), can be stored at room temperature in a dry, shady, cool place. Pulp seeds, such as naupaka (*Scaevola sericea*), should be sown right away, but can be stored if first cleaned of their pulp. Cuttings can be stored overnight, but immediate propagation is best.

Seeds

Collecting seeds: Collect ripe or mature seeds from plants and place in zip-lock or plastic bags. Collect only what you need. Collect from plants that have a large enough seed source so that the habitat will not suffer from the collection. Seeds should be cleaned before they are sown.

Cleaning dry seeds: To prepare dry seeds, such as 'emoloa (*Eragrostis variabilis*), leave seeds out or in a paper bag at room temperature to dry. Then, set a strainer over a bowl. Empty seed material into the strainer and gently rub so that the seeds fall through the strainer and the debris is left. Discard the debris.

Cleaning fleshy fruit: To prepare seeds from fruit that is fleshy or pulpy, such as naupaka (*Scaevola sericea*), use ripe seeds or ripen seeds in a plastic bag, ripe seeds are easier to clean and will yield better germination. Once ripe, put seeds in a bucket or bowl of water and gently separate seeds from pulp by mashing or massaging fruit. Pour off remaining water and pulp. Seeds are ready to be sown. If storing seeds, dry well before storage, and store in cool, dry place.

Cleaning dry seed capsules or bundles: To prepare seeds in capsules or bundles, manually separate seeds from their seed packets. Tools may sometimes be needed to pry or break seeds free from hard seed coats. Soak seeds in tap water 24 hours before sowing.

Soaking seeds: Seeds are sometimes soaked to provide speedy, even germination or to overcome dormancy. Water is absorbed by the dry seed which swells and may break its seed coat. Hot or cold water can be used, hotter water used for harder seeds. Soaking time can vary from a few minutes to several days, overnight with tap water is common soaking regime.

Propagating seeds: Once seeds are ready to be sown, prepare seed tray or pots with well drained potting mix. Seeds can be sown in pots or trays. Seed trays are preferred because they will allow for proper development of roots and easy up-potting. Wet down tray before sowing. Sow seeds evenly on tray or pots. A general rule of seed sowing is to sow them as deep, or up to 3 times as deep, as seed diameter. Alena (*Boerhavia repens*) is a small seed so it will only need to be sown just below the surface. Naupaka (*Scaevola sericea*) is a larger seed and would be sown deeper under the soil. Water well and evenly.

Transplanting seedlings: Seedlings will be ready to up-pot from trays when they have at least 2 sets of mature leaves. Use a pencil or your fingers to gently pry each seedling apart from others, try to touch or injure roots as little as possible. Arrange clean 3 ½ " pots in tray, 25 pots will fit in a tray. Currently, there are a few potting trays and some 3 ½ " pots, it is suggested that more be purchased and used in the future. This system allows for quick and efficient growth of plants and ease of moving large amounts of plants to out-planting sites. Fill pots with well drained potting mix about 1/3 full. Place

seedling in pot, one seedling per pot, fill remainder of pot with potting mix, plant should be planted at same level as it was in seed tray. Water well. Young plants will be ready to up-pot to gallon pots or be out-planted when they are at least twice as high as the pot and roots can be seen protruding from the bottom of the pot. Plants will be ready for out-planting in a few months to a year, depending on the species.

Sowing seeds directly to out-planting areas: Some plants can be directly seeded into out-planting areas. Seeds should be sown just before or during the rainy winter months to give the plants the highest chance of survival. This has worked well in the past with certain species in restoration efforts elsewhere. Some experiments have been done using this method on Midway and should be pursued further. Some species which may work well this way include: 'emoloa (*Eragrostis variabilis*), alena (*Boerhavia repens*), *Fimbristylis cymosa*, *Lepturus repens*, *Eragrostis paupera*, nohu (*Tribulus cistoides*), 'ena 'ena (*Gnaphalium sandwicense*), and others. Experiments should be done to evaluate the effectiveness of this method for all native species.

Cuttings

This propagation technique is a speedy way to multiply plants. Cuttings are essentially clones of the parent plant. Many plants native to Midway Atoll can be easily propagated from cuttings including, 'akulikuli (*Sesuvium portulacastrum*), alena (*Boerhavia repens*), pohuehue or beach morning glory (*Ipomoea pes-capre*), nohu (*Tribulus cistoides*), and others. Some species simply can not be propagated this way in which another method should be used. Length of time from propagation to out-planting will vary among species.

Collecting cuttings: For collection of native plants to propagate by cuttings, you will need: gloves, clippers, zip-lock or plastic garbage bag for collection, and some water. Collect plants from the site, taking care to take only what you need. Collect from areas that have a large enough population so that damage will be minimal. Gently pull or cut strands of plant from main patch. Place in trash bag or plastic bag. Add a small amount of water to bag and store in a dry, cool, shady area. Most plants can be stored this way over night, but immediate propagation is best.

Propagating cuttings: Work in a shady area once back in the nursery. Use clean 3 1/2" pots arranged in tray. Use well drained potting mix. Fill pots about 1/3 full. Cut plants into desired lengths, at least 3 nodes per strand (6-8 inches in length). Place about 3 strands in each pot. This is done because the success rate for cuttings is usually not 100% but more like 75-80% and so using a few strands per pot increases the likelihood that at least 1 strand per pot will be successful. Rooting hormone may be used for certain species while other species do not need it. Fill the rest of the pot with potting mix. Water daily. Cuttings need to be kept in a moist humid environment. In the nursery, this can be achieved by misting plants several times during the day to keep them moist. Plants will begin to develop roots as early as a couple weeks and will be ready for out-planting from 2-6 months, depending on the species.

Direct Stick

Another way to out-plant is the direct stick method. This method is harsh and should be done in areas where irrigation is available and with hearty species, such as 'akulikuli (*Sesuvium portulacastrum*), for best results. Experimentation should be done to see what other species can be out-planted in this manner.

Collecting direct stick: Collect and store plants as if propagating by cuttings.

Out-planting direct stick: Dig hole or trench. Cut plants into desired lengths, at least 3 nodes per strand (6-8 inches in length). Place plant strands into hole or trench. Fill in hole, leaving at least 1 node above ground, keep hole concave or like a basin so that rainfall will collect in hole. Water daily until plants are established.

Digging Out Plants

Plants can be dug out and moved to out-planting sites or put in pots for future out-planting. This method can be used for plants that are in areas that are about to be disturbed and the plants are in danger of being killed or in areas with dense growth of natives where taking plants will not be harmful to the site.

Collecting dug up plants: Dig out plant, try to retain as much root ball as possible. Place in pots, wheel barrow, or plastic bag with a small amount of water.

Moving dug up plants: Plants may be moved directly to out-planting site. Weed seeds may also come along with the plant, so the area will have to be monitored. At site, dig hole, it is best to cluster plants close together. Place plant in hole and fill in leaving hole concave or like a basin so that rainfall can collect in hole. Water well.

Potting dug up plants: Use clean 3 1/2" pots arranged in tray or larger pots depending on the size of the plant and root ball. Add potting mix to pots so that they are about 1/3 full. Place plants into pots. Fill the rest of the pot with potting mix. Water daily.

IV. Out-planting

Outplanting sites should be chosen carefully. On Sand Island, many sites on the coast, such as fuel farm, west beach, south beach, bulky dump, pavilion beach, frigate point, and rusty bucket, are good places to begin restoration. On Eastern, sites such as the east and north coastal areas are good places for restoration. The entire island of Spit is worthy of restoration. These areas should be focused on initially because they have the highest concentration of native plants on Midway Atoll. They provide a head start in restoration and the aid of harsh winds and salt blown from the ocean act as natural herbicides against

weeds which are not adapted to the environment. Furthermore, if these areas are ignored, there would be a loss of parent plant material needed for propagation in future restoration efforts. Restoration would then stem inland from these sites once they are well established. Restoration and outplanting should be focused to produce effective results. Sites should be monitored and photo points should be set up to keep track of restoration efforts. Focus in these areas should be to pull weeds away from existing native plants allowing them to expand and spread, to out-plant native plants, and to sow seeds of native plants. Other pristine atolls and islands in the Northwestern Hawaiian Archipelago can be used as examples or models to assist in composing vegetation communities during habitat restoration.

Irrigation is an important element in out-planting success. It is possible to time out-planting with winter rains, but winter can be inconsistent and this limits your out-planting time available and plants may die using this method. It is better to not rely on luck and have an irrigation system in place. The fuel farm is a good example. With established irrigation, planting is more successful and can occur at any time of the year. Also, other methods, such as direct stick, can be used there successfully. It may be possible to extend the irrigation from the fuel farm to pavilion beach for out-planting efforts there. Another irrigation possibilities include having large bladders with drip irrigation set up to plants. Live fire hydrants need to be identified. Further investigation is needed to evaluate practical and efficient ways of watering out-planting sites. Plants should be watered daily for at least 4-6 weeks or until plants are well established. In addition, automatic timers would increase the efficiency of restoration, decrease mortality due to missed waterings, and decrease person hours spent on watering. Without water, plants will most likely die. Plants that have time and money invested in them should not be out-planted without a practical irrigation plan.

Native plants can be encouraged to be used in landscaping. Native plants are naturally adapted to the environment here and require little attention once established. There are many grasses, shrubs, and groundcovers native to Midway that are well suited for landscaping.

Out-planting potted plants: Plants will be ready to be out-planted when they have established in the nursery. The time it will take for each species to be ready for out-planting varies depending on species and method of propagation. Only healthy plants should be out-planted. Store potted plants in shade at site until ready for out-planting. Dig holes at desired intervals. Plants can be planted tightly to create a ground cover along a sandy bank or can be intermixed with other native plants. Holes can be dug as close as ½ meter apart for a tighter planting. The closer plants are planted, the quicker the area will fill. Turn pot upside down over hole and gently tap to release plant. Gently pull plant out and place in hole. Fill in hole, do not fill higher than original surface of potting soil, keep hole concave or like a basin so that rainfall will collect in hole. Water daily until plants are established.

Other out-planting techniques: The direct stick method can be used in areas with irrigation. Sowing seeds directly to disturbed areas after weeding is often effective. This

should be done just before the winter rains so that seeds have the highest chance for germination and survival. Plants can be dug up and moved to out-planting areas.

IV. Species Treatments

The following section will describe native plant species known from Midway Atoll and techniques for propagating and out-planting them. Plants are arranged in alphabetic order by genus. For each plant the following information is included: common name, scientific name, family, distribution in the World, Hawai'i, and Midway Atoll, potential out-planting sites, propagating techniques, out-planting techniques, and pests and diseases. Illustrations of each plant are included in appendices. For definitions of scientific terms, see the glossary of: *The Manual of the Flowering Plants of Hawai'i* by Wagner et al. (1990).

Common name: 'Ae 'ae (Ni'ihau), bacopa, water hyssop

Scientific name: *Bacopa monnieri*

Family: Scrophulariaceae, Figwort family

Description: Prostrate succulent herb often forming dense mats. Leaves simple, opposite, blade oblanceolate, 1-2.5 cm long, sessile, surfaces glabrous. Flowers solitary in the leaf axils, with two linear bracts at the base. Calyx of 5 unequal, ovate overlapping sepals 5-9 mm long. Corolla campanulate, lavender to white, deeply 5-lobed, 6-10 mm long. Stamens 4. Ovary superior, stigma capitate. Fruit an ovoid to conical capsule 5-8 mm long.

Distribution: Indigenous to Hawai'i. Widespread in tropical and subtropical regions. In Hawai'i, occurring in coastal areas on mud flats, sand, bare calcareous sandstone, rocks, marshes, or shores of brackish streams, 0-230 m. Historically known from Midway Atoll but not observed there since 1933 by V. J. Meagher. Found on all of the main islands except Kaho'olawe. Now frequently cultivated in many places as a ground cover or water plant.

Potential out-planting sites: Out-plant near wet areas such as the edge of the dump pond on Sand Island. 'Ae 'ae is typically found in moist areas and can even grow directly in water. Any wet area would be a suitable site. It has also been widely cultivated to use in water or pond landscaping and also in fish tanks.

Propagation techniques: 'Ae 'ae is no longer known from Midway Atoll and would have to be shipped from the main islands. The best way to do this will need to be discussed. Whole plants in pots could be shipped, but it may not be wise to ship plants in dirt because of contaminants. Plant parts could be shipped, minimizing potential movement of pests or weeds in the dirt. Plants can be literally thrown in water and they will grow. Plants can be propagated similar to that of beach morning glory (*Ipomoea pes-caprae*) where cuttings are placed in water then out-planted once roots are well established (about 2 months). Propagation by cuttings in soil/pots will work as well.

Out-planting techniques: Out-plant healthy plants once roots have established. If planted close enough to the water or in wet areas, watering will be minimal.

Pests and diseases: None known.

Common name: Alena, anena (Ni'ihau), nena

Scientific name: *Boerhavia repens*

Family: Nyctaginaceae, Four-o'clock family

Description: Low slender herb with prostrate stems radiating from thickened taproot. Leaves simple, opposite, blade narrowly lanceolate to oblong. Flowers several, white to pink, in axillary cymes. Fruit club shaped, 1 seeded, surface sticky. The thickened tap root is reported to be a famine food in Samoa, Tonga, and other parts of Polynesia.

Distribution: Indigenous to Hawai'i. Alena is distributed from Africa to Hawai'i. In Hawai'i, occasional, probably formerly much more common, on shores and moderately dry coastal areas and leeward, at least semi-dry lower slopes, on Kure, Midway, and Pearl and Hermes Atolls, Lisianski, Laysan, French Frigate Shoals, and all of the main islands. Alena is presently common on all three islands of Midway Atoll. Alena can be collected from coastal sites or from any site where it is abundant. A convenient collection site on Sand Island is located between the fuel farm and the Pavilion bar. On Eastern, alena is abundant on the runway and just inland along the north beach.

Potential out-planting sites: Alena is one of the common coastal species found among the Northwestern Hawaiian Islands where it forms mats with other strand species such as Nohu (*Tribulus cistoides*) and pohuehue (*Ipomoea pes-capre*) along the coast and also inland. On Midway, Alena should be one of the main restoration species and be out-planted in coastal areas and at any restoration site on Midway. Plants form thick mats and help to keep out weeds. This purple flowered ground cover also makes a good landscaping plant.

Propagation Techniques: Alena is easily propagated from cuttings. No rooting hormone is necessary. Survival rate is about 75-80% and cutting should be ready for out-planting in 2-3 months. Alena can also be propagated from seeds. No preparation is necessary for seeds. Seeds germinate quickly and viability is high.

Out-planting techniques: Potted plants and dug up plants can be out-planted. Plants should be watered daily for at least 4-6 weeks or until they are well established. With proper irrigation, plant mortality should be minimal. Some methods which may be successful which have not been tried yet include the direct stick method in areas with irrigation and sowing seeds directly to out-planting areas.

Pests and diseases: There is something which produces a stunted growth in plants, perhaps a scale or mold. This does not kill the plant and it may even be natural. However, avoid using these parts of plants for cuttings.

Common name: Maiapilo, pilo, pua pilo

Scientific name: *Capparis sandwichiana*

Family: Capparaceae, Caper family

Description: Woody, prostrate or low shrub up to 1 m in height. Leaves simple, alternate, blade somewhat fleshy, elliptic to ovate, 2-7 cm long, mostly rounded at both ends, petiole 1-4 cm long. Flowers solitary, opening after sunset, turning pink with age, on a pedicel 5-8 cm long. Corolla of 4 unequal, showy white petals 2.5-5 cm long. Stamens numerous, about 120-180, filaments 3-7 cm long, gynophore 1-1.5 cm long at anthesis, elongating to 5-6 cm long in fruit. Berries orange at maturity, seeds dark reddish brown to gray, embedded in foetid orange pulp.

Distribution: Endemic to Hawai'i. Scattered on coral, basaltic rocks, or in soil along the coast or somewhat inland, 0-100 m elevation. Historically known from Midway Atoll, Pearl and Hermes Atoll, and Laysan, but thought to be extirpated from these locations today. On all of the main islands. On Midway, Maiapilo was known from Eastern Island where it was last collected in 1923 by E. L. Caum in the central plain of the island.

Potential out-planting sites: Inland or near coast on any of the three islands of Midway Atoll. This shrub with its night blooming and intensely sweet smelling flowers would make an excellent landscaping plant as well.

Propagation techniques: Because it no longer occurs in the Northwestern Hawaiian Islands, seeds will have to be obtained from the main islands where Maiapilo is also declining due to loss of habitat. It is locally abundant in rocky, lava, coastal sites of the main islands. It would have to be decided whether seeds should be cleaned before shipping, which would decrease potential introduction of invertebrates, or if fruit should be shipped whole, which would allow seeds to retain moisture during shipping. . Maiapilo is somewhat tough to grow, but has been grown from seeds and cuttings in the past. For propagation by seeds, pick the fruits when ripe (soft, orange, and pulpy). Immature seeds will not germinate. Clean seeds as described for pulpy fruit. Pretreat seeds with a 24 hour soak in cold water. Seeds do not store, sow immediately. Seeds sprout in about 1 month and are ready to out-plant in about 1 year. Follow general guidelines for propagation by cuttings.

Out-planting techniques: Out-plant healthy plants from the nursery and water daily until plants are well established. Maiapilo is listed as vulnerable, so care should be taken in seed collection, propagation and out-planting of this species.

Pests and diseases: Leaves are mined by native *Plutella* moths on the main islands and it is suspected the alien diamond back moth (*Plutella xylostemma*) here on Midway would also mine leaves, however, plants usually survive. None others known.

Common name: 'Emoloa, Kawelu, kalamalo, bunch grass

Scientific name: *Eragrostis variabilis*

Family: Poaceae, Grass family

Description: Tufted perennial grass usually 4-8 dm tall or taller. Blades usually flat near base up to 50 cm long and ca. 1 cm wide. Panicles narrow, up to 40 cm long, somewhat open or dense and spike-like. Fruit dark reddish brown, ellipsoid to ovoid, .8-1.2 mm long.

Distribution: Endemic to Hawai'i. Occurring on sand dunes, grasslands, open sites, dry forest, and exposed slopes and ridges or cliffs, 0-1,130 m. Known from Kure, Midway, Pearl and Hermes Atolls, Lisianski, Laysan, Nihoa, and all of the main islands. 'Emoloa is currently one of the dominant species on Laysan, Lisianski, and Pearl and Hermes Atoll where it is widely used by seabirds for nesting and foraging. In 1923, Christophersen and Caum reported that 'emoloa was fairly abundant on the eastern-central plain of Sand Island, Midway Atoll. By 1995, Bruegmann reported observing only a small population in the sand dunes by Frigate Point. Since then, seeds have been collected from Laysan, propagated and out-planted on both Sand and Eastern Islands. The small population of plants known from Midway at Frigate Point still exist today and it is suggested that seeds from these plants be propagated and planted in the future to keep the Midway genetics alive. There is currently no 'emoloa on Spit Island.

Potential out-planting sites: On other Northwestern Hawaiian Islands such as Laysan, Lisianski, and Pearl and Hermes Atoll, large bands or fields are usually found beginning at the crest of the dunes extending inland. On Midway Atoll, 'emoloa can be planted in similar habitats. 'Emoloa also makes an attractive accent plant in the garden.

Propagation techniques: 'Emoloa is easily propagated from seeds. Follow dry seed procedures for propagation. Incorporate Midway seeds for future propagation. Seeds take 10-14 days to germinate. Follow general guidelines for up potting. Plants will be ready for out-planting in 4-6 months. Mortality is minimal.

Out-planting techniques: Out-plant potted plants. 'Emoloa can also be dug up or split by root divisions from one area and out-planted to another, this has worked well in the past. Trials have shown that sowing seeds directly to restoration sites can be successful. 'Emoloa is extremely hardy and very little mortality has been witnessed. Water plants daily for 2-4 weeks or until well established. Planting during the rainy season has been successful.

Pests and diseases: Aphids have been observed on plants in the nursery. They can be removed by power washing and rubbing them off by hand.

Common name: Eragrostis, native bunch grass

Scientific name: *Eragrostis paupera*

Family: Poaceae, Grass family

Description: Perennials; culms densely tufted, tough, stiff, strictly erect, up to 2 dm tall, sharply scabrous, almost completely covered by leaf sheaths. Blades up to 5 cm long, but usually shorter. Inflorescences paniculate, weakly branched; spikelets few to ca. 40, straight, 5-45 mm long, flattened, 1-2 mm wide. Caryopsis golden brown somewhat flattened, subglobose to ovoid, .5-.8 mm long, .4-.5 mm wide.

Distribution: Indigenous to Hawai'i. Native to the Pacific equatorial region. In Hawai'i, occurring in coastal sites on coral sand, gravel and saline flats, sometimes as a pioneer species, on Kure, Midway and Pearl and Hermes atolls, French Frigate Shoals, and formerly at Barber's Point, O'ahu. On Midway, most abundant on Spit Island. One small patch located in dirt/coral roads leading from runway to dump on Sand Island as of 1999. None found on Eastern Island in 1999 but listed as occasional from there in 1995. Found at the high-tide mark of most Northwestern Hawaiian Islands mixed with *Lepturus repens*.

Potential out-planting sites: Any coastal site near the high-tide mark where adequate watering could be done. The fuel farm may be a good place to start.

Propagation techniques: Because of the limited abundance of this plant, care should be taken in propagation. Not much propagation of this species has been done, but should be done in the future to ensure the survival of this species on Midway Atoll. Propagate plants from seeds. Viability percentage and length of time for germination is not known. Follow dry seed propagation guidelines.

Out-planting techniques: Out-plant healthy plants from nursery to out-planting site. Water daily until plants are well established.

Pests and diseases: None known.

Common name: Mau'u 'aki 'aki (Ni'ihau), button sedge

Scientific name: *Fimbristylis cymosa*

Family: Cyperaceae, Sedge family

Description: Densely tufted sedge up to 30 cm in height. Culms erect, base covered with leaf sheaths and their remains. Leaves linear, stiff, mostly 2-12 cm long, 1-3 mm wide, glabrous. Flowers in heads 7-15 mm in diameter, or open corymbs 3-5 cm long. Spikelets brown, oblong, 3-6 mm long, many flowered. Stamens 3. Fruit an obovoid, 3-angled achene .5-1 mm long.

Distribution: Indigenous to Hawai'i. Common on sandy beaches and in shallow sand or soil on and among rocks and cracks in lava, widely distributed in coastal areas across the Pacific Basin including Australia, western Malesia, Pacific islands, and the Neotropics. In Hawai'i, occurring from 0-60 m elevation, on Kure and Midway Atolls, Laysan, French Frigate Shoals, and documented from all of the main islands except Kaho'olawe. On Midway, plants are abundant on runways of both Sand and Eastern Islands and along rubbly and sandy shorelines of all three islands (Sand, Spit, and Eastern).

Potential out-planting sites: Along shorelines or inland in coral rubble or sand. Seems to like compacted substrates and even grows in cracks in the runway.

Propagation techniques: Plants can be grown from seed following the dry seed propagation guidelines. Button sedge may be tough to transplant, however. It may be possible to sow seeds directly to out-planting sites.

Out-planting techniques: Out-plant healthy plants from nursery. As mentioned above, plants sometimes do not transplant easily and sowing seeds directly to out-planting sites may be best. Further experimentation is needed.

Pests and diseases: None known.

Common name: 'Ena 'ena

Scientific name: *Pseudognaphalium [Gnaphalium] sandwicense sandwicense*

Family: Asteraceae, Sunflower family

Description: Perennial herb with woolly, erect to prostrate stems 10-60 cm long. Leaves simple, alternate, mostly 1-7 cm long, sessile, surfaces densely woolly. Flowers in terminal, clusters of heads, each 2-3 mm long and surrounded by many overlapping bracts. Ray florets absent. Disc florets 2-3 mm long, bisexual or female, yellow, 5 lobed. Fruit an oblong, brown achene less than 1 mm long.

Distribution: Endemic to Hawai'i. In Hawai'i, found on all the main islands except Kaho'olawe and also on Midway and Kure Atolls. It grows in dry places such as coastal sand dunes near sea level, and also inland on cinder or lava at up to 3000 m elevation. On Midway, 'ena ena can be found along the coast and occasionally inland often in dry consolidated sand. Especially dense near the coast at the fuel farm on Sand Island.

Potential out-planting sites: Along the coast or inland. 'Ena 'ena with its silvery foliage can also be used in landscaping.

Propagation techniques: 'Ena 'ena has been dug up from the fuel farm where it is abundant and placed into 3 ½ " pots in the nursery. Plants respond well and can be propagated in this manner to out-plant to other sites. Sparsely occurring along the north, west, and south coastal areas, these areas would lend themselves well to further out-planting of this endemic species. 'Ena 'ena can also be propagated from seeds. Use dry seed guidelines for propagation by seeds.

Out-planting techniques: Out-plant healthy potted plants from the nursery. Water plants daily for 2-4 weeks or until well established. Other methods not attempted yet that may work include directly sowing seeds to site.

Pests and diseases: None known.

Note: The drawing shown here depicts a different variety than that known from Midway Atoll, but is similar in appearance.

Common name: Koali 'awa, morning glory

Scientific name: *Ipomoea indica*

Family: Convolvulaceae, Morning glory family

Description: Vines; stems twining, herbaceous to somewhat woody near base, often more than 5 m long, many-branched, appressed pubescent to glabrate. Leaf blades membranous, broadly ovate, 5-9 cm long, densely pubescent, especially on lower surface, 3 lobed or entire, apex acuminate to obtuse, base cordate, petioles about as long as blades. Flowers 1 to few in cymes, these usually silky white pubescent, pedicels ca. 10 mm long; sepals herbaceous, lanceolate to ovate, 14-23 mm long; corolla blue or purple, rarely white, funnelform, 5-7 cm long, the limb 6-8 cm in diameter. Capsule brown, often 4 angled. Seeds 1-4, tan to dark brown, rounded, 4-5 mm long.

Distribution: Indigenous to Hawai'i. Pantropical. In Hawai'i, common in low elevation, dry, often disturbed areas, usually below 150-1,250 m elevation, on Kure and Midway Atolls, Lisianski, Laysan, Nihoa, and all of the main islands. On Midway Atoll, previously known from Sand and Eastern Islands, but not seen there in 1999.

Potential out-planting sites: Along the coast and inland. This viney, sometimes climbing, morning glory with heart shaped leaves also makes an attractive landscape plant.

Propagation techniques: This plant was not seen during the 1999 botanical inventory and may no longer exist on Midway Atoll or may return with winter rains. It is abundant on Lisianski, where it occurs in habitats similar to that of beach morning glory (*I. Pes-capre*) on other Northwestern Hawaiian Islands, twining with littoral species such as nohu (*Tribulus cistoides*) and alena (*Boerhavia repens*). Seeds could be sent from there for propagation on Midway. Plants also exist on the main islands, however, Lisianski is much closer and would have the most similar genetics, so attempts to acquire plants should be from Lisianski first.

Out-planting techniques: Out-plant seedlings once they have established (possibly 6 months to 1 year). It may be possible to sow seeds directly to out-planting sites.

Pests and diseases: None known.

Note: There is a similar species *Ipomoea purpurea* which has escaped from cultivation on Sand Island.

Common name: Pohuehue, beach morning glory

Scientific name: *Ipomoea pes-capre*

Family: Convolvulaceae, Morning glory family

Description: Trailing glabrous vine with purple stems, often rooting at the nodes, fleshy to nearly woody, from a thickened taproot. Leaves simple, alternate, blade fleshy, oblong to suborbicular, 3-10 cm long, notched at the tip, surfaces glabrous. Flowers solitary or occasionally in cymes, corolla pink to rose purple. Fruit an ovoid to subglobose capsule 12-17 mm long, containing 4 dark, ovoid, densely hairy seeds 6-10 mm long.

Distribution: Indigenous to Hawai'i. Pantropical, found on all the major high archipelagoes of Polynesia and all the low and high archipelagoes of Micronesia. It is one of the most abundant species on rocky and sandy beaches of high islands, sometimes forming almost pure stands, but is uncommon on atolls. On sandy beaches, its creeping stems extend almost down to the high-tide mark. In Hawai'i, occurring on beaches, occasionally inland, 0-460 m, on Midway Atoll, Lisianski, Laysan, French Frigate Shoals, Nihoa, and all of the main islands. On Midway Atoll, during the 1995 botanical inventory, pohuehue was listed as occasional from Sand Island only. Today, it is still occasional in coastal areas along south beach and inland near the runway. A small patch of it was found on the north-eastern corner of Eastern in 1999. It is also being used in landscaping.

Potential out-planting sites: Pohuehue is a common component of the coastal zone and can be planted in any restoration site, especially along the coast. It is a good binder for dunes and erosion areas. Its crawling habit and showy purple flowers lends it well to landscaping.

Propagation techniques: Pohuehue is easily propagated from cuttings. Cuttings can be propagated as the general guidelines suggest. It has also been successfully propagated by cuttings by placing strands about 50 cm long in buckets of water. Replace water in buckets weekly. Roots will begin to show in 2-3 weeks. Plants will be ready to out-plant in about 2 months. This method is the quickest, most efficient way to propagate pohuehue on Midway. For propagation by seed, follow the dry capsule seed guidelines. Seeds can be stored. Seeds can be cold soaked for 1-3 days before sowing. Germination time is 2-3 weeks. Seedlings will be ready to out-plant within a year.

Out-planting techniques: Out-plant potted plants or cuttings from buckets. Success of out-planting is higher when well irrigated. Water daily for 2-3 weeks or until well established. Some methods which may be successful are direct stick in areas with irrigation and sowing seeds directly to out-planting areas.

Pests and diseases: none known.

Common name: 'Anaunau, 'anounou, kunana, naunau, *Lepidium*

Scientific name: *Lepidium bidentatum* var. *o-waihiense*

Family: Brassicaceae, Mustard family

Description: Subshrubs 1.5-6 dm tall; stems ascending to weakly erect, herbaceous for most of their length, glabrate. Leaves thick and somewhat fleshy, obovate, rarely nearly linear, 3-12 cm long, 1-2 cm wide, margins usually coarsely serrate. Flowers in 1 to several terminal racemes, sepals green, margins white, stamens 6, as long or nearly as long as petals, each with a gland at base. Seeds reddish brown, 1.9-2.5 mm long, .8-1.3 mm wide.

Distribution: Indigenous to Hawai'i. Widely distributed from Hawai'i nearly throughout the south, central, and eastern Pacific islands and in New Caledonia. In Hawai'i, in coastal sites and low elevation, dry, steep, rocky slopes near the coast, 0-240 m, on Pearl and Hermes Atoll, Kure Atoll (not known if still present), extirpated from Midway Atoll and Laysan, on Kaua'i, O'ahu, Moloka'i, Lana'i, Maui, and Hawai'i. On Midway Atoll, historically known from Eastern Island and last collected there from a single colony located at the southeastern corner in 1980 by D. Herbst and W. Takeuchi. Previous collections were also made in the central plain of Eastern Island. In 1999, seeds were gathered from Pearl and Hermes Atoll where it is common in coastal sites on at least Southeast Island, Seal/Kittery, and North Island. This plant is becoming rare and seeds should be continued to be gathered from Pearl and Hermes Atoll and propagated for out-planting on Midway Atoll.

Potential out-planting site: In coastal sites near (above) the high-tide mark on any of the three islands on Midway Atoll.

Propagation techniques: 'Anaunau is easily propagated from seeds or cuttings. For propagation by seeds, follow guidelines for dry seed preparation. Seeds can be stored. No soaking is necessary. Surface sow seeds. Seeds will germinate in less than 1 month. Plants are fast growing and ready for planting in the ground in 6 months. For propagation by cuttings, any part of the plant can be used (tips, side branches). Remove all foliage. No rooting hormone is required. Place in Medium under mist.

Out-planting techniques: Out-plant healthy plants and water daily until well established. Although rare, 'anaunau is a hearty plant and sowing seeds directly to out-planting sites has been successful in the past on Maui.

Pests and diseases: None known.

Common name: *Lepturus*

Scientific name: *Lepturus repens*

Family: Poaceae, Grass family

Description: Tufted perennial grass. Culms up to 30 cm or more in height, creeping, rooting at nodes. Leaf blade linear, 3-14 cm long, glabrous. Flowers in narrow cylindrical spikes 5-15 cm long. Spikelets solitary, lanceolate in outline, mostly 7-10 mm long, embedded in cavities and falling attached to a cylindrical section of the jointed spike.

Distribution: Indigenous to Hawai'i. Native to the Mascarene Islands, Sri Lanka, Malaysia, northern Australia, and Polynesia. In Hawai'i, commonly occurring on coastal sands above the high-water mark, on Kure, Midway, and Pearl and Hermes Atolls Lisianski, Laysan, and French Frigate Shoals. *Lepturus* is widely distributed from the Mascarene Islands in the Indian Ocean to Eastern Polynesia, and occurs in nearly all the archipelagoes of Micronesia and Polynesia except the Marquesas and the main islands of Hawai'i. It is often the most abundant grass on rocky and sandy shores of atolls and high islands throughout the region, and only rarely grows very far inland. On Midway Atoll, occasionally occurring at the high-tide mark on all islands in the atoll.

Potential out-planting sites: Along the coast, at the high-tide mark. It is a stabilizer of sand dunes.

Propagation techniques: Plants can be propagated from seeds and root divisions. Follow general guidelines.

Out-planting techniques: Out-plant healthy potted plants. Water daily until well established. It may be possible to sow seeds directly to out-planting sites.

Pests and diseases: None known.

Common name: 'Ihi, portulaca

Scientific name: *Portulaca lutea*

Family: Portulacaceae, Purslane family

Description: Prostrate to ascending, succulent, perennial herb with a swollen tuberous root. Leaves simple, mostly alternate, blade ovate to suborbicular, mostly 5-30 mm long, surfaces glabrous. Flowers 1-3, in terminal, congested cymes. Calyx of 2 suborbicular sepals 7-9 mm long. Corolla of 5 yellow obovate petals 9-12 mm long. Stamens 18-50, yellow. Fruit an ovoid capsule 6-8 mm long, opening by means of a cap that splits off to release the numerous, tiny, shiny black seeds. Easily confuse with the alien species, *Portulaca oleraceae* and also forms hybrids with this species as well. *P. lutea* can be distinguished from *P. oleraceae* and the hybrid by the size of the flower and number of stamens. *P. oleraceae* will have older stems without secondary growth; stamens 7-10(-15); capsules ca. 4 mm long. As compared to *P. lutea* with older stems with a thin, pale, corky layer of secondary growth; stamens (-12) 18-55; capsules 7-9 mm long. The hybrid is somewhere in between. Care needs to be taken when distinguishing the three but it is possible.

Distribution: Indigenous to Hawai'i. Widespread in the Pacific from New Caledonia to Pitcairn Island north to Polynesia and Micronesia. In Hawai'i, occurring in coastal and strand habitats, 0-40 m, on lava, raised coralline reef, sand dunes, and in soil pockets or cracks, on all of the Northwestern Hawaiian Islands except Kure Atoll and Pearl and Hermes Atoll, and windward, occasionally leeward coasts of O'ahu, Moloka'i, Lana'i, Maui, and Hawai'i. On Midway, *P. lutea*, *P. oleraceae*, and the hybrid have been observed. Often flowers were not observed on plants and were indistinguishable.

Potential out-planting sites: Along the coast or inland. With its prostrate habit and pretty yellow flowers, *P. lutea* makes an attractive gardening plant.

Propagation techniques: Propagating this species is a bit of a can of worms, due to the presence of the alien *P. oleraceae* and the hybridization of the two. It needs to be decided whether or not to tackle this problem and propagate the native species. If so, plants will need to be positively identified, then cuttings will be the appropriate way to propagate the plant. Propagation by seeds can not be done because of the hybridization problem. It is easily propagated by cuttings. Mortality is minimal. Plants will be ready to out-plant in a few months.

Out-planting techniques: Out-plant healthy plants from the nursery. Water daily until well established.

Pests and diseases: None known.

Common name: *Pycreus*

Scientific name: *Pycreus polystachyos*

Family: Cyperaceae, Sedge family

Description: Slender annuals or in favorable conditions apparently becoming short-lived perennials, tufted with fibrous roots or in favorable conditions developing a short rhizome; culms stiffly erect, 20-50 cm tall. Leaves few, basal, sub-rigid, linear, much shorter than or longer than the culm, 1.5-3 mm wide. Inflorescences open, forming umbelliform corymb, with 2-7 rays 2-6 cm long. Involucral bracts 3-5 spreading, usually surpassing the inflorescence, the longest one up to 30 cm long; spikelets yellowish brown to pale or dark reddish brown, numerous, 8-40 flowered.

Distribution: Indigenous to Hawai'i. Native to tropical and subtropical regions worldwide. In Hawai'i, common on open or grassy, often disturbed areas, from mesic coastal sites to mesic and wet forest, 0-1,420 m, on Midway Atoll and documented from all the main islands except Kaho'olawe. On Midway Atoll, *Pycreus* can be found in wet areas near the runway edge and the dump pond on Sand Island. Not found on Spit or Eastern Islands.

Potential out-planting sites: Any area with a moist substrate. *Pycreus* is an attractive sedge that would also make a nice accent plant in the garden.

Propagation techniques: *Pycreus* can be dug up from areas of dense concentration and moved to desired locations or held in the nursery for future out-planting. *Pycreus* can also be propagated from seeds following the dry seeds propagation guidelines. Viability and length of time for germination is uncertain.

Out-planting techniques: Out-plant healthy potted plants. It may also be possible to directly sow seeds to out-planting sites.

Pests and diseases: None known.

Note: The subspecies shown in the illustration is not the same as the one on Midway Atoll, however, it is similar in appearance.

Common name: Naupaka kahakai, naupaka

Scientific name: *Scaevola sericea*

Family: Goodeniaceae, Goodenia family

Description: Shrubs up to 3 m tall with leaf axils bearing a tuft of white hairs. Leaves simple, alternate, crowded at stem tips, blade somewhat fleshy, oblanceolate to suborbicular, 5-20 cm long, margins revolute, surfaces glossy, glabrous. Flowers several, in short axillary cymes 1-4 cm long. Corolla white to pale yellow, split along one side and 5 lobed, 1.5-2.3 cm long. Fruit a fleshy white drupe, 8-15 mm long. Fruit white, pulpy, with seeds beige, corky, and ridged.

Distribution: Indigenous to Hawai'i. Naupaka is distributed from India to Hawai'i, and is found on all the major archipelagoes of Polynesia and Micronesia. It is one of the most common littoral shrubs, often forming dense thickets on rocky and sandy coasts throughout the area. In Hawai'i, common in coastal sites throughout the Hawaiian archipelago, except on Gardner Pinnacles, Necker and Nihoa. On Midway Atoll, naupaka is common in coastal sites and some sites inland.

Potential out-planting sites: A prominent feature in dune systems, naupaka can be planted in almost any restoration site, especially along the coast. Many bird species nest in and under naupaka. It helps bind sand dunes and erosion areas. With its attractive half flowers, white berries, and soft foliage, it is often used in landscaping as a hedge or in clusters.

Propagation techniques: Naupaka is easily grown by cuttings, seeds, or digging up plants from areas of dense growth. The quickest and easiest way to propagate is by digging up plants. Follow the general guidelines. For cuttings, choose use stems that are at least 1 cm in diameter. Fairly large branches can be used, about 30-50 cm long or longer. Collect portions from young growth with at least 3 nodes. Rooting hormone can be used. Mortality should be minimal. Plants will be ready to out-plant in about 6 months. To propagate by seeds, follow guidelines for pulpy fruit propagation. Experiments have shown successful germination after soaking in salt water up to 250 days.

Out-planting techniques: Out-plant healthy plants from the nursery. Water plants daily for 3-4 weeks or until well established. Plants are more likely to survive if watered. Some methods that have not been tried yet are the direct stick method in areas with irrigation and sowing seeds directly to an area.

Pests and diseases: Spider mite infestations have occurred in the nursery. Infestations can be overcome by power washing of leaves and rubbing spider mites off persistently. Make sure plants have sufficient air flow and are getting enough water. Infestations have been overcome using these methods in the past in about a month, so be persistent.

Common name: 'Akulikuli, sea purslane

Scientific name: *Sesuvium portulacastrum*

Family: Aizoaceae, Fig-marigold family

Description: Prostrate succulent herb with red to green stems, rarely erect, often rooting at the nodes, fleshy, many-branched, glabrous, often forming dense mats. Leaves green, blade succulent, often becoming yellow or red with age, terete or flattened, linear, elliptic to narrowly obovate. Flowers solitary, pinkish purple, divided into 5 acute lobes. Fruit capsule containing numerous small black seeds.

Distribution: Indigenous to Hawai'i. Pantropical in distribution. In Hawai'i, 'akulikuli can be found in coastal habitats on Pearl and Hermes Atoll, Lisianski, Laysan, Necker, Midway Atoll, and all of the main islands. It grows well on rocky shores, sea cliffs, and in salt marshes, and is one of the most salt-tolerant of the littoral species; it grows in and dominates wave-splashed or saline habitats, where few other species can survive. 'Akulikuli was first collected from Midway Atoll during the 1995 botanical survey from Spit Island where it was described as rare in distribution. During the 1999 botanical survey, 'Akulikuli was listed as common to dominant on Spit Island and as rare on Eastern Island and Sand Island. On Spit Island 'akulikuli can be found and collected from most anywhere on the island and is particularly dense in areas adjacent to the salt pond. On Eastern Island, few plants can be found in coastal areas along south shore and one clump is located on northwest tip. On Sand Island, plants can be collected from the dump pond and there is one small patch on bulky dump.

Potential out-planting sites: 'Akulikuli can be used to bind sand on dunes and in areas of erosion. It can be out-planted at any restoration site at Midway Atoll. This striking red/green groundcover with purple flowers can be used in landscaping and tolerates extremely dry to wet conditions. Out-planting at the edge of the dump pond will increase the collection pool on Sand Island and provide good habitat for migratory birds. It forms dense mats and helps prevent invasion of weeds to out-planting areas.

Propagation Techniques: 'Akulikuli is easily propagated from cuttings. No rooting hormone is needed. Survival rate is close to 100%. Plants will be ready for out-planting from 2-6 months. 'Akulikuli can also be propagated directly to out-planting site by the direct stick method. This method works best in irrigated areas. 'Akulikuli can be propagated from seeds, however, cuttings are much quicker.

Out-planting Techniques: Out-planting can be done with the direct stick method described above or with established potted plants. 'Akulikuli is a hearty plant once established, but water is an essential part of out-planting success.

Pests and Diseases: Canaries and other pests such as beetles are suspected to nibble on 'akulikuli. It is best to keep the nursery screened in and free of pests. Otherwise, use row covers to keep pests off plants.

Common name: 'Ilima

Scientific name: *Sida fallax*

Family: Malvaceae, Mallow family

Description: Prostrate to erect shrub up to 1.5 m or more in height. Leaves simple, alternate, blade ovate to suborbicular, mostly 3-9 cm long, petiole about half as long, margins toothed, lower surface velvety pubescent. Flowers solitary, axillary, on a stalk up to 7 cm long in fruit. Calyx campanulate, 6-12 mm long, divided about halfway into 5 triangular lobes. Corolla rotate, pale orange, 8-15 mm long, divided into 5 broadly ovate petals unequally lobed at the tip. Stamens many. Fruit a schizocarp 2.5-4 mm long, splitting at maturity into 6-9 beaked segments.

Distribution: Indigenous to Hawai'i. Widespread on Pacific islands to China. In Hawai'i, occurring on rocky or sandy coasts or raised limestone reefs, also open arid lava fields and dry forest to diverse mesic forest and rarely low elevation wet forest, 0-1,980 m, on Midway Atoll, Nihoa and on all of the main islands. On Midway Atoll, only one small 'ilima plant was collected on Eastern Island by Christophersen and Caum during the Tanager Expedition in 1923. Another collection was made in 1983 by S. Conant on Sand Island at the west end of deserted housing. This plant has not been seen in recent surveys.

Potential out-planting sites: Any restoration site would be suited for 'ilima should it be decided that it should be propagated. It is also commonly used in landscaping, usually the prostrate form, as a groundcover. The pretty, delicate, orange-yellow flowers are used to make lei in Hawai'i.

Propagation techniques: This plant is no longer found on Midway Atoll, but is relatively abundant on the main islands. Material for propagation would have to be secured from any of the main islands. Plants are easily propagated from cuttings and seeds. For cuttings, follow general guidelines. Rooting hormone does increase the survival rate for cuttings. Plants can be out-planted in 4-6 months. For seeds, follow dry seed guidelines. Plants will readily germinate and be ready for out-planting in about a year.

Out-planting techniques: Out-plant healthy plants once established in the nursery. Water daily for 4-6 weeks or until well established.

Pests and diseases: None known.

Common name: Popolo, 'akia (Ni'ihau)

Scientific name: *Solanum nelsonii*

Family: Solanaceae, Nightshade family

Description: Sprawling or trailing shrubs up to 1 m tall, forming clumps up to 1.5 m in diameter. Leaves gray-green, densely pubescent, entire, alternate, broadly ovate to orbicular. Flowers lavender to pale purple. Berries 1-4 in clusters, usually black when mature. Four varieties of this plant are known throughout Hawai'i. Two varieties have been collected from Midway Atoll.

Distribution: Endemic to Hawai'i. Occurring from coastal sites up to 150 m in coral rubble to pure sand. Historically known from Kure, Midway, Pearl and Hermes Atolls, Laysan, Nihoa, Ni'ihau, Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i. Popolo is a federally listed species of concern and has declined dramatically in the Hawaiian islands. It is currently not known from many of the islands mentioned above. On Midway Atoll, popolo was presumed extinct, with a few recent observations, but no location information. It was last collected from Eastern Island in 1980 by D. Herbst and W. Takeuchi from a single plant located on the southeastern corner. It was seen again in 1996 by N. Seto. It was rediscovered on Spit Island during the 1999 plant inventory. A small population occurs there on the north-eastern shore. Fruit was collected and is currently being propagated. Fruit was also sent to Maui to be propagated at the Department of Land and Natural Resources nursery. Future out-plantings are planned to hopefully ensure the survival of this species.

Potential out-planting sites: Because popolo is so rare, it should be out-planted in sites where out-planting success is likely to be high. The fuel farm is a good candidate location because it has irrigation. Any coastal site would be suitable, as long as watering could be secured. To ensure the survival of this species, on going propagation and out-planting should be carefully continued.

Propagation techniques: Popolo is easily propagated from seeds and cuttings. Seeds are pulpy and should be cleaned accordingly. Seeds can be stored, if necessary. No soaking is necessary. Plant seeds about 1/8 " deep. Seeds germinate usually within a month. Seedlings will be ready to out-plant within a year. For cuttings, use green tip, 5-6 " in length, remove lower foliage, keeping tip and new leaves. No rooting hormone is necessary. Place in medium under mist. Cuttings will be ready to out-plant in about 6 months. Because of the rarity of this plant, extreme caution should be taken when collecting, propagating, and out-planting.

Out-planting techniques: Out-plant healthy plants once well established in the nursery. Out-plant to coastal sites where plants have a high chance of survival.

Pests and diseases: Row covers have been used as a precaution to prevent injury from canaries and other pests.

Common name: 'Aki 'aki, 'aki, mahiki, beach dropseed, seashore rushgrass

Scientific name: *Sporobolus virginicus*

Family: Poaceae, Grass family

Description: Erect, wiry perennial grass, spreading by extensive stiff, scaly rhizomes. Culms 5-50 cm in height, spreading by means of scaly underground rhizomes. Leaf blade linear, usually involute, mostly 3-12 cm long, sheaths overlapping, mostly glabrous. Ligule tiny, with a fringe of hairs about .5 mm long. Flowers in dense, narrow, cylindrical, spike-like panicles 2-9 cm long. Spikelets lanceolate in outline, laterally compressed, 2-3 mm long, acute-tipped, glabrous, 1 flowered.

Distribution: Indigenous to Hawai'i. Native to sandy, usually coastal sites in tropical and subtropical areas worldwide. In Hawai'i, common on coastal dunes and other coastal sites, from just above the high-tide mark, 0-15 m elevation. Historically known from Midway Atoll and Laysan but currently not known from there. Occurring on all of the main islands. On Midway, 'aki 'aki was collected in 1931 by D. R. Chisholm.

Potential out-planting sites: 'Aki 'aki should be planted along the coastal dunes where it stabilizes sand.

Propagation techniques: Plants grow in long runners and rhizomes and can be separated to make more plants. No seeds have ever been observed by the authors. Because plants are no longer found in the Northwestern Hawaiian Islands, plants will need to be shipped from the main islands. The best way to do this will need to be discussed. Whole plants in pots could be shipped, but it may not be wise to ship plants in dirt because of contaminants. Plant parts could be shipped, minimizing potential movement of pests or weeds in the dirt. Once plants are received, separate and plant in pots and store in nursery until they are healthy enough to out-plant. Seeds could be sent if found.

Out-planting techniques: Out-plant healthy plants from the nursery. Or, plants can be separated and planted directly to out-planting sites that have irrigation. Water daily for 6-8 weeks until plants are well established.

Pests and diseases: None known.

Common name: nohu, nohunohu, caltrop, puncture vine

Scientific name: *Tribulus cistoides*

Family: Zygophyllaceae, Creosote bush family

Description: Prostrate to ascending perennial herb with densely pubescent stems. Leaves opposite, 3-10 cm long, pinnately compound with leaflets 5-10 pairs. Blades oblong to elliptic, 8-24 mm long, silvery pubescent. Flowers fragrant, solitary, on a long, axillary pedicel, corolla yellow with 5 petals 15-20 mm long. Fruit a green spiny schizocarp of 5 sections, each of which bears two spines up to 8 mm long.

Distribution: Indigenous to Hawai'i. Native to the Old World, now pantropical and widespread in Polynesia and in Micronesia. It usually grows on sandy shores, but is occasionally found inland in open places at up to 400 m elevation. In Hawai'i, occurring in coastal habitats, 0-50 m, on all of the Northwestern Hawaiian Islands except Gardner Pinnacles and Necker, also on all of the main islands. One of the most common littoral species found on most of the Northwestern Hawaiian Islands. Many seabirds nest in or use nohu for nesting materials. On Sand Island, Midway, occurring occasionally in coastal sites along south beach, Frigate Point, and sparsely in areas inland. On Eastern Island, occasional throughout the island with dense mats just inland of naupaka hedges on the eastern end. On Spit, common throughout the island.

Potential out-planting sites: Nohu forms dense mats and prevents invasion of weed species. Nohu is usually found in mats along with other coastal species such as pohuehue (*Ipomoea pes-capre*) and alena (*Boerhavia repens*). Nohu can be planted at any restoration site, especially along the coast with these other species. With its fragrant yellow flowers and silvery foliage, it can be used in landscaping as a groundcover, though some people may be adverse to the spines on the fruit.

Propagation techniques: Easily propagated by cuttings. Success is usually around 75-80%. Roots will begin to form as early as 1-2 months and will be ready to out-plant in 4-6 months. Nohu can also be propagated from seeds, though this will take longer than cuttings. Follow dry seed capsules or bundles preparation methods. Viability is high.

Out-planting techniques: Out-plant healthy plants in pots from the nursery. Water plants daily for 2-4 weeks or until well established. Other out-planting techniques which have not been tried but may work include the direct stick method, if irrigation is available, and sowing seeds directly to out-planting site.

Pests and diseases: None known.

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Appendix

The following appendices show illustrations of the native plants described in species treatments. Also included are worksheets which are currently used to keep track of relevant information about the nursery, propagation and out-planting. These forms are likely to change over time as the needs and goals of management change.