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Minimum Irrigation Requirements for Landscape Plants[1]

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Abstract. Several field-established broadleaved and coniferous evergreen shrubs and 2 ground covers, *Carpobrotus* sp. and *Hedera helix* L., survived, and maintained adequate appearance with greatly restricted growth, without supplemental irrigation from May through September on deep soils at San Jose and Santa Ana, CA. *Eugenia uniflora* L. at Santa Ana required 1 irrigation (9.4 cm) in July to insure survival and both *Coprosma baueri* Endl. and *Cotoneaster pannosa* Franch. required 1 or 2 irrigations to insure adequate foliar density. At San Jose only *Nerium oleander* L. lost leaves or lost leaf color and turgidity in the non-irrigated plot. The plantings at both locations had viable roots down to 1 m and probably deeper. Non-irrigated and bimonthly irrigated soils were at or below the permanent wilting percentage down to 1 m. Leaf temp in the non-irrigated *Xylosma congestum* (Lour.) Merr. and *Carpobrotus* plots were 6 and 15° C, respectively, above ambient and yet no permanent foliar injury was observed. We suggest that leaf temp may be used to measure critical water stress in landscape plants. Our findings indicate that substantial savings in water costs and in controlling vegetative overgrowth can be realized by reducing irrigation frequency in established landscape plantings.

In many crop plants there is a direct, although not linear, correlation between consumptive water use and yield (6, 9, 11, 14). That is, maximum yields per unit land area are attained generally with high irrigation frequency to prevent water stress (11, 14) although Shmeuli (13) presents a more complex view of optimization of irrigation for each crop. For landscape plants yield is not a factor, only appearance and, ultimately, survival. We wish to maintain the minimum leaf area consistent with acceptable appearance and shading or screening functions. Thus, irrigation requirements for established landscape plants should be quite different from and, overall, considerably less than for comparable areas of crop species. Nevertheless, in many areas of California deep and shallow irrigations, particularly for species indigenous to humid regions, are made monthly, or even more frequently in warm weather from May through September.

We undertook research at the San Jose and Santa Ana (South Coast) Field Stations to determine the influence of reduced irrigation schedules on the growth, appearance, and survival of several commonly planted evergreen shrubs, trees, and ground covers.

Materials and Methods

Three irrigation regimes (Table 1) were established: a) biweekly at San Jose and monthly at Santa Ana, the normal schedule for orchard plantings at both locations; b) bi-monthly; c) no irrigation. Furrow irrigation was employed. At each irrigation approximately 9.4 cm was applied; the furrows were flooded for 8 hours and the soil was wet to an approximate depth of 65 cm. The rainfall and irrigation schedule for 1974 at San Jose and at Santa Ana are shown in Table 1. In the years prior to testing, when the plants were established, the blocks were irrigated at 30-day intervals and fertilized with complete nutrients once annually. There were 4 plants per treatment for *Xylosma*, *Oleander*, *Cotoneaster*, *Juniper*, *Eugenia*, and *Coprosma* and 5 plants per treatment for *Hedera* and *Carpobrotus*. At both Santa Ana and San Jose the woody perennial plantings were at least 4 years old and growing uniformly. The ice plant (*Carpobrotus* sp) and English ivy (*Hedera helix* L.) plantings at San Jose were entering their second year at the start of the irrigation treatments. Irrigation commenced at both locations approximately 30 days after the last substantial rainfall (>0.25 cm) in the spring.

Soil samples, to determine moisture content, were taken at the end of the experimental period using a soil auger; they were placed in cans with tight-fitting lids. The soil samples were oven dried (100° C) for 24 hours and gravimetric moisture content was calculated.

Plant growth was estimated by branch elongation of 10 randomly selected branches for a 60 cm^2 area of each block of 4 plants.

Leaf temp were estimated with an infra-red pistol thermometer (Raytek Model LR-120/n). Emissivity of all species was assumed to be 1.

Results and Discussion

Growth, whatever the parameter used, was closely correlated with irrigation frequency in all species examined (Figs. 1 and 2). At Santa Ana differences in growth rate (Fig. 3, lower) were apparent 30 days after the last rainfall or irrigation. There were sharp increases in

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growth rate subsequent to irrigation in the bimonthly treatments. The decline in growth rates in the August to September interval reflect the influence of decreased daylength on branch elongation. Injury symptoms, such as leaf discoloration, necrotic lesions and tip dieback, were first seen in the *Eugenia* non-irrigated plot in late-July; thus, this block received 1 irrigation on 26 July. Note the rapid increase in growth rate subsequent to irrigation (Fig. 1, lower). The appearance of this block in September was approximately equivalent to that of the bimonthly block although overall growth was considerably less. The

Table 1. Rainfall and irrigation data for San Jose and Santa Ana Field Trials, 1973–74.

	San Jose	Santa Ana
Rainfall (in.)		
Oct. 1973	2.36	0.08
Nov. 1973	2.29	1.37
Dec. 1973	2.39	0.26
Jan. 1974	2.38	4.83
Feb. 1974	0.72	0.32
Mar. 1974	3.65	3.13
Apr. 1974	1.29	0.66
May 1974	0.00	0.20
June 1974	0.07	0.00
Total	15.15	10.85
Irrigation	*May 17[z]	May 2
	June 17	May 31
	June 30	*June 28
	*July 15	July 26
	Aug. 1	*Aug. 23
	Aug. 16	Sqt. 24
	Aug. 27	
	*Sept. 17	

[z] Asterisks indicate bimonthly irrigation dates.

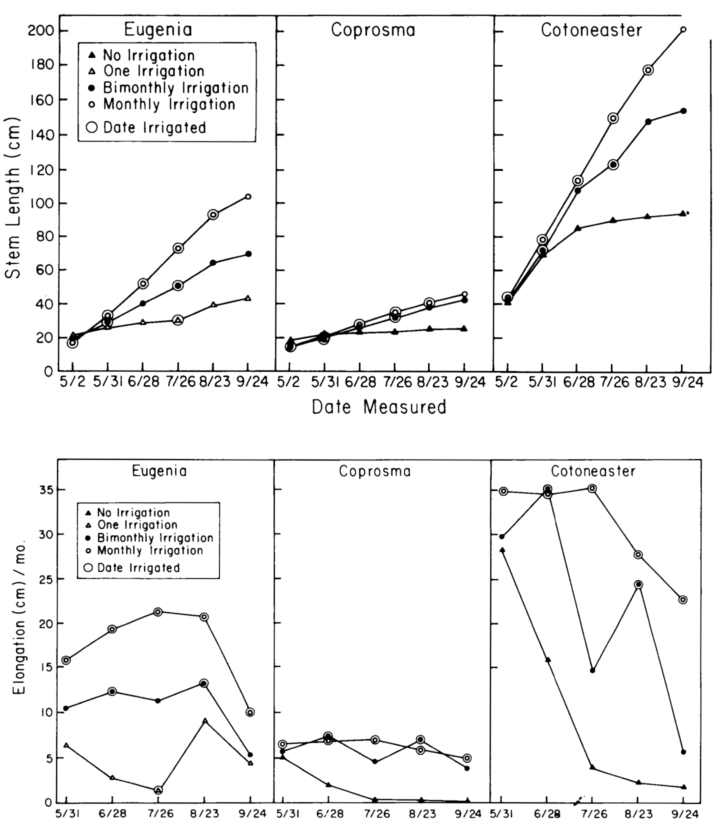

Fig. 1. Stem length (upper) and elongation rate (lower) in 3 evergreen species under 3 irrigation regimes at Santa Ana, 1974. LSD 0.05 (cm) for stem length on 9/24 are: *Eugenia*—28.1; *Coprosma*—10.7; *Cotoneaster*—24.1.

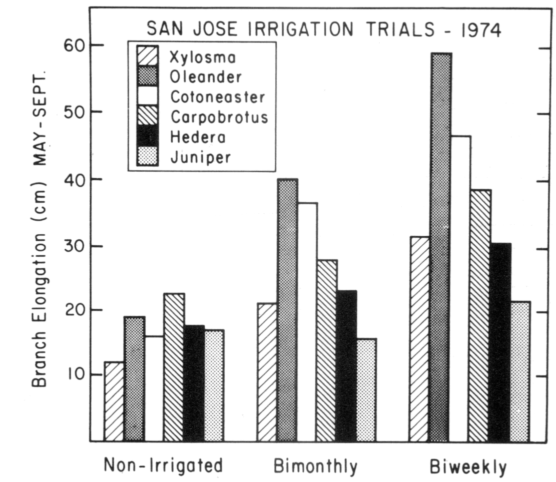

Fig. 2. Branch elongation in 6 evergreen species under 3 irrigation regimes at San Jose, 1974. LSD 0.05 (cm) for elongation are: *Xylosma*—3.3; *Oleander*—7.3; *Cotoneaster*—7.0; *Carpobrotus*—4.2; *Hedera*—4.1; *Juniper*—1.8.

non-irrigated *Coprosma* and *Cotoneaster* plots also showed severe leaf discoloration and leaf drop in August and September.

At San Jose only the non-irrigated oleander block showed injury symptoms and then only in mid-September. Leaf curling, discoloration, and some necrosis were observed. Inflorescence initiation and overall floral display were reduced in both the bimonthly and non-irrigated oleander blocks. Flowering and berry set in *Cotoneaster* and flowering in *Carpobrotus* must be assessed in the spring and summer of 1975. For all species studied, at both locations, the bimonthly irrigation plots revealed no injury to vegetative structures and the leaf area was sufficient to provide effective light screens (Fig. 3).

Soil samples at San Jose and Santa Ana revealed roots down to 100 cm. Soil moisture content in September at San Jose and in October at Santa Ana, 1 and 2 months, respectively, after the last bimonthly irrigation, indicated that both the bimonthly and non-irrigated plots were at or below the permanent wilting percentage (PWP) down to 100 cm (Fig. 4). PWP is roughly 50% of field capacity (6), or 7–8% for Santa Ana and 5–6% for San Jose soils. Since survival of the bimonthly irrigated plots was never in question, and there was no dieback or leaf drop, the functional rooting depth may have been below the 3′ layer. Certainly other species in deep soils have roots below 6′ (6, 8, 11) and extract some water from these depths (8). Exploration of rooting depth is planned 2 years, hence, when the trials will be terminated. It appears likely, however, at San Jose and Santa Ana, that water storage at greater than 1 m depths, and the amount of annual winter rainfall will both influence "dry" season irrigation requirements in established landscape plantings.

We expect, however, that rooting depth will change with minimum irrigation schedules, and this may in turn influence subsequent irrigation practices. Indeed, other research indicates overall reduction and more shallow root systems in water stressed plants (3, 11). Shearman and Beard (12) have shown, however, that water use rate in a bentgrass, *Agrostis palustris* Huds., was reduced in stressed compared to non-stressed plots. One explanation for this phenomenon was the 40% reduction in foliar cover in the stressed plot. Similar considerations would apply to shrubs and trees since foliar cover per unit ground surface area was reduced in the non-irrigated and bimonthly irrigated plots (Fig. 3).

Clark et al. (2) have made careful survival measurements of several native shrubs of the lower Mojave desert under dry soil conditions. They observed no visible injury symptoms at −15 bars soil moisture potential, considered to be the PWP for many plant species; leaf necrosis and shoot dieback did not occur until 4 days after the soil moisture potential had dropped to −60 bars. Thus, it appears that the estimated PWP is not a good indicator of damaging soil water

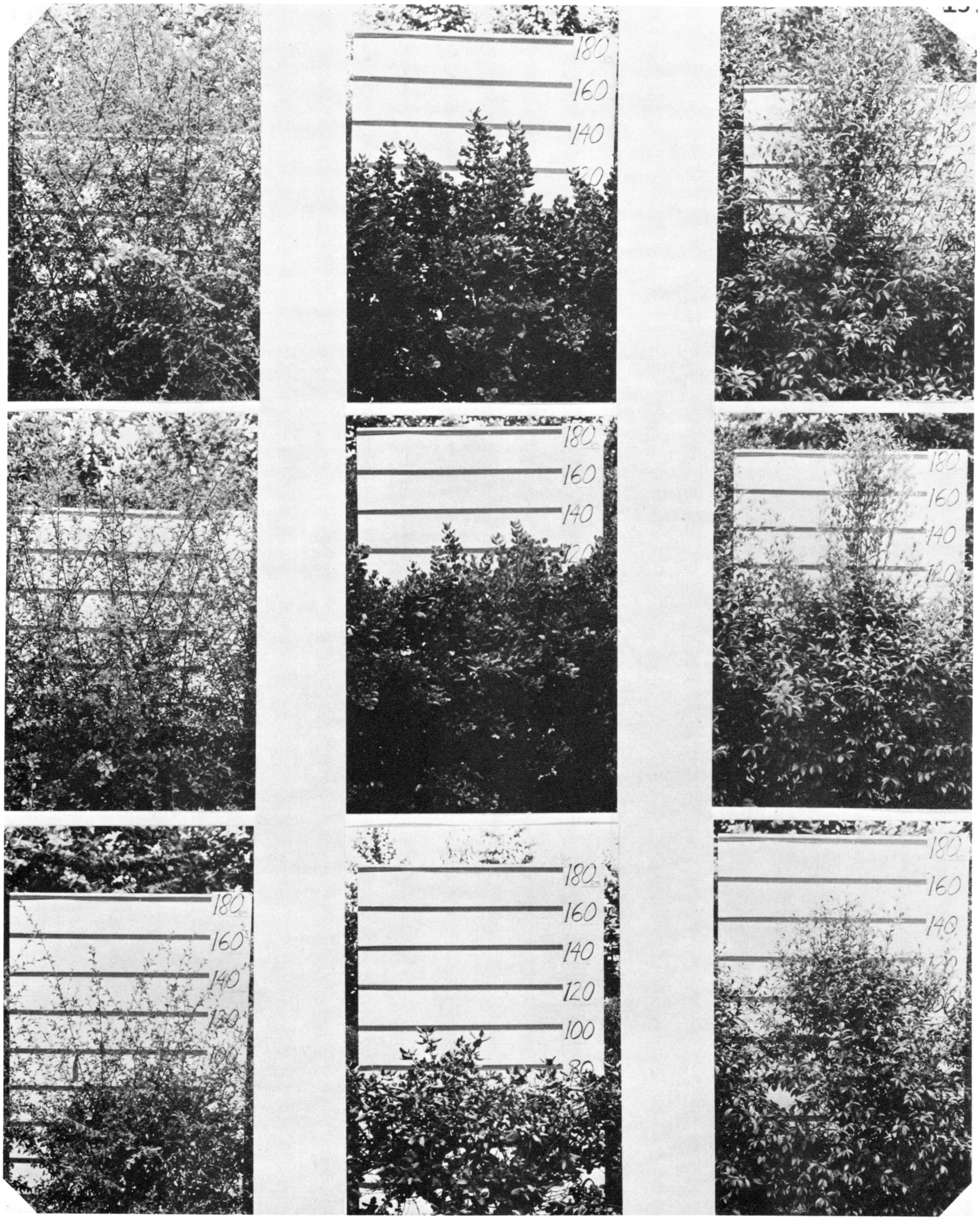

Fig. 3. Influence of irrigation frequency on growth of (l to r) *Cotoneaster*, *Coprosma*, and *Eugenia*. Irrigation schedule (top to bottom): monthly, bimonthly, no irrigation (*Eugenia* received one irrigation) from May through September. Photographs made October 2, 1974. Scale behind plants is ruled in 20 cm intervals.

potentials for xerophytic species, and may not be useful for many plants used in our studies.

Our best estimates of stress on the plants in the different blocks were derived from measurements of leaf temp using the infrared pistol thermometer. Although several readings were made in September and October, 1974 at San Jose, the results reported in Table 2 must be considered preliminary. Clearly, the plants in bimonthly and non-irrigated plots were considerably warmer than the monthly irrigated plants and well above ambient; in the case of *Carpobrotus* the differences were large and, in the non-irrigated plot, approached temp at which heat injury occurs in most plant tissues (6). Yet the shoot system of the non-irrigated *Carpobrotus* planting differed from the monthly irrigated plot only in reduced growth rate and greater anthocyanin pigmentation in the leaves. Since 24° C ambient is a moderate summertime temp (30 to 35° C is the more usual range), on other warmer days leaf temp must have risen considerably above those measured. Indeed, some readings for non-irrigated *Carpobrotus* at San Jose and *Coprosma* at Santa Ana were in excess of 40° C when ambient temp approached 30° C. Apparently leaf tissues of *Carpobrotus* are heat tolerant; such heat tolerance may be the key to the generally good appearance of this species in the non-irrigated plots. *Coprosma*, on the other hand, was severely damaged in the non-irrigated block; presumably, this species is less heat tolerant and/or more susceptible to desiccation injury than *Carpobrotus*.

As Tanner (15) suggested leaf temp readings, particularly since infrared radiometers are portable and give rapid response, may be a most convenient indicator of water stress in plants. Future research objectives will be to determine (1) the absolute leaf temp associated with high temp induced injury and (2) the leaf temp elevation over ambient temp associated with desiccation injury. Tanner found that a 10% decrease in transpiration would cause a 1° C rise in alfalfa leaf temp at noon on a bright, relatively still day. Clark and Hiler (1) found a 2 to 3° greater leaf temp in stressed *Vigna sinensis* L. (Endl.)

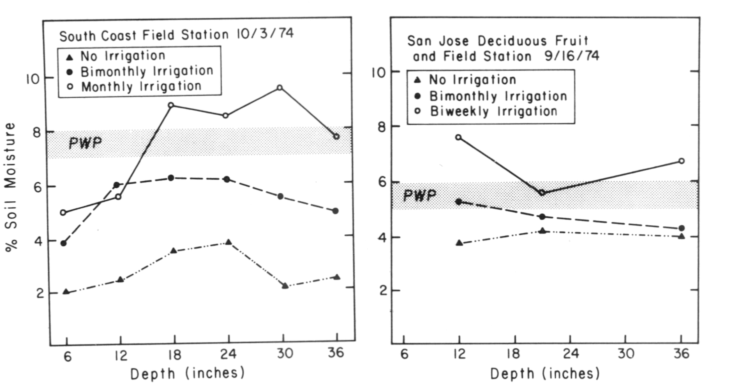

Fig. 4. Soil moisture readings at Santa Ana, and San Jose. The broad shaded area indicates the permanent wilting percentage (PWP), computed as 50% of field capacity.

Table 2. Leaf temperature measurements using infrared pistol thermometer. San Jose: 26 July 1974; 4 PM; ambient temp. 24° C (76° F); wind velocity less than 6 mph, bright sunlight. Measurements made from northwest side of plantings.

	Temperature, ° C		
	Biweekly Irrigation	Bimonthly	Non-Irrigated
Xylosma	22	27	30
Carpobrotus (ice plant)	27	33	39

plants compared to well-watered plants. The stressed *Vigna* plants received 0.7 the water applied to the "non-stressed" plot when tensiometer readings were −40 centibar (cb) and leaf water potential was −8 bars; in our monthly irrigated plots tensiometer readings at 45 cm were −40 to −60 cb and in the non-irrigated plots were −60 to −80 cb from May 31 through September 24.

Gates (5) has indicated the complexity of standardizing leaf temp measurements since they depend upon many environmental factors, including irradiance, solar angle, wind velocity, and relative humidity. We assumed that emissivity was the same for all species and equal to 1, but Fuchs and Tanner (4) found emissivities of 0.97 for sudangrass and alfalfa crop stands. Comparative studies of leaf temp among species, or for one species at different developmental stages, require accurate measurements of emissivity.

If environmental variables and emissivity can be accounted for, leaf temp may ultimately be the best guide for determining irrigation schedules for landscape plants. These schedules should represent the *minimum* water requirements. In mixed plantings, of course, irrigation schedules would be set by the least heat or desiccation tolerant species. Pruitt (10) has described a guide to irrigation, based on evapotranspiration (ET) rates, that is applicable to landscape plantings (particularly to grasses). To our knowledge, however, this system has not been tested for shrubs and trees and would be difficult to apply where microclimatic conditions play an important role in determining ET or where rooting depth and soil moisture availability are difficult to estimate.

Our data suggest that a bimonthly, or less frequent irrigation schedule, totaling 9.4 to 18.8 cm during the "dry" season, was suitable for maintaining established plantings of several landscape species grown on deep, well-drained soils. Compared to monthly irrigation schedules considerable savings in water were realized, and vegetative overgrowth, a costly maintenance problem, was reduced substantially.

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