19. Mountain apple	*Eugenia malaccensis*	India, Malaya
20. Mulberry	*Morus nigra*	Asia Minor, Persia
21. Naranjilla	*Solanum quitoense*	Trop. & temperate regions
22. Rose apple	*Eugenia jambos*	India, Malaya
23. Roselle	*Hibiscus sabdariffa*	Trop. America
24. Sapodilla, chicle	*Achras zapota*	Central America
25. Soursop	*Annona muricata*	Trop. America
26. Strawberry	*Fragaria sp.*	Europe
27. Strawberry guava	*Psidium cattleianum*	Brazil
28. Surinam cherry	*Eugenia uniflora*	India Malaya
29. Tamarind	*Tamarindus indica*	Trop. Africa, Trop. Asia
30. Watermelon	*Citrullus vulgaris*	Trop. Africa

MODERATOR WARNER: Thank you very much. Our last speaker this morning will be Dr. William S. Stewart. He has a PhD from Cal Tech as a plant physiologist. He has worked as a plant physiologist in a number of areas in citrus and has spent three years here in Hawaii with the Pineapple Research Institute. He was called back to Riverside to be chairman of the Horticulture Department in the U. C. Citrus Experiment Station. Later he was Director of the Los Angeles City and County Arboretum. He is now Director of the Pacific Tropical Botanic Garden in Kauai. Today he is going to share some of his experiences with us.

TROPICAL PLANTS ADAPTABLE TO MAINLAND LANDSCAPES

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As you will discover here in Hawaii, the "tropics" are not always just hot, humid, lands that abound in luxuriant vegetation, as in lowland equatorial rain forests, but may have a wide range of climates. For example, there are large areas within the tropics that are deserts with desert plants or, at higher elevations with temperate climates and dry forests; and, going still higher, areas with winter snow, alpine plants and, here in Hawaii, even skiing on Mauna Kea on the island of Hawaii.

In Hawaii, the 50th state of our United States, all of these conditions are represented and all are conveniently accessible. For these reasons it is important to recognize the climatic zone within the tropics where a plant is growing to evaluate where on the mainland it might be adaptable. On the mainland under

indoor or conservatory conditions almost any tropical species can be grown if ingenuity is used to modify the environment. An excellent reference for this field of work is Exotica 3, "A Guide to Care of Tropical Plants Indoors."

The greatest success outdoors on the mainland with tropical plants will occur when they are grown under conditions that are most similar to their habitat in the tropics (4, 5, 6). This means that the subtropical, mainland, areas offer the most favorable conditions. There can be many surprises as to the adaptability of tropical plants for outdoor mainland gardening and, rather than theorize — if there is no prior information — it is wise to make a test planting. As you all know, even within your own small garden or yard there are many microclimates.

Lists of tropical plants adaptable to mainland outdoor landscapes are available in the landscape horticultural literature. One of the most useful of these is Hoyt's "Reference Handbook of Check Lists for Ornamental Plants of Subtropical Regions" (3). Here are listed — for "Tropical Effects" — 33 species of trees, 48 different kinds of shrubs, 28 vines, and 55 herbaceous plants. He also lists tropical plants for humid regions on the mainland as, for example, the gulf coast and bayou areas with high water tables — and another category is designated, "Borderline South." His opening sentence to these lists states, "This is where one approaches the tropics to find scant literature — and less instruction — in an almost untouched field of ornamental horticulture"; and later he says: "These tropical plants, as used northerly into subtropical regions, should not be hurried out of the unaccustomed winter chill. Do not fertilize or otherwise stimulate them until late spring or early summer — wait for some sign of interest."

Another source of information for tropical plants in subtropical regions is "Sunset Magazine" and the "Western Garden Book" by the editors of Sunset Magazine. The yearly indexes to Sunset Magazine have one section on "Subtropical and Tropical Plants." Their garden book names 67 plants with "dramatic leaves" to add a tropical feeling to the garden.

Most of the tropical plants cited in both Hoyt and the Sunset books for mainland landscapes are found around the world throughout the low, humid tropics. These are, to mention a few: palms, *Brassaia*, *Papaya*, *Ficus*, *Strelitzia*, *Dracaena*, *Erythrina*, banana, bamboo, *Gunnera*, *Cycas*, *Hibiscus*, *Ixora*, *Tetrapanax*, *Macadamia*, *Plumeria*, *Thevetia*, *Tibouchina*, *Beaumontia*, *Bougainvillea*, *Monstera*, *Fatshedera*, *Hoya*, *Philodendron*, *Petrea*, and such herbaceous material as *Anthurium*, *Begonia*, *Clivia*, *Kalanchoe*, *Peperomia*, *Sansevieria*, *Spathophyllum*, and so on — and, of course orchids. Species of most of these genera are available from nurseries.

Many of these tropicals lend themselves to bonsai and, as container plants, create much interest in addition to the more traditional temperate climate bonsai plants (8).

In addition to these more common, usual, "pan-tropical" species there are, however, some plants of our native Hawaiian flora that are absolutely unique and which have never been used in mainland subtropical landscaping. First a little background about our native plants.

Because of the isolation of the Hawaiian Islands by vast ocean areas many of those plants that finally made their way and established themselves here in the early times found an area ideally suited to their growth. Lacking their former natural enemies, some of the characteristics required for survival in their original environment were unnecessary. Other features gave the plants survival advantages in Hawaii and were preserved by natural selection while certain mainland characteristics, such as thorniness, were reduced or eliminated altogether. The Hawaiian flora presents a veritable laboratory for seeing evolution in action with the expression and survival of new, unique, species found nowhere else in the world. These are called endemic species. Dr. Harold St. John in his forthcoming book, "List and Summary of the Flowering Plants of the Hawaiian Island", being published by the Pacific Tropical Botanical Garden (7), points out that endemism in the 2,600 native species is 97.3%! The exotic flora (introduced plants) adds 5,000 species for a total count of 7,600 kinds of plants in the relatively small area that is Hawaii.

Growing these plants on the mainland must be considered as experimental. However, eleven different Hawaiian native plant species have been reported by Sherwin Carlquist (2) in the Pacific Tropical Botanical Garden's Bulletin, Vo. II, No. 3, as having been successfully grown in California.

Among many of the Hawaiian plants I suggest as worthy of trial plantings on the mainland are the following:

1. *Metrosideros collina* subsp. *polymorpha*. For mainland subtropical landscapes where soil is on the acid side *Metrosideros collina* subsp. *polymorpha* may be an interesting addition. In Hawaii it is known as ohia-lehua, or Lehua. It is found on all of the islands between elevations of 1000 to 9000 feet. It is extremely variable as recognized by its botanical name, *polymorpha*. On the island of Hawaii it may be seen as trees nearly 100 feet tall while in the Alakai Swamp on Kauai small plants bloom that are only 10 inches high. In addition to the conspicuous flowers with brilliant red stamens, the young leaves also are an attractive reddish color. The 'ohia-lehua' is well-known in Hawaiian songs, legends,

and mythology. Very appropriately the Hawaiians made the red 'ohia-lehua' groves sacred to Pele, goddess of volcanoes. One other story about 'ohia-lehua' is that if the flower is plucked on the way to the mountains it will rain. This is a fairly safe bet since in many areas where the 'ohia-lehua' grows it rains very frequently.

2. *Freycinetia arborea*. The 'ie'ie (its Hawaiian name) is a strong climbing plant with branches every several feet. Each lateral terminates in leaf clusters with the leaves being about an inch wide to three feet long. From the center of each cluster a gaudy scarlet red inflorescence is formed up to six or seven inches in diameter. 'Ie'ie is found at elevations up to 3500 feet and was considered a sacred plant by the early Hawaiians. They tell the following story: Laukaieie (leaf of the 'ie'ie), was a beautiful maiden cared for by the goddess Hina. Laukaieie was given to a lonely couple, and her playmates and servants were the birds and flowers. She married a bird man, and soon the time came for her to change form. Her eyes flashed fire, leaves sprouted on her tender body, and her husband carried her to the woods with the words, "You cannot stand alone. Climb trees! Twine your long leaves around them. Let your blazing red flowers shine between the leaves like eyes of fire! Give your beauty to all the 'ohi'a trees of the forest." And so the maiden became the 'ie'ie vine(5).
3. *Acacia koa*. Koa is one of the most common of the Hawaiian forest trees. Probably depending on both its environment and genetic strains it may be a tall monarch of the forest as on the island of Hawaii where at elevations of 1500 to 4000 feet it may be over 50 feet in height; or in other less favorable sites, it may be a twisting smaller tree to twenty feet whose branches form an eye intriguing, intricate pattern. It is this latter form that may be of particular interest for mainland landscaping, as it would provide another source for a contrast in stem texture and pattern. The so-called "leaves" (actually broad petioles functioning as leaves) are smooth, stiff, and have an interesting crescent or sickle shape. The flowers are small puff balls of pale yellow and are not spectacular. It is the intricate growth habit of the stems that make this species a candidate for mainland landscape test planting. It also is fairly drought resistant. Koa may be propagated readily by seed.
4. *Erythrina sandwicensis*. The coral tree or flame tree is found in the drier parts of nearly all of the islands. Most

other species of this genus have red flowers; the Hawaiian species, however, is unique in having flowers varying by tree to tree from a chartreuse green to orange. It is readily propagated by seed or cuttings. The Hawaiian name for this tree is wiliwili, so the harbor on Kauai named Nawiliwili means "the Erythrinas."

5. *Kokia kauaienis*. This tree at flowering time is very spectacular with its brilliant canopy of orange-red blooms borne at the branch tips. It is usually in full bloom in June or July and, if it proves hardy on the mainland, would offer real horticultural possibilities. It is closely related to the hibiscus being a member of the Malvaceae. It is found only on Kauai and even there is not very abundant. It is propagated by seed.
6. *Hibiscus rockii.* A potential hibiscus ground cover seldom seen as growing much above 2 1/2 feet in height and, when grown on banks, it is usually much lower and more prostrate. Flowers are a clear lemon yellow. This is one of the 300 endangered native species and is from Kauai. Hibiscus is the official state flower of Hawaii.
7. *Hibiscus waimeae.* On Kauai, where this is a vigorous grower, there are some very old plants with main stems or "trunks" ten to twelve inches or more in diameter. It grows in the wild at about 3,500 feet elevation. At sea level in gardens on Kauai it produces large shrubs in a short time. In addition to the red staminodal column contrasting with the pure white petals, one of the very nice features of this hibiscus is the delightful fragrance of its flowers. The perfume is not as strong as gardenia or plumeria but is most pleasant.
8. *Hibiscus saintjohnianus*. The special orange color of the petals of this medium-sized flower is its particular feature. It does not seem to grow as vigorously as *Hibiscus waimeae* but possibly may be more drought tolerant. On Kauai it grows at an elevation of about 1,800 feet on a ridge west of Kokee in a rainfall area of about 25 inches per year.
9. *Dianella sandwicensis*. If this botanical name for an endemic species bothers you, you may prefer the Hawaiian name of 'uki'uki. The interesting feature of this fairly hardy, grass-leaved member of the lily family is the conspicuous bright blue berries which once were used by the Hawaiians to dye tapa. In growth habit it may be suggestive of a two to three foot high version of Mondo grass [*Ophiopogon japonicus*] although the leaves are not as dark green.

10. *Wilkesia gymnoxiphium*, or if you prefer the Hawaiian name — iliau. It is closely related to the famous silversword plant [*Argyroxiphium sandwicense*] of Haleakala. It also is a member of the Compositae family and quite closely related to the tarweeds of California. The interesting story of evolution of the silverswords and their relatives is given in Carlquist's fascinating book, "Hawaii, A Natural History" (1). While silverswords and greenswords are found only on Maui and Hawaii, their counterpart — the iliau, is found only on Kauai. It grows as a perennial and is suggested for mainland landscapes as it is found in the drier portions of Kauai. It has a curious growth habit with a rosette of green, almost sword-like, leaves at the top of a spear-like stem extending above the surrounding vegetation. Then the flower stalk grows out of the rosette and, in appearance, resembles that of yucca but with yellow flowers instead of white. It has been grown successfully from seeds in gardens on Kauai and in Santa Barbara.

    Another iliau species, more recently discovered, is *Wilkesia hobdyi*. It, too, has particular landscape potential. It is almost as if it were a scaled-down version of the iliau so that instead of a stem 3 to 4 feet in height, with a flower stalk of about three feet, this new species of iliau has a shorter branching stem of about 2 feet and a flower stalk of another two feet. No garden experience has been obtained with *Wilkesia hobdyi* but it seems to me it has as much interest for mainland gardening as the larger iliau. Both of these species offer a new dimension for landscaping.

In summation: There are many tropical plants adaptable to subtropical mainland landscaping, particularly if special microclimatic locations are sought for their culture. References to lists of these tropical plants are given. In addition, ten of the many native Hawaiian plants with horticultural potential are suggested for trial plantings. The native flora as yet has not been used for mainland landscaping and offers real possibilities for exciting new landscaping materials. Horticultural interest in the native flora also will serve to make laymen and plantsmen alike aware of these treasures of Hawaii and should help to preserve many of the nearly 300 endangered species of our rare and fragile native Hawaiian flora.

I would now like to show you a brief film that will give you a feeling for some of the more remote and seldom seen areas on Kauai where the native plants just mentioned are found growing. Kauai also is the location of the main garden of the Pacific Tropical Botanical Garden.

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MODERATOR WARNER: We certainly appreciate your talk, Bill. Thank you very much.

Saturday Morning Session, August 11, 1973

GEORGE OKI: I think one of the most fascinating things about plant propagation is the subject of tissue culture. In 1967 I had the pleasure of visiting Hawaii and the University of Hawaii's Plant Science Department and had the occasion to go through their tissue culture laboratory and I was immensely impressed. Of all the things happening in our world today, I think this is one of the most fascinating subjects.

It is my pleasure at this time to introduce Richard Maire, our past President, who will be moderator for this session on tissue culture. Dick:

RICHARD MAIRE: Thank you, George. The speakers that we're going to have in this session are outstanding in the field of propagation. I remember one of the first IPPS meetings that I attended fascinated me the most. I have never forgotten a talk by Dr. Nitsch from Paris on tissue culture. At that time it seemed almost like something in the Twenty-first century, way beyond

our possible realm of using. Now we have within the group at the University of California at Riverside, one of the leading educators and research people in the field of tissue culture, Dr. Toshio Murashige. Toshio has been on the UC campus at Riverside since 1964. He came there from the University of Hawaii. Tosh, you have held tissue culture seminars and lectures for the nurserymen and many of them are practicing tissue culture in their own labs and nurseries; this is all due to your fine work, so come on up and tell us about what is new in tissue culture.[1]

[1] Dr. Toshio Murashige and Ms. Jeanne Jones, U.C. Staff Research Associate, discussed their work in the field of tissue culture.

TISSUE CULTURE OF BROMELIADS[1]

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Abstract. Numerous pineapple [*Ananas comosus* (L.) Merr. variety Smooth Cayenne] plantlets and protocorm-like bodies were produced from shoot tips when a combination of orchid shoot tip technique and callus method for organogenesis was applied sequentially and in correct order. Initially, explants from shoot tip, stem and root tips failed to grow in 42 different media. Meristematic protocorm-like bodies and plantlets were produced from pre-shaken shoot tip cultures in Murashige and Skoog's basal medium plus adenosine, 30 ppm, or adenine, 20 ppm. Ornamental bromeliads were more recalcitrant in culture, but, with slight modifications of cultural media, the same procedures appeared applicable. *Portea petropolipana* and *Guzmania* sp. have shown positive response and a wild pineapple, *Ananas erectifolius*, L.B. Smith has produced several lateral shoots and protocorm-like bodies.

REVIEW OF LITERATURE

The bromeliads, in recent years, have gained popularity as indoor and rock garden ornamentals. They range in appearance from the dull gray *Tillandsia usneoides* (Spanish moss of Florida) to the brilliantly colored flowering aechmeas, billbergias and vriesias. They belong to the pineapple family, Bromeliaceae.

In most bromeliaceous plants, seeds are produced when pollinated but among the best horticultural varieties, only 1 or 2% of the seedlings come true (observations forwarded by Howard Yamamoto, Honolulu bromeliad nurseryman). Then there are other plants like the commercial pinneapple (*Ananas*

[1] Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Journal Series No. 1676.