SOME HELPFUL RESOURCES ABOUT NATIVE HAWAIIAN PLANTS

NEW - nativeplants.hawaii.edu - over 200 detailed horticultural information and 100's of photos of native plants for the landscape linked to nurseries growing native plants and their business information and plant inventory

1. MANUAL OF THE FLOWERING PLANTS OF HAWAI'I by Wagner, Herbst and Sohmer: Two Volumes. Technical but most complete.

2. IN GARDENS OF HAWAII by Marie Neal. Mostly about non-native plants but includes many natives as well.

3. PLANTS AND FLOWERS OR HAWAII by Sohmer and Gustafson. Easiest book to use with many color photos. Limited number of plants.

4. WEBSITE: http://www.botany.hawaii.edu/faculty/carr/natives.htm Most complete online resource with hundreds of pictures of native plants. Disadvantage for novice: all plants listed by scientific names. Provided by Dr. Carr of University of Hawai'i.

LCC RESOURCES

1. *Plants in the Hawaiian Environment* is televised every semester starting in the 3rd week of August and 2nd week of January at 5:30 or 5:45 for 1 ¼ hour. Labs on Saturday mornings.

2. Website for the course can be found at: http://emedia.leeward.hawaii.edu/millen/bot130/ It contains about 200 pages with many graphics.

3. Native plant gardens with over 130 species and types of native plants. All are labeled and can be found at several sites on campus.

4. Seeds and cuttings of native plants available to groups interested in propagating them for teaching and conservation.

5. Shade house propagation center used for education and training.

NATURAL HISTORY OF HAWAIIAN NATIVE PLANTS

Native White Hibiscus *Koki'o ke'o ke'o*
Hibiscus arnottianus

Hawaiian Plant and Ecology Unit

1. Understand how tectonic plate movement and the hot spot formed the Hawaiian Island chain.

2. Explain the general geologic period in which the Hawaiian Islands were formed and the types of life forms present in the rest of the world.

3. Explain the most likely geographical sources for plants (colonists) that came to the Hawaiian Islands, the time and their numbers.

4. Be able to define and distinguish between the major groups of plants found on the islands today: NATIVE with two sub groups of endemic and indigenous and INTRODUCED with two subgroups of Polynesian and recent.

5. Be able to give the reasoning behind the probable dispersal of plants (Water, Wind and Wing theory) from the rest of the world to the Hawaiian Islands.

6. Give a brief summary of characteristics of the colonist plants and in what ways they changed over millions of years to become native plants. Understand how the Silversword alliance native plants illustrate these concepts.

7. Be familiar with the concepts of vegetation zones found on the islands and how elevation and rainfall are major factors in their determination.

8. Understand three main periods of the history of the Hawaiian Islands and how it impacted the environment for native plants and animals.

9. Describe some of the present day conditions for the vegetation zones and the plants and animals that live in them.

10. Describe the state of Hawaiian flora in terms of endangerment today, state and federal laws concerning protection and reasons for saving the native plants.

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1. Understand how tectonic plate movement and the hot spot formed the Hawaiian Island chain.

a. Crust, the outer solid material of the earth, is made up of plates. They are in constant motion due to convection currents under the crust which is called plate tectonics (responsible for such phenomenon as mountain building, volcanoes and earthquakes).

b. The volcanic and earthquake activity at the edges where the oceanic Pacific plate meets continental plates is called the "ring of fire" which is due to all the volcanic activity at the edges of the Pacific plate.

c. "Hot Spot" Theory: an explanation of the origin of the Hawaiian Island Chain from T. Wilson in 1963. The Hawaiian Islands formed as Pacific plates moved slowly northwest over some melting point, (now called the "hot spot"), deep within the mantle thus forming the island chain. Its location is close to the of the Big Island today.

d. What we commonly call the Hawaiian Islands, from Kaua'i to the Big Island of Hawai'i, are really part of a longer island chain called the Northwestern or Leeward Island chain which is about 1600 miles long. The highest mountain tops on Maui and Hawai'i (Haleakala, Maunea Loa and Mauna Kea) are actually the tallest mountain structures in the world! If measured from the ocean floor, they are about 5 1/2 miles high!

e. The oldest island is Kure is at the north-west tip, and the youngest, the Big Island, is at the south-east tip of the chain, about 30 million years old, Kaua'i 5-6 million years old and the Big Island, 1 to half a million years ago. Also, a new island is being formed underwater off the coast of the Big Island, called Lo'ihi.

2. Explain the general geologic period in which the Hawaiian Islands were formed and the types of life forms present in the rest of the world.

a. Positions of the continents at the time of Hawaiian Island emergence are basically the same as today.

b. The Hawaiian Islands are the <u>most remote island chain in the world.</u> They are 2 1/2 thousand miles from the closest continental area, North and Central America, and the nearest island chain is the Marquesas, to the south-east.

c. What types of life forms existed on the earth, when the Hawaiian Islands arose from the ocean?

1. The time frame for the earliest forms of the Hawaiian Island chain is about 35-45 million years ago. Of present-day larger Hawaiian islands, the oldest, Kaua'i is about 5-7 million years old and the Big Island a 1 million or less.

2. First mammals and flowering plants were present over 100 million years ago. Human-type life was present about 4 million years ago, a little after the formation of Kaua'i.

d. In conclusion, the Hawaiian Island Chain arose from the floor of the Pacific Ocean, <u>after</u> the world's great continents were essentially <u>in the position they are found today,</u> and <u>all the recent plant and animal life</u> forms were also present on the earth. In the continuing, story, what was going to happen to these large sterile surfaces in the distant ocean? They began with no life forms on them. When the first Polynesians discovered them, they were teeming with life forms which they had never seen. What had happened and how?

3. Explain the most likely geographical sources for plants (colonists) which came to the Hawaiian Islands, the time and their numbers.

a. Fosberg's theory for geographical origins for Hawaiian native plants: 272 original colonists.

1. The area of highest source of ancestral plants of Hawaiian natives, is the Indo-Pacific region, at 40%. which has a similar tropical climate and growing conditions matching Hawaii more than other areas.

2. The next source of ancestral species is the North American continent. It is the closest land mass to Hawaii. However, it is not the largest source of plants, perhaps because of its temperate climate, less tropical.

3. Australia and New Zealand provide 16%.

4. 15% are pan-tropical that means they are found world-wide, and their original homeland is in the tropics. 10% origins could not be determined and the smallest group, 3 % are from the most northern part of the world to Hawaii, Alaska to the east, and Asian continent to the west.

b. Fosberg's Estimation of Time and Probability for Hawaiian Flora to Develop.

1. The second part of the theory, has to do with the time element involved in the dispersal and successful establishment of the new colonists in the Hawaiian Islands.

2. Given the present day islands from 30 to 70 million years in age, the shortest time period in which one new plant could become established would be 20 to 30 thousand years, (or as much as 100 thousand years) which gives enough time span to account for the 272 original colonists.

3. What these incredible figures tell us, is that the improbable, or unlikely event, of any seed or progagule (seeds, spores or any plant pieces which gives rise to a new plant), getting to Hawaii over 2 and half to several thousand miles, is no longer unlikely, but almost a certain event for some plants, given these great lengths of time.

4. Be able to define and distinguish between the major groups of plants found on the islands today: NATIVE with two sub groups of endemic and indigenous and INTRODUCED with two subgroups of Polynesian and recent.

a. These terms best used in reference to a **particular geographical site.** Our reference will always be the **Hawaiian Islands** unless stated otherwise.

b. NATIVE: Occurring naturally. Developed or migrated to the site without human help or intervention.

1. TWO TYPES OF NATIVE PLANTS: INDIGENOUS : found naturally at others sites, not restricted. ENDEMIC: found naturally only at the site and not elsewhere in the world,

2. Of the native 1,000 species today. Of these, about 900 (89%) are endemic species, the highest percentage of a native flora in the world and 100 (10%) of these species are indigenous.

c. INTRODUCED: Brought to site intentionally or accidentally with human help or activity. TWO TYPES OF INTRODUCED PLANTS.

1. POLYNESIAN INTRODUCTIONS: Brought by original Polynesian voyagers to the islands. Many have been here 1,000 or more years, about 26 spp.

LIST OF POLYNESIAN INTRODUCED PLANTS

Scientific Names	***Hawaiian* & Common Names**
1. **Aleurites moluccana**	*kukui,* candlenut
2. **Alocasia macrorrhiza**	*'ape*
3. **Artocarpus altilis**	*'ulu,* breadfruit
4. **Broussonetia papyrifera**	*wauke*, paper mulberry
5. **Calophyllum inophyllum**	*kamani*
6. **Cocos nucifera**	*niu,* coconut
7. **Colocasia esculenta**	*kalo, taro*
8. **Cordia subcordata**	*kou*
9. **Cordyline fruticosa**	*ti* or *ki*
10. **Curcuma longa**	*'olena*, turmeric
11. **Dioscorea alata**	*uhi,* yam
12. **Hibiscus tiliaceus**	*hau*
13. **Ipomoea batatas**	*'uala,* sweet potato
14. **Lagenaria siceraria**	*ipu,* gourd
15. **Morinda citrifolia**	*noni*
16. **Musa acuminata** hybrids	*mai'a*
17. **Piper methysticum**	*'awa*

18. **Saccharum officinarum**	*ko*
19. **Schizostachyum glaucifolium**	*'ohe*
20. **Syzygium malaccense**	*'ohi'a 'ai*, mountain apple
21. **Tacca leontopetaloides**	*pia,* arrowroot
22. **Tephrosia purpurea**	*'auhuhu,* fish poison plant
23. **Thespesia populnea**	*milo*
24. **Zingiber zerumbet**	*'awapuhi,* shampoo ginger

2. RECENT INTRODUCTIONS: Brought to the islands starting at contact with the western world, 1778 when Captain Cook came, up to present time. Also called exotics, especially for introduced cultivated plants like orchids, anthuriums. Also includes plants called aliens or weeds, which have often have a negative impact on the environment, like koa haole.

5. Be able to give the reasoning behind the probable dispersal of plants (Water, Wind and Wing theory) from the rest of the world to the Hawaiian Islands.

a. Carlquist suggests that of the 272 original colonists, 1.4% came by wind, 22.8% by water and 74.8% by wings

b. 1.4% came by air flotation. Propagules must be very small, example: 'Ohia lehua (Metrosideros polymorpha) has very small seeds. The JET STREAM and Kona storms could both be involved. To test this mode of dispersal, J. Linsey Gressitt, an entomologist, took airplane up to the jet stream and found small insects and plant spores.

c. By Water: 22.8% could involve two methods by which plant propagules could move: oceanic drift (14.%) and by a rare rafting event (8.5%).

1. By oceanic drift: seeds and fruits must be adapted for flotation and resistance to lengthy salt water immersion. 'Akulikuli (Sesuvium) stems float readily and the white spongy fruits Naupaka (Scaevola).

2. Rafting is a rare event which involves a large piece of river bank, or soil, held together by roots of plants. Koa (Acacia koa) with closest relative in Australia and islands off the coast of Africa may have arrived this way.

3. One would expect more plants to be dispersed by water, but a series of counter currents south of Hawaii, going east-west could explain why that mode was less common.

d. By Wing (Birds): 74.8%. Plant propagules could be carried in several ways:

1. externally: 13%.. Embedded in mud on feet or other parts
10.3%. Attached by viscid or sticky substances
12.8%. Attached by mechanical devices

2. internally: 39%. Carried in digestive tract of birds.

6. Give a brief summary of characteristics of the colonist plants and in what ways they changed over millions of years to become native plants. Understand how the Silversword alliance native plants illustrate these concepts.

Characteristics of the Successful Flowering Plant Colonizers of the Hawaiian Islands

They **arrived**, **survived** and **thrived** over several million years

COLONIZER CHARACTERISTICS	COMMON NATIVE TRAITS
Weedy, aggressive	"Fragile", easily displaced by introduced plants
Seeds, fruits & propagules small	Large fruited or seeded
Annual, rapidly-growing and and establishing itself	Perennial, woody, semi-woody generally slow-growing
Many armed with prickles, thorns or chemicals such as poisons or strong, smelly oils	Thornless, lacking chemical or physical defenses
Easily dispersed by wind, water or wing	Dispersal characteristics lost
Coastal-adapted, originally from coastal areas	Dryland plant forms evolved into wet forest forms

The Silversword Alliance

Adaptive radiation: It is pattern of evolutionary development, where many different forms or species develop from a single founder organism. The Silversword alliance is a prime example(is a group of closely related species (28) belonging to 3 different genera: *Ili'au* (Wilkesia), (Dubautia,) and the *Hinahina,* Silverswords (Argyroxiphium).

Through the work of Dr. Gerald Carr at University of Hawaii and others, there is evidence that all the silversword alliance evolved from a single seed arriving about 5 million years ago from plants related to the 99 species of "tarweeds" found in California and Mexican deserts today.

The adaptive radiation of these Hawaiian species in the Silversword Alliance from a single colonist plant to Hawaii is quite spectacular. Hybrid was made between **Dubautia** and "tarweed" relative from North America. This TRANSOCEANIC hybrid confirms their shared genetic background.

THE SILVERSWORD ALLIANCE

I. A group of closely related species belonging to 3 different genera.

II. The 3 genera:

A. Wilkesia: *Ili'au*, 2 spp. on Kauai, most ancient.

B. Dubautia: *Na'ena'e*, 21 spp. youngest. Many on Big Island, vines, shrubs, semi-shrubs.

C. Argyroxiphium, *hinahina*
World famous green- and silversword. Found at alpine deserts to bogs.

II. Research by Dr. Gerald Carr, at UH Manoa and others have demonstrated:

ALL SILVERSWORD ALLIANCE descended from a single colonist, 5 million years ago from the "tarweeds" of North America and Mexico.

An outstanding example in plants of ADAPTIVE RADIATION. (As found birds like Darwin finches and the Honeycreepers of Hawaii.)

One founder gives rise to many different species reflecting the many different environmental conditions.

III. How does the Silversword alliance fit the theories of dispersal colonist plants to Hawaii and their subsequent changes?

A. Dispersal from a great distance, North America.

B. Dispersal by birds evident by characteristics of fruit: Tar and bristles.

C. Tremendously varied habitats found in Hawaii exert natural selection resulting in many different forms (28 spp.)

D. Can cross with mainland relatives, even after 5 million years. Species within Hawaii can interbreed, creating a larger gene pool with helps in survival.

E. Annual plant forms evolving into perennial and woody-like life forms.

7. Be familiar with the concepts of vegetation zones found on the islands and how elevation and rainfall are major factors in their determination.

a. COASTAL is mostly on leeward side. Rainfall is 15-40 inches per year, elevation is 0-300 meters (about 900 ft.).

1. Native plants found are *Naupaka* (Scaevola sericea) very common plant in this zone, *'Ilima* (Sida fallax) and *Pa'u o hi'iaka* (Jacquemontia ovalifolia). Native trees and shrubs are *wiliwili* (Erythrina sandwicensis), coastal Sandalwood (Santalum ellipticum) *Naio* (Myoporum sandwicense) also called false sandalwood, and *Ma'o* (Gossypium sandvicense).

2. This region has been greatly reduced due to development of the shoreline for tourism. Now introduced plants dominate: Haole koa (Leucaena leucocephala), Mesquite or Kiawe (Prosopis pallida) and Ironwood (Casuarina equisetifolia). The windward side was dominated by forest of native palm (Pritchardia) and Hala which is now virtually extinct.

b. DRYLAND FOREST AND SHRUB. Elevation is 200/300 meters to 900 meters. Area most impacted by burning and agriculture of the Hawaiians, also prime agricultural and ranch land since contact times.

This area has probably suffered the greatest loss and extinction of species of any zone. Presently it is dominated by introduced grasses, Also lantana (LANTANA CAMARA), haole koa, mesquite, and prickly pear cactus (OPUNTIA) are present.

c. MESIC FOREST vegetation zone. Most species rich of any zone.Occurs at 750 to 1,250 meters above sea level. Occurs best at Koke'e Plateau on Kauai,

1. Natives include: *koa* (Acacia koa) and *'ohi'a lehua* (Metrosideros polymorpha) are the common trees here. Found in some places relatively untouched,

serious degradation has occurred, especially in the last 100 years, where converted into pastures, like Waimea area on the Big Island.

2. Here the introduced plants that dominate are: Kikuyu grass Banana poka (Passiflora mollissima) has escaped from garden cultivation, and covers and smothers the native plants. Also Christmas berry (Schinus terebinthifolius), lantana, Grevilla banksii (silk oak tree), and firetree (Myrica faya) invade and take over from the native plants.

d. **THE RAIN FOREST**. High rainfall, 150 to 300"/ yr. C. Occurs at elevations of 450 to 1,700 meters, above mixed mesic forest. About the only natural vegetation visitors to Hawaii may encounter at Volcanoes National Park on the Big Island and also on Oahu, at the *Pali* and *Likelike* passes.

1. Dominant trees are *'ohi'a lehua,* and usually *koa*. Other characteristic plants are *hapu'u* (Cibotium sp. or native tree fern), and the vine *maile*.

2. Characteristic structure of the rain forest is many "layers" of growth, An extremely important function of the native plants found in the rain forests of Hawaii is to provide the watershed area, enhanced water aborption to recharge the fresh water lens. Introduced plants: interfere significantly and REDUCE this absorption of water in two WAYS, less layers = less aborption and also non-natives tend to used more water.

3. Greatest of DIVERSITY of plants (numbers of different kinds) and numbers of unique species (endemics) is found in this zone. Perhaps this zone is less altered than any other, PARTLY due to its relative inaccessibility , and laws that protect designated WATERSHED areas. However, it is under attack by feral (animals from domesticated stock, now gone wild), animals, especially PIGS.

e. **SUB-ALPINE Woodland/shrubland** and **ALPINE DESERT**. This zone occurs above the TEMPERATURE INVERSION ZONE, at 6000 feet and higher, only on the highest mountains of the islands: basically HALEAKALA on Maui and MAUNA KEA and MAUNA LOA on the Big Island.

It has been damaged by overgrazing, especially by feral goats. The woodland dominated by the Mamane tree, and the desert the famous Silversword or *Ahinahina.*

f. **EXOTIC** (as in introduced) LANDSCAPES. These are the human-planted areas that most tourists and many locals assume are filled with the natural plants of the islands. They dominate the coastal and lowland areas.

Plants that are found here are Ironwood (Casuarina) at the beaches (and all the way up the Pali), Korean Koa, Kiawe (Prosopis) most grasses, bright colored bougainvillea, gingers, shower trees and plumerias, to name just a few. Kapio'lani park is filled with these non-natives, for example.

8. Understand three main periods of the history of the Hawaiian Islands and how it impacted the environment for native plants and animals.

9. Describe some of the present day conditions for the vegetation zones and the plants and animals that live in them.

a. Early Polynesian/Hawaiian Period. (Pre-contact.)

1. Population: highest population estimated at 500 -800 thousand Down 1/20th in 100 years after contact, largely due to introduced diseases.

2. Agriculture probably had greatest impact of native plants. wetland taro and dryland sweet potato, Hawaiian irrigation system: largest and most sophisticated in Polynesia.

3. Deforestation along with erosion were natural consequence of Hawaiian agriculturewhich increases solar radiation (hotter and less water), faster water run-off, and drought. Fire was primary way for Hawaiians to clear land, and most native Hawaiian plants are not adapted to survive fires.

b. Early Post-European Contact Period; 1778 to 1850.

1. Period starts with the arrival of Captain Cook, or the contact with the Americans and Europeans. Whaling ships needed great amounts of firewood to render whale blubber into oil for transport Sandalwood trade Sandalwood once dominant in Ko'olau, gone.

2 In event to have longest lasting damage was the release of cattle, goats and sheep, introduced1802 by Vancouver on the Kona Coast. By 1823, their presence was recognized as having serious impact: the forests of Waimea were destroyed to open plains. John Parker started the ranching on the islands

c. Changes in the Vegetation Since 1850

1. The GREAT MAHELE of 1848. It provided for a land division diametrically opposed to the Hawaiian concept of the ahupua'a where slices of land from mountain to sea provided all resources for life in the Hawaiian way, as a social, economic and political entity. By 1890, more than 25% of all private lands were owned by people of European descent.

2. Agriculture on a profitable, large-scale system. (The ultimate loss of the Hawaiian monarchy in 50 years is traceable to the business concerns of these agricultural land owners.) Sugar cane was the first, then pineapple, coffee, cut flowers, bananas, and pakalolo or marijuana, at one time recently, probably had greater monetary value than cane.

3. Cattle ranching uses 3 times the land for crop production, therefore having much greater impact. It involves **more than 25% of the total land** of the state! Zoning and taxing laws have contributed to the conversion of native vegetation to ranchland. One half land controlled by the state has been used for grazing during recent times. Impact of cattle is: reduction of native plants, dries soil, loss of under story, kills shallow-rooted plants and introduction of aliens grasses.

4. Introduced Plants and animals(feral goats, sheep, cattle, deer, rodents and game birds have had a major impact on flora include; thousands of plants now making up 47% of the flora today. 86 species have presented serious problems, 28 are capable of invading undisturbed native ecosystems like **Miconia.** These so-called alien plants and animals are a major factor in native extinctions in Hawaii.

5. Presently, fire has major impact on flora. In the past it occurred at a low rate in the islands, maybe every 700-1000 years before human occupation. Now greatly increased resulting in only 50% of native trees regenerating while alien grasses increase in growth.

6. Urbanization and housing developments. Polynesian populations were primarily restricted to coastal lowlands, now building widespread.

7. Many resorts are on the coast, and has forced out many natives in those areas. Increasingly popular are resorts away from urban centers, but their presence brings more development near-by.

8. State of conservation efforts today by federal, state and private organizations.

Positive recent steps in protecting the native Hawaiian ecosystem are several. The State Natural Area Reserves System, established in the 1970's include 18 reserves on five islands, including the one on Mount Ka'ala and Pahole on Oahu. Other organizations that have important roles in protection are the National Park Service, with two major parks (Volcanoes on the Big Island and Haleakala on Maui), U.S. Fish and Wildlife Service and The Nature Conservancy of Hawaii. These organizations protect almost 500, 000 acres. The conservation that protects a large enough piece of land, with all the life forms associated with it is called <u>in situ,</u> literally, in place.

10. Describe the state of Hawaiian flora in terms of endangerment today, state and federal laws concerning protection and reasons for saving the native plants.

a. In conclusion, the changes the plants underwent, from their colonist characteristics (to often diametrically opposed traits in the millions of years that followed their dispersal to the islands) to those which suited them to the new homeland, did not

prepare them for the future, when humans brought both introduced plants and animals from which the native plants lacked protection.

b. This, along with human activities that have highly altered the environment, the Hawaiian flora (along with much of the fauna) is one of the most endangered in the world.

1. There have been more animal and plant species becoming extinct in the Hawaiian Islands than in all of the rest of the United States.

2. In all of the United States, there are about 580 endangered plants listed. Hawaii has almost 50% of the endangered plants of the U.S. but only .06% of the total land mass. This figure does not even include another 100 native Hawaiian plants species under consideration for federal listing.

3. The Hawaiian flora is the most endangered in the world. If we can reverse this trend, Hawaii could be in the forefront of developing new approaches to plant conservation that could benefit the rest of the world that also has this problem but to a lesser extent.

4. Of the1,100 species and subspecies in the Hawaiian flora, 270 are listed by the Federal Government as endangered.

5. What does "listed" mean as in the Endangered Species Act?

a. In the 70's, federal laws were written to protect plants and animals whose numbers were dramatically decreasing and were threatened by extinction.

b. The organism must be proposed for listing, studies made, public hearings held, and final decisions made - all of which may take years. This process costs a great deal, easily $100,000 or more.

Meanwhile, the organism remains unprotected.

c .When listing for a species is completed, only that particular species is protected by certain federal and state laws.

The organism's habitat is not under this protection. Listing does not carry any funding for protection of the species. A fence can be built around a cluster of rare plants (if some agency can find the money) but insects and small herbivores can get through and the habitat around the area can be so damaged that the organism may not be able to survive.

d. Many conservationists today would like to see the Endangered Species Act rewritten so as to protect the habitats of endangered plants and animals. This would be much more effective in their preservation.

6. Hawaii's Laws Protecting Endangered Plants.

a. In Hawaii, we have the unusual situation where our state laws protect endangered native plants to a greater extent than do the federal laws.

b. Until recently, it was against the state law to own, propagate, or transport any endangered native Hawaiian plant without special permission which was difficult to obtain. This is not the case under federal law.

(The rationale for this state law was to provide greater protection for our highly endangered plants and to keep the rare kinds from "mingling genetically" with other plants as they might when grown side by side in cultivation. This would result in diluting and losing the original types.

In reality, this state law seems to have contributed to even greater declining numbers of endangered plants, decreasing opportunities for them to be grown and observed by others, while they are totally disappearing in the wild.)

c . As of this time, the state law controlling the propagation and possessing of endangered Hawaiian plants is being modified, and appears to be headed for ratification. It will allow for some endangered plants to be grown by individuals and institutions, that previously could not get permission, but only if the plants are from certified cultivated sources.

7. If conditions not reversed, the flora, in the next 20 years, is predicted to lose another significant percentage of native plants to extinction. Dr. Gary Ray, sent to Hawaii by the Center for Plant Conservation, an organization dedicated to preserving endangered plants, has found that there are 110 taxa (groups of plants at species and subspecies level) with 20 or less individuals left in the wild. He estimates it would take 1 million dollars to save them.

8. Why Save Critically Endangered Hawaiian Plants ... Or Any Organism?

a. Traditional answers often include the direct benefits we see for ourselves as humans: essential new medicine resources, the protection of related important economic plants - to name just a few.

b. Scientists have special interest and fascination in most any life form and Hawaiian plants have many unique characteristics that make them especially attractive to study.

c. An important moral issue is simply that, as humans, we need to share the planet with other life forms. It could be greatly to our benefit in the many ways we already know and also in ways may not yet know of at this time. Once these life forms are gone, as they say ... extinction is forever.

PLANT PROPAGATION BY SEEDS

The goal of this project is for the student to successfully propagate plants by sexual means. When seeds are grown, propagation is through sexual reproductive structures: **the seeds**. It results in all unique genetic individual plants.

When a **VEGETATIVE** part of the plant (root, leaf or stem) is used in propagation, it is asexual reproduction. In asexual reproduction, all **new plants are genetically the same as the parent plant** .

PROCEDURE

1. Fill pots with potting medium, tamping it down as demonstrated.

This is not "soil" that is a natural substance formed at site where collected that has rock particles and organic materials. Potting medium is mixed from synthetic materials (like perlite) and natural materials like sphagnum moss and lava rock to provide good water-and air-holding capacities, ideal for growth in containers. They often are sterile, or nearly so.

It is important to have **sterile potting medium and pots** to grow seeds. If pots were previously used, soak in soapy water with 10% bleach overnight to sterilize. There are soil-borne fungal diseases that can appear and quickly kill many healthy seedlings.

1. **Label each pot.** On the label put **date and scientific name.** If known, or common name. Put your **name on label** for identification. Points off for failure to do so,

2. Plant seeds as demonstrated. Generally **seeds are planted shallowly**, about the depth that the seed is long. Firm a layer of potting medium over the seeds.

FOLLOWING TREATMENT ONLY ON NATIVE SEEDS

3. **Many native seeds are slow to germinate.** One way to hasten is **to scarify or cut** into the tough seed coat of large seeds. Usually a knife or sandpaper will make an abrasion just through the seeds coat to allow water to enter immediately. Imbibition of water by a seed is the first step in germination.

4. Another technique is to **pour a cup of boiling water over the seeds** in a dish and let them sit for several hours. (Caution: if seeds are soaked too long, over 12 hours or so, they may begin to rot. Also sometimes seeds are started between moist paper towels, but in a couple of days, molds will start growing and kill them.)

   For example, wiliwili seeds have germinated in 5 days with scarifying the seed coat and pouring hot water over them. Most hibiscus seeds germinate much more rapidly with hot water treatment, like Ma'o, and any Koki'o.

DO NOT USE HOT WATER TREATMENT ON SOFT SEEDS or MOST INTRODUCED PLANT SEEDS

FOR ALL SEEDS

5. Most seeds, small or large, will benefit from 12 hours of soaking in room temperature water, before planting. Be patient, native seeds may germinate over the course of many months!

6. The seed germination process usually requires a **steady amount of moisture** and **warm** but not hot temperatures. If the seed dries out significantly, germination stops and no seedling will grow.

Refer to ***Growing Plants for Hawaiian Lei*** published by College of Tropical Agriculture and Human Resources, UH Manoa for helpful information about propagating specific plants. For instance: native plants like a'ali'i, 'ilima, ma'o and wiliwili.

One Potting Media Recipe for starting seeds

2 - 3 parts fine perlite
1 part #4 Sunshine Peat Mix or Potting Mix

Mix two materials together thoroughly. Moisten if dry. Clean up any spilled mix. See following sheet for detailed instructions for planting seeds.

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- **See demonstration for mixing media, filling pots and mixing media.**

- **Always clean up your workplace and put tools and supplies back before leaving**

Instructions for Planting Seeds

1. Pretreat seeds if necessary – see following pages for directions.

2. Mix potting media as described. Be sure that it is moistened.

3. Select clean small pots.

4. WRITE LABELS with date on top. Name of plant and your name (not initials) in PENCIL. Do not use any kind of pen as it will fade.

5. Fill pots almost to the rim, tamp down media gently and EVENLY. Need to leave a space for watering.

6. Select seed, use only 4 or 5 if medium- or large-sized, if very small, just a tiny pinch. Spread evenly.

7. Cover fine seed with about ¼ inch of media.

8. Cover larger seed as they are long, usually ½ to 1 inch deep.

9. Gently firm on the top surface to eliminate air pockets. Seeds need to be in contact with the media.

10. Water gently and thoroughly with watering pot with fine spray. Do it on the table by the sink. Be sure to WATER SEVERAL TIMES until water comes out the bottom of the pots.

11. Place pots in a FLAT with others, so they won't tip over. Instructor will indicator what table to put them.

12. For seeds to be taken home, bring a small cardboard box to carry them home.

SEEDLING CARE: Once the first true leaves appear (after the seed leaves), water with dilute water-soluble fertilizer like Rapid-Gro. See the effect below:

The Effect of Fertilization on Seedlings

- The pot on the left has been fertilized. They show large set of true leaves.
- Pot on the right shows larger seed leaves - the first ones at germination and very small first true leaves.

CARE FOR SEEDS AT HOME:

1. Keep seeds evenly moist, do not let them dry out. If the seeds were well watered at the beginning, they may not need but a little bit of water for several days.

2. Seed and seedling need for water varies a lot. Some depends on location of pot (hot, cool, windy or still), type of media, size of pot and size of seedlings – they need more water as they get bigger.

3. Use finger touch test to determine if watering is needed – touch the top ½ inch of media – if somewhat dry, water lightly for seeds and more for seedlings.

ABOVE: Seedlings allowed to dry out too much and are dying.

4. When watering, be sure water goes through the pot and LET DRAIN before returning them to a saucer. Leaving them in standing water will kill them very quickly.

5. Keep is bright indoor room during germination, they do not need very much light at this time.

6. Once they germinate, put into a window with some bright light every day. DO NOT put them outside in hot sun at this time, because they may dry out too fast.

7. Birds, pets and children, insects and strong winds can do young seedlings in. KEEP THEM PROTECTED.

8. Start FERTILIZING lightly with a water soluble fertilizer such as Rapid-Gro for vigorous seedling growth.

MAKING SOFT STEM CUTTINGS

- **Take <u>fresh tip cuttings</u> from soft-stemmed plants in the early part of the day when plants have been well watered. IMMERSE cutting into bucket filled with cool water.**

- **Only use HEALTHY plants. Stressed plants do not make good material. Do not pick flowering stems.**

- **Re-cut stems under water if possible.**

- **DO NOT LEAVE cutting material out of water, keep them immersed at all times except when directly processing cutting.**

- Prepare plastic labels for EACH POT. USE PENCIL, not pen, because it doesn't fade or wash off. Include scientific name, YOUR NAME, DATE at the top, ex: 23/1 for Jan. 23rd, and common name is optional.

- **Prepare potting media as follows: See instructor demonstration.**

4 parts fine perlite to 1 part of #4 Sunshine Peat Mix

SOME HINTS WHEN MIXING POTTING MEDIA:

- **Use pots to measure "parts"**
- **Mix media thoroughly in a container**
- **Fill pots almost to brim, press lightly and remove media in the "rim" zone of the pot to allow for watering.**

- **Only when you have prepared labels and pots should you proceed to processing the cuttings.**

- **See illustrations on following page for location of cuts. To make, always use a SHARP tool.**

- **A dull cut slows water flow into stem. CUT AT AN ANGLE to increase surface area for water uptake.**

- **Trim stem pieces so that there are <u>2 nodes</u> that will be placed beneath potting medium.**

- **<u>Hold up cutting to pot</u> to see if it is deep enough. Some stems have longer internodes than others.**

- **Also should be about <u>2 nodes,</u> including apical meristem and small leaves to be above the potting medium.**

    - **Cuttings should be about 4" long depending on factors above.**

- **Dip cutting end into rooting solution or powder. DO NOT DRIP OR ALLOW DUST from rooting chemical to fall on tables, but shake off excess over container.**

- **CREATE a HOLE into which to put the cutting with a pencil or similar tool. DO NOT force stem tip into potting media or that will damage it.**

- **Press media firmly around cutting and water thoroughly with gentle spray of watering can. Let drain near sink and place on plant table.**

- **FOR CUTTINGS AT HOME, success will be greatly enhanced if you provide a moist environment by placing a CLEAR plastic bag, like one you use for vegetables at the store and place LOOSELY over pot with cutting.**

    - **DO NOT fasten bottom and use a chopstick to hold it off the cutting leaves.**

    - **Helps to punch a few holes in the upper part of bag for ventilation.**

    - **KEEP OUT OF DIRECT SUNLIGHT and do not place outside, but in a well-lit area.**

Cutting is made, must trim off most of the leaves and the flower stem.

Final trimming, ready for placing in pot.

Normal Cutting at beginning.

Notice some leaves have been trimmed to decrease water loss.

- **Place cuttings <u>in flats</u> on shade house benches so they don't tip over.**
- **Do not be concerned if all or most leaves fall off the cuttings. That is normal. Without roots, leaves are difficult for the plant to maintain.**

Cutting of an 'Awa plant.

Notice that all leaves have fallen off original stem but new ones are coming up at the base.

- **CHECK cuttings every time you are in the shade house. REMOVE DEAD LEAVES.**

- **CHECK to see if STEM is NOT shrunken or darkened. That is usually a sign the cutting has died. Don't remove cutting until you have checked with the instructor.**

Cuttings at Home

- **Take other cuttings at home. Place them in bright INDIRECT light and keep them evenly moist.**
- **CHECK frequently and remove dead leaves.**
- **Sometimes placing a clear plastic bag over them with several large holes poked into it, and kept loose at the bottom provides moisture that is needed and enough air circulation at the same time.**
- **If you gently pull on cuttings, some resistance will indicate rooting.**
- **When first leaves are developed, lightly fertilize as with seeds.**

Nicely rooted Coleus cutting.

It has developed new leaves.

Pest Control

- Strive to use primarily non-toxic chemicals for pest and disease control. Reasons for this are: toxic chemicals may have long-lasting negative effects on you as the applier, negative long term effects on the environment, and often give rise to more resistant strains of insects and other disease organisms.

- Peppermint Soap. Can be bought in natural food shops. Dr. Brunner's Peppermint soap is marketed as a human product. However it can be effective as an insect repellent/killer. Soaps or any detergent can remove oils and fats from the insect's body and may destroy them. Furthermore, mints extracts are poisonous to insects. Works best on aphids, caterpillars, and spittle bugs. One tablespoon per pint of water.

- Fine Oil, horticultural grade. Found in any good plant nursery supply firm. This has a strong effect on difficult pests such as scales, white fly (larvae) and spider mites. The oil will "suffocate) the insect by clogging its air openings on its body. Be sure to shake well before application because oil will quickly separate from the water base. See bottle for mixing instructions.

- Baking soda solution. This is a helpful alternative to poisonous fungicides and helps to control common fungal diseases such as mildew. Mix about one tablespoon, a few drops of detergent to help sticking (special ones available in nursery supply stores) and stir in a small container. Add to a pint (24 fluid oz) spray bottle and apply when temperatures are cool and in absence of direct sun (same conditions apply to all applications). There may be phytotoxic effects (like some burning of leaves) so adjust amount of baking soda according. Still, it is well worth using this non-toxic approach vs. toxic fungicides.

- DON'T DESTROY the Mealy Bug Destroyer. Many growers mistakenly destroy one of their best allies, the Mealy Bug Destroyer. For more information, look it up on the internet. It

looks like a mealy bug, white and fuzzy and found under leaves, but is about 2 x the size of a mealy bug – and eats them up. Another beneficial insects are lady beetles or bugs that come in several colors and the praying mantis. Another reason to use less toxic chemicals.

- Simple Green. Another "soap" or "detergent" tool like peppermint soap. Usually about 2 tablespoons per pint spray bottle filled with water.

- NOTE ON APPLICATIONS: Generally most non-toxic sprays are slower to combat the disease and pest problem. This means that you must apply more frequently, daily or every other day. Still, the lack of toxicity to you , the environment and to the pest is a great advantage and safety concern in the long run.

- WORST PEST ON NATIVES: The Chinese rose beetle has proven to be a very common and most difficult insect to control. It will eat many roundish holes in leaves of native plants, and roses, to the point that they are skeletonized. It comes out at night and is light-phobic, so if the plant is near an all-night light source, damage will be limited. You can also go out at night and pick them off. They will not be affected by any of the non-toxic treatments given above. This is the only case where toxic chemicals could be considered for control. Orthene is an effective because it is absorbed by the plant and poisoned the beetle that feeds on it.

    - **USE GREAT CAUTION IN APPLICATION**: dress in LONG sleeved shirt and pants, socks and shoes. Rubber gloves to protect hands, hat, glasses or goggles and mouth/nose rounded filter that you can buy in the paint stores. You DO NOT WANT to have any spray from the toxin absorbed through your skin, nose, mouth and eyes. Apply in WINDLESS conditions, and cool. When you are finished, wash clothing along in machine, and take a shower.

- **Fertilizing.** Almost all plant growers agree on this one: minimize fertilizing and over watering of native plants. The problem is that too much lush growth attracts pests and diseases. I usually use some slow-release fertilizer such as Nutricote when growing young

plants in pots. Later, when plants are planted in the ground, I give a light application of granular fertilizer once or twice a year. Everyone will find their own "balance" in using fertilizers and watering.

- **Irrigation.** I find it invaluable to have a drip irrigation system for native plant gardens. Rainfall, especially in dry areas is sporadic and in recent drought conditions, is not always enough and a regular source of water can be important in any plant zone.

    - Drip Irrigation advantages: Uses about 1/10th the water as compared to aboveground spray systems, is less expensive, easier to install, does not water all the weeds between plants, is more effective in delivering water deeply to the root system, does not cause erosion, and less likely to "drown" a plant.

    - Drip irrigation is not too difficult for the novice to install. There are usually booklets near the supplies in a home or garden shop. Basically you will need:
        - Probably a pressure reducer at the water outlet source since most water pressure will at 80 to 60 PSI (pounds per square inch) and pressure in a drip system should be about 25 psi.
        - Filter: also installed at the source.
        - Anti-siphon device to prevent water reversing into your water supply.
        - A device to connect your 3/4 inch water outlet source, like a hose bib to the 1/2 inch polyvinyl tubing.
        - One or more rolls of polyvinyl 1/2" tubing
        - One of more rolls of polyvinyl 1/4 " tubing
        - Hole punch (looks like the old paper hole punch tool)
        - Goof plugs to fill up holes you don't want to use
        - Barbs: small pointed devices that connect 1/4" tubing to emitters (different styled devices that slowly allow water to drip into the ground near the plant)
        - Different types of emitters. The most common are the disk-shaped "bubblers) that will emit 1/2 gallon, 1 or 2 gallons per hour (see labeling on package) or small spray emitters.

- **Mulching.** Mulching your planting is one of the best methods to conserve water, reduce weeds, keep soil temperatures down and add organic matter to the soil. Often you can "catch" a tree trimmer and ask them to drop their load of chips near your garden area. Be sure to let the chips dry out for several weeks: green organic material can be hard on plants. Apply liberally around plants but don't pile up around the woody base of a tree or shrub as it may cause damage.

- **Labeling and keeping records.** Nothing is more important than keeping records of your plants. It is time-consuming but ultimately worth it. It will provide important and useful information for you and about your plants that have direct application to their successful growth and reproduction. When starting seed and cuttings, put the date, source of plant and its name on the label. As your collection grows, it is helpful to keep permanent records as the date and source of all your plants.

- **STATE LAWS GOVERNING NATIVE PLANTS**

    - NEVER plant native plants back into "the wild". Only authorized organizations are allowed to do that. We need to keep the wild populations the same genetically and not change them by introducing different genetic strains.

    - NEVER collect seeds or plants from the wild. Again, only authorized organizations may do that. Collecting plants only further decreases the wild populations and they do not transplant well. Seeds should be obtained through botanic gardens, nursery stock and from private gardens where they are being legally grown.

    - You may SELL ENDANGERED NATIVE PLANT SPECIES legally ONLY if you have obtained the 10 cent orange plastic label from the state Department of Land and Natural Resources for each individual plant. This gives the buyer important information about proper use of the plant.

    - An individual may give away FREE a native endangered plant.