



Desert Willow

**Ten - Year Research Findings
on Selected Water Efficient
Ornamental Plants Using Tertiary
Treated and Potable Water.**

Ten-Year Research Findings on Selected Water Efficient Ornamental Plants Using Tertiary Treated and Potable Water

by

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Forward

By Dan M. Ainsworth, General Manager, Desert Water Agency

Desert Water Agency has long enjoyed a cooperative relationship with the Coachella Valley Resource Conservation District. As a direct result of our joint efforts, the look of the Coachella Valley has shifted from traditional, high water use landscapes, to water efficient themes in most commercial and many residential applications. While this trend is a positive step towards preserving our valuable water supply, it is only one component. Desert Water Agency owns and operates a tertiary treatment water recycling facility, which produces irrigation water from wastewater, thus conserving our groundwater supply. This study serves as a milestone in that it provides scientific data showing how plants commonly grown in the Coachella Valley perform using recycled water.

Introduction

The Coachella Valley Resource Conservation District (CVRCD) and Desert Water Agency (DWA) recognize water quality is a locally important issue. As the Coachella Valley population increases, so does the demand for water and the need to make the best environmental use of the increasing sewage load. Keeping this in mind and building upon the success of our first Field Evaluation Planting (FEP), "Water Efficient Ornamental Plants," we initiated the Water Quality Field Evaluation Planting in 1989. This research, conducted by specialists from USDA Natural Resources Conservation Service, (NRCS) compared the performance of selected water efficient trees and shrubs irrigated with tertiary treated and potable water.

Objectives

- demonstrate the feasibility of tertiary treated water to irrigate trees, shrubs and turf
- demonstrate the feasibility of growing water efficient plants using tertiary treated irrigation water and provide the public with an example of what these plants look like (public could view plants at DWA site)
- develop means to measure the effect of tertiary water on plant growth in comparison to potable water
- inform local golf course operators, growers and nursery managers on tertiary water for irrigation use

Irrigation Systems

Plants were started in June 1989 using potable water from DWA sources. After 3 months, 50 percent of the plants were switched to treated sewage water from DWA's new tertiary treatment plant constructed on site. The water was applied through 2 equally designed micro irrigation systems at 20 psi. Each test plant was irrigated from a riser attached micro tubing containing 2 gallon-per-hour drip emitters. Irrigation scheduling was based on water use data collected during the previous FEP and using daily evapotranspiration rates obtained through a local California Irrigation Management Information System (CIMIS) weather station. Water emission uniformity (EU) tests were periodically performed on the systems. Irrigation tests showed the systems operated at an EU of 80 percent, which is considered "good."

The most significant problem encountered with the drip irrigation systems was rodent damage to the distribution micro tubes. The systems were monitored and repaired regularly. Accumulation of salt deposits in the emitters was minimal due to the high quality of the water used and the absence of fertilizer injection. The filters connected to the irrigation system processing tertiary treated water required monthly cleaning due to excessive algal accumulation.

Water Application

During the first year, test plants were irrigated at a rate of 2 gallons of water per plant each day from June through September. From October through May, each plant received 1 gallon per day. During the second through fourth year, each plant received 4 gallons of water per day from June through September. From October through May, each plant received 2 gallons each day. During the fifth and sixth year, each plant received 6 gallons per day from June through September, and 3 gallons during October through May. During the seventh year, irrigation was increased to 12 gallons per plant each day from June through September, and 6 gallons per day from October through May. Occasional tilling between rows kept weed growth minimal.

Soils

Soils at the research plot consist of Myoma sand. This soil has good drainage. Plants grown in heavier soils may require split irrigation applications to prevent over-watering.

Coachella Valley soils are calcareous, saline (high salt content), stratified and compacted. Soil modification may be needed prior to planting. For soil information, modification techniques and planting instructions, contact your local USDA-NRCS.

Experimental Design

The site was evenly split by plant type and species between potable and tertiary treated water. Water was applied in equal amounts. The planting consisted of 20 species of trees and shrubs, as well as a Bermuda grass turf area. 12 specimens of each plant were randomly located throughout the planting site to satisfy the rules of statistical variability. The turf grass area (60 feet by 110 feet) was divided into 2 separate irrigation treatment sections (potable and tertiary treated water).

Findings

Of the 40 tree and shrub species initially planted, 35 survived and were monitored for the project duration. Seven (20%) of the trees and shrubs had 100 percent survival rate under both irrigation treatments. Willow Acacia, Yellow Bird of Paradise, Desert Olive, Blue Ranger, African Sumac, Vetiver Grass and Mexican Fan Palm had 100 percent survival rates under tertiary treated and potable water irrigation (Table 1).

However, 6 of these 7 species grew faster under tertiary treated water. Under tertiary treated water, Willow Acacia, Yellow Bird of Paradise, Mexican Fan Palm, Desert Olive, Blue Ranger and African Sumac grew more rapidly (Table 1.1). However, Vetiver Grass grew 14 percent more rapidly under potable water irrigation (Table 1).

Table 1.1 – percent plant growth under tertiary treated water irrigation

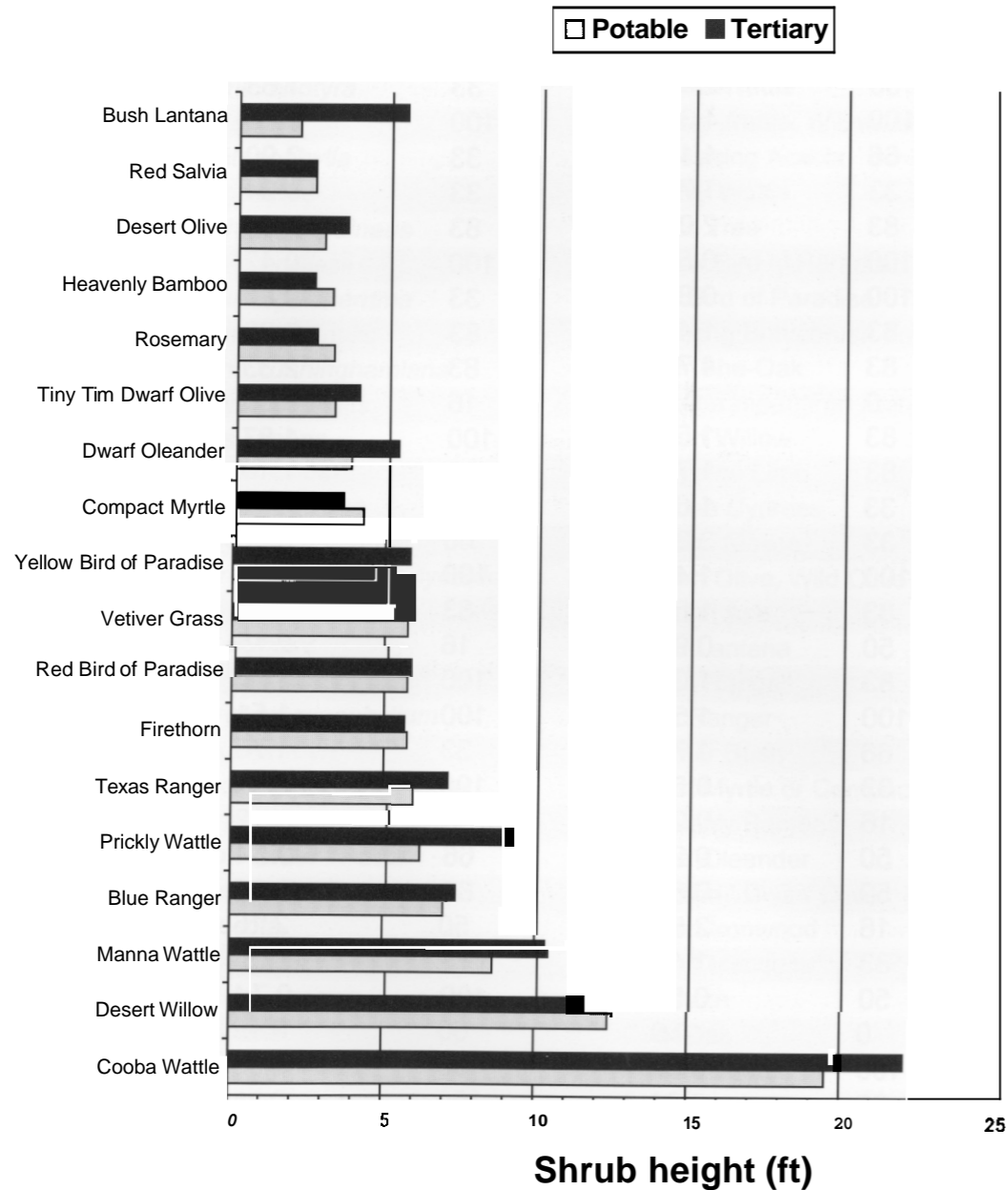
TREE OR SHRUB	INCREASED PERCENT GROWTH
Willow Acacia	14
Yellow Bird of Paradise	16
Mexican Fan Palm	16
Desert Olive	63
Blue Ranger	2
African Sumac	3%

BOTANICAL NAME	COMMON NAME
<i>Acacia farnesiana</i>	Sweet Acacia
<i>Acacia microbotyra</i>	Manna Wattle
<i>Acacia salicina</i>	Cooba Wattle, Willow Acacia
<i>Acacia stenophylla</i>	Acacia
<i>Acacia victoriae</i>	Prickly Wattle
<i>Brachychiton populneus</i>	Bottle Tree
<i>Caesalpinia gilliesii</i>	Yellow Bird of Paradise
<i>Caesalpinia pulcherrima</i>	Red Bird of Paradise
<i>Callistemon viminalis</i>	Weeping Bottlebrush Tree
<i>Casuarina cunninghamiana</i>	River She-Oak
<i>Chamaerops humilis</i>	Mediterranean Fan Palm
<i>Chilopsis linearis</i>	Desert Willow
<i>Citrus calamondin</i>	Philippine Lime
<i>Cupressus arizonica</i>	Arizona
<i>Eucalyptus spathulata</i>	Swamp Mallee
<i>Forestiera shrevei</i> (F. phillyeoides)	Desert Olive, Wild Olive
<i>Fraxinus uhdei</i>	Shamel Ash
<i>Lantana camara</i>	Bush Lantana
<i>Leucophyllum frutescens</i>	Texas Ranger
<i>Leucophyllum zygophyllum</i>	Blue
<i>Lysiloma thomberi</i>	Feather Bush
<i>Myrtus communis</i> 'Compacta'	Dwarf Myrtle or Compact Myrtle
<i>Nandina domestica</i>	Heavenly Bamboo
<i>Nerium oleander</i> 'Petite'	Dwarf Oleander
<i>Olea europaea</i>	'Tiny Tim' Dwarf Olive
<i>Olneya tesota</i>	Desert Ironwood
<i>Prosopis chilensis</i>	Hybrid Mesquite
<i>Pyracantha</i>	Firethorn
<i>Quercus suber</i>	Cork Oak
<i>Rhus lancea</i>	African Sumac
<i>Rosemarinus officinalis</i>	Rosemary
<i>Salvia greggii</i>	Red Salvia
<i>Scinus molle</i>	California Pepper Tree
<i>Vetiveria zizanioides</i>	Vetiver Grass
<i>Washingtonia robusta</i>	Mexican Fan Palm

TERTIARY TREATED WATER		POTABLE WATER	
Survival %	Average annual growth (feet)	Survival %	Average annual growth (feet)
50	2.67	50	1.37
50	2.02	33	1.63
100	4.32	100	3.70
66	1.15	33	3.90
33	1.75	33	1.04
83	2.08	83	1.45
100	0.50	100	0.42
100	0.87	33	0.85
83	1.41	83	2.23
83	1.72	83	2.33
0	0.0	16	0.55
83	1.58	100	1.87
83	1.78	33	1.15
33	1.63	66	2.91
33	3.88	66	3.08
100	1.46	100	0.54
83	1.50	83	1.92
50	0.98	16	0.15
83	1.07	100	0.86
100	1.57	100	1.54
66	1.76	33	1.76
33	0.54	100	0.77
16	0.29	50	0.52
50	0.25	66	0.51
50	0.81	83	0.65
16	2.53	50	2.16
33	1.46	66	2.13
50	0.58	100	1.74
0	0.0	50	0.19
100	3.33	100	2.05
83	0.21	100	0.36
1	0.06	33	0.09
100	1.96	83	2.13
100	1.01	100	1.18
100	1.62	100	1.36

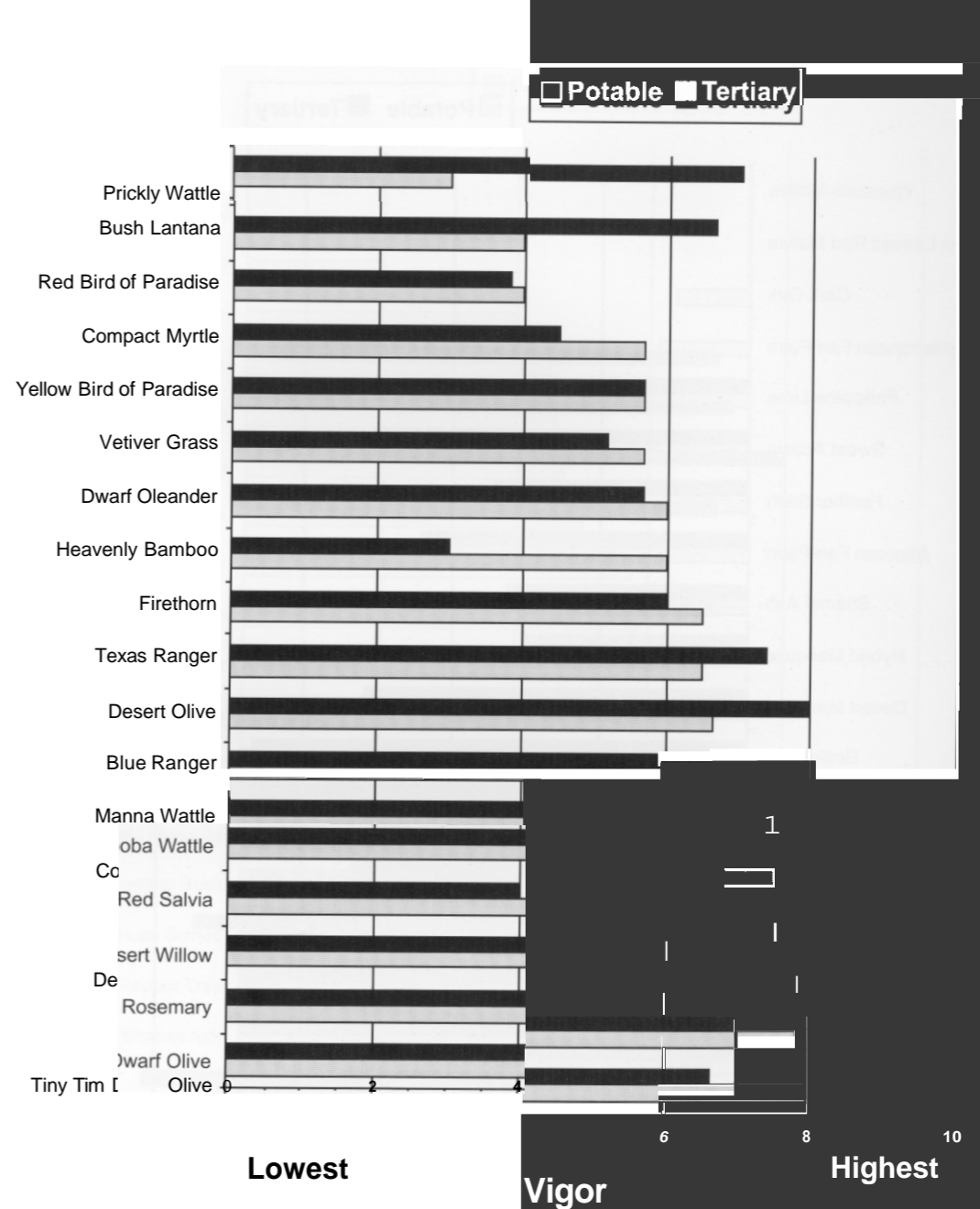
Table 1 - comparisons between survivability and average annual growth of water efficient ornamental plants irrigated with tertiary treated and potable water.

Shrub Evaluations



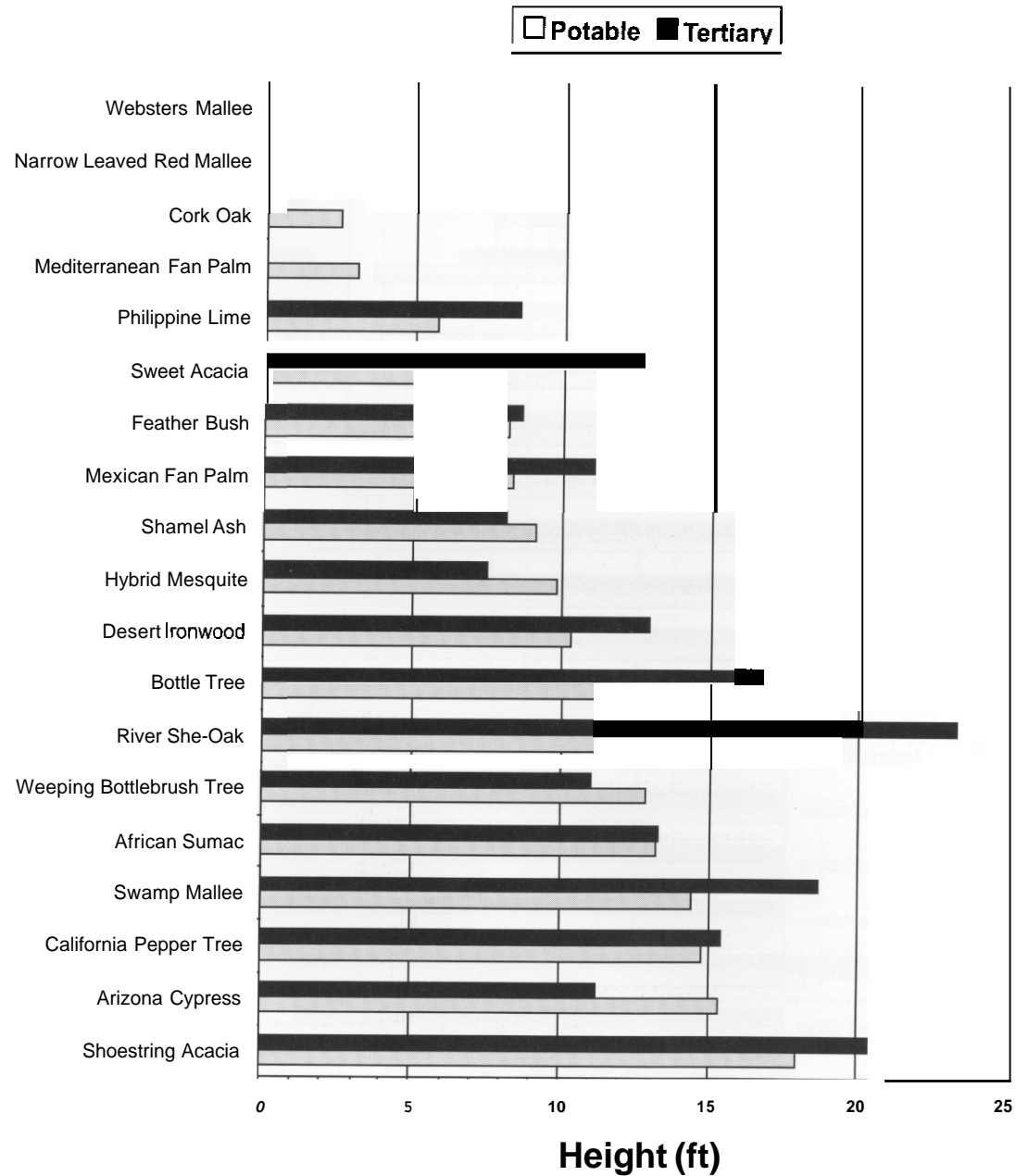
9 out of 18 shrub species tested grew taller under tertiary treated water irrigation than under potable water. The remaining 9 species grew **equally well** under both irrigation treatments

Shrub Evaluations



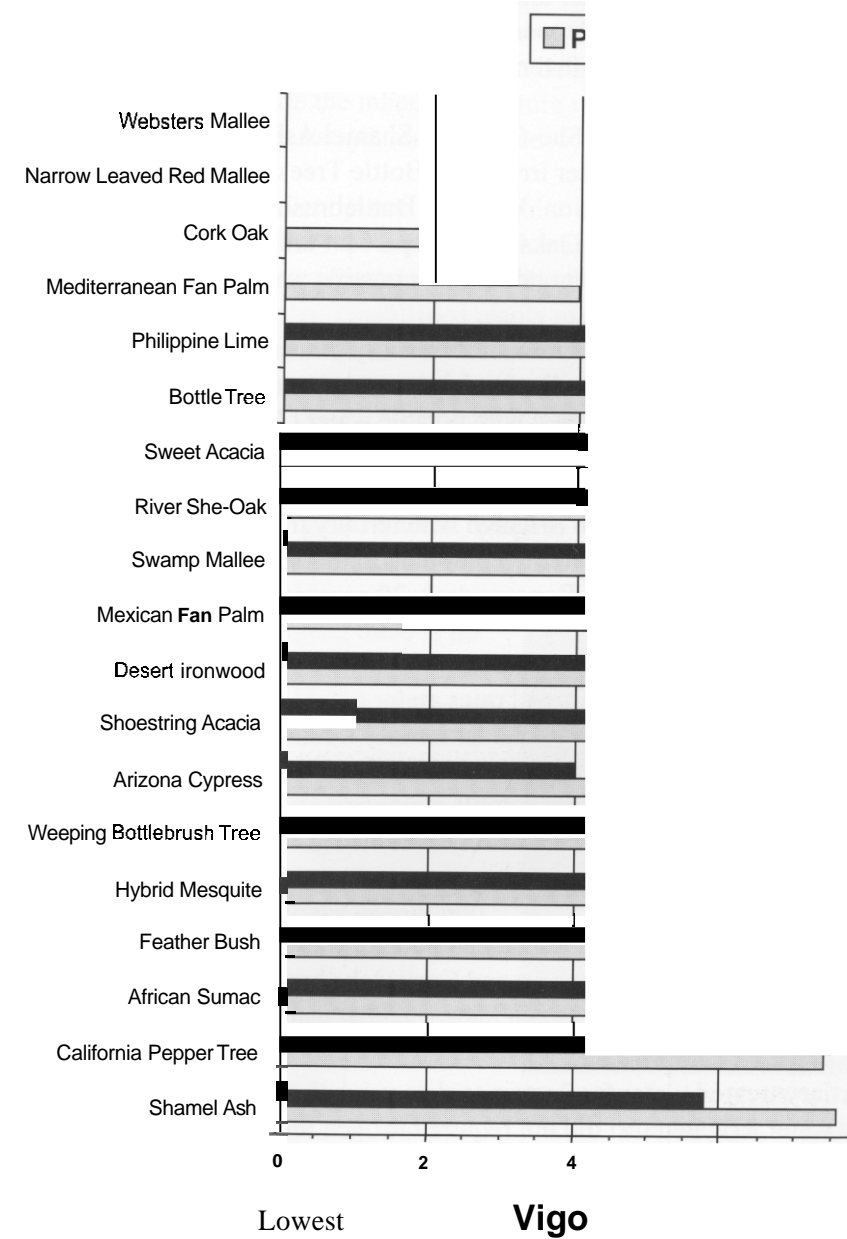
4 of 18 shrub species tested grew more vigorously under tertiary treated water irrigation. 8 grew more vigorously under potable water irrigation. 6 grew with equal vigor under both irrigation treatments.

Tree Evaluations



10 of 19 tree species tested grew taller under tertiary treated water irrigation. 6 grew taller under potable water irrigation. 2 tree species did not survive under tertiary treated water irrigation. 2 tree species survived under either irrigation treatment.

Tree Evaluations



5 of 19 tree species grew more vigorously under tertiary irrigation treatments. 5 tree species grew more vigorously under potable water irrigation, 5 tree species grew equally vigorously under both irrigation treatments. 2 species did not survive under either irrigation treatment.

Red Bird of Paradise and California Pepper trees had a 100 percent survival rate under tertiary treated water irrigation versus an 80 percent survival rate under potable water irrigation. However, the Red Bird of Paradise only grew 2 percent taller under tertiary treated water irrigation than did those under potable water irrigation. California Pepper trees irrigated with potable water grew an average of 8 percent taller than those irrigated with tertiary treated water (Table 1).

Bottle Trees, Weeping Bottlebrush trees, River She-Oaks and Shamel Ash had 83 percent survival rates under both tertiary treated and potable water irrigation. Bottle Trees grew an average of 30 percent taller under tertiary treated water irrigation. Weeping Bottlebrush trees grew 37 percent taller under potable water irrigation. River She-Oaks grew 51 percent taller when irrigated with tertiary treated water. Shamel ash grew 22 percent taller under potable water irrigation (Table 1).

Philippine Lime trees had an 83 percent survival rate under tertiary treated irrigation water versus 33 percent when irrigated with potable water. Philippine Limes under tertiary treated water irrigation grew 35 percent taller than those irrigated with potable water (Table 1).

Desert Willows, Texas Rangers and Rosemary had 100 percent survival rates under potable water irrigation compared to 83 percent survival when irrigated with tertiary treated water. Desert willows grew 16 percent taller under potable water irrigation. Rosemary grew 42 percent taller under potable water irrigation. However, Texas Rangers grew 20 percent taller under tertiary treated water irrigation (Table 1).

Dwarf Myrtle and Firethorn had 100 percent survival rates under potable water irrigation versus 33 and 50 percent survival rates, respectively, when under tertiary treated water irrigation. Dwarf Myrtle and Firethorn grew 20 and 22 percent taller when irrigated with potable water. 'Tiny Tim' Dwarf Olive had an 83 percent survival rate under potable water irrigation versus 50 percent under tertiary treated water irrigation. 'Tiny Tim' Dwarf Olives also grew 20 percent taller under potable water irrigation (Table 1).

Other plant materials tested under both tertiary treated and potable water irrigation had survival rates of 66 percent or less. Mediterranean Fan Palms and Cork Oaks had 0 percent survival rates under tertiary treated irrigation and 16 and 50 percent under potable water irrigation (Table 1).

Turf was grown under tertiary treated water for 3 years to determine the effects on Bermuda grass. The tertiary treated water irrigated turf did not require nitrogen fertilizer. Turf grown under potable water irrigation required 40 to 60 pounds of nitrogen fertilizer to achieve similar growth and color as turf grown under tertiary treated water irrigation.

Water Use Recommendations

Several factors must be considered when determining how much water to apply, and how often. These include the inherent moisture requirement for each plant, its age, soil type, water quality, temperature, humidity and wind, the season and how water is applied.

Even the most water efficient plants need regular amounts of water when planted until they have become *established* – have lived and grown through one summer season. Keep the soil around plants moist (not wet) from planting through the first summer. Gradually reduce irrigation as fall temperatures become cooler. Established plants may require water every 3 to 4 days during summer. Some plants may require more or less water. Be aware some plants can receive too much water. Over-watered plant roots are deprived of oxygen and may experience stunted growth or death.

One way to avoid over-watering or under-watering plants is to learn how to read the soil moisture content. Using a shovel, dig down about 6 inches near plants, being careful not to cut into the roots. Moist soil will be darker in color than the surrounding soil. If you can feel the moisture with your fingers, there is no need to water. If the soil is dry, apply water and check again one or two days later. In time, you will learn to understand your soil and recognize how seasons and weather conditions affect your plants and their water needs.



Sandy loam soil at 75-100% wet forms a ball with wet outline left on hand, light to medium staining of fingers and makes a weak ribbon.

Water plants slowly so it soaks deeply into the soil. Sprinkling for a short time produces shallow roots near the soil surface. Plants become more dependent on frequent irrigation and are more likely to be toppled by strong winds.

Regardless of the time of year or other conditions, plants growing in coarse, sandy soils may require water more often, even every day. Plants planted in fine clay or loam soils may be watered every other day. If you choose to water every other day, double the amount of water you apply.

Mulches Save Water

Placing a layer of mulch on the soil surface around plant roots helps keep the soil cool. Moisture lost through evaporation is reduced, so the upper soil layer stays moist longer to the benefit of the plant roots.

Many materials can be used for mulches. Organic mulches such as grass clippings, compost, animal manure, leaves, sawdust, bark chips or straw can be used, and benefit the soil when they decompose. Inorganic mulches such as rock, pea gravel and decomposed granite conserve moisture and reduce weeds, but do not break down to improve the soil. They are often used as ground covering around plants in place of lawn or other living ground covers.

In mild-winter areas, apply mulch after temperatures warm during spring. This allows the soil to warm up and stimulate plant growth. Apply mulch before heat gets too intense to reduce moisture loss through evaporation and to modify the soil temperature around the root zone.

Mulches also reduce weed growth so moisture goes to plants, not to greedy weeds. The weeds that do grow are more easily removed when rooted in mulch rather than soil.

Plant Summaries

Botanical Name: *Acaciafarnesiana*

Common Name: Sweet Acacia

Plant Type, Form and Size: Deciduous small tree, grows up to 20 feet high and 15 to 25 feet wide. Leaves are feathery and finely divided. Branches are thorny. Flowers are deep yellow, fragrant and in single balls. Blooms January through April, and longer.

General Adaptability: Does well in alkaline soils of low and high deserts where temperatures do not drop below 15 degrees Fahrenheit.

Remarks: Native to the tropics and subtropics of the Americas. It is grown throughout the warm climates of the world. A similar and more cold tolerant (10 degrees Fahrenheit) species is *A. smallii* / *A. minuta* or Southwestern sweet acacia. Water generously for fast growth and protect from wind damage.

Evaluation: 50 % survival rate and 2.7 feet average annual growth under tertiary water irrigation; 50 % survival rate and 1.4 feet average annual growth under potable water irrigation.

Observations: Vigor and cold tolerance ratings were significantly higher using tertiary water versus potable water. Growth was higher under tertiary water irrigation, but was not significantly different from potable water treatment. Acacia species flowered 2 to 3 weeks earlier under tertiary treated water irrigation.

Botanical Name: *Acacia microbotrya*

Common Name: Manna Wattle

Plant Type, Form and Size: This small tree typically has several stems which give it a bushy, spreading growth habit. On deep loamy soils with adequate moisture, it can attain a height of up to 20 feet and 10 - 20 feet wide. The flower is yellow, weakly fragrant, a single ball of 0.5 inch in diameter. Blooms in February through March with fruit maturing in June.

General Adaptability: Does well on granitic soils but prefers deep loamy soils. It can withstand temperatures from 20 degrees Fahrenheit to 110 degrees Fahrenheit. In Australia, it grows naturally in the 11 to 20 inches precipitation zones.

Remarks: Tree introduced from Australia. It is thornless and true leaves fall off early in its growth leaving flattened, 4 to 5 inches long leaf-like phyllodes.

Evaluation: 50 % survival rate and 2 feet average annual growth under tertiary water irrigation; 33 % survival rate and 1.6 feet average annual growth under potable water irrigation.

Observations: Cold tolerance, vigor and height were not significantly different from the potable water treatment. Plant height was less using potable water versus tertiary water. However, plant height and percent survival were higher using tertiary water. Acacia species flowered 2 to 3 weeks earlier under tertiary treated water irrigation.

Botanical Name: *Acacia salicina*

Common Name: Willow Acacia

Plant Type, Form and Size: A thornless tree between 20 and 40 feet high and 10 to 20 feet wide. Leaf-like phyllodes are retained throughout the year. It flowers twice a year—in February and again in August through September in response to summer monsoons. Flowers are white, 0.5 to 1 inch in diameter, and weakly fragrant. Fruit matures approximately 90 days after flowering. Seeds are dark brown and have a red integument.

General Adaptability: Prefers alluvial or clay soils but also does well on sandy soils with adequate moisture. It can tolerate low temperatures of 20 degrees Fahrenheit and highs above 110 degrees Fahrenheit.

Remarks: An introduced tree from Australia. Drooping foliage and small branches give it a general resemblance to weeping willow. A fast growing tree. Once established, is drought resistant and cold hardy.

Evaluation: 100% survival rate and 4.3 feet average annual growth under tertiary water irrigation; 100% survival rate and 3.7 feet average annual growth under potable water irrigation.

Observations: No significant differences were found between the potable and tertiary water treatments. This plant performed very well under both water treatments. However, the tertiary water treatment has consistently higher cold tolerance ratings and taller plants. *Acacia* species flowered 2 to 3 weeks earlier under tertiary treated water irrigation.

Botanical Name: *Acacia stenophylla*

Common Name: Shoe String Acacia

Plant Type, Form and Size: Evergreen tree with a moderate growth rate to above 20 feet tall and 15 feet wide. It is an erect to bending tree with a sparsely foliated open crown. Phyllodes are grayish green, up to 16 inches long and 0.25 inches wide. Flowers are white and single balls. Flowering occurs in the fall through spring.

General Adaptability: Tolerant to poor soil conditions, drought and heat. Prefers heavy textured soils.

Remarks: Native to Australia. Good specimen or transitional plant. Prune and stake young plants to obtain desired shape and protect from wind damage. Protect young plants from grazing by rabbits and rodents. Plants are susceptible to sunburn.

Evaluation: 66% survival rate and 4.2 feet average annual growth under tertiary water irrigation; 33% survival rate and 3.9 feet average annual growth under potable water irrigation.

Observations: Good cold tolerance and above average vigor ratings. Low survival may have been due to herbivores and low fertility of the soil. Under tertiary water, this was the tallest tree. *Acacia* species flowered 2 to 3 weeks earlier under tertiary treated water irrigation.

Botanical Name: *Acacia victoriae*

Common Name: Prickly Wattle

Plant Type, Form and Size: A small tree or bushy shrub attaining a height of 10-20 feet and a width of 10-15 feet. Young bark and foliage is bluish green and glaucous; mature bark is brown and slightly furrowed. Flowers are capitate, pale yellow, and 0.5 to 1 inch in diameter. Blooms April through May with fruit ripening in July through August.

General Adaptability: Does well on sandy loam to loamy soils. Is tolerant to temperature lows of 20 degrees Fahrenheit and highs above 100 degrees Fahrenheit. Established plants are very drought tolerant and can persist under annual precipitation of less than 7 inches.

Remarks: Introduced from Australia. True leaves fall off early in its growth leaving flattened leaf-like phyllodes that are 0.5 to 1.5 inches long. Phyllodes are subtended by two short slender spines 0.25 inches long.

Evaluation: 33% survival rate and 1.8 feet average annual growth under tertiary water irrigation; 33% survival rate and 1.04 feet average annual growth under potable water irrigation.

Observations: There were no significant differences between water treatments for vigor, cold tolerance and height due to the low number of survivors. Plants irrigated with tertiary water had much higher ratings for cold tolerance and vigor than plants irrigated with potable water. Plants grew approximately 3 feet more with tertiary water versus potable water. *Acacia* species flowered 2 to 3 weeks earlier under tertiary treated water irrigation.

Botanical Name: *Brachychiton populneus*

Common Name: Bottle Tree

Plant Type, Form and Size: Evergreen tree of moderate height, 30 to 50 feet. Very heavy trunk, broad at base and tapering sharply gives this plant its common name. Leaves, 2 to 3 inches long. Clusters of small, bell-shaped, white flowers open in May and June, noticeable close up. The 2.5 to 3 inch woody h i t s that follow are noticeable in the litter they produce.

General Adaptability: Appreciated in low desert where frequently used as screens or high windbreaks.

Remarks: Tolerant to most soil conditions but is susceptible to iron chlorosis, cold damage below 18 degrees Fahrenheit and Texas root rot. Young trees may need staking to avoid wind damage and to promote upright growth. Trunk should be protected from sunburn.

Evaluation: 83% survival rate and 2.1 feet average annual growth under tertiary water irrigation; 83% survival rate and 1.5 feet average annual growth under potable water irrigation.

Observations: Exhibited lower vigor and cold tolerance in potable water treatment than tertiary treatment.

Botanical Name: *Caesalpinia gilliesii*

Common Name: Yellow Bird of Paradise

Plant Type, Form and Size: Semi-evergreen shrub or small tree up to 10 feet high. Tough, fast growing with finely cut filmy foliage on rather open angular branch structure. Dark green leaves with many 0.8 inch long leaflets. Drops leaves in cold winters. Blooms all summer, clusters of yellow flowers with protruding bright red 4 to 5 inch long stems.

General Adaptability: Adapted to a wide variety of soil types. Grows well in full sun to partial shade. Plants are cold tolerant to 10 degrees Fahrenheit. Continued cold temperatures may cause dieback to the ground. However, recovers quickly in warm weather.

Remarks: To ensure good flowering, provide ample supplemental water during blooming season. Pods and seeds are poisonous. Cut back to the ground during the winter to develop a low thick shrub or do not trim to develop a tall open plant.

Evaluation: 100 % survival rate and 0.5 feet average annual growth under tertiary water irrigation; 100 % survival rate and 0.4 feet average annual growth under potable water irrigation.

Observations: No significant differences between the two water treatments with regard to cold tolerance, vigor, or height. However, plants irrigated with tertiary water were consistently taller than potable water irrigated plants.

Botanical Name: *Caesalpinia pulcherrima*

Common Name:

Red Bird of Paradise

Plant Type, Form and Size: Semi-evergreen shrub or small tree up to 10 feet high. Tough, fast growing with finely cut filmy foliage on rather open angular branch structure. Dark green leaves with many 0.8 inch long leaflets. Blooms throughout warm weather. Flowers orange or red, clustered.

General Adaptability: May be evergreen in mild winters. Useful for quick screening. Well adapted to most soil

types. Performs well in either full sun or partial shade. Requires supplemental watering for best growth and flowering. Plant will die back to the ground when temperatures drop to 30 degrees Fahrenheit or below.

Remarks: Pods and Seeds are poisonous. In cool areas, the base of the plant should be mulched to protect against freezing and aid in a faster spring recovery.

Evaluation: 100 % survival rate and 0.9 feet average annual growth under tertiary water irrigation; 33 % survival rate and 0.9 feet average annual growth under potable water irrigation.

Observations: Survival was much lower with potable water. Plants irrigated with tertiary water had significantly lower cold tolerance and vigor ratings.



Botanical Name: *Callistemon viminalis*

Common Name: Weeping Bottlebrush Tree

Plant Type, Form and Size: Evergreen shrub or small tree with pendulous branches. Fast growing 20 to 30 feet high with 15 feet spread. Leaves, 6 inches long, narrow, and light green. Bright red branches. Blooms May through July and with scattered bloom throughout the year. Inclined toward sparseness because leaves tend to grow only at ends of long hanging small branches.

General Adaptability: Needs ample water. Unsuitable for windy, dry areas.

Remarks: As a tree, it needs staking and thinning of surplus branches to prevent tangled, top-heavy growth. Young plants should be staked to promote proper form and protect from wind damage.

Evaluation: 83 % survival rate and 1.4 feet average annual growth under tertiary water irrigation; 83 % survival rate and 2.2 feet average annual growth under potable water irrigation.

Observations: Has higher growth rate using potable water. Vigor and cold tolerance were virtually the same for both water treatments throughout the life of the project.

Botanical Name: *Casuarina cunninghamiana*

Common Name: River She-Oak

Plant Type, Form and Size: Evergreen tree. Grows to 130 feet high and over 3.5 feet in trunk diameter. Leaves with leaf-teeth in whorls of 6 to 8. Fruit is a small sub-globose "cone." Shapely tree, do not prune at branch phase level.

General Adaptability: Tolerates tough conditions, wet or dry soil, salinity, heat, cold (hardy to 15°F) and wind. Adapted temperate to tropics. Needs 3 to 4 times more water to form full tall tree than trees well suited to Coachella Valley.

Remarks: Native to Australia and New Guinea. Some established in Florida.

Fixes nitrogen in soil, when inoculated with specific bacteria.

Evaluation: 83 % survival rate and 4.7 feet average annual growth under tertiary water irrigation; 83 % survival rate and 2.3 feet average annual growth under potable water irrigation.

Observations: Cold tolerance ratings were the same for both water treatments. Vigor and height were much better using the tertiary water treatment. This species had twice the growth using tertiary water versus potable water.



Botanical Name: *Chamaerops humilis*

Common Name: Mediterranean Fan Palm

Plant Type, Form and Size: Grows up to 20 feet high. Palm leaves are bluish green.

General Adaptability: Versatile – used in containers, under trees, and for landscaping.

Remarks: Drought and wind resistant. Feed and water in summer to speed growth.

Evaluation: 0 % survival rate and 0.0 feet average annual growth under tertiary water irrigation;

16 % survival rate and 2.3 feet average annual growth under potable water irrigation.

Observations: This species was a very poor performer in all categories. It exhibited poor adaptability, vigor, cold tolerance, low survival and growth.

Botanical Name: *Chilopsis linearis*

Common Name: Desert Willow

Plant Type, Form and Size: Deciduous large shrub or small tree. Ranges from 6 to 20 feet high. Leaves smooth, narrow and willow-like, 4 to 6 inches long.

Flowers: trumpet shaped with crimped lobes; pink, white, rose or lavender marked with purple. Very fragrant.

Blooms in spring and often through late fall.

General Adaptability: Very hardy and drought tolerant. Well suited to Coachella Valley. Colorful landscape plant.

Remarks: Native to Southwest. Specimen or single trunk tree to 20 feet high. Can be trained as a screening plant. Has a good deal of natural variation in growth forms.

Evaluation: 83 % survival rate and 1.6 feet average annual growth under tertiary water irrigation; 100 % survival rate and 1.9 feet average annual growth under potable water irrigation.

Observations: Statistics show that potable water treatment was significantly higher versus tertiary water treatment. There are no differences between water treatments for cold tolerance and height.



Botanical Name: *Citrus calamondin*

Common Name: Philippine Lime

Plant Type, Form and Size: No information related to this particular species.

General Adaptability: Information not available.

Remarks: None.

Evaluation: 83 % survival rate and 1.8 feet average annual growth under tertiary water irrigation; 33 % survival rate and 1.2 feet average annual growth under potable water irrigation.

Observations: Cold tolerance ratings were good for established trees. However, vigor was low for the surviving plants under both irrigation treatments.

Botanical Name: *Cupressus arizonica*

Common Name: Arizona Cypress

Plant Type, Form and Size: Evergreen tree, 50 to 60 feet high. Dense upright conical crown that becomes relaxed with age. Smooth reddish-brown bark. Leaves, scale-like, gray-green, blue-green, or silvery. Fruit are cones 1 inch in diameter.

General Adaptability: Not recommended for use in soils with high water table. Somewhat drought tolerant once established. Under irrigation, very well suited to Coachella Valley.

Remarks: Native to Arizona. Excellent for windbreaks. Selected varieties more uniform. Once stressed due to lack of water, trees are susceptible to beetle infestations and begin dying back from the top. It is important to use trees propagated in similar climates.

Evaluation: 33 % survival rate and 1.6 feet average annual growth under tertiary water irrigation; 66 % survival rate and 2.9 feet average annual growth under potable water irrigation.

Observations: Height and survival were higher under potable water, but the values were not significantly different. Cold tolerance and vigor were significantly lower with potable water.

Botanical Name: *Eucalyptus spathulata*

Common Name: Swamp Mallee

Plant Type, Form and Size: Evergreen, small, erect, multiple-trunked tree, 6 to 20 feet high.

Leaves 2 to 3 inches long and ribbon-like. Smooth red bark. Many one-half inch cream and gold flowers that bloom all summer long.

General Adaptability: Prefers loam to clay loam soils and areas that receive extra moisture.

Remarks: Native to Western Australia. Attains a height of 15 - 20 feet in a 12-15 inch rainfall area, but can attain a height of 35 feet with higher moisture. Good for bushy wind screens.

Branches move nicely in breezes.

Evaluation: 33 % survival rate and 3.9 feet average annual growth under tertiary water irrigation; 66 % survival rate and 3.1 feet average annual growth under potable water irrigation.

Observations: Potable water irrigated plants performed well and had a higher survival rate, but they did not perform as well with regards to cold tolerance, vigor and height as those irrigated with tertiary water.

Botanical Name: *Forestiera shrevei* (*F. phillyreoides*)

Common Name: Desert or Wild Olive

Plant Type, Form and Size: A dense, slow growing, deciduous shrub 3 to 12 feet tall. A native shrub found in the Sonoran desert at elevations between 2,000 and 4,500 feet.

General Adaptability: As a cultivated plant, it has performed well on deep well-drained loamy soils. It is drought and cold tolerant.

Remarks: Leaves are bright green, lanceolate to narrowly oblong. Flowers are apetalous, green with purple anthers and inconspicuous.

Evaluation: 100% survival rate and 1.5 feet average annual growth under tertiary water irrigation; 100% survival rate and 1.1 feet average annual growth under potable water irrigation.

Observations: Plants had significantly higher vigor ratings under tertiary water than potable water. Although not statistically significant, plants were taller using tertiary water than potable water. No significant differences between water treatments for height and cold tolerance. Vigor was significantly lower under potable water versus tertiary water

Botanical Name: *Fraxinus uhdei*

Common Name: Shamel Ash

Plant Type, Form and Size: Evergreen to semi-evergreentree which grows fast-25 to 30 feet high in 10 years, 40 feet high in 20 years. Makes upright narrow tree when young, eventually spreading. Leaves divided into 5 to 9 dark green leaflets about 4 inches long. The leaflets are serrated.

General Adaptability: In mildest weather areas, leaves stay through winter. In colder sections, trees lose most or all foliage, but often only for a short time. Serious damage at about 15 degrees Fahrenheit or lower. Needs regular pruning of weak branches.

Remarks: Native to Mexico. Tends to be shallow rooted. Site preparation to 4 feet deep. Deep watering will encourage deep root growth. Disease "Fursarium wilt" can be a problem.

Evaluation: 83 % survival rate and 1.5 feet average annual growth under tertiary water irrigation; 83 % survival rate and 1.9 feet average annual growth under potable water irrigation.

Observations: Plants using potable water had higher values for cold tolerance, vigor and height than those using tertiary water. However, the differences were not significant. Cold tolerance, vigor and height were lower than with potable water.

Botanical Name: *Lantana camara*

Common Name: Bush Lantana

Plant Type, Form and Size: Semi-evergreen shrub up to 6 feet high. Dark green leaves. Flowers in 1 to 2 inch clusters, yellow, orange, or red.

General Adaptability: Not particular as to soil type. Favors full sunlight. Valued for profuse show of color throughout the year in frost-free areas. Frost sensitive when temperatures drop below 30 degrees Fahrenheit.

Remarks: Prune severely in spring to prevent dead wood. Water deeply, but infrequently. May need replacement after hard winter. The fruit occurs as clusters of tiny black berries and is poisonous.

Evaluation: 50 % survival rate and 1 foot average annual growth under tertiary water irrigation; 16% survival rate and 0.2 feet average annual growth under potable water irrigation.

Observations: Due to the low number of observations, data could not be analyzed statistically with accuracy. Plants using potable water had lower survival rates, poorer growth, lower cold tolerance and vigor ratings. Plants performed better using tertiary water.

Botanical Name: *Leucophyllum frutescens*

Common Name: Texas Ranger

Plant Type, Form and Size: Evergreen compact shrub, 5 to 12 feet high and 4 to 6 feet wide. Small silvery leaves. Flowers 1 inch long with bell shaped rose-purple color. Requires heat in order to flower and bloom in summer.

General Adaptability: Does well in desert areas, takes any degree of heat and wind velocity. Tolerates some alkalinity if drainage is good.

Remarks: Native to Texas and Mexico. Useful as a round headed gray mass, as clipped hedge, or in mixed plantings.

Evaluation: 83 % survival rate and 1 foot average annual growth under tertiary water irrigation; 100% survival rate and 0.9 foot average annual growth under potable water irrigation.

Observations: Tertiary irrigated plants were over 1 foot taller than those irrigated with potable water. However, these differences were not statistically significant. No significant differences between water treatments for cold tolerance, vigor and height. In general, plants irrigated with potable water did not perform as well as plants irrigated with tertiary water.

Botanical Name: *Leucophyllum zygophyllum*

Common Name: Blue Ranger

Plant Type, Form and Size: A rounded evergreen medium sized shrub which can grow to 6 feet in height and width. Foliage is gray-green and produces dark violet flowers.

General Adaptability: Tolerant to temperatures above 100 degrees Fahrenheit and down to 15 degrees Fahrenheit. Tolerant to alkaline soils that have good drainage.

Remarks: Native to the Chihuahuan Desert of Texas and Mexico.

Evaluation: 100% survival rate and 1.6 feet average annual growth under tertiary water irrigation; 100% survival rate and 1.5 feet average annual growth under potable water irrigation.

Observations: There were no significant differences between water treatments. The 1991 and 1992 evaluations did show that the potable water treatment had lower cold tolerance, vigor and growth than plants irrigated with tertiary water. However, by 1995 there were no differences between water treatment for the three evaluation factors.

Botanical Name: *Lysiloma thornberi*

Common Name: Feather Bush

Plant Type, Form and Size: Semi-evergreen shrub or small tree up to 12 feet high. Makes a broad canopy of finely cut bright green leaves, somewhat like an Acacia. Flowers, tiny white in 0.5 inch heads. Blooms May through June. Seed pods flat, rigid, 4 to 8 inches long and 1 inch wide.

General Adaptability: Takes desert heat and drought when established. Good informal background shrub, patio tree, and transitional planting between garden and desert.

Remarks: Native of foothills of Ricon Mountains of Arizona. Sometimes killed by heavy frost, but usually comes back.

Evaluation: 66% survival rate and 1.8 feet average annual growth under tertiary water irrigation; 33 % survival rate and 1.8 feet average annual growth under potable water irrigation.

Observations: Plants performed well under both water treatments once they recovered from the 1990 December freeze. Evaluation factors were similar between water treatments. Cold tolerance and vigor were above average while height was somewhat below what was expected. Water treatment differences were not significant with regards to cold tolerance, vigor and height.

Botanical Name: *Myrtus communis* 'Compacta'

Common Name: Dwarf or Compact Myrtle

Plant Type, Form and Size: Evergreen shrub, slow growing, small, compact, water dense set small leaves. Grows 2 to 3 feet high and wide.

General Adaptability: Very popular for edgings and foundation plantings. Excellent for compact, formal hedge. Soil should be well drained and performs well in partial or full sun.

Remarks: Can be susceptible to root rot if soil is kept too damp during the summer.

Evaluation: 33 % survival rate and 0.5 feet average annual growth under tertiary water irrigation; 100% survival rate and 0.8 feet average annual growth under potable water irrigation.

Observations: No significant differences were found between water treatments for the 3 evaluation factors. Plant survival was much higher using potable water than using tertiary water. Overall, plant vigor and cold tolerance were higher using potable water than tertiary water.

Botanical Name: *Nandina domestica*

Common Name: Heavenly Bamboo

Plant Type, Form and Size: Semi-evergreen shrub of slow to moderate growth rate, 6 to 8 feet high. Leaves intricately divided into many 1 to 2 inch pointed, oval leaflets, creating a lacy pattern. New foliage slightly pink or bronze red on expanding, later soft light green. Flowers slightly pink white or creamy white in loose erect 6 to 12 inch clusters at branch ends. Blooms late spring or summer. Shiny red berries if plants are grouped. Single plants seldom fruit.

General Adaptability: Best in rich soil with ample water. Needs some shade in desert and hot valley areas.

Remarks: Can be held to 3 feet high by pruning. Apply iron sulfate or chelates to correct chlorosis in alkaline soils. There were not enough observations to accurately determine significant differences between evaluation factors for the 2 water treatments.

Evaluation: 16% survival rate and 0.3 feet average annual growth under tertiary water irrigation; 50 % survival rate and 0.5 feet average annual growth under potable water irrigation.

Observations: Survival was much lower in tertiary water than in potable water.

Botanical Name: *Nerium oleander*

Common Name: Dwarf Oleander

Plant Type, Form and Size: Low growing evergreen shrub 2 to 4 feet tall and wide. Blooms from spring through summer.

General Adaptability: Tolerant to a wide range of soils including poorly drained, heavy and alkaline soils. Heat tolerant but can be damaged at temperatures below 20 degrees Fahrenheit.

Remarks: All parts of the plant are poisonous. It can be susceptible to insects (aphids and scale) and diseases. Very low maintenance is required.

Evaluation: 50 % survival rate and 0.3 feet average annual growth under tertiary water irrigation; 66 % survival rate and 0.5 feet average annual growth under potable water irrigation.

Observations: Plants irrigated with tertiary water had significantly higher cold tolerance ratings and height than potable water. No significant vigor differences between the two water treatments.

Botanical Name: *Olea europaea*

Common Name: 'Tiny Tim' Dwarf Olive

Plant Type, Form and Size: Evergreen small tree with dark gray-green leaves. Height at maturity has not been established.

General Adaptability: Prefers loamy well drained soils but is tolerant to shallow, gravelly and alkaline soils. Heat tolerant, but sensitive to cold temperatures below 15 degrees Fahrenheit.

Remarks: We have no information regarding this species flowering, fruiting and pollen production characteristics. However, other dwarf species appear to flower less than the common tree types.

Evaluation: 50 % survival rate and 0.8 feet average annual growth under tertiary water irrigation; 83 % survival rate and 0.7 feet average annual growth under potable water irrigation.

Observations: There were no significant differences between water treatments for cold tolerance and vigor, although, plants irrigated with potable water were significantly smaller than those irrigated with tertiary water. Survival was higher using potable water than tertiary water.

Botanical Name: *Olneya tesota*

Common Name: Desert Ironwood

Plant Type, Form and Size: Evergreen broad-crowned tree, 25 to 30 feet high and as wide. Leaves gray-green divided into 0.8 inch leaflets. Clusters of 0.5 inch long white to rose-purple flowers which bloom from April to June.

General Adaptability: Deciduous in hard frost and can not endure prolonged freezes. Tolerates heat, but slow growing. Well suited to Coachella Valley. Plant makes good hedge to keep out intruders. Requires pruning every few years, which is a prickly job.

Remarks: A native of desert washes and valleys of southwestern California, southern Arizona, and northwestern Mexico.

Evaluation: 16 % survival rate and 2.5 feet average annual growth under tertiary water irrigation; 50 % survival rate and 2.2 feet average annual growth under potable water irrigation.

Observations: Little to no difference between water treatments with regard to cold tolerance and vigor. Survival was higher with potable water.

Botanical Name: *Prosopis chilensis*

Common Name: Hybrid Mesquite

Plant Type, Form and Size: Deciduous tree or large shrub, to 30 feet high and 40 feet wide. Multi-trunked. Small dark greenish yellow flowers in 1.5 to 2.5 inches long spikes. Flat seed pods are 2 to 6 inches long.

General Adaptability: Very drought tolerant, but will tolerate irrigated conditions. Summer watering may be required for plant to form a tree. Tolerates alkaline conditions, but when young (small), rabbit browsing can kill this plant.

Remarks: Native to South America. Young plants may require protection from herbivores and staking to promote proper form and protection from wind damage. Plant fixes atmospheric nitrogen and may aid growth rate under domestic water irrigation.

Evaluation: 33 % survival rate and 1.5 feet average annual growth under tertiary water irrigation; 66 % survival rate and 2.1 feet average annual growth under potable water irrigation.

Observations: Plants performed better under potable water with regard to growth, cold tolerance and vigor.



Botanical Name: *Pyracantha* sp

Common Name: Firethorn

Plant Type, Form and Size: Evergreen shrub with stiff branches that bear sharp thorns and dark green leaves. Can grow up to 10 feet high and as wide depending on maintenance. Used as an espalier, hedge, specimen, shrub or tree.

General Adaptability: Needs soils that are well drained. Hardy to 10degrees Fahrenheit and likes full, partial or reflected sun.

Remarks: Needs good maintenance program. Berries are eaten by birds. Subject to iron chlorosis, fire blight and red spider mites.

Evaluation: 50% survival rate and 0.6 feet average annual growth under tertiary water irrigation; 100% survival rate and 0.7 feet average annual growth under potable water irrigation.

Observations: No significant differences were found between the 2 water treatments for all 3 evaluation factors. Survival was much higher under potable water than under tertiary water.

Botanical Name: *Quercus suber*

Common Name: Cork Oak

Plant Type, Form and Size: Evergreen tree, moderate growth rate, 70 to 100 feet high, with equal spread. Trunk and principal limbs covered with thick, corky bark (the cork of commerce). The 3 inch serrated leaves are shiny dark green on the upper surface and gray on the lower surface.

General-Adaptability: Needs good drainage, but fairly tolerant of different soil types. It is likely to turn yellow in alkaline soils. Established trees can take considerable drought.

Remarks: Native to Mediterranean region.

Evaluation: 0% survival rate and 0.0 feet average annual growth under tertiary water irrigation; 50% survival rate and 0.2 feet average annual growth under potable water irrigation.

Observations: Survival was good under potable water irrigation, but the plants' overall performance was very poor. Cold tolerance and vigor ratings were very low. This species appears to be poorly adapted to the Indio-Palm Springs area.

Botanical Name: *Rhus lancea*

Common Name: African Sumac

Plant Type, Form and Size: Evergreen tree, up to 25 feet high. Open spreading habit and graceful weeping outer small branches. Dark red rough bark. Leaves 4 to 5 inches long, dark green divided into 3 willow-like leaflets. Pea-size yellow or red berry-like fruit on female trees. Can be messy on pavement.

General Adaptability: Slow grower. Drought tolerant and does well in lawns. Grows well in any soil, but needs good drainage. Tends to sucker. Prone to be an invader in irrigated landscapes.

Remarks: Introduced. Useful as screens, clipped hedges, or background plantings. Excellent wildlife food and cover plant. Recommend planting only male trees. Spider mites were noticed on all of the plants, but damage, if any, was difficult to determine.

Evaluation: 100% survival rate and 3.3 feet average annual growth under tertiary water irrigation; 100% survival rate and 2.1 feet average annual growth under potable water irrigation.

Observations: This species performed very well under both water treatments with regard to cold tolerance, vigor and growth. There were no significant differences between water treatments for the evaluation factors.

Botanical Name: *Rosmarinus officinalis*

Common Name: Rosemary

Plant Type, Form and Size: Evergreen shrub/herb, 2 to 6 feet high. Leaves narrow, aromatic, glossy green upper surface and grayish white on lower surface. Light lavender-blue flowers about 0.5 inches long.

General Adaptability: Endures hot sun and poor soil. Needs good drainage. Requires some water in desert, but very drought tolerant. Well suited to Coachella Valley, but when young (small), rabbit browsing can kill this plant.

Remarks: Introduced. Leaves are widely used in seasoning. Useful as clipped hedges. Low growing varieties useful as ground and bank covers.

Evaluation: 83% survival rate and 0.2 feet average annual growth under tertiary water irrigation; 100% survival rate and 0.4 feet average annual growth under potable water irrigation.

Observations: Plants using potable water grew taller than those irrigated with tertiary water. There were no significant differences between water treatments for cold tolerance and vigor. Plants performed better over all 3 evaluation factors from 1991 to 1995 using potable water versus tertiary water.

Botanical Name: *Salvia greggii*

Common Name: Red Salvia

Plant Type, Form and Size: Evergreen shrub, upright branching, bushy plant, 3 to 4 feet tall. Leaves are 0.5 to 1 inch long and medium green. Flowers are 1 inch long, rosey red, in loose spike-like clusters in late spring and summer.

General Adaptability: Ordinary garden soil and watering, full sun or light shade. Cold hardy to 15 degrees Fahrenheit and drought tolerant after plants are established.

Remarks: Old flower spikes should be removed to enhance flowering

Evaluation: 16 % survival rate and 0.06 feet average annual growth under tertiary water irrigation; 33 % survival rate and 0.09 feet average annual growth under potable water irrigation.

Observations: Poor survival and poorer ratings for cold tolerance and vigor using tertiary water compared to potable water.

Botanical Name: *Schinus molle*

Common Name: California Pepper Tree

Plant Type, Form and Size: Evergreen tree, 25 to 40 feet high with equal width. Leaves bright green and 1.5 to 2 inches long. Tiny yellowish-white flowers in summer. 4 to 6 clusters of rose colored berries in fall and winter.

General Adaptability: Grows well in any soil. Drought tolerant once established. Tolerates poor drainage. Needs 2 times more water to form full tall tree than trees well suited to Coachella Valley. Pruning and shaping will be required.

Remarks: Introduced species. Good songbird food and cover plant.

Evaluation: 100 % survival rate and 2 feet average annual growth under tertiary water irrigation; 83 % survival rate and 2.1 feet average annual growth under potable water irrigation.

Observations: No significant differences between water treatments for each of the evaluation factors. Cold tolerance and vigor ratings were very high for both water treatments.



Botanical Name: *Vetiveria zizanioides*

Common Name: Vetiver Grass

or Khus-Khus

Plant Type, Form and Size: An intr perennial grass from India. A robust tufted, deep rooted grass that grows 6 to 10 feet high. Individual plants can up to 2 or more feet wide at the base.

General Adaptability: A tropical grass with excellent drought tolerance once established. Established plants are cold tolerant to temperatures of 25 degree Fahrenheit. Prefers deep well-drained to loamy soils.

Remarks: The "sunshine" variety has transplanted rooted plants or slips. They produce oil for perfume from its aroma makes it ideal for stabilizing soils and erosion control.

Evaluation: 100 % survival rate and 1.2 feet average annual growth under tertiary water irrigation; 100 % survival rate and 1.2 feet average annual growth under potable water irrigation.

Observations: This plant performed well under both water treatments.

Botanical Name: *Washingtonia robusta*

Common Name: Mexican Fan Palm

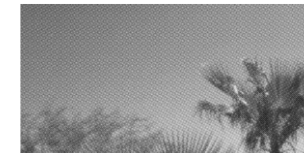
Plant Type, Form and Size: Slender palm tree up to 100 feet tall. Leaf stalks are shorter, with a distinguishing red streak on undersides. Compact crown with less smooth thatch.

General Adaptability: Takes poor soil or drought, but grows faster with good conditions. Hardy down to about 24 degrees Fahrenheit.

Remarks: None

Evaluation: 100 % survival rate and 2 feet average annual growth under tertiary water irrigation; 100 % survival rate and 2 feet average annual growth under potable water irrigation.

Observations: Growth was significantly different between water treatments.



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