Overview of Hawaiian Dry Forest Propagation Techniques

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1997

Introduction

Statewide, the rare Hawaiian dry forest ecosystem has been reduced to less than ten percent of its original extent, and restoration may be the only way to save it. Inspired by a desire to restore the Kanepu`u Dry Forest on Lana`i, The Nature Conservancy designed the "Hawaiian Dry Forest Propagation Survey" to compile and synthesize propagation information on Hawaiian dry forest species. In addition to the species native to the Kanepu`u Dry Forest, the survey was broadened to include related dry forest tree species in an attempt to make the results applicable to the broader restoration effort in Hawaii.

The Hawaiian Dry Forest Propagation Survey included the following materials: an overview survey of propagation techniques (Appendix I), a summary of previously-published propagation techniques for several individual species, and a "propagation tips" form requesting detailed information for each of 35 listed species (Appendix II). We were unable to include every knowledgeable person due to time and other constraints, and extend our apologies to those whom we failed to contact. Of 35 people who were sent the survey in 1996-7, 13 responded (Appendix III). The wealth of information they provided is summarized in this report. Special thanks for their substantial contributions are due to Bruce Koebele, Kerin Lilleeng-Rosenberger, Jeanine Lum, Richard Nakagawa, and Anna Palomino.

This report compiles knowledge and experience to date with growing species included in the Hawaiian Dry Forest Propagation Survey. The survey respondents suggested many other species (herbs, shrubs, subalpine types, etc.) that they had some experience with growing and that they felt should be included in the list. The information they provided on most of these additional species was insufficient to merit inclusion here; only *Caesalpinia kavaiensis* has been added to the original list. Ideally, this overview should some day be expanded to include all dry forest species; it currently focuses on the most common elements, especially those found on Lana`i. Perhaps one of our readers will be inspired to pick up where we left off and expand the document to include the further wealth of information that is available.

General Propagation Techniques for Dry Forest Species

Seed propagation is unpredictable: there are numerous variables to consider, and some cannot be controlled. In addition, many seedlings grow very slowly, requiring a great deal of patience and persistence on the part of the grower. What works for one person may not work for another, due in part to variations among the individual propagators styles, as well as to their nursery situations and capabilities. There is also enormous variation among seeds, available sunlight and moisture, soil type and fertility, etc. Recognizing this, the survey did not strive for absolutely consistent, quantifiable data; rather, it was designed to elicit the full range of individuals experiences.

Fortunately, there are some general propagation concepts and techniques, which, if understood, can be applied in individual situations. The tips below are compiled from the comments of several growers regarding their general experiences with growing dry forest species. Further information can be found in the references by Kenneth Boche, Heidi Bornhorst, and Kerin Lilleng-Rosenberger (Appendix IV).

Seeds (source, quality, fertility): A high rate of success depends largely on the use of *fresh*, *viable* seeds. For seed sources, select only plants that are growing well in the wild at the time. Choosing plants by flower quality or new traits alone can narrow the gene pool for a species. Timing of seed collection and sowing is also important, as is the detection and advance removal of nonviable seeds. There is much variability among the seeds themselves, even from the same source.

It is often helpful to open some seeds to assess the thickness of the seed coat or to determine their viability by verifying the presence of an embryo. (For example, some fruits, such as *Myoporum* and *Styphelia*, are mistaken for seeds. They are actually multi-seeded drupes, and may contain no seeds at all.) Flowering strategies (i.e., whether a plant is monoecious, dioecious, etc.) may also make a difference as to whether a particular plants flowers are pollinated efficiently or not.

Seed preparation: If time and resources permit, germination time can often be decreased with soaking and scarification (although no pretreatment may work fine, too). Soak for about 24 hours—less for small, thin seeds, more for large, thick seeds—in water that is 115-120º or 160-180ºF (opinions vary as to the optimal temperature, but boiling is usually too hot). Variability in seed coat thickness affects heat tolerance—the same temperature can work fine on one seed and kill another of the same species. Scarification can be done by any number of techniques, depending on seed size and the propagators ingenuity. When clipping and sanding, be careful with how much and where the seed is scarified, and don't scarify on or near the hilum.

The section below on **Individual Species Propagation Tips** describes a couple of fairly standard preparation methods for most species. The following is an alternative to these standard treatments that has worked very well for one grower:

> Sterilize the seeds in a 10-15% Clorox solution for 15-30 minutes, then rinse thoroughly with water (rinsing is optional). Plant seeds in a small tray (a bento or tofu container with holes drilled in the bottom works well) filled with horticultural-grade vermiculite. Cover seeds with a thin layer of green moss available at many garden shops (the green moss is believed to inhibit fungal growth). (A pinch of sulfite can also be added to further inhibit fungus.) Water thoroughly and cover with a clear container. Rewater periodically to keep the vermiculite and moss moist. When the seeds germinate, allow them to develop 1-2 sets of true leaves, then transfer to individual pots (2 square by 4 deep) containing a potting medium of 2 parts fine cinder, 1 part vermiculite, and 1 part new potting soil (commercial).

Because the seedlings are in pure vermiculite, transferring them seems to cause little root damage. Place a small amount of slow-release fertilizer on top of the medium in each pot.

Medium: The medium varies with the species, and there are many possibilities. Two standard media that work for most species are suggested in the **Individual Species Propagation Tips** below. Other growers suggest: 1) 1 part peat, 2 parts perlite, covered with screened cinder or fine grit depending on the size of the seed; 2) 1 bag perlite (cinder), 1 bag peat moss, bag sand; 3) 1 part perlite, 1 part Sunshine #5. Other comments: 1) vermiculite is the best sterile medium to use, but only for a short period of time, as it absorbs moisture and gets very soggy; 2) generally, cinder should be avoided in germinating mixes, as root injuries are heavy during transplanting; 3) cinder, if available (perlite can be substituted) can be used for up to 50-90% of the medium; also, cinder can be strained to produce different types of media—sometimes the size of the seed dictates the grade, as smaller seeds can be buried too deeply by large-sized particles.

Water and drainage: Good drainage and an appropriate watering regime are critical for germination of most dry forest species. The watering regime depends on the medium, the nursery location and situation (e.g., shaded greenhouse, full sun, wind, etc.), and the type and size of the container. It is probably better to have too much drainage and risk underwatering than the reverse. Uhiuhi, sandalwood, and lama can never have enough drainage. Drenching flats several times per week rather than daily seems to work best for dryland species, although opinions differ.

Sowing and transplanting: One grower suggests that, if time and resources permit, transplanting time can be saved by sowing seeds with faster germination times (1-2 months) and higher germination rates (50% and up) in individual containers. Others suggest that, because most seeds germinate over a long period of time, it is preferable to sow in flats and then transplant as soon as possible into containers (use a medium of 1:2:1 peat, perlite, and 1/8 screened black cinder), and continue to drench several times per week, making sure that adequate drying occurs between waterings. Once seedlings are established and putting on good growth, move them out to full sun, which seems to help build up stem thickness and lignify tissue. Adequate spacing between plants helps to minimize plant-to-plant contact and encourage air circulation, thus reducing disease problems.

Fertilization: Fertilize regularly when the plant is young, in a pot, and growing up, then moderately once it is planted in the ground. Add slow-release fertilizer at a low rate to all growing mixes and supplement with liquid fertilizer. Use a foliar fertilizer with equal formulation (15-16-17) plus micronutrients every other week at 100 ppm nitrogen. To supplement species with slower root development (*Caesalpinia, Colubrina, Santalum*), use a foliar fertilizer higher in phosphorus.

Storage: There are two standard techniques suggested throughout the **Individual Species Propagation Tips**.

Pests: Fungi and slugs are the biggest threats to seedlings.

Outplanting: If planting is being done to prevent erosion, choose plants that will establish themselves and grow quickly. Of the species on the list, the fastest growing are *Abutilon*, *Dodonaea*, *Myoporum*, *Sida*, and *Waltheria* (it might even be worthwhile to simply broadcast some of these seeds in the wild). The other species need a lot of hand-holding to get started.

Outplanting can be complex and controversial. Techniques will vary and must be adapted to the natural conditions—habitat, terrain, slope, soil conditions, etc. For the initial outplanting, a reliable water source is mandatory. In general, the best time to outplant is at the beginning of the winter rainy season—it can save resources, water, time, etc. Summer is generally not recommended, as many of these species just dont do much at this time, even if water is supplied. A berm and mulch (if possible) can also help to conserve water. Soil augmentation, even with poorly-drained and/or claylike soil, does not seem to benefit outplantings; native soil works best.

For at least one grower, the most serious outplanting problem is damage from the Chinese rose beetle (*Adoretus sinicus*). There is no effective deterrent or control.

Individual Species Propagation Tips

In the survey, usually only three or four people—sometimes just one or two—commented on their experiences with an individual species, or on a particular aspect of growing that species. In the summaries below, we have tried to capture the diversity of growers experiences, as well as consistency among them when it exists. When growers suggested alternative techniques, their descriptions have been separated by the word *or*. While these sometimes conflicting descriptions may be confusing, they also provide evidence that there is no absolute recipe for plant propagation. We hope that this compilation will provide some new tips and comparative experiences for those who are currently growing a species, as well as encouragement and techniques for those who want to start growing new ones. The tips for each species fall into five categories: **Propagation**, **Germination**, **Storage**, **Pests**, and **Notes**, as described below.

1. Propagation: includes seed preparation instructions, medium type and proportions, preferred containers for germinating and transplanting seeds, watering instructions and other suggestions for optimal germination, and suggestions for transplanting and fertilization.

2. Germination: time from planting to germination, and germination success rates.

3. Storage: techniques for cleaning and preparing seeds to induce dormancy for storage, as well as preferred containers and conditions.

4. Pests: those that affect seeds and seedlings.

5. Notes: other information that doesnt fall into the above categories.

Sometimes the instructions for propagation or storage call for standard seed-cleaning procedures. Kerin Lilleeng-Rosenberger suggests the following techniques:

Dry Seed Cleaning Procedure:
1. Leave seed material out or in a paper bag and air-dry at room temperature.
2. Set a strainer (choose hole size according to seed size) over a bowl.
3. Empty seed material into the strainer; carefully rub it so that the seeds fall through the container and the debris is left.
4. Discard the debris.

Fleshy/Pulpy Seed Cleaning Procedure:
1. Ripen seeds in a plastic bag. (Seeds are easier to clean when the pulp is softened.)
2. Once ripened, remove the flesh to prevent spoilage. One way that works best with large seeds is to use a colander or strainer placed under running water. (A concentrated stream can really help.) Rub seeds to dislodge the pulp. Another way is to put the seeds in a large bowl of water, and massage the seeds by hand to separate them from the pulp. The heavy (good) seeds will sink to the bottom. The lighter pulp and empty seeds will float to the top and can be poured off. (Note: this is true for the species specified. However, a floating seed does not always mean it is not viable; some seeds disperse by floating.)
3. Wash the seeds thoroughly.
4. Dry them on a paper towel.

Abutilon eremitopetalum (Hidden-petaled `ilima)
Abutilon menziesii (Ko`oloa`ula)

Propagation: Collect seed capsules after ripening, usually in a dry state, and spread in shade for further drying. Remove seed from capsules, soak 1-24 hours in tap or hot water until seeds sink, and discard floaters.

> 3:1 perlite #2, Sunshine Mix #4 or 1:1:1 peat, perlite, soil
> Plant 1/8" deep in shallow flats.
> Water every other day, keeping medium moist until germination. *or* Reduce water after emergence to prevent damping-off.
> Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth.
> Transplant into individual containers (3.5-4 square).

Germination: soaked seeds—2-4 weeks; unsoaked seeds—3-6 months; success high (95%). Use liquid fertilizer during this period.

Storage: Pry open capsules to release seeds (or shake or beat fruit in bag or other container to dislodge seeds). Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%). *or* Dry in shade, then put in sealed glass container and refrigerate.

Pests: Chinese rose beetle.

Notes: Grows easily from seeds or cuttings. Beware of hybrids if growing both *Abutilon* species.

Alphitonia ponderosa (Kauila)

Propagation: Black seeds have two coats. Use hammer to remove first coat, then clippers to remove second coat. Soak in tap water for 7 days; change every other day. Discard floaters. *or* Scarify and soak 24 hours; discard floaters. *or* Collect seeds from opened capsules; do not soak.

> 3:1 perlite #2, Sunshine Mix #4
> Plant seeds 1" apart in shallow flats.
> Water every other day, keeping medium moist until germination; avoid damping off.
> Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: soaked seeds—if scarified, 6 weeks to 3 months (10-50% success), otherwise, 3-6 months (10% success); unsoaked seeds—from opened capsules, 3 weeks to 8 months (7-30% success), otherwise, 9-12 months.

Storage: Can store with seed coats on or removed. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Notes: Very difficult to cut through hard fruit. Can also try a knife or cutting pliers.

Antidesma platyphyllum (Hame)

No information provided.

Bobea sandwicensis (`Ahakea)

Propagation: Remove pulp (two seeds/berry). If pulp is difficult to remove, soak one day in tap water. Best to use fresh seeds: just clean and sow.

3:1 perlite #2, Sunshine Mix #4 or 4:1 cinder, soil
Plant 1/8" deep in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area or in greenhouse (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 4 weeks to 3 months; success poor (10%).

Storage: Remove pulp and air-dry seeds. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Bonamia menziesii

Propagation: Grown easily from seed. Remove pulp and plant fresh seeds. or Scarify and soak 2 hours in 120º water. *or* Soak 24 hours in cold water.

3:1 perlite #2, Sunshine Mix #4 or 1:1:1 peat, perlite, soil or 4:1 cinder, soil
Plant 1/4" deep in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth. Can also plant in full sun.
Transplant into individual containers (3.5-4" square) after true leaves are fully formed.
Use liquid fertilizer at seedling stage.
Acclimate gradually to full sun; use slow-release fertilizer (14-14-14).

Germination: 2-4 weeks; success high.

Storage: Seeds are best started fresh. If necessary to store, remove pulp by hand or in strainer. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%). *or* Dry fruits in shade; large seeds can then be removed easily from dried capsules. Put in sealed glass container and refrigerate.

Notes: Can also be grown from cuttings, with difficulty. Plant in 100% cinder, keep in greenhouse, and do not mist.

Caesalpinia kavaiensis (Uhiuhi)

Propagation: Remove seeds from capsules. Scarify with clippers, file, or sandpaper on seed edge (away from tip where hilum and micropyle are located).

3:1 perlite #2, Sunshine Mix #4
Plant individual seeds 1/8" deep in 3" pots (does not transplant well).
Water every other day, keeping well-drained and on the dry side (susceptible to root rot).
Supplement with high-phosphorus foliar fertilizer to assist slow root development, and do not over-fertilize with nitrogen, even though the foliage may look pretty.

Germination: 5-7 days if seeds are healthy; success rate 100% with healthy seeds. Seeds with holes bored by beetles may rot and not germinate.

Storage: Remove from capsules. Air-dry at room temperature and store in paper envelope. Seeds can be desiccated and kept in refrigerator or freezer.

Pests: Beetles that bore holes in seeds; mealy bugs in root area (especially when root development is poor); ants.

Notes: May grow slowly after initial burst; occasionally tips die.

Charpentiera obovata (Papala)

Propagation: Follow Dry Seed Cleaning Procedure (dry seeds in paper bag). *or* Store without pretreatment.

3:1 perlite #2, Sunshine Mix #4 or 1:1:1 peat, perlite, soil
Sprinkle small seeds on medium in shallow flats.
Mist with fine spray, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth.
Transplant into individual containers (3.5-4" square).
Use liquid fertilizer at seedling stage.
Acclimate gradually to full sun; use slow-release fertilizer (14-14-14).

Germination: with pretreatment, 2 weeks to 1 month; without pretreatment, 8-16 weeks. High success.

Storage: Follow Dry Seed Cleaning Procedure (dry seeds in shade). Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%). or Dry panicles in sun or shade; small seeds can then be removed easily with fingers. Put in sealed glass container and refrigerate.

Cocculus trilobus (Huehue)

Propagation: Remove seeds from capsules. Soak 1 hour in tap water; discard floaters.

> 3:1 perlite #2, Sunshine Mix #4
> Plant seeds 1/8" deep in shallow flats.
> Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 1-3 months or more; poor success.

Storage: Remove seeds from capsules; keep dry. Dry at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Colubrina oppositifolia (Kauila)

Propagation: Remove seeds from capsules. Soak 3 days in tap water or scarify with clippers or file. or Soak in 170º water for 24 hours; discard floaters.

> 3:1 perlite #2, Sunshine Mix #4 or 4:1 cinder, soil
> Plant in shallow flats.
> Water every other day, keeping medium moist until germination.
> Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: soaked seeds—2 weeks to 2 months (scarified seeds germinate 5 days sooner), 65% success (40% if soaked in 170º water); unsoaked seeds—3 weeks to 3 months, 40% success.

Storage: Remove seeds from capsules; keep dry. Do not soak or scarify, just put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Notes: Has slow root development so use a high-phosphorus foliar fertilizer.

Diospyros sandwicensis (Lama)

Propagation: Grown easily from seed. Follow Fleshy/Pulpy Seed Cleaning Procedure to remove fleshy orange pulp from light brown seeds. Seeds can be started fresh with no pretreatment, or can be soaked overnight in warm or tap water.

3:1 perlite #2, Sunshine Mix #4 or 1:1:1 peat, perlite, soil
Plant 1/8" deep in shallow flats.
Water every other day, keeping medium moist until germination; good drainage is key.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth.
Transplant into individual containers (3.5-4" square) after first true leaves are fully formed.
Use liquid fertilizer at seedling stage.
Acclimate gradually to full sun; use slow-release fertilizer (14-14-14).

Germination: 25 days to 2 months; very good (50-90%) success, depending on seed viability at time of collection (or 8-16 weeks if soaked overnight; 50% success). (Scarification and soaking in hot water can decrease germination time from 3 months to 1 month; 60% success.)

Storage: Poor germination with dried seed; best to use fresh material. If necessary to store, remove pulp (soaking overnight helps to soften) and air-dry seeds. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Notes: Very slow growing—2-3" in 6 months.

Dodonaea viscosa (`A`ali`i)

Propagation: Remove seeds manually from paper capsules or follow Dry Seed Cleaning Procedure. Soaking can increase and speed germination, but may not be necessary with fresh seeds. Soak seeds for 4-24 hours in tap or hot water; discard floaters.

3:1 perlite #2, Sunshine Mix #4
Plant seeds 1/8" deep in shallow flats or put 2 seeds each in quart-sized gro-bags.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth. Full sun may be preferred, as too much water is not tolerated.
Transplant into individual containers (3.5-4" square) when seedlings have 2 sets of leaves, then to ground when 6-24 tall.

Germination: 1 week to 6 months; moderate to good success, 50% and up, depending on seed health at time of collection.

Storage: Remove seeds from paper capsules; air-dry at room temperature and keep dry. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: No pests of consequence; occasionally thrips in nursery.

Notes: Best grown from seeds, but can also use cuttings or air layers.

Erythrina sandwicensis (Wiliwili)

Propagation: Grown easily and rapidly from seeds. Remove large red to orange seeds from pods and soak in 120º water for 1 hour or more (only until they swell; seeds will rot if they take in too much water). Careful scarification with clippers or by sanding speeds up germination.

> 3:1 perlite #2, Sunshine Mix #4 or 4:1 cinder, soil
> Plant seeds just below surface, several per 6" pot, or one per 3" pot. The latter method results in less root damage when transplanting.
> Needs maximum sunshine and well-drained soils. Keep on the dry side; moisture encourages fungi and mites, and seeds rot easily.
> Slow release fertilizer (14-14-14) at half dosage is recommended.

Germination: 4-5 days with scarification; longer if not. Success high (90-100%).

Storage: Remove seeds from pods and keep dry. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%) or in refrigerator.

Pests: Chinese rose beetles and spider mites can be problems. Young plants are sometimes attacked by a leaf-eating caterpillar. Overwatering, too much shade, or the rainy season can bring powdery mildew to leaves. Mature plants have few pests.

Notes: Can also be grown from cuttings (2-6") and from air layers.

Gardenia brighamii (Nanu/Na`u)

Propagation: Follow Fleshy/Pulpy Seed Cleaning Procedure to remove seeds from fruit. Soak one hour in tap water, then sow. Best if sowed fresh.

> 3:1 perlite #2, Sunshine Mix #4
> Plant apart in shallow flats.
> Water every other day, keeping medium moist until germination; needs good drainage.
> Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 4-5 weeks, up to one year (longer if not soaked). Success very good if sowed fresh; if desiccated, fewer germinate.

Storage: Remove pulp, air-dry at room temperature (not in sun). Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Notes: Can also graft or air layer.

Kokia drynarioides (Koki`o)

Propagation: Grown easily from seed. Remove brown hairy seeds from capsules, and manually remove some of the hair to reveal a smooth seed coat. Nick seed coat with clipper and sow. Can also soak 4 hours or overnight in 120º water.

> 3:1 perlite #2, Sunshine Mix #4 or 1:1:1 peat, perlite, soil
> Plant seeds 1/8" deep in shallow flats or individual 3" containers to reduce transplant root disturbance.
> Water every other day, keeping medium moist until germination. Reduce water after emergence to prevent damping-off. Needs good drainage.
> Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth.
> If planted in flats, transplant to individual containers as soon as first true leaves are fully formed.
> Use liquid fertilizer at seedling stage.

Germination: 10 days if scarified; 100% success if seeds are good (or 1 week to several months, with 50-65% success, if scarified and soaked).

Storage: Seeds store well. Remove seeds from capsules; air-dry at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%). or Dry in shade; put in sealed glass container and refrigerate.

Pests: Aphids love this plants—need to control ants. Chinese rose beetles also seem to cause some damage.

Notes: Can also graft or air layer.

Metrosideros polymorpha (`Ohi`a)

Propagation: Grown easily from seeds. Best to plant fresh seeds as soon as possible. Collect seed capsules when brown; place in paper bag or envelope; let dry. Dust-like seeds will fall out of open seed capsules. No further treatment is necessary.

3:1 perlite #2, Sunshine Mix #4 or black cinder or 1:1 potting mix, fine grade cinder or sterile potting soil
Sprinkle seeds onto firm, moist medium in shallow flats.
Water gently every 1-2 days (mist is best), keeping medium moist and well drained.
Keep flats in covered, shaded area or in greenhouse (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth or in sun.
Transplant into individual containers (3.5-4" square) when seedlings have two sets of leaves. Use well-drained medium of 3:1:1 potting mix, perlite, cinder.
Use slow-release fertilizer (14-14-14).

Germination: 1 week to 3 months; success rates are variable and moderate (very high with fresh seeds). Germination can be low or none after storage.

Storage: Seeds do not store well; they lose viability. If necessary to store, remove from capsules and air-dry at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%). Will also germinate at reduced rates after 3-4 years of refrigerated storage.

Pests: Rose beetles, nematodes, and root-rotting fungi. Ants (carrying scale, aphids, etc.) can weaken plant. Control thrips with water pressure or mild insecticidal soap.

Notes: Can also grow from cuttings or air layers. ***Cuttings:*** Select 1/4" diameter wood, 4-6" long. Tip and stem cuttings with healthy leaves work best. Cut leaves in half and remove leaves from lower inch of the cutting. Dip cutting into strong rooting hormone solution for 10 seconds. Good rooting medium is 1:1 perlite, peat moss or pure vermiculite or pure perlite. Air layers: Follow standard practices, using a strong rooting hormone.

Myoporum sandwicense (Naio)

Propagation: Use fresh seeds. Fruit is a drupe and has unusual multiple seeds within. Collect only large, ripe, white, and juicy fruits; many smaller ones have no seeds. Remove pulp; follow Fleshy/Pulpy Seed Cleaning Procedure. Soak cleaned seeds in tap water or hand-hot water 12-48 hours or longer. Change water daily. Sanding may speed up germination but is troublesome.

3:1 perlite #2, Sunshine Mix #4
Plant in shallow flats.
Water every other day, keeping medium moist until germination, and well-aerated.

Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: Varies widely, from less than one month to 18 months. Best results with fresh seeds. Success is variable, from low to very good (10-70%), depending on health of seed at time of harvest. Once germinated, growth can be very fast, almost weedy.

Storage: Best to use fresh fruit. If storage is necessary, remove pulp and air-dry at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: Few problems, occasionally spider mites and powdery mildew; may be susceptible to nematodes.

Notes: Can also be grown from cuttings (success depends on age of plant). Air layering produces large plants fast.

Myrsine lanaiensis (Kolea)

Propagation: Soak 24 hours and remove floaters.

Germination: Six to twelve months; very low rates due to low seed viability.

Notes: Difficult to grow; most success from sprouting root runners.

Nesoluma polynesicum (Keahi)

Propagation: Remove pulp; follow Fleshy/Pulpy Seed Cleaning Procedure. Soak seeds 48 hours in tap water; discard floaters.

3:1 perlite #2, Sunshine Mix #4 or 1:1:1 peat, perlite, soil
Plant deep in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth.
Transplant into individual containers (3.5-4 square).
Use liquid fertilizer at seedling stage.
Acclimate gradually to full sun; use slow-release fertilizer (14-14-14).

Germination: 8 weeks to 6 months; very good success with fresh, healthy seeds.

Storage: Remove pulp, air-dry at room temperature. Put in paper envelope or bag, then in

airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%). or Dry in sun (no cleaning is necessary). Put in sealed glass container and refrigerate.

Nestegis sandwicensis (Olopua)

Propagation: Remove pulp; follow Fleshy/Pulpy Seed Cleaning Procedure. Soak in tap water 24 hours; discard floaters. or Crack and remove seed coat. Soak 2 hours at room temperature, then put in Petri dish with filter paper. Radical forms in 2-3 weeks, with germination 1-2 weeks later.

3:1 perlite #2, Sunshine Mix #4
Plant seeds 1/8 deep in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 2-3 weeks to 6-9 months; good success if seeds are viable (some problems with rotting).

Storage: Remove pulp. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: Protect seeds from rats.

Nothocestrum breviflorum (`Aiea)

Propagation: Follow Dry Seed Cleaning Procedure. No further treatment is necessary.

3:1 perlite #2, Sunshine Mix #4
Plant in shallow flats; sprinkle 1/16 of medium on top of small seeds.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 1-5 months; transplant at 4 months; good success with fresh, healthy seeds.

Storage: Follow Dry Seed Cleaning Procedure. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: Cucumber beetles can be a problem with young seedlings.

Nothocestrum latifolium (`Aiea)

Propagation: Follow Dry Seed Cleaning Procedure. No further treatment is necessary.

3:1 perlite #2, Sunshine Mix #4 or 4:1 cinder, soil
Plant in shallow flats; sprinkle small seeds on medium and press down.
Water every other day, keeping medium moist until germination.
Keep flats under 50% shade cloth.
Transplant into individual containers (3.5-4 square) when 1 high.

Germination: 8-16 weeks; success moderate; slow-growing.

Storage: Follow Dry Seed Cleaning Procedure. Dry in shade; put in sealed glass container and refrigerate.

Pisonia sandwicensis (Papala kepau/aula)

Propagation: Grown easily from seed, with no pretreatment necessary.

1:1:1 peat, perlite, soil
Separate seeds and plant deep in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats under 50% shade cloth.
Transplant into individual containers (3.5-4 square).
Use liquid fertilizer at seedling stage.
Use slow-release fertilizer (14-14-14) after 6 of growth.

Germination: 6-12 weeks; moderate success.

Pleomele sp.

Propagation: Remove pulp; follow Fleshy/Pulpy Seed Cleaning Procedure. Treat with a fungicide to prevent rotting. Air-dry seeds on paper towel before sowing.

3:1 perlite #2, Sunshine Mix #4
Plant in shallow flats.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings). Transplant as soon as possible.

Germination: 5 weeks to 6 months; low rate (5-10%). Seeds tend to rot easily if medium is kept too wet or if fungicide is not used.

Storage: Does not store well; best to start fresh. If necessary to store, air-dry on paper towel at

room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Notes: Can also be grown from cuttings.

Pouteria sandwicensis (`Ala`a)

Propagation: Grown easily from seed. Remove pulp, soak seeds in fungicide (follow label directions) for 10 minutes, then sow. Scarification or overnight soaking in hot water may help.

1:1:1 peat, perlite, soil or black cinder
Plant seeds deep in shallow flats or 4-6 individual containers or tree tubes (for tap roots).
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth.
Transplant into individual containers (3.5-4 square) after first true leaves are fully developed.
Use liquid fertilizer at seedling stage.
Acclimate gradually to full sun; use slow-release fertilizer (14-14-14).

Germination: 6 weeks to 8 months, with low to high success, depending on freshness and viability of seeds, and potential for rotting; slow growing.

Storage: Start fresh; does not store well (loses viability). or Seeds can be removed easily from ripe, soft fruits. Dry in shade; put in sealed glass container and refrigerate.

Psydrax (Canthium) odoratum (Alahe`e)

Propagation: Grown easily from seeds. Soak 24-48 hours in tap water; change daily.

3:1 perlite #2, Sunshine Mix #4 or 1:1 perlite, peat moss
Plant in shallow flats.
Water every other day, keeping medium moist until germination. Keep well-drained.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).
Transplant into individual containers (3.5-4 square) when first true leaves emerge. Use 2:1:1 peat moss, cinder, perlite.
Fertilize young plants regularly with organic and slow-release fertilizers incorporated into potting medium, and with foliar fertilizer.

Germination: can be slow, from 1 to 6 months. Success rates are very good if seeds are good, but most are damaged and must be discarded. Seedlings grow slowly at first, then increase in speed once in the ground.

Storage: Remove pulp and air-dry on paper towel at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: Most seeds are attacked by a parasite and will not germinate. Spraying seeds during development on parent tree will prevent this problem. Overfertilized or overshaded seedlings and young plants may be attacked by sucking insects such as aphids and scales. Treat with insecticidal soap or standard insecticides and ant bait.

Rauvolfia sandwicensis (Hao)

Propagation: Remove pulp from seeds, then soak seeds 5 hours in tap water. Seeds should sink to bottom; air-dry on paper towel.

3:1 perlite #2, Sunshine Mix #4
Plant in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 1 to 6 months; good success if seeds are good.

Storage: Best to start fresh. If necessary to store, remove pulp, air-dry on paper towel at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: Ants can sometimes bring in scale.

Reynoldsia sandwicensis (`Ohe)

Propagation: Grown easily from seeds. Follow Fleshy/Pulpy Seed Cleaning Procedure, then soak 1-6 hours in tap water. Seeds should sink to bottom after 1 hour; discard floaters.

3:1 perlite #2, Sunshine Mix #4 or 1:1:1 peat, perlite, soil
Plant in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth.
Transplant into individual containers (3.5-4 square) after first true leaves emerge.
Use liquid fertilizer at seedling stage.
Acclimate gradually to full sun; use slow-release fertilizer (14-14-14).

Germination: 1-6 months if seeds are fresh and not old; good to very good success if viable seeds are used.

Storage: Best to start fresh; loses viability with storage. If necessary to store, follow Fleshy/Pulpy Seed Cleaning Procedure. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%). or Dry in shade; put in sealed glass container and refrigerate.

Santalum freycinetianum (`Iliahi)

Propagation: Remove pulp; follow Fleshy/Pulpy Seed Cleaning Procedure. Soak 24 hours in tap water; seeds should sink to bottom. Soak 5 minutes in fungicide and air-dry at room temperature before sowing. or Soak several weeks, changing water and removing pulp from seeds several times/day.

3:1 perlite #2, Sunshine Mix #4
Plant in shallow flats.
Water every other day, keeping medium moist until germination. Keep well-drained.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).
Transplant into individual containers (3.5-4 square) after 2-3 pairs of true leaves have formed.
Somewhat difficult to transplant: if seed does not fall off readily from cotyledon, dont bother to transplant. Protect from rodents and birds by covering flats or tables with wire cages.

Germination: 1 month to 1 year; fair to low success (10-50%). Seeds are very susceptible to rot, but fungicide helps. The fresher the seed, the better.

Storage: Remove pulp, air-dry on paper towels at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Notes: May or may not need host plant during seedling stage. Pruning the host plant can be a lot of work; can have good results without one. May be more important for outplanting.

Sapindus oahuensis (Lonomea/Aulu)

Propagation: Remove pulp and scarify seeds (with file or lightly on grinder) or soak (1 hour in hand-hot water or 24 hours in tap water). or Remove all seed coats and propagate with embryo.

3:1 perlite #2, Sunshine Mix #4
Plant in shallow flats.

Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 1-6 months (may start to rot after 2 months); very good success if seeds are healthy. Embryo propagation: 1 week; very good success.

Storage: Remove pulp and air-dry on paper towel at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: Twig/stem borer (affects stems up to 1 mm in diameter); Chinese rose beetle; small gray weevil.

Notes: Fast growing if all the pests are controlled.

Senna gaudichaudii (Kolomona)

Propagation: Best grown from seed. Pretreatment is usually preferred: nicking or scarification reduces germination time, and seeds should be soaked in 120(water until they take in water (up to 24 hours), then cooled 24 hours. Discard floaters.

3:1 perlite #2, Sunshine Mix #4 or 1:1 peat, perlite
Plant in shallow flats; good drainage is critical.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings). or Keep in full sun and water daily.

Germination: Varies. With soaking and/or scarification, 5 days to 2 months. Moderate success if seeds have not been eaten by insects.

Storage: Remove seeds from pods; if wet, air-dry at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: Few are reported, although seeds are often attacked.

Notes: This is not a very hearty plant; it does not do well in red dirt (Pearl City type, well-drained).

Sida fallax (`Ilima)

Propagation: Grown easily from seeds, with no special care needed. Remove seeds from capsules and soak 1-24 hours in hand-hot or tap water; discard floaters and dry seeds on paper towel.

3:1 perlite #2, Sunshine Mix #4
Plant in shallow flats.
Water every other day, keeping medium moist until germination. Beach ecotypes need less water than upland ecotypes.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings). May be able to start in full sun; fungi attack leaves if conditions are too moist.

Germination: 10 days to 3 months; erratic. Success rates also vary, from none to very good. Seedlings grow quickly.

Storage: Remove seeds from capsules; can shake or beat in bag to dislodge most seeds. Air-dry at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Pests: Upland ecotypes may be susceptible to nematodes; beach ecotypes appear to be resistant. Ant-associated pests (scales and mealybugs) can be a problem.

Notes: Can also grow from cuttings (80-90% success rate).

Styphelia tameiameiae (Pukiawe)

Propagation: Seeds (.5 mm) in multi-seeded drupe. Best results from gently cracking drupe with hammer and removing seeds, then soaking 20 minutes in vinegar followed by 2 hours in 120(water. or Remove red-orange pulp; follow Fleshy/Pulpy Seed Cleaning Procedure. Soak seeds in hand-hot water for a few hours or tap water for 24-48 hours. Helps to soak hard seed coat 5 minutes in 5% acetic acid, then rinse thoroughly with fresh water through a strainer.

3:1 perlite #2, Sunshine Mix #4 or 1:1:1 peat, perlite, soil or black cinder
Plant 1/8-1/2 deep in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings), or under 50% shade cloth.
Transplant into individual containers (3.5-4 square) after first true leaves are fully developed.
Use liquid fertilizer at seedling stage.
Acclimate gradually to full sun; use slow-release fertilizer (14-14-14).

Germination: 1-6 months, with 50% success rate, if crack drupe to remove seeds and soak in water and vinegar; otherwise, 16 weeks to 9 months, with poor to moderate success rate.

Storage: Best to start fresh seed. If necessary to store, follow Fleshy/Pulpy Seed Cleaning Procedure and air-dry on paper towel at room temperature. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%). or Dry in shade; put in sealed glass container and refrigerate.

Notes: A difficult species to grow. Digging up seedlings from the wild works best, but is not good for the wild! Germination, if it occurs, is very slow, as is subsequent growth. Seed source may be important because of flowering strategy. Many flowers may not be pollinated, but drupes may still occur, with varying amounts of seed production. Might be faster to air-layer 12 plants; these may take 4-6 months to form roots. Nene also propagate pukiawe.

Waltheria indica (`Uhaloa)

Propagation: Follow Dry Seed Cleaning Procedure. No further pretreatment is necessary.

3:1 perlite #2, Sunshine Mix #4
Plant 1/8 deep in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 1-3 months, very good success.

Storage: Follow Dry Seed Cleaning Procedure and air-dry if wet on paper towel. Put in paper envelope or bag, then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Xylosma hawaiiense (Maua)

Propagation: Follow Fleshy/Pulpy Seed Cleaning Procedure. No further pretreatment is necessary (can soak hour in tap water).

Sphagnum moss or 2:1 perlite, potting mix
Plant 1/8 deep in shallow flats.
Water every other day, keeping medium moist until germination.
Keep flats in covered, shaded area (to control moisture and to keep rain from harming seeds and seedlings).

Germination: 1-6 months; fair to good success.

Storage: For best germination, start fresh seeds. If necessary to store, follow Fleshy/Pulpy Seed Cleaning Procedure. Air-dry on paper towel at room temperature. Put in paper envelope or bag,

then in airtight container with silica gel or other desiccant. Keep in cool, dry place (relative humidity 25%).

Notes: Seeds are susceptible to rot.

Zanthoxylum dipetalum (Kawa`u)

Germination: 5 weeks to 6 months; success 20-50%.

Pests: Bird damage.

Notes: Difficult to outplant. Need to provide shade and protection from ants.

APPENDIX I

Overview Survey

Preparers name _____

Do you have any recommendations, general or specific, for people trying to germinate dry forest species (e.g. time saving ideas, protection from rats, etc.)?

Do you recommend that we contact anyone else for this survey?

Are there other native dry forest species that you are familiar with that are not included in our list?

Do you have any experience and/or suggestions about outplanting the species mentioned in the list?

APPENDIX II

Propagation Tips Form

Species name(s) (list all species applicable) _____

*Please comment as best you can on the following topics. In instances where there is more than one response (method) per question please rank the methods. Also, indicate if there are any particularly unfavorable treatments. If not applicable, please indicate N/A.

Germination

Seed preparation (e.g. overcoming embryo dormancy, hard seedcoats, etc.)

Media type (e.g. perlite, cinder, peat moss, etc.) and proportions

Growing conditions (e.g. watering regimes, shade cloth, etc.)

Container types (e.g. tree-tubes, plastic storage boxes, plastic pots, etc.) and sizes

Usual time from planting to germination

Success rates of germination

Seed Storage

Cleaning techniques

Preparation methods (e.g. drying in the shade, under a transparent cover, etc.)

Container type

Conditions of storage (e.g. humidity, temperature, etc.)

APPENDIX III

Survey Respondents

Heidi Leianuenue Bornhorst, Wahiawa, Oahu

Royalene Fernandez, Lanai Company Nursery, Lanai

Andy Graham, Tropical Gardens of Maui, Wailuku, Maui

Stan Ishizaki, SMI Nursery, Aiea, Oahu

Robert Joy, Natural Resources Conservation Service/Plant Materials Center, Hoolehua, Molokai

Bruce Koebele, Leeward Community College, Pearl City, Oahu

Kerin Lilleeng-Rosenberger, National Tropical Botanical Garden, Lawai, Kauai

Burt Lum, Honolulu, Oahu

Jeanine Lum, DLNR, Division of Forestry and Wildlife, Kamuela, Hawaii

Richard Nakagawa, DLNR, Division of Forestry and Wildlife, Kahului, Maui

John Obata, Honolulu, Oahu

Anna Palomino, Ho`olawa Farms, Ha`iku, Maui

Peter Van Dyke, Amy B.H. Greenwell Ethnobotanical Garden, Captain Cook, Hawaii

APPENDIX IV

Resources/References

Growing Native Hawaiian Plants, by Heidi Leianuenue Bornhorst, 1996. The Bess Press, P.O. Box 22388, Honolulu, HI 96823.

Propagation Techniques for Native Hawaiian Plants, by Kerin Lilleeng-Rosenberger, October 1996. National Tropical Botanical Garden, P.O. Box 340, Lawai, HI 96765 (808) 332-7324.

The Propagation of Selected Native Hawaiian and Polynesian Introduced Plants, by Kenneth Boche. Aikane Nursery, P.O. Box 981, Kapa`au, HI 96755 (808) 889-5906.

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