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WATER APPLICATION PRACTICES AND LANDSCAPE ATTRIBUTES ASSOCIATED WITH RESIDENTIAL WATER CONSUMPTION

Technical Completion Report

Project No. C-4060-NMEX

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TECHNICAL COMPLETION REPORT

PROJECT NO. C-4060-NMEX

Department of Horticulture and
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in Cooperation with

New Mexico Water Resources Research Institute
and New Mexico State University
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I INTRODUCTION

In recent years, the demand for water often has exhausted community water supplies during periods of peak water use, and in some cases, has severely depleted the available water resources. In many regions of the country, water is in short supply and insufficient amounts are available to meet all the needs of industrial, agricultural, and residential consumers. Moreover, the urbanization of society in the United States has placed an additional burden upon the water resources in many areas of the country.

The shift from a rural society to an urban one has been occuring steadily in the United States for the past several decades. For example, Johansen (27) reported that in 1900 approximately forty percent of the population lived in cities. However, by the year 1930, the urban percentage had increased to fifty five, and in 1970, seventy five percent of the 200 million population in the U.S. were city dwellers. Based upon this trend, it is projected that eighty percent of the population will reside in urban communities within the next few decades.

Concomitant with expanding urbanization is the need for additional water services. Linaweaver indicated that in 1920, the daily water usage rate was 35 gallons per capita. (37). Then, by 1950, the demand had reached 67 gallons, and in 1965, it was reported to be 80 gallons per capita. Thus, the figures indicated a rapid and substantial rise in the amount of water used by American consumers. The per capita water consumption is projected to increase in the future, and is expected to become critically short in many regions of the country as more people take up residence in the city.

Residential dwellers, as one consumer, accounted for a large portion of the water used in urban communities. Linaweaver (37) calculated the average daily water use rate for dwellings throughout the U.S. as 215 gallons per residence.

In addition, an average of 160 gallons was used to maintain the landscape. Thus, the average amount of water used upon residential landscapes approaches the amount used inside the home.

Linaweaver also reported large variations in residential water use in different regions of the country, and stated that some of the factors effecting landscape water usage included: climate, water availability, metering, residence density, and the economic status of the homeowner. No discussion, however, was made in reference to the water use efficiency, or water usage for different types of landscapes, for example, landscapes which vary in the amount of vegetation and non-plant objects. Nor was there any reports of the amount of water required to maintain landscapes with differing esthetic attributes.

The landscape of the average American home uses approximately 70% of the water utilized in the residence. Moreover, the water used on the landscape is, by and large, consumed. Landscape water is relatively price inelastic in arid western areas (24). In short, the landscape water used is fixed and is not recycled. In spite of impending shortages of water, homeowners persist in using a high percentage of water to maintain their landscapes. Thus, it is apparent that esthetic and psychological factors are contributing to the use of water by homeowners. This contention is supported by a 1970 national survey of a cross-section of Americans in which 95 percent of the sample indicated that "green grass and trees around me" was an important contributor to their happiness (23).

In summary, there was an increasing rate of per capita water usage in the United States in spite of apparent critical shortages of water resources in many regions of the country. One substantial user of water was residences. Accordingly, a need exists to study in additional detail the watering practices used by homeowners, establish base line data relative to the amount of water used by different types of landscapes, and determine if the esthetic attributes of a landscape are associated with the amount of water used to maintain the landscape.

Purpose

The purpose of the project was to identify water application practices associated with residential landscapes. In addition, to measuring the amount of water used by residents with differing types of landscapes, the study was planned to identify some of the elements of landscape design as well as water application practices which were associated with the amount of water used by residents to maintain landscapes. A need existed to obtain information about residential water use, as one alternative for identifying ways of reducing the peak water consumption in a community.

Objectives

Many different factors influence the amount of water residents apply to their landscapes. Some of the factors include for example, the amount of vegetation in the landscape, the consistency and type of water application practice employed, climate, the design of the landscape, the amount of water needed to maintain the landscape as well as the psychological and esthetic values an individual attaches to his own landscape. Accordingly, in this exploratory project several approaches were taken to study different factors influencing the water applied to residential landscapes. Specifically, the project included the following objectives:

1. Analyze the methods for measuring the water applied to residential landscapes.
2. Compare the predicted amount of water needed by the landscape to the amount of water applied to the landscape.
3. Identify the association among esthetic and design attributes of residential landscapes with the water applied to the landscape.
4. Describe water application practices used by residents as well as professionals to maintain landscapes.

Rationale

Water consumption is increasing at an alarming rate, and in many arid regions of the country the demands may soon exceed the available water supplies. In view of the critical shortage of water which exists, particularly in the southwest, there is a need to examine existing water practices in an attempt to identify viable procedures for reducing the amount of water used by consumers.

Landscapes consume approximately 70 percent of the water used at residences, and an increase in urbanization in the United States is projected which will increase the need for additional water services. Accordingly, it was hypothesised that a study of water practices used by residents to maintain their landscapes was a line of inquiry with high potential. However, there are many psychological and esthetic values attached to the landscape of a home. Thus, it was necessary to explore ways of objectively measuring the psychological and esthetic values attached to landscapes. Little objective and systematic research has been completed in the psychological and esthetic domains associated with landscapes.

Nevertheless, it was postulated that residents are, indeed, influenced by objective information and educational techniques. Thus, the possibility existed that if information was available about how esthetic attributes of landscapes, and water application practices were associated with the economical use of water, and at the same time not disrupt the values residents attach to their landscape, it would indeed be a viable way in which residential landscape water application could be reduced.

Review of Related Research

The literature revealed many studies which provided a knowledge base for the project. Studies had been conducted on the amount of water applied to landscape in different regions of the country, climatic factors effecting water use, the psychological and affective aspects of the plant-man interaction and several studies of the utilitarian benefits of plants. Accordingly, some of the studies relevent to this one are discussed in detail in the following section.

Urban Water Use. Suburbanites have used water for domestic, irrigation, air conditioning, and recreational purposes. Linaweaver (37) reported that the daily domestic average water use in the United States was 80 gallons per capita, and a principal factor affecting domestic water use was the market value of the home. Presumably, the market value of the residence was an index of owner income, and affluent homeowners use more water than the less affluent.

The daily domestic water use rate in all regions of the United States was approximately the same, and the average was 215 gallons per dwelling. Comparison for example, were made between metered and unmetered sites, dwellings with and without septic systems, apartment buildings vs. private dwellings, and Western vs. Eastern geographic areas. Despite the contrasts, the average gallons per dwelling for domestic use inside the home were remarkably similar. Linaweaver also reported that the average daily use of water to maintain the landscape was 160 gallons per residence. However, the variation between geographic areas in the U.S. was substantial. Among the factors which affected landscape water use were water price, metering, residence density, climate, and consumer economic status.

Climatic factors affecting the amount of water used to maintain residential landscapes include rainfall, evapotranspiration, temperature, wind, relative humidity, latitude, season, and hours of sunshine. The average water landscape application rates in arid regions of the west exceeded that in humid eastern regions by 133 percent. Rainfall is the most important factor which determined the amount of water used to irrigate landscapes. Linaweaver and coworkers (37) reported that summer water usage fell to winter water usage rates when rainfall was plentiful. A correlation coefficient of -.46, which identified the association between water use data and rainfall of different geographic areas in the United States was computed by Porges (46). The correlation indicated a significant inverse association between the amount of water used and the amount of rainfall.

While rainfall was clearly the most significant factor associated with water use, other factors also affect the amount of water used. Water demand tends to increase as temperature increased on days without precipitation. Brock (8) found a significant correlation between the maximum daily domestic water demand and the number of consecutive days the temperature was over 100^{o}F.

Water use was higher when a "flat rate" water price systems was used than when comparable residences used a "metered" water cost system. Linaweaver stated that an average of 160 gallons per day per residence was used in a metered area and 420 gallons per day were used when homeowners paid a flat rate for water (260% increase). Porges (46) reported substantially higher usage where consumers were metered less than 50 percent of the time, compared to a metering time of 95 to 99 percent. Weeks and McMahon (56) report that landscape water use in unmetered areas of Australia was 50 to 100 percent greater than in metered areas.

Domestic water use was relatively stable and unaffected by the season of the year. On the other hand, landscape water usage was seasonal and sporadic with occasional peak demands. Hudson and his coworkers (26) identified two summer water demand peaks in midwestern and southern cities: one corresponding to air-conditioner use occurring between 2:00 p.m. and 5:00 p.m. and the other when landscape irrigation was at a peak between 7:00 p.m. and 9:00 p.m. The maximum demand for landscape water was twice the amount used for air conditioning. Peak landscape irrigation demands ranged from 125 to 175 gallons per capita.

Landscape size also effected water use. Linaweaver and coworkers (37) only measured landscape size in terms of the number of residences per acre and included this number in their prediction model. No studies in the literature were found which measured the quantity of water used to maintain landscapes of specific sizes.

Plant-Man Interaction. Man's environment has altered considerably during this century. Many people moved from rural plant-filled environments to cities where plants were scarce. Studies have been conducted which identify some aspects of the plant-man interaction. Plants benefit man in at least two different ways: psychological and utilitarian. The utilitarian benefits include: noise abatement, pollutant amelioration, wind reduction, temperature modification, erosion control, and sight screening. Some of these benefits have been relatively easy to quantify. However, the psychological dimension was more difficult to quantify and little research has been conducted to measure this dimension.

In a 1970 poll conducted for Life magazine (23), a cross section of Americans were asked to choose six items they considered important to their happiness.

From the list of 26 items, 95 percent selected "green grass and trees around me". Secretary of Agriculture Earl L. Butz (9) commented, "There is a touch of farmer in most of us, a love of growing things. Green vegetation and flowers satisfy some psychological need we have."

In a national psychographic study, 62 percent of the sample indicated a "love for flowers" (5). The respondents also indicated a desire to "know more about flowers" (41%) and "to know more about plants" (35%). In a Las Cruces, N. M. survey, people rated the importance of green in the landscape as "very desirable."

Many people express a desire for plants in their environments. However, Steinbrook (53) noted that persons under stress have a more acute need for natural surroundings.

> An environment of ugliness, dilapidation, dirtiness, overfilled space and lack of natural surrounds (italics added) confirms the negative self-appraisal a person may have developed through other contacts with society. Self-esteem is the keystone to emotional well-being; and poor self-appraisal among other factors determines how one treats his surroundings and how destructive he will be toward himself and others. These reactions set up a vicious circle difficult to break.

The beneficial effects of plants provide people with an opportunity to break that cycle. Lewis (34, 35) viewed the plant-man interaction in a public housing garden contest in New York City, a window box program in Philadelphia, and an elementary school gardening project in Chicago. He stated a common benefit was the feeling of "togetherness" that an individual gains when caring for plants. In addition, the gardener established a base of information about plants which allowed him to share social relations with others.

Psychologists (36, 53) state that human needs within the starkness and sterility of our urban industrial complexes include:

1. The need for stimulation to break the monotony of daily living;
2. The sense of community resulting from spontaneous actions;
3. Sense of mastery or control over one's environment.

Lewis also stated that urban gardening addresses itself to the above points, and based his report upon findings in studies of urban gardening projects and gardening contests. He reported that gardens improved the self-concept of the individual participants, the residents refrained from throwing debris into yards and streets, vandalism decreased, and the participants initiated clean-up and civic projects.

Prisons are stark and stressful environments. Neese (44), a prisoner, wrote about the soothing effect of plants on prisoners in Iowa State Prison. A single gloxinia plant stimulated genuine interest in growing things, forming a garden club, and establishing a prison garden. Inmate conversation lost its bitterness in favor of planning future gardens. In a Florida prison, recidivism declined from 57 percent to 13 percent when prisoners were trained to work with plants (41). Former prisoner Dick Gregory, reflecting on prison reform, said "the lack of opportunity for prisoner-nature interaction is serious" (19). He suggested allowing prisoners access to sky, plants and animals as an important step toward establishing normalacy.

Several case studies describing therapeutic value of gardens and plants have been published (2, 30, 36, 38, 40, 53). Few have scientifically documented observations. However, Kaplan (30) identified three psychological benefits from gardening: tangible outcomes (food production, budget savings), primary gardening (knowledge gain, work outdoors in soil, watch plants grow), and sustained interest (diversion, relaxation, esthetic pleasure, sense of achievement).

Utilitarian Benefits. Plants also benefit man in utilitarian ways. Kerbeck (31) defined as "any sound (regardless of intensity, duration, pattern of exposure or frequency) that may produce an undesired physiological or psychological effect in an individual or animal or that may interfere with the social ends of an individual or a group." The noise level of mechanized urban society is high, pervasive, and unlimited by territorial boundaries. Noise, among other things can cause the following effects upon a person:

1. Permanent and temporary hearing loss;
2. Interference with speech and auditory signals;
3. Disturbance of sleep;
4. Disturbance of task performance;
5. Adverse influence on mood and relaxation.

Plants were found to be effective noise abaters. Lanphear (32) reported that plants were especially effective in reducing human sensitivity to high frequency noises. Plantings from 20 feet to 40 feet wide reduced high frequency noises by as much as 10 to 20 decibels. The most common outdoor source of urban noise was transportation (11, 12, 14). Cook and Haberbeke (11) demonstrated that a 100 foot to 150 foot wide belt of plants reduced highway sound levels from four to eight decibels. In another study Cook and Haberbeke (12) offered the following recommendation as an instrumentality for highway noise abatement.

1. The practical maximum sound reduction by using plants is approximately 20 decibels.
2. Use several rows of trees and shrubs adjacent to land forms.
3. Conifers, which retain their leaves all year, are preferred to deciduous trees for year-round noise screening.

Plants also reduce the temperature in city and urban environments. Lanphear (32) reported that differences in air temperature between an open city park and a nearby business district were as much as 10^{o}F. The average annual temperature difference between urban and rural areas was 0.5 to 1.5^{o}F. The largest temperature difference reported in an urban community was a 10^{o}F to 20^{o}F difference between downtown San Francisco and nearby Golden Gate Park (17).

Myrup (43) called a city an urban-heat island and stated that an urban-heat island resulted from interacting physical factors which included for example: wind, evaporative cooling, seasonal variation, city building height, conductivities of building materials, and the blanket effect of aerial pollution. In cities, sensible heat, solar energy heating the air, accounted for more than half the net radiation at noon. A vegetated park creates a temperature drop of up to 20.7^{o}F at midday and 14.6^{o}F at dawn. These figures corroborate the ones reported by Federer (17) for San Francisco. Myrup (43) concluded that the addition of sufficient plants would reduce the temperature in cities during the summer. He proposed that the temperature of a city with 25 percent of its area devoted to plants would be as much as 6.3^{o}F degrees higher than one with 35 percent plants.

The surfaces of living, transpiring vegetation were cooler than the surfaces of nonliving plants. Madison's (39) data showed that four-inch bluegrass leaf temperature was 67^{o}F (11^{o} below ambient air temperature). Plastic turf, although similar in color and profile, was 125^{o} (46^{o} above ambient) under the same conditions.

Plants cleanse the air of gaseous and particulate pollutants. Rich (49) reported that the intake of sulphur dioxide (SO_2) differed among plant species.

Lanphear (32) cited data which indicated that SO_2, hydrogen flouride and aerosols were removed from the air by plants. A single 15-inch diameter Douglas fir removed 43.5 lbs. SO_2 per year from the air. Rich's model predicted removal of 1 to 13 micrograms of ozone per hour, which reduced the concentration in the upper foliage from 140 to 68 parts per billion. He also found that plant cleansing of urban air occurred at low concentrations of these chemicals, but higher concentrations injured the same plants. Two gases, each at concentrations below damaging levels, caused injury to the plant when the gases were mixed. Tingey and his coworkers (55) reported that although 200 parts per hundred million (pphm) NO_2 or 40 pphm SO_2 did not, when used separately, injure the six common food plants tested, but a mixture of 5 pphm of each was harmful to the plants.

Geiger (18) found that trees in a forest reduced air-borne dust particles from 4,000 to 2,000 particles per liter. He proposed that this was due partially to sedimentation and the higher sustained particulate production of a non-forest environment. He reported an 80 percent reduction when air speed was measured immediately behind a dense windbreak composed of trees. The original speed of the wind was not restored until a distance of 20-25 times the height of the windbreak was reached.

<u>Summary</u>. The literature provided information about the amount of water that on the average was used by residences both for domestic and for landscape uses, but little factual data existed for the amount of water applied to unique types of landscapes. In addition, little information was available for the arid southwest.

Some of the psychological factors associated with landscapes and natural surroundings were identified, but little objective and systematic research has been conducted on this topic. A dearth of research exists particularly in the area of esthetics, although numerous how-to-do-it and landscape design publications were available. However, no studies were found which identified the association among the esthetic attributes of a landscape, and the corresponding water consumption of the landscape. It was inferred from the literature that esthetics was an important value attached to residential landscapes.

II RESULTS AND DISCUSSION

The project included separate but interrelated components for studying water application practices for landscapes in the Southwest. The components included several activities for conducting each portion of the study. Accordingly, the results of each component are presented separately, and a summary of the major findings of the study is presented in the final chapter. In overview, this section of the report presents the following four separate thrusts of the study.

First, methods for estimating the amount of water applied to residential landscapes were analyzed to identify one which was feasible for use in this study. Specifically, this component of the study included the analysis of the water meter readings recorded by the City Water Service Agency, the accuracy of water meter readings installed by the investigators to measure the amount of water applied to the residential landscape, and two projects for measuring the amount of water used inside the home for domestic purposes.

Second, following the identification of a technique for measuring the amount of water applied to residential landscapes, the water application rates for a sample of residences in the community were computed. The amount of water applied to two different types of landscapes, Green and Intermediate Green, was compared. Then, using formula obtained from prior investigators, the amount of water needed to maintain a landscape was predicted for a sample of residences. The predicted need for water was compared with the amount of water applied by the residents to the landscapes.

Third, a Rating Scale was developed for measuring esthetic attributes of residential landscapes. The instrument was used to rate a sample of residential landscapes, and a statistical analysis was conducted to identify the association between the esthetic attributes and the amount of water applied to the landscape.

Last, a survey of a sample of residents in the community was conducted to identify some of the water application practices which were used to maintain their landscapes. In addition, a study of the water application practices on two portions of the university campus was conducted to determine the feasibility of a water conservation program.

Measurement of Water Application

One portion of the study was conducted to identify a method for measuring the amount of water applied to residential landscapes. Thus, it was necessary to examine some of the techniques which had been used before, compare the accuracy of the techniques, and to identify one which was feasible to use with a sample of residents.

The "Winter Base Rate" Method. Each month the city water service meters the amount of water used at a residence. The records accurately indicate the total amount of water used by the residents for domestic purposes as well as the water applied to the landscape. Accordingly, it was necessary to find a technique for separating the water used for the two purposes. Linaweaver (37) estimated domestic water use by computing an average of the amount used during the three winter months in areas where winter rainfall is normally sufficient to satisfy landscape water needs. Assuming the residents were not irrigating the landscape, and in the absence of other uses, e.g., swimming pools, car washing, etc., all the water used would be for domestic purposes.

Then, by subtracting the average amount of water used inside the home from the total amount of water metered by the city water service, an estimate of the amount of water used each month on the landscape was obtained. This method of computing the amount of water applied to the landscape was called the "winter base rate" method. Weeks and McMahon (54) also used this method for computing the amount of water applied to the landscape.

Measuring Domestic Water Use. Two separate analyses were conducted to measure the amount of water used for domestic purposes. The purpose of the analysis was to substantiate the findings that the winter rate was a suitable technique for measuring the water applied to the landscape. First, the water meter records maintained by a subdivision developer for a housing project in Albuquerque, New Mexico were analyzed. All the homes had desert landscapes and contained very few mesophytic plants. The landscapes, however, did include a few native pinon pine, range plants, and large boulders. All residences were observed to verify the absence of swimming pools, and other unusual uses of water. A total of 24 landscapes from the 42 residences observed were selected for the study.

A winter base rate was obtained by computing an average monthly rate for the four "low" usage months; November through February. Then, an average monthly rate for the "high" usage summer months, May through August was computed and compared to the "low" usage winter rate. The amount of water used at the residences and the ratio of the summer to winter water rates are presented in table 1.

Table 1. Mean Domestic Water Use and Summer-Winter Water Use Ratios for 1972 and 1973 in Albuquerque, New Mexico

Item	1972	1973
Summer-winter ratio	1.03 ± 0.12	1.04 ± 0.13
Ratio range	.85 - 1.24	.82 - 1.37
Domestic water (gal/month)	10,400	9,500
No. residences[1]	13	24

[1]The 1972 winter base rate for 13 residences was used in computing the 1973 figures.

If the summer-winter ratio were exactly 1.00, then the water use rates for summer and winter were the same. The average summer-winter ratios are approximately 1.00 and the range of the ratios for the sample was .85 to 1.24 in the year 1972, and .82 to 1.37 in 1973. Accordingly, it was inferred from the consistency of the ratios for the sample of residences measured that domestic water use in winter was approximately the same as domestic water use in the summer.

The authors also conducted a second analysis to corroborate that the average winter water rate was an accurate estimate of domestic water use. The water use rates on a sample of 20 residential sites in Las Cruces, New Mexico, a region of low winter rainfall, were metered during the winter months of 1973 and 1974. Separate estimates of water applied to the landscape during the winter were based upon computations with two and with three "low" water use months. The winter months normally included December, January, and February.

The average amount of water which was applied to the landscape during the two lowest winter months was 1,300 gallons per residence per month and based upon the three lowest water months it was an average of 2,150 gallons per residence per month. Assuming the average residence used 10,000 gallons per month for domestic purposes, the winter base rate was inflated by approximately 13 percent by winter landscape irrigation, if the computation was based upon a 2 month average and by 22 percent if the domestic rate was based upon the average of the three lowest months. Accordingly, it was inferred that using the winter base rate procedure tended to underestimate the amount of water used on the landscape by a small percentage. The small number of residences (N=20) precluded a definitive statement, and additional research with a larger sample is needed to quantify winter landscape water use.

Metering Water Applied to Residential Landscapes. Another analysis was conducted to directly measure the amount of water applied to the landscape by installing water meters at a sample of residences in the community. Thus, an opportunity existed to compare city water meter readings with the meter readings installed by the investigators, as an additional means to corroborate the Winter Base Rate Method for measuring residential water application.

Water meters were installed in twenty residences in Las Cruces, New Mexico The landscapes were classified as Green, and Intermediate Green. The landscape was classified Green if turf and other mesophytic plants covered 71 to 100 percent of the landscape area. The landscape was classified Intermediate green if turf and other mesophytic plants covered 50 to 70 percent of the landscape area and the remaining portion was covered with mulch, rock or native xerophytic plants.

Water meters were installed in March 1973, and readings were taken for the following sixteen months. Although, the residents gave permission to install the water meters, many of them asked to withdraw from the project. Some of the stated reasons included: "not wishing to get involved in a long term project, not wanting their water use procedures under surveillance," and in some cases the water meters caused a significant decrease in the water flow to the home, and the owner indicated that the water flow decline "hindered his ability to irrigate the landscape."

Moreover, it was possible to monitor only a portion of the total landscape (47 percent). The participating homeowners were reluctant to change their watering practices by using only the metered taps, and insufficient water meters were available to monitor all taps. Accordingly, the sample included only two residences where the entire landscape was monitored by the water meters. However, a factor based upon the proportion of each unit monitored was used to estimate the amount of water applied to the total landscape for the sample of metered homes.

Despite the problem encountered when using water meters installed at residences to monitor the amount of water used on the landscape, the total number of gallons used at the residences for the 9 month period beginning March 1, 1973 to December 31, 1973 and the 7 month period beginning 1 January 1974 through July 31, 1974 was computed and presented in table 2. Estimates from the city water meters also were included in the table. The estimates for the water applied to the total landscape were based upon a two month winter base rate formula.

A test was used to determine if a significant difference existed between the values obtained from the two methods employed to estimate the water application rates for the sample of residences. The total number of gallons estimated by the residential meters were significantly lower than the number obtained from the city water records.

Table 2

Landscape Water Use Estimated from Residential Meters and City Water Meters

Estimating Procedure	Total Water Used (gallons/residence) 1973 (9 mo)	1974 (7 mo)
Metered	130,900	84,300
City Records	155,800*	113,200*

* Significant difference at the .05 level.

Accordingly, it was inferred that the accuracy of the values obtained from the installed water meters depended to a large degree upon monitoring all the taps used to irrigate the total landscape. Moreover, based upon the comparison of the two ways of obtaining measures of residential water that the City water meter amounts adjusted by the Winter base rate method was by far the more accurate estimate.

The analysis of different techniques for estimating landscape water application from the meter readings supplied by the city water services was completed. The analysis indicated that summer and winter domestic water use was relatively constant, and that the estimate of domestic water use was the more accurate when it was based upon the two lowest months instead of the three or four months used in prior studies.

Although, some evidence with a small sample of homes indicated that in regions of low winter rainfall the 2 month Winter base rate method underestimates the water applied to the landscape, the evidence was insufficient to rule out this commonly used estimate of residential water use. Thus, the method was selected as the most accurate one available to the authors.

Residential Landscape Water Application Rates. Another objective of the study was to measure the amount of water that was applied to residential landscapes in the southwest. Residents in the region used differing numbers of mesophytic plants as well as non-plant objects to create their residential landscapes. Moreover, the amount of water required to maintain the landscapes differed sharply. In addition, the amount of water applied to the landscapes by residents also differ as a result of individual watering practices. Accordingly, in this portion of the study, the water application rates for different types of landscapes in the southwest were compared, and estimates were made to prescribe the amount of water needed to maintain the landscapes.

The residences included in the study were located in Las Cruces, New Mexico. The city is in an arid region in the southern part of the state. The homes were owned, predominately, by middle income residents, and the landscapes were designed with differing amounts of vegetation and non-plant objects. The residences were screened to exclude any homes with swimming pools, or any other special or unusual uses for water. A total of forty residences were selected in the final study group.

The total area of the landscape was measured as well as the amount of area which included vegetation and non-plant material. Based upon the measured amount of living plants on the landscape, each one was classified as either a Green or Intermediate Green landscape type.

Water meter readings were obtained for each residence from the Las Cruces City water service, and the amount of water metered to the residence was calculated. The Winter base rate method, based upon the two lowest months was used to estimate the water which was applied to the landscape.

The results presented in table 3 show that the total landscape water used for the Green category (Table 3), was about twice that of the Intermediate Green type. However, Green landscapes averaged about 2,000 square feet (56 percent) larger than the Intermediate landscapes. While increased area accounted for some of the difference, the water application rate totaled 10 acre-inches more per unit area for landscapes for both years. Domestic water used was reasonably consistent over categories and years averaging about 112,000 gal/residence/year.

A significant positive correlation occurred between monthly landscape water use and open pan evaporation for both landscape types (Table 4). In both years maximum water use rate plus rainfall approached open pan evaporation for both categories in summer months when mesophytic plants would be most active, and during the less active period during early spring and late fall.

Table 3
Landscaped Area and Domestic and Landscape Water Use During 1971 and 1972 for 20 Green and 20 Intermediate Green Residences in Las Cruces, New Mexico

	Area per Landscape Maintained (sq. ft.)	Annual Domestic Use (1,000 gal/ residence)	Water Applied to Landscape: Total (1,000 gal/ residence)	Water Applied to Landscape: Rate (inches)	Effective Rainfall (inches)[1]	Annual Water Available to Plants (inches)[1]
1971						
GREEN	5219 ± 2240	108.8 ± 42.2	203.8 ± 96.4	62.6	4.2	66.8
INTERMEDIATE	3328 ± 1290	106.8 ± 54.2	108.1 ± 55.6	52.1	4.2	56.3
1972						
GREEN	5219 ± 2240	124.8 ± 70.6	180.3 ± 76.3	55.4	7.0	62.4
INTERMEDIATE	3328 ± 1290	111.5 ± 42.7	93.9 ± 51.4	45.3	7.0	52.3

[1] Depth of Water applied to an area, one inch over an acre equals 27,154 gallons

Table 4. Monthly open pan evaporation and rainfall (inches), and mean monthly water use rate (acre inches) for Green and Intermediate green residences in Las Cruces, New Mexico for 1971 and 1972.

1971	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Open Pan	5.35	9.17	10.77	13.51	12.94	13.63	9.77	8.86	5.95	3.90
Green	1.34	2.53	6.23	8.76	13.83	12.57	8.78	6.23	1.89	0.76
Intermediate	1.30	2.48	4.87	5.60	10.14	12.56	6.42	5.52	2.28	1.36
Rainfall (total 8.01")	-0-	-0-	0.13	-0-	-0-	1.77	1.39	0.57	1.27	0.42
1972										
Open Pan	5.39	9.40	10.97	11.60	11.46	12.55	9.92	6.66	6.30	3.47
Green	0.48	4.94	6.91	8.07	8.06	9.02	9.19	3.58	4.62	0.31
Intermediate	1.47	4.21	4.86	8.04	7.45	8.12	6.56	2.17	1.80	0.15
Rainfall (total 12.21")	-0-	-0-	-0-	0.11	1.81	1.29	3.23	1.44	3.11	0.28

	1971	1972
Monthly Pan x Green Monthly Usage	0.895**	0.926**
Monthly Pan x Intermediate Monthly Usage	0.836**	0.961**

**Significant at the 1 percent probability level.

Home owners with either type landscape tended to apply maximum water amounts during June or July (Table 4). If it is assumed that landscape evapotranspiration follows open pan evaporation (4, 45), one would expect usage to more closely correspond to monthly plateaus of maximum open pan evaporation. Rainfall would effect this interpretation, but in 1971 rain fell mainly in July and August (Table 4). Frequencies of peak use rates (Table 5) show 13 residences peaked in June and only one in May. However, in both months similar plant activities and water requirements would be expected.

Rainfall in 1972 was higher with fairly uniform distribution from July through September. Since no rain fell in April and May, a higher frequency of peak usage would be expected to occur during these months. This was not the case. Thus, variation in monthly water use rate appears to involve factors in addition to plant water requirements and rainfall. The lack of irrigation patterns corresponding to summer evaporation and rainfall indicates urban agriculturists do not know enough about plant water requirements.

Mean water application rates ranged between 45 and 62 inches, varying for both year and landscape type. Estimates of turf water requirements in Las Cruces, New Mexico, and El Paso, Texas are 42 arce-inches (A") (48) and Mesa, Arizona turf requires 43.5 A" (16). Assuming turf water needs represent landscape requirements, the water available (applied plus effective (37) rainfall) to landscapes in this study exceeded requirements. Mean excessive water application was 55 percent in 1971 and 45 percent in 1972 for the Green category. It was 30 and 22 percent for Intermediate green in the same years (Table 3).

The residents in the sample applied more water than was indicated by factors governing mesophytic plant water needs. The evidence supports the conclusion that urbanists lacked sufficient knowledge or sensed the urgency to use water in concert with plant needs.

Table 5. The Number of Urban Residences' with Peak Landscape Water Use for Green and Intermediate Green Categories During the Months Indicated During 1971 and 1972

Category	Year	April	May	June	July	August
Green	1971	-0-	1.0	13.0	5.0	1.0
	1972[1]	2.0	2.8	4.3	9.8	1.0
Intermediate Green	1971	-0-	-0-	5.0	14.0	1.0
	1972[2]	-0-	7.5	3.0	7.5	2.0

[1]One residence had same peak rate in May and July; another, same rate in May, June and July.

[2]One residence had same peak rate in July and August; another, same rate in May and August.

Formula for Predicting Water Needs. Numerous studies have been published in the field of agriculture which describe specific equations for predicting evapotranspiration requirements of crops under monoculture. However, no empirical information was available for the water consumption rates of multi-species plants commonly used for residential landscapes. Among the predictive equations developed in agriculture were ones by Blaney-Criddle (6), Thornthwaite (54) and Penman (45). The purpose of this component of the study was to compare the amount of water applied to a residential landscape with predicted water needed by the landscape based upon the formulas.

The amount of water applied to a landscape in relation to the amount of water necessary to maintain the landscape was a comparison which had implications for the problem of reducing peak water consumption. The comparison of application rates with estimated amounts needed for retaining the esthetic and plant health qualities of the landscape might identify watering practices which were uneconomical in terms of water conservation.

The Blaney-Criddle formula was a method for estimating the irrigation requirements for one specific crop. The seasonal evapotranspiration potential was computed from the following equation:

$$U = KF$$

where

U = seasonal E_{tp} in inches

K = empirical crop coefficient for the entire growing season (average of monthly k)

F = sum of the monthly E_{tp} factors (f)

k = monthly empirical crop coefficient for pasture grass (3)

$f = \frac{t \times p}{100}$ = monthly E_{tp} factor

t = mean monthly temperature in degrees F.

p = monthly percent of daytime hours of the year which varies with latitude

The Thornthwaite formula used local climate data and empirically derived constants to predict evapotranspiration of a crop. Thornthwaite developed the following formula, and also published day length adjustment factors for each geographical latitude and month of the year.

Thornthwaite employs local climatic data and empirically derived constants to predict evapotranspiration of a crop:

$$E = 1.6\ (10T/I)^{a}$$

where

E = unadjusted (30 days--each a 12-hour day) E_{tp} in centimeters

T = mean monthly temperature in degrees C.

I = annual heat index (sum of i)

$i = T/5^{1.514}$ = monthly heat index

$a = 0.000000675\ I^3 - 0.0000771\ I^2 + 0.01792\ I + 0.49239$
(a constant that varies from place to place)

Penman concluded that an energy supply was necessary to provide heat for vaporization while a transport mechanism removed the vapor. He combined these concepts into two terms: (Q_n) in energy and the aerodynamic term (E_a) to derive the equation for estimating evaporation from an open water surface. Penman's estimate of potential evapotranspiration was calculated by use of Rijkoort's (50) nomograms. The following local input data were used:

a) Mean Monthly Air Temp- obtained fron NMSU National Weather Service (NMS) monthly weather summary.

b) Mean Monthly Percent Relative Humidity - calculated from monthly totals of two different observations made at 7:30 AM and 5:00 PM daily. (From worksheet of NWS and NMSU Weather Station.)

c) Mean Monthly Wind-Speed - obtained from NWS and NMSU weather station monthly summaries.

d) n/N - Ratio of actual sunlight hours to total possible. Used MWS for El Paso, Texas.

e) Cal-cm^2 day^{-1}- Data for 32^o N Latitude taken from Rijkoort's tables.

Each formula was used to compute an estimated evapotranspiration rate for each month of the years 1971-1972 in Las Cruces, New Mexico. Separate calculations were made for green and intermediate landscapes. The predicted estimates are presented in Table 6 and the table also includes the metered amount of water used by the residents to maintain the landscape, and the open pan evaporation rate.

The results indicated that each formula predicted relatively uniform water requirements for the months May through August, and the predicted values were lower than the actual application rates used by homeowners. The homeowners applied as much as 50% more water to the landscape than the amount predicted by the formulas. Note also that the prediction made from each formula varied substantially when compared to the others.

Table 6

Mean Monthly Landscape Water Application Rates (acre inches) for Green and Intermediate Landscapes and the Rates Estimated from the Penman, Blaney-Criddle, and Thornthwaite Formulas

	Green	Intermediate	Penman	Blaney-Criddle	Thornthwaite	Open Pan
Year 1971						
Feb.	1.3	1.3	3.6	1.9	0.6	5.4
Mar.	2.5	2.5	5.7	3.3	1.4	9.2
Apr.	6.2	4.9	6.8	4.2	1.9	10.8
May	8.8	5.6	8.3	5.8	3.7	13.5
June	13.8	10.1	8.6	6.9	5.9	12.9
July	12.6	12.6	7.8	5.7	5.3	13.6
Aug.	8.8	6.4	6.8	5.6	4.5	9.8
Sept.	6.2	5.5	5.9	4.7	3.6	8.9
Oct.	1.9	2.3	2.9	2.5	0.9	6.0
Nov.	0.8	1.4	2.0	2.0	0.5	3.9
TOTAL	62.9	52.6	58.4	42.6	28.3	93.0
Year 1972						
Feb.	0.5	1.5	3.3	1.9	0.7	5.4
Mar.	4.9	4.2	5.0	3.7	2.1	9.4
Apr.	6.9	4.9	6.1	4.5	2.4	11.0
May	8.1	8.0	7.8	5.8	3.7	11.6
June	8.1	7.4	7.1	5.1	3.4	11.5
July	9.0	8.1	7.8	6.0	5.4	12.9
Aug.	9.2	6.6	4.6	3.8	2.8	9.9
Sept.	3.6	2.2	4.4	3.8	2.4	6.7
Oct.	4.6	1.8	1.2	1.4	0.0	6.3
Nov.	0.3	0.2	1.6	1.9	0.3	3.4
TOTAL	55.2	44.9	48.9	37.9	23.2	87.8

As one method to compare the accuracy of each equation to predict actual water application, a ratio was computed between the average amount of water applied to the landscape and the predicted amount of water used. The ratio was based upon the 10 month period of time. The over-all ratio approached 1.00 for the Penman formula, 1.30 for the Blaney-Criddle formula, and 2.1 for the formula derived by Thornthwaite. The monthly ratios between actual and predicted water used varied considerably, and in particular for the Penman and the Blaney-Criddle models.

A regression analysis was computed between the actual values and the predicted water use values obtained by employing each one of the formulas. The correlation coefficients, the regression values are included in Table 7. Note that all the correlation coefficients were significant at or beyond the .01 level. Accordingly, a high association existed between the actual and the predicted water use rates. However, the intercept and slope values varied considerably for each formula, the type of landscape and for the different years.

When predicted water required is compared to that applied, the Penman equation results were the closest. The Thornthwaite equation estimates differed the sharpest from the actual water application rates (Table 6). However, the regression and correlation analysis show that the Thornthwaite formula predicts more closely urban landscape water use.

Table 7

Correlation Coefficients, Intercept and Slope for the Regression of Landscape Water Used on Predicted Rates, for Green (G) and Intermediate (IG) Landscapes.

	Intercept (gallons x 1000)		Slope		Correlation Coefficient	
	1971	1972	1971	1972	1971	1972
Penman (G)	-4.34	0.39	1.82	1.05	0.90**	0.76**
Penman (IG)	-2.33	-0.99	1.30	1.12	0.80**	0.90**
Blaney-Criddle (G)	-4.57	-0.62	2.55	1.62	0.96**	0.80**
Blaney-Criddle (IG)	-2.54	-1.73	1.83	1.64	0.86**	0.91**
Thornthwaite (G)	-0.11	1.83	2.26	1.59	0.97**	0.80**
Thornthwaite (IG)	0.39	0.78	1.72	1.60	0.93**	0.90**

**significant at .01 level

Landscape Esthetics Associated with Water Application Rates

Another objective of the project was to determine if an association existed between the esthetic attributes of a residential landscape and the amount of water applied to maintain the landscape. However, the literature revealed no systematic way to measure esthetic attributes of landscapes nor were any studies identified which reported the association of how specific elements of landscape design were related to the amount of water applied to the landscape. Accordingly, in this section of the report the technique which was developed to measure residential landscape esthetics is described as well as the way in which specific esthetic attributes were associated with the amount of water applied to the landscape.

First, a rating scale was developed to measure esthetic attributes of residential landscapes. The Residential Landscape Rating Scale (RLRS) included items describing specific elements of landscape design as well as items which were used to rate subjective esthetic qualities of landscapes. A copy of the RLRS is enclosed in Appendix A. The design elements included, for example: the use of color, arrangement, texture, non-plant objects, vegetation, and focal points. On the other hand, the RLRS also included items which the observer employed to rate the qualitative attributes of the landscape. For example, interesting, comfortable, barren, unusual, and creative. Thus, the instrument was developed to provide as objective as possible a measure of the esthetics of residential landscapes, but with the fact in mind that many salient attributes of a landscape are, indeed, subjective and qualitative.

Second, the RLRS was used to rate esthetic attributes of a sample of different types of residential landscapes. In addition, the amount of water applied to the landscape was calculated for each of the residences in the sample

The technique of multiple regression was used to compute the association between each item on the RLRS and the amount of water applied to the landscape.

Last, the results of the analysis were discussed in the context of the basic esthetic attributes which were identified, and recommendations were suggested for reducing the amount of water used to maintain residential landscapes and at the same time minimize the effect upon the esthetic attributes of the landscape.

Rating Esthetic Attributes of Landscapes. The Residential Landscape Rating Scale (RLRS) was developed to measure esthetic attributes of residential landscapes. A principal component analysis of the 30 items in the RLRS indicated that the following four basic esthetic attributes were measured by the Scale: Harmony, Composition, Accent, and Uniqueness. In other words, each item in the RLRS was classified into one of the above four basic esthetic attributes on the basis of the statistical and semantic analysis of the items. The definitions for each of the four basic attributes is presented in Plate 1.

The RLRS was used to rate a sample of 44 residences in Las Cruces, New Mexico. The landscapes included ones classified as Green, Intermediate green, and Desert types. The residences were predominantly middle income family homes, and the residents had lived in the home sufficiently long to establish a relatively consistent water application pattern. Four staff members, trained to use the RLRS were employed to obtain the ratings for the sample of residences. The ratings were completed during a 2 month period during the summer months when the landscape was well maintained.

Plate 1

Definitions of the Constructs Measured by the Residential Landscape Rating Scale (RLRS)

Harmony refers to the blending of different elements in the landscape and how components fit together to create unity. The attributes include color, arrangement, form, shape, texture, non-plant objects and vegetation. The landscape is planned and designed to achieve balance, whether symmetrical or asymmetrical, and the component parts create a harmonious effect. The component attributes are sufficiently similar to blend together without being identical. Harmony implies that there are no extraneous, irrelevant or dangling parts in the landscape which do not "fit" into the landscape plan.

Composition refers to the proportional arrangement of elements in the landscape. Vegetation and non-plant objects are an appropriate size; for example, the trees are too large or too small in relationship to the other plants and objects in the landscape. No plants or objects block the view of other parts of the landscape, and each part is proportionate to the other components. Overcrowding and excessive vegetation affect composition by making one plant disproportionate to other plants. An excessive number of plants or objects the same size produces "clutter" and indicates a lack of composition. The number, size, and arrangement of landscape elements contribute to composition.

Accent refers to elements which bring attention and emphasis to the landscape. Attributes which accent a landscape include contrasting colors, a variety of textures, objects, and plants which are appropriately placed, differing shape of plants and objects, and elements arranged in a pattern. Conversely, a lack of accent is evident when the landscape is barren, has large empty portions, or has no objects or plants to break up a large monotonous area.

Uniqueness refers to how different or creative landscape is in comparison with typical landscapes. Creativity makes the landscape interesting and unusual. Uniqueness may be attained by using objects and plants different from those commonly used, but not odd or bizarre.

Measurement of Water Applied to the Front Landscape. The winter base rate method with city water service records was the basis for calculating the amount of water applied to the landscape. However, it was necessary to modify the basic formula to account for two additional variables: (1) the amount of water applied to only the front landscape and (2) the area of the front landscape.

Accordingly, the size of the green area in the front and in the back was measured, and the percent of the total green area which comprised the front landscape was calculated. This percent of green in the front landscape was multiplied by the total gallons of water applied to the landscape to calculate the number of gallons of water applied only to the front landscape.

The size of each front yard in the sample of landscapes differed, accordingly it was necessary to adjust for the difference. The adjustment was made by dividing the total number of gallons of water applied to the front landscape by the size of the front landscape area. Thus, the final figure obtained indicated the number of gallons of water per square foot of front landscape which was applied for the year. It is important to note, that only the front landscape was rated with the RLRS, and thus it was necessary to calculate the amount of water applied only to the front landscape area.

Esthetics and water applied to landscape. The next step in the analysis was to determine if an association existed between the esthetic attributes of landscapes and the amount of water which was applied to maintain the landscape. Accordingly, a multiple regression analysis was computed with the 30 items of the RLRS as independent variables and the total gallons of water applied to the landscape as the dependent variable.

Thus, the results presented in table 5 show the correlation of each item in the RLRS and the gallons of water applied to the front landscape. In addition, the items in table 5 have been grouped with respect to the basic esthetic attributes measured by the rating scale.

The multiple correlation of .71 between the RLRS items and water applied to the landscape was significant beyond the .01 confidence level. A multiple correlation coefficient of that magnitude indicated that approximately 50% of the variance was accounted for in the regression analysis. Thus, the esthetic attributes measured by the RLRS were significant predictors of the amount of water applied to the landscape and a sufficient amount of variance was accounted for to warrant additional analysis and interpretation.

Table 5 also shows how each element of landscape design was related to the amount of water applied. Note, for example, that item No. 7, "concrete areas were attractively shaped" obtained a beta correlation coefficient of .-19 with the gallons of water applied to the landscape. The negative correlation was significant beyond the .05 confidence level, and indicated that when attractively shaped concrete areas were used, less water was applied to maintain the landscape. Also, it is important to note that attractively shaped concrete areas contributes positively to the <u>Harmony</u> of the landscape.

Another specific element of landscape design, item No. 8, "textures in the landscape are related to textures in the house" obtained a beta correlation coefficient of .-18 with the water applied to the landscape. The correlation was significant and indicated that when, for example, the resident had employed gravel or rocks in the landscape to blend with a gravel roof, the water applied to the landscape was reduced. This element of landscape design also contributed positively to the basic esthetic attribute of <u>Harmony</u>.

"The landscape looks planned" was an item which obtained a correlation of .-26 with the amount of water applied. Homes which were rated high on this item, No. 17, used significantly less water than those receiving a low rating. The item describing this subjective aspect of the landscape was included with the items describing the Harmony of the landscape. Accordingly, it was inferred that for this sample of homes the ones that appeared to be more planned were the ones that the residents used less water to maintain the landscape.

Another esthetic attribute, item No. 31, "The landscape was creatively designed" also obtained a significant correlation .-27, with the total number of gallons of water used on the landscape. Thus, front landscapes receiving high ratings on this item were low water consumers, and at the same time were rated high on the basic esthetic attribute of Harmony. "Creatively designed" is, of course, a subjective attribute of the landscape but sufficient agreement existed among the raters, for the item to obtain a significant association with the objective measure of the amount of water used on the landscape.

Table 8 shows that two items in the RLRS classified as relating to the basic esthetic attribute of Composition obtained significant correlations with water application rates. Item No. 9 "Trees too large or too small" was correlated .-14 with yearly gallons of water for the landscape. Note, that the item was inversely related to Composition, e.g. if the observor "agrees" with the item statement, then there was an adverse effect upon Composition. For the sample in this study, residences which were rated high on this attribute also were the ones using the lowest amount of water. Accordingly, it was inferred that appropriately sized trees tend to use more water than inappropriately sized trees. However, appropriately sized trees, add to the Composition of the landscape, but also tend to use more water

Table 8

Multiple Regression Analyses RLRS

Items with Gallons of Water Applied to Residential Landscapes in 1971[1]

(N=176)

No.	RLRS Item	Correlation 1971	Correlation 1972
	Uniqueness		
6+	landscape is similar to others	.19*	.21*
13	landscape has a focal point	-.07	-.14*
21	something unusual in landscape	.14*	.14*
28	different from typical landscapes	.26*	.14*
	Composition		
3+	vegetation blocks view of other parts	.04	-.04
9+	trees too large or too small	-.14	-.02
14+	landscape is cluttered	.11	-.02
25+	landscape is crowded	.03	-.02
27+	excessive green vegetation	.33*	.46*
	Accent		
1	contrasting colors in landscape	.01	.06
2	a variety of textures in landscape	-.01	-.16*
11+	grass area in monotonous	.23*	.33*
15+	are empty parts in landscape	-.12	.00
20	eyes follow a pattern	-.08	-.05
24+	too many plants shaped alike	-.16*	.08
30+	landscape is barren	-.27*	-.16*
	Harmony		
5	landscape fits architectural style	.09	.05
7	concrete areas attractively shaped	-.19*	-.09
8	landscape textures related to house textures	-.18*	-.09
10	landscape colors blend with house colors	.06	.04
16	plant or object doesn't belong	.12	.07
17	landscape looks planned	-.26*	-.19
18	landscape is balanced	.13	.08
19	type of plants go together	-.07	-.12
22	landscape is interesting	.00	.03
23	landscape makes you feel comfortable	.12	.14*
26	landscape has attractive non-plant objects	.09	.18*
29	non-plant objects blend with landscape	-.03	-.15*
31	landscape was creatively designed	-.27*	-.33*
32	colors in landscape harmonize	-.08	.03

[1] the item statements have been abbreviated
+ items are inverse measures of the basic esthetic attribute
* significant at or beyond .05 level

than inappropriately sized trees. The other item associated with Composition, No. 27, "excessive green vegetation" correlated significantly with water application (r=.33) thus, residences with excessive green vegetation were high water consumers, and at the same time were rated low on Composition. Reducing excessive vegetation improved the Composition of the landscape, and also reduced the amount of water used on the landscape.

Several items classified in the basic esthetic attribute of Accent obtained significant correlations with water application rates. "Grass area is monotonous" correlated .23 (significant at .05 confidence level) with the measure of water applied. Thus, homes with large monotonous grass areas were rated low on the basic attribute of Accent, and also were large consumers of water. Thus, the esthetic quality of the landscape could be improved if the homeowner avoided monotonous grass areas. The other items in the RLRS which are measures of Accent suggest design options for improving the Accent quality of the landscape and at the same time do not effect water consumption. For example, Accent was improved by the use of color in the landscape (item No. 1) and at the same time was not associated with water consumption.

The item, No. 24, "Too many plants shaped alike" correlated significantly with low water consumption (.-16). A high rating on this attribute indicated that a low degree of the basic esthetic quality of Accent existed in the landscape. The item was an impetus for suggesting how the Accent quality of the landscape could be improved, and it is an option to the resident to select an alternative which also reduces the amount of water used by the landscape. For example, if the total number of plants were reduced to achieve Accent, then the amount of water applied would also be reduced.

A similar suggestion can be made with regard to the finding that the "landscape is barren" was associated significantly with low water consumption (r=.-27) obviously, a barren landscape was not rated as esthetically attractive, but it was associated with low water application rates. However, a number of ways exist to reduce the barreness of the landscape, and do not require an increase in the amount of water used. The alternatives for improving Accent include, for example: the use of contrasting colors, a variety of textures, focal points, etc. All of these elements of landscape design improve Accent without a corresponding increase in water application for landscape maintenance.

Three of the four items comprising the basic esthetic attribute of Uniqueness correlated significantly with the amount of water applied to the landscape. The first, "landscape is similar to others" obtained a .19 beta correlation with water applied. Thus, landscapes which were low on the quality of Uniqueness, and were similar to others were, by and large, high consumers of water. The same relationship was found for "something unusual in the landscape" (r=.14) and for "different from typical landscapes" (r=.26). It was inferred that the Uniqueness attribute of landscapes had been achieved by employing elements of landscape design which were associated with high water consumption. It is suggested that homeowners explore non-water consuming alternatives for creating Uniqueness in residential landscapes.

It can be recalled that the multiple regression analysis was computed with the ratings on the RLRS and the gallons used for the year 1971. A second multiple regression analysis was computed with the amount of water applied to the landscape for the year 1972, even though the ratings were made in 1971. The second analysis was completed as a means to cross-validate the findings for the year 1971. It was expected, however, that exactly the same results would not be found, because the residents may have made changes which effected their landscapes as well as watering practices. In addition, more rainfall occurred in 1972.

The beta correlation coefficients for the RLRS items and total gallons of water applied to the landscape is included in appendix B. However, an overview of the results of the analysis for the year 1972 is presented in brief. Generally, the results were very similar to the results for year 1971. Nine of the 13 significant correlations were the same for both years, and two items, No. 9 and No. 24 did not obtain significant correlations with the 1972 data. In addition, the following items obtained significant correlations for the year 1972, but not for the year 1971:

23	landscape makes you feel comfortable	.14
26	landscape has attractive non-plant objects	.18
29	Non-plant objects blend with landscape	-.15
2	a variety of textures in the landscape	-.16
13	landscape has a focal point	-.14

The first two items, No. 23, and No. 26 were classified as esthetic attributes associated with Harmony. Landscapes which were rated high on these two attributes achieved Harmony, but at the expense of increased water consumption. However, No. 29 "non-plant objects blend with the landscape" also contributed positively to the Harmony of the landscape but, instead was associated with lower water application rates. Again, it was shown that optional ways exist to achieve Harmony, and a number of the ways were associated with low water consumption.

"A variety of textures in the landscape," and "landscape has a focal point" were both associated with the basic esthetic attribute of Accent. The correlation coefficients indicated that Accent was, in many cases, being achieved by techniques of landscape design which required a low amount of water. It was inferred that in both cases Accent was enhanced by the use of non-plant objects to provide textural variety and focal points for the landscapes.

In short, the results of the multiple regression analysis with the 1972 water application data corresponded to the results obtained with the 1971 data. It was inferred from the cross-validation study that the findings illustrating the association of esthetic attributes of residential landscapes with water application rates were relatively stable. Thus, the RLRS provided sufficiently objective ratings, to be of assistance in suggesting alternative techniques of landscape design which were associated with lower water application rates.

The analysis of specific elements of landscape design indicated which ones were associated with water consumption and which ones were not. Accordingly, since each basic attribute of landscape design, e.g., Harmony, Composition, etc., includes elements of design associated with the attribute as well as with high and low water use, it is possible for a landowner to plan to achieve beauty in the landscape and at the same time plan to employ elements which are associated with low water consumption. In other words, Esthetic beauty may be obtained by several different ways, a homeowner has the option to select from elements which have a high or low association with water consumption. In brief, the following elements of landscape design were identified as the ones most closely associated with low water consumption of residential landscapes, and at the same time the element enhanced the beauty of the landscape.

1. employing attractively shaped concrete areas which contribute to the Harmony of the landscape.

2. Creating Harmony in the landscape by using gravel, rocks, decorative bark which have textures similar to the materials in the house itself.

3. A small number of tress with different sizes placed to enhance the Composition of the landscape.

4. Reducing the number of plants which "cluttered" the landscape.

5. Eliminating plants which didn't belong or distracted from the Harmony of the landscape.

6. Reducing excessive green vegetation in the landscape which adversely effected Composition.

7. Avoiding large green areas which were monotonous and minimized the Accent quality of the landscape.

8. Including empty parts in the landscape, where Accent is achieved by other elements of design.

9. Including a fewer number of plants with different sizes and shapes.

10. Creating a quality of "barreness", but achieving Accent with other elements of design.

11. Achieving Uniqueness in the landscape by the use of non-plant objects

12. Using non-plant objects and portions of the house as focal points for the landscape.

In summary, the above 12 points are the findings of this portion of the project. The data indicated that these elements of landscape design were associated with high beauty and also low water consumption. It is important to note, that this portion of the study did not include all elements of landscape design, but only the ones which were retained as reliable and valid by the analysis. The items comprising each subscale only represent a sample of similar items describing the basic landscape attributes. The item sets were, of course, not inclusive of all items comprising the concept. The items, however, may serve to stimulate residents to select elements of landscape design which are related to low water use and high beauty for the landscape.

Survey of Urban Water Application Practices

Data collected on the amount of water applied to the landscapes of homes in Las Cruces, New Mexico indicated that homeowners were using an excessive amount of water to maintain the vegetation. Additional information from homeowners about their water application practices was needed. Accordingly, a survey of homeowners in the city was conducted in order to discover the practices used by the residents to irrigate their landscapes.

Residents were selected by a random sampling procedure through intermdiate units. The city was separated into nine sections each one comprised of relatively homogenous types of homes. However, differences among sections included, for example, home values, landscape type, landscape maintenance, and landscape esthetics. Then, a technique of sample random sampling was used to select the residents for the survey from each of the nine sections. A total of 115 interviews with residents were conducted. However, 14 of the residents were excluded from the analysis because they had not lived in the home long enough to establish a consistent water application pattern, and two other residents used private water supplies to irrigate their landscapes. Accordingly, 101 residents were included in the final results of the survey.

The questionnaire was administered in July, 1974 by a trained interviewer who explained the purpose of the survey, and asked the questions to the residents. There were no refusals on the part of the residents to participate in the study. The questionaire was composed of 32 items which spanned the following topics:

1. Characteristics of the residents.
2. Attributes of the residential landscapes.
3. Water application practices of residents.

Also, the esthetic quality of the landscape was rated by the interviewer on four attributes: (1) overall beauty, (2) uniqueness, (3) well planned and (4) condition of the vegetation. Also, the amount of water used at the residence was obtained from the City water service, and the domestic and landscape use was calculated with the winter base rate procedure. A copy of the questionnaire and the responses of the total sample to each question is attached in Appendix C.

The analysis indicated that the residents had the following characteristics: Ninty-six percent were purchasing the home, and on the average, four persons lived at each residence. The majority (58%) of the sample had lived in the southwest for 12 or more years and 38 percent were native to Las Cruces. The newcomers in the sample, living in Las Cruces for less than 12 years, had arrived from differing types of climates. Forty-six percent had lived in a humid climate; forty percent in a semi-humid region, and fourteen percent arrived from an arid climate. Most of the residents interviewed were housewives or working persons who were on vacation.

The attributes of the landscape were obtained by ratings made by the interviewer prior to conducting the interview with the resident. The interviewer recorded if the landscape was Green, Intermediate green or Desert. The results indicated that two-thirds of the landscapes were classified Green, thirty percent were Intermediate, and approximately 3% of the landscapes were Desert. The ratings of the condition of the landscape at each residence included: 44% good, 43% average and 13% poor. The size of the landscapes ranged from 2000 sq./ft. or less to approximately one-half acre. A full range (scale of 1-6) ratings on the following three esthetic attributes were obtained: Attractiveness, Uniqueness and Well planned. Thus, the sample included a variety of green and desert landscapes, differing in size, esthetic attributes, and the condition in which the landscape was maintained.

The residents were asked to state the reasons why they preferred their type of landscape. The following were typical responses for residents with Green landscapes: "it was more attractive to them than a desert landscape" "green landscapes are easier to maintain," "the house already had this type of landscape," "I need a green environment close to home," "the trees and plants reduce the noise," "plants make the home cooler," and "the children have a nice place to play."

On the other hand, residents with Intermediate green or Desert landscapes offered the following reasons for preferring their landscape: "it was more attractive than a green landscape," "desert landscapes are easier to maintain than green ones," "the house already had this type of landscape," and "the landscape uses less water than a green one." Thus, a portion of the sample expressed personal as well as perceived utilitarian reasons for the preference for Green, Intermediate green, and Desert landscapes.

A variety of water application practices were reported by the residents. Specifically, the time of day the residents irrigated the landscape was equally separated into the morning and evening hours; 44% reported the landscape was watered in the morning and 44% indicated that it was watered in the evening. When the resident had "time available" or "to conserve water" were the two reasons which were stated most frequently when the residents were asked when the landscape was watered. The watering schedule also varied for the sample of residents: 43% indicated that water was applied on a regular schedule, 40 percent applied water only when they observed that the plants needed it, and approximately 2 percent indicated the landscape was watered only when they saw a neighbor who was watering his yard. Sixty percent of the sample stated the landscape was irrigated on a schedule of three or four times a week during the hot summer season. Also, the most frequent responses to the question, "duration of water application per setting," were the alternatives one hour or less (31%) and two hours (28%).

In summary, the residents employed water application practices which tend to use more water than needed by the landscape. Some of the practices included for example, applying water too frequently or on a irregular time schedule. In addition, many of the residents had Green landscapes, and applied more water to their landscape than the residents with Desert and Intermediate green landscapes thus, the survey indicated that a need existed for information describing techniques for reducing the water applied to residential landscapes.

University Campus Water Conservation Plan. Liberal use of mesophytic plants was found in many public parks, golf courses and university campuses in the southwest. However, information was not available about the amount of water applied to these large turf areas. Accordingly, an experiment was conducted to measure the amount of water applied by a professional landscape maintenance crew on a university campus.

Water meters were installed on a 26,000 sq. ft. portion of a university campus planted with three-year-old fescue CV. Kentucky 31, cool season turf.

A grass which, in the southwest, typically requires a large amount of water. The plot of fesque also indicated six small ash trees with a trunk diameter of 2.5 inches and a height of 4 feet, as well as five Japanese black pine trees with a trunk diameter of 3.0 inches and all were approximately 5 and one-half feet tall. The trees were comingled with the turf, but grass comprised approximately 95 percent of the turf area.

The other 42,340 sq.ft. portion of the university campus which was metered was planted in hybrid bermuda CV., Tifway, a warm season turf. The area was principally used as an archery range and did not contain other landscape plants.

Both areas were irrigated with permanent underground rotating sprinklers, and different gardeners maintained each site. The soil for both areas varied from gravel to fine sandy loam. Water penetration as well as water percolation was high in both of the areas. In addition, runoff could occur after excessive sustained water application.

The amount of water applied to the landscapes and the effective rainfall for 1973 and 1974 were presented in Table 9 (fescue) and Table 10 (bermuda). Open pan evaporation and available water minus open pan are given for each period for comparison. The application rate for fescue was substantially higher than for bermuda throughout the test. Fescue requires more water and water deficiency symptoms severely affect its appearance. However, water applied to the fescue often exceeded or approached twice open pan evaporation in 1973. The amount of water available to the bermuda turf seldom exceeded an open pan evaporation rate in the year 1973. Assuming that maximum evapotranspiration of a predominantly turf area is equal to 0.8 of the open pan evaporation (4), the water available, applied and rainfall, was excessive in 1973 on both sites.

but in the extreme at the fescue site.

When it was noted that an excessive amount of water was being applied to the landscape plots on the campus, a conservation plan was initiated to reduce the water use, and still maintain the esthetic qualities of the sites. The conservation plan consisted of providing instruction to the landscape maintenance crew, and monitoring the amount of water applied to the landscapes. Accordingly, the water application rates presented in table 6 and 7 for the year 1974 were influenced by the water conservation plan which was initiated.

A comparison of 1973 and 1974 showed a significant reduction of water available to plants in 1974 at both sites. As a result of the conservation plan used March 1 to August 31, 23.5 inches and 11.9 inches less water was available to the fescue and bermuda, respectively, in 1974. The amount of water conserved for the two years were 48 and 47 percent, respectively.

Turf at both sites was healthy in both years. Water was conserved without sacrificing esthetics. The root system of the fescue grass changed from a shallow, thin, poorly colored complex in 1973 which was assumed to be caused by overwatering, to a deep, vigorous root system in 1974. The figures for the year 1974 indicated that while there was still a tendency to overwater, the conservation plan did influence to some extent the amount of water applied to the landscapes. It is important to note, however, that watering practices of individuals were difficult to change even when systematic plans were initiated.

Thus, table 9 and table 10 describe the water application rates on a university campus in the southwest. The data presented by no means is an optimal amount to maintain the esthetic and health attributes of the landscapes.

Table 9

Water Applied to Alta Fescue at NMSU Campus During 1973 and 1974. Water Conservation Plan Began in March, 1974.

Date	Water Applied (inches)	Effective Rainfall (inches)	Water Available (inches)	Water Available per Day (inches)	Open Pan Evaporation (inches)	Water Available Above Pan Evaporation (inches)
1973						
03/01-03/31	9.4	0.30	9.70	.313	.212	.101
04/01-04/15	5.5	0.00	5.50	.367	.279	.088
04/16-04/30	7.1	0.00	7.10	.473	.349	.124
05/01-05/31	17.3	0.20	17.50	.565	.359	.206
06/01-06/30	24.8	1.12	25.92	.864	.438	.426
07/01-07/31	18.4	3.68	22.08	.712	.365	.347
08/01-08/31	23.0	0.72	23.72	.765	.332	.433
09/01-09/15	3.1	0.00	3.10	.207	.292	-.085
09/16-09/30	11.0	0.15	11.15	.743	.270	.473
10/01-10/30	12.5	0.02	12.52	.417	.204	.213
11/01-11/12	3.8	0.00	3.80	.317	.164	.153
11/13-11/30	4.5	0.03	4.53	.252	.142	.110
12/01-12/17	4.7	0.00	4.70	.277	.132	.145
1974						
12/18-04/15	24.0	1.03	25.03	.210	.185	.025
04/16-04/30	5.3	0.00	5.30	.353	.358	.005
05/01-05/31	14.3	0.00	14.30	.461	.385	.076
06/01-06/30	15.5	0.00	15.50	.517	.486	.031
07/01-07/31	10.9	3.10	14.00	.452	.337	.115
08/01-08/15	6.5	1.57	8.1	.540	.307	.233
08/15-09/15	13.6	3.26	16.9	.367	.300	.067

Table 10

Water Applied to Hybrid Bermuda Turf at NMSU Campus During 1973 and 1974. Water Conservation Plan Began in March, 1974.

Date	Water Applied (inches)	Effective Rainfall (inches)	Water Available (inches)	Water Available per Day (inches)	Daily Evaporation (inches)	Water Available Above Pan Evaporation (inches)
1973						
03/01-03/31	1.78	0.30	2.08	.067	.212	-.155
04/01-04/15	0.94	0.00	.94	.063	.279	-.216
04/16-04/30	1.15	0.00	1.15	.077	.349	-.272
05/01-05/15	3.51	0.20	3.71	.247	.325	-.078
05/16-05/31	4.99	0.00	4.99	.312	.391	-.079
06/01-06/15	4.97	1.12	6.09	.406	.417	-.011
06/16-06/30	4.09	0.00	4.09	.273	.459	-.186
07/01-07/15	6.12	2.36	8.48	.565	.435	+.130
07/16-07/31	3.71	1.32	5.60	.350	.299	+.051
08/01-08/31	13.86	0.72	14.58	.317	.319	-.002
09/01-09/15	5.87	0.00	5.87	.391	.292	+.099
09/16-09/30	3.39	0.15	3.04	.236	.270	-.034
10/01-10/31	3.67	0.02	3.69	.123	.204	-.081
11/01-11/31	1.29	0.03	1.32	.044	.151	-.104
12/01-12/17	0.39	0.00	0.39	.023	.132	-.109
12/18-12/31	1.05	0.00	1.05	.075	.117	-.043
1974						
01/01-02/28	4.76	0.00	4.76	.122	.134	-.012
03/01-03/31	2.56	0.39	2.95	.099	.237	-.138
04/01-04/15	0.56	0.00	0.56	.037	.333	-.296
04/16-04/30	1.82	0.00	1.82	.121	.358	-.237
05/01-05/15	4.21	0.00	4.21	.281	.357	-.076
05/16-05/31	2.84	0.00	2.84	.178	.411	-.233
06/01-06/15	2.61	0.00	2.61	.174	.475	-.301
06/16-06/30	5.08	0.00	5.08	.339	.494	-.155
07/01-07/15	1.53	1.68	3.21	.214	.321	-.107
07/16-07/31	1.43	0.56	1.99	.124	.351	-.227
08/01-08/15	7.51	3.20	5.71	.381	.307	-.074

Instead, however, the tables illustrated the amount applied to the landscape by a professional maintenance crew with and without a water conservation plan. Both water application rates were excessive when compared with the open pan evaporation rate. Nevertheless, one finding which was serendipitous, in this portion of the study, and which suggested the need for additional research was the fact that despite the water conservation plan, the established water practices of professional individuals were difficult to change.

III Conclusions

The study was conducted to identify esthetic and human factors which were associated with water applied to residential landscapes. The increased demand for water, especially during peak periods, has placed a burden upon existing water supplies. One segment of the community which used large amounts of water was residential landscapes. However, residents attach a variety of psychological and esthetic values to their landscapes. A simple "use less water" caveat as an intervention would, in all probability be doomed to failure from the beginning and even price increases do not greatly reduce water use in arid regions (24). Accordingly, in this study the investigators planned to examine different aspects of the problem, in an attempt to provide information which would assist in the identification of viable techniques for reducing the amount of water applied to residential landscapes and still preserve the esthetic qualities. In addition,the study provided information about water application rates in the Southwest for landscapes with differing amounts of vegetation.

Review of Findings

The specific objectives and the procedures employed to conduct the separate portions of the study already have been discussed in detail in prior sections of this report. At this juncture, a review of the major findings of the study is presented, to provide a brief summary of the project.

Measuring Water Applied to Residential Landscapes. A variety of methods have been employed to measure the amount of water applied to residential landscapes. Some of the methods include for example: using City Water Supply Service data, installing meters on site at the residence, and estimating the predicted need for water based upon weather, wind, temperature and other climatic factors. It was found in this study that a modification of the "Winter base rate method" employed by Linaweaver (37) was a reasonable accurate method for measuring water applied to the landscape. The modification based the winter base rate on the lowest two months of the year instead of the lowest three months as reported by Linaweaver. It appeared that the 2 month base rate procedure was more appropriate for the arid Southwest than in the regions with higher winter rainfall. Linaweaver developed the formula with the three month base in regions with variable summer climates and rainfall but uniform in receiving adequate winter rainfall. It was noted that in this region residents apply water to the landscape even in the winter months, (13 percent of domestic base), and therefore the winter base rate formula is an underestimate of the water applied to the landscape. Nevertheless, until more accurate formulas are conceived, the winter base rate method still combines practicality and accuracy.

Comparison of Predicted Need with Water Applied to Landscapes. One objective of the project was to compare the amount of water predicted by several formulas derived by different investigators, with the amount of water which was applied by residents to maintain the landscapes. Water application rates were measured for a sample of 40 residential landscapes in the Southwest Community. The landscapes were classified as either Green or Intermediate green depending upon the percentage of mesophytic plants in the landscape. The water application rates were examined, and it was found that the residents with Green landscapes applied approximately 100% more water to the landscapes when compared to the residents with Intermediate green landscapes with only 56 percent more area with vegetation.

Next, the predicted need for water formulas developed by Thornthwaite, Penman, and Blaney-Criddle were used to estimate the amount of water needed by the landscapes in the sample. The values obtained with each formula were compared with the water application rates for the residences. The Penman predictions were the ones which were most similar to the total amount of water applied to the landscapes by the residents. However, discrepancies existed with the Penman predictions when the water applied to the landscape were compared on a monthly basis.

Residents applied more water than needed to maintain the landscape, and the specific amounts depended upon the season and landscape type. Thus, with the information available it was not possible to identify the specific formula which was the best predictor of water needed by the landscape. However, the Penman formula, provided the most accurate approximation of the water applied to the landscape, but the Thorthwaite formula correlated most closely with water used. Additional research on the measurement of the amount of water required to maintain multi-specie plant arrangements is needed before a research based decision related to the best formula for predicting estimated water need for landscapes can be made.

Landscape Esthetics and Design Associated with Water Application

Another objective of the study was to identify if esthetic and design elements of landscapes were associated with the amount of water applied. An instrument, the Residential Landscape Rating Scale (RLRS) was developed employing a factor analytic statistical technique. The reliability and validity of the RLRS was established, and the instrument was used to rate a sample of residential landscapes. A multiple regression analysis was conducted to determine if an association existed among the esthetic attributes and the amount of water applied to the landscape. The results of the analysis indicated that the RLRS accounted for 50% of the variance associated with the water applied. Accordingly, it was concluded that a significant association existed among esthetics and elements of landscape design and water application rates. In addition, the analysis identified specific esthetic and design elements which were associated with water application to the landscape.

The findings of this portion of the study indicated that it was feasible to measure the esthetic and design attributes of landscapes, and the attributes were related to water application. It was also shown that many attributes contributed to the overall beauty of the landscape, and concurrently less water was necessary when these attributes were employed to design the landscape. Thus, alternatives were identified which residents could employ to enhance the beauty of their landscape and at the same time conserve water.

Water Application Practices. A survey of residents in the community was completed to identify some of the procedures used to apply water to residential landscapes. The findings indicated that few coupled water applications with plant needs; 43% applied water in a regular schedule, and 40% indicated that water was applied when they observed that the plants needed it. Watering patterns were characterized by more frequent applications with short durations than would be deemed desirable. In addition 86% of the sample indicated a willingness to seek information about efficient and economical water application practices.

In short, the major findings of the survey indicated that the majority of residents did not employ systematic water application procedures, tended to use more water than needed to maintain the landscape, and expressed an interest in obtaining information about improving watering practices.

A second study of water application practices was conducted with two landscaped areas on a university campus. The initial plan was to determine the amount of water being used to maintain public landscaped areas. However, when the first year (1973) data was analyzed, the amount of water applied to the landscape was excessive. Accordingly, a water conservation plan was initiated with the professional grounds maintenance staff to reduce the amount of water applied to the landscape based upon a more accurate estimate of the amount of water needed to maintain the landscape. As a result of the water conservation plan, the water applied to the landscape was reduced by approximately 47% and the landscape retained esthetic and vigor qualities.

The water conservation plan was successful in some degree, despite the difficulty in changing long-standing water application practices of the landscape maintenance crew. The examination of the second year, 1974 water application data indicated, in the judgement of the investigators that an excessive amount of water still was being applied to the landscape. Thus, the water applied could be reduced an additional amount and still maintain the esthetic and health qualities of the landscapes.

Further Research

An implicit objective of exploratory projects, is to identify topics for additional research. As much as possible in this report, the investigators have candidly described the procedures that were used to accomplish the objectives of the project. In specific cases, it was evident that some existing techniques of measurement, although reasonably accurate, were in need of improvement. For the most part, these topics have been covered in detail in prior sections of the report. However, a review of additional areas for study in the topic of residential water application is briefly presented.

1. Develop educational materials for describing, efficient and practical water application practices which can be used by residents to maintain the health and beauty of their landscapes.

2. Refinement of the winter base rate procedure for estimating water applied to residential landscapes. Additional control for water not applied to the landscape, as well as measures of water applied to the landscape during winter months is one basis for obtaining additional accuracy with the winter base rate procedure.

3. Establish base line data for water applied to landscapes with varying areas devoted to multi-specie plants.

4. Identify additional esthetic and design elements of residential landscapes which provide residents alternatives for conserving water and contributing to the beauty of their landscapes.

In summary, various aspects of water application procedures employed with residential landscapes were explored in this study. The findings indicated that esthetic elements of landscape design, and water application practices, all were associated with the amount of water applied to the landscape. The most feasible method of reducing municipal peak water usage is to minimize excesses and utilize landscape design criteria which conserve water and are esthetically attractive. In view of the fact that residents tend to apply up to 50% more water than needed to maintain the esthetic and health qualities of the landscape, it is recommended that an educational program be initiated to improve the water application practices as well as the design of landscapes as one technique for reducing the amount of water used to maintain residential landscapes.

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Appendix A

Residential Landscape Description Questionnaire

(RLRS Form III)

This questionnaire is used to describe the attributes of a residential landscape. When rating a specific attribute of the landscape, please ignore the other attributes and attempt to rate each attribute alone and as accurately as possible. In other words, respond to each question in the inventory independently, and ignore the ratings you have given the landscape in other questions.

The scale that is used to rate each question is printed at the top of each page. Circle the appropriate alternative to indicate how strongly you agree or disagree that the attribute described is present in the landscape you are rating. Please observe the landscape very carefully before you make the rating. Thank you.

Landscape No. ______________________________

Rater's Name ______________________________

Office of Water Resources Research Grant No. 14-31-0001-9012

New Mexico State University

Las Cruces, New Mexico

1973

NA Not Applicable
1 Strongly disagree
2 Disagree
3 Agree
4 Strongly agree

1.	There are contrasting colors in the landscape.	NA	1	2	3	4
2.	There is a variety of textures in the landscape.	NA	1	2	3	4
3.	Vegetation in the front blocks the view of other parts of the landscape.	NA	1	2	3	4
4.	The trees in the landscape are attractively shaped.	NA	1	2	3	4
5.	The landscape fits the architectural style of the house.	NA	1	2	3	4
6.	The landscape is similar to many other landscapes.	NA	1	2	3	4
7.	Concrete areas are attractively shaped.	NA	1	2	3	4
8.	Textures in the landscape are related to textures in the house.	NA	1	2	3	4
9.	Some trees are too large or too small.	NA	1	2	3	4
10.	Colors in the landscape blend with colors in the house.	NA	1	2	3	4
11.	The grass area in the landscape is monotonous.	NA	1	2	3	4
12.	Non-plant objects are excessively repeated.	NA	1	2	3	4
13.	The landscape has a focal point which attracts your eye.	NA	1	2	3	4
14.	The landscape is cluttered.	NA	1	2	3	4
15.	There are empty parts in the landscape.	NA	1	2	3	4
16.	There is a plant or object which does not belong in the landscape.	NA	1	2	3	4
17.	The landscape looks as if it had been planned.	NA	1	2	3	4
18.	The landscape is balanced.	NA	1	2	3	4
19.	The type of plants in the landscape go together.	NA	1	2	3	4
20.	Your eyes follow a pattern in the landscape.	NA	1	2	3	4
21.	There is something unusual in the landscape.	NA	1	2	3	4
22.	The landscape is interesting.	NA	1	2	3	4

NA	Not Applicable
1	Strongly disagree
2	Disagree
3	Agree
4	Strongly agree

23.	The landscape makes you feel comfortable.	NA	1	2	3	4
24.	Too many of the plants are shaped alike.	NA	1	2	3	4
25.	The landscape is crowded.	NA	1	2	3	4
26.	The landscape has attractive non-plant objects.	NA	1	2	3	4
27.	There is an excessive amount of green vegetation.	NA	1	2	3	4
28.	The landscape is different from typical landscapes.	NA	1	2	3	4
29.	The non-plant objects blend with the landscape.	NA	1	2	3	4
30.	The landscape is barren.	NA	1	2	3	4
31.	The landscape has been creatively designed.	NA	1	2	3	4
32.	The colors in the landscape harmonize.	NA	1	2	3	4

OVERALL RATING

33. Not beautiful — Very beautiful

1 2 3 4 5 6

34. Not unusual — Very unusual

1 2 3 4 5 6

35. Not planned — Well planned

1 2 3 4 5 6

Please include written comments about your reaction to the landscape. What were the essential attributes which stand out in your mind?

Appendix B

Development of the Residential Landscape Rating Scale (RLRS)

Numerous publications were available on the topic of residential landscape design. Some of authors included, for example: Hubbard and Kimball (10), Robinson (13) and, Nehrling (12). All the authors described principles of landscape design, as well as provided examples of what each one considered esthetically attractive. The authors discussed many principles in detail, and described esthetics from differing theoretical and conceptual frameworks. It was apparent that landscape design was a complex field, and the development of expertise required long time training as well as experience planning residential landscapes.

Landscape design artists, employ different basic principles of design to create esthetic effects, on the other hand, homeowner's often have not had specific training in principles of landscape design. An instrument for rating the esthetic qualities of residential landscapes would assist residents to examine the esthetic quality of their landscapes as well as to identify specific elements of landscapes which are associated with elements of design used by landscape artists. Accordingly, the development of a landscape rating scale which could be used by a resident with no training in landscape design to rate the esthetic attributes of landscapes. Its application would provide first-hand experience with a complex but satisfying activity which many residents routinely perform.

The purpose of this report is to describe the development of the Residential Landscape Rating Scale (RLRS) an instrument for rating esthetic attributes of residential landscapes. The RLRS was developed as a means to rate, as objectively as possible, a variety of different residential landscapes. The RLRS included statements describing objective elements of landscape design as well as statements which describe subjective and esthetic attributes of landscapes. The following statements are examples of the items which were included in the rating scale. The items are rated on a four point scale which range from "strongly agree" to "strongly disagree".

1. Colors in the landscape blend with colors in the house.
2. There is a variety of textures in the landscape.
3. The landscape has a focal point which attracts your eye.
4. The landscape is crowded.
5. The landscape has attractive non-plant objects.

The goal of the investigators was, of course, to construct an instrument which denoted observable and objective attributes of the residential landscape. However, the very nature of esthetics precluded a completely objective technique for rating the artistic and esthetic qualities of a landscape. Nevertheless, during the item identification and screening procedures, a rigorous content analysis of the statements was conducted to retain items which minimized, to a large extent, the subjective attributes of the landscape.

Sources for the items

Important in the development of a measuring instrument is the variety of sources which are used to contribute statements for constructing the items for the rating scale. Obtaining items from only a few sources often inadvertantly precludes the measurement of an important aspect of a topic. Obtaining items from different sources is one way of securing a broad span of statements as potential items to be included in the final instrument.

One major source that was used in the development of the item bank was, of course, the literature pertaining to landscape design. Books, articles and unpublished manuscripts were reviewed to identify concepts which might serve as a basis for the generation of items for the instrument. Each author had differing views as to the way in which landscape design was discussed. Therefore, each one was reviewed objectively, with no predilection for one particular view or another. The concepts offered by the authors served as an impetus for the construction of items describing residential landscapes.

Another primary source of items was from professionals working in occupations associated with landscape design. Interviews were conducted on the topic of landscape design as a means to discover what elements were being used by the professionals. Discussions with people in the field was an impetus for creating items which tapped the applied aspect of landscape design. This facet was, in large part, remote from the theoretical concepts found in the formal texts on landscape design.

Landscape styles change, and as an additional source of information about contemporary landscape design, students currently enrolled in graduate courses in the university were asked about their conception of landscape esthetics. Comments and statements by the graduate students were reviewed, and served as input for the construction of items. Thus, input from persons with fresh and creative viewpoints about the esthetics of residential landscapes was obtained.

A final source of input to the "item bank" was the investigators. Items were "arm-chaired" and keyed to the investigators' conceptions of elements of landscape design. Numerous "brainstorming" sessions were conducted in which project staff freely exchanged ideas about the problem, and offered their opinions about contributors to the esthetic qualities of a residential landscape.

At this juncture, it is important to note that the review of the literature had not discovered any studies which employed an instrument to measure the esthetic attributes of a landscape. Thus, the endeavor began essentially from "scratch" and prior instruments did not provide a basis for the development of the rating scale. Accordingly, an effort was made to include as many different sources as possible, so that the instrument would serve as a prototype for further research.

Item Selection Technique

More than 100 statements related to landscape esthetics and design were obtained through several approaches. Many of the statements were not in a format acceptable for inclusion in a questionnaire, and were simply notes taken during a discussion of a key concept. On the other hand, some statements included several concepts, from which one or more specific items were constructed. The statements were analyzed and then items written according to the standards for the questionnaire items proposed by Adkins (1).

Although, an integrated conceptual framework for the instrument was not provided by the literature, a number of concepts important to landscape design had been identified. The item bank was examined to insure the array included items describing a wide variety of landscape attributes, as well as did not include items which were redundant, unclear or not relevant. The authors planned to employ statistical and semantic analyses methods to identify the basic esthetic attributes which were measured by the items.

The first form of the Residential Landscape Rating Scale (RLRS) was developed and included 55 items which had survived the initial screening procedures. Although the instrument was long, it was known before hand that many of the items would be eliminated by the statistical analysis. It was advisable to have more items than needed in the preliminary form, in order to insure that a sufficient number of items remained after the analysis was completed.

The field test of the RLRS was conducted with a sample of 335 ratings of 50 different residential landscapes. The raters included members of the project staff, the principal investigators, advanced Horticulture graduate students, and graduate students in other fields. A heterogeneous sample of raters was selected to insure that the items were generalizable for differing audiences, and not appropriate only for persons with expertise in landscape design.

The field testing procedure employed color slides for residential landscapes with differing esthetic styles. The styles included large and small lots, Green and Desert style landscapes, well planned and natural growth landscapes, and ones associated with a range of costs to establish. A projector was used to display the slides, and sufficient time was given for the observers to rate the attributes of the landscape. In addition, the observers were requested to critique the items in the rating scale. The input from the raters was used in subsequent modification of items for the instrument.

Component Factor Analysis of the RLRS

Factor analytic techniques often have been used for the construction of measuring instruments. Harman (9) provides a brief overview of the historical developments in the factor analytic approach. Authorities in the field have employed factor analysis in the development of measuring instruments as well as the analysis of a variety of data matrixs (Rummels, p. 13, 14). Some of the investigators who have constructed measuring instruments with the statistical technique, include: Thurstone (19), Guilford (3), Horst (13), Cattell (3), and Taylor (18).

Horst, as one authority, states that "We have seen that factor analytic procedures enable us to obtain a useful estimate of the dimensionality of a set of variables...". Horst also offers the following caveat "... although theoretically the factor analytic approach may be the best, there is still not complete agreement as to what are the best factoring techniques" he also goes on to add " the alternatives to factor analysis, namely, the criterion scales, the rational scales, and the single and the random scales, are even more subject to criticism."

Despite the issues which engage theoreticians in dialogue on the topic of factor analysis, the method is widely used to assist in the construction of measuring instruments. Buros Mental Measurement Yearbook notes the number of instruments developed by the method. The investigators selected component factor analysis (14) as the statistical technique for the development of the RLRS. In addition, the techniques reported by Horst (13), as well as Comrey (4), which employ semantic as well as statistical criteria were used during the development of the RLRS.

Briefly, component factor analysis assists in classifying items into relatively homogeneous sets of items. Then, the set is content analyzed to determine a label or name for each set of items. The name for the set is based upon the common semantic relationship among the items. Traditionally, the procedure allows one to hypothesize the basic concepts measured by the items. In short, component factor analysis provided a means for reducing a great number of variables to a fewer number of basic concepts.

A component factor analysis was computed with the 55 item form of the RLRS. The statistical criteria was based upon the concept of simple structure described by Thurstone (20). The semantic criteria included a content analysis of the item groups identified by the component factor analysis. Items were not retained if they did not fit the semantic connatation of the items set. Based upon the Comrey procedure 20 items were eliminated, and a second form of the RLRS with 35 items was developed.

The 35 item form II of the RLRS was administered to a sample of 150 raters. The sample included the same project staff members and graduate students as employed in the first field test, but new residential landscapes were rated to test how well the items held up with different types of landscapes. In addition, the items were rearranged in an entirely different sequence, in order to control for position effects among the items. The factor matrix of the 35 item form was examined and it was found that some of the item clusters contained too few items for a reliable measure of the factor. Accordingly, ten new items were generated, and included in form III of the RLRS.

The third administration of the RLRS was different from the prior ones in the following three ways. First, definitions were written for each item to clarify the esthetic attribute described by the item. A copy of the definitions for the RLRS items is included in Enclosure A. Second, instead of rating photographs of residential landscapes, the raters viewed "live" landscapes in the community. Additional accuracy for the ratings was obtained when the raters were on-site, and viewed the residences from various perspectives. The third change in the field testing procedure for the RLRS was with respect to the raters; only the two principal investigators, and the two research assistants completed the rating forms. Prior analysis had shown that the item statements were generalizable to a broad segment of persons. The final analysis, however, was completed with raters who had been trained to use the instrument.

It is well to point out that each of the four raters had different backgrounds and preferences for differing esthetic qualities of landscapes. The RLRS however, was specifically planned to minimize subjective differences, and as much as possible, be an objective instrumentality for describing the esthetic attributes of residential landscapes.

The Basic Attributes Measured by the RLRS

The matrix for the four factor solution for the 30 items in the RLRS is presented in Table B-1. Note, all the items have been rearranged into item clusters measuring the specific factors. For example, the items which obtained high loadings on Factor I are presented in the first set; items loading on Factor II, the second set, and so forth for the four item clusters. The item is numbered to indicate its sequence in the rating scale.

The items retained in the final form of the RLRS all obtained the highest factor loading on the factor that identified the basic item cluster. In a great majority of the cases, the items obtained near zero loadings on the other factors. A high loading on one factor, and near zero on the other factors is an indication of the factorial purity of the instrument.

All the items obtained a factor loading above .40 on the appropriate factor except one item, No. 18, which obtained a factor loading of .35

Table B-1
Principal Components Factor Analysis and
Varimax Rotated Factor Loadings for
Residential Landscape Rating Scale
(N=370)

No.	I	II	III	IV	h^2	Item Clusters (**)
						Uniqueness
* 5	-72	-12	22	-09	59	Landscape similar to others
11	-41	-12	-14	21	25	Landscape has a focal point
19	78	10	-22	15	69	Something unusual in landscape
26	80	10	-18	13	70	Different from typical landscape
						Composition
* 3	05	70	-08	-07	51	Vegetation blocks view of other parts
* 8	10	57	23	-30	48	Trees too large or too small
*12	18	62	-14	-31	53	Landscape is cluttered
*23	06	78	-25	-18	70	Landscape is crowded
*25	-15	74	21	04	61	Is excessive green vegetation
						Accent
1	30	-24	-50	-01	40	Contrasting colors in landscape
2	30	08	-62	06	49	Variety of textures in landscape
*10	-19	-02	78	-08	66	Grass area is monotonous
*13	00	-36	67	-21	62	Are empty parts in landscape
*22	-18	24	49	-08	34	Too many plants shaped alike
18	33	-02	-35	31	32	Eyes follow a pattern
*28	06	-36	67	-32	53	Landscape is barren
						Harmony
4	-04	-14	-06	54	32	Landscape fits architectural style
6	21	-08	-08	41	23	Concrete areas attractively shaped .
7	35	-06	14	42	32	Landscape textures related to house textures
9	19	-00	04	56	35	Landscape colors blend with house colors
*14	14	38	07	-45	37	Plant or object doesn't belong
15	22	-24	-44	46	51	Landscape looks planned
16	08	-22	-41	48	45	Landscape looks balanced
17	-01	-40	-09	47	39	Type of plants go together
20	50	04	-31	59	69	Landscape is interesting
21	01	08	-21	77	64	Landscape makes you comfortable
24	23	-26	-21	49	40	Has Attractive non-plant objects
27	30	-17	-03	46	33	Non-plant objects blend with landscape
29	30	-20	-47	64	76	Landscape was creatively designed
30	25	-08	-12	62	47	Colors in landscape harmonize
	7.70	3.80	1.70	1.60		Eigenvalue
	.26	.38	.44	.49		Percent variance
	.84	.77	.75	.75		Coefficient alpha reliability

* Items are inversly scored
** The item statements were abbreviated.

Plate 1
Definitions of the Constructs Measured by the Residential Landscape Rating Scale (RLRS)

Harmony refers to the blending of different elements in the landscape, and how each component goes together to create unity. The attributes include the use of color, arrangement, form, shape, texture, non-plant objects, and vegetation. The landscape is planned and designed to achieve balance, whether symmetrical or asymetrical, and the component parts create a harmonious effect. The component attributes are similar to blend together without being identical. Harmony implies that there are not extraneous, irrelevant or dangling parts in the landscape or objects or plants which do not "fit" into the landscape plan.

Composition refers to the proportional arrangement of elements in the landscape. Vegetation and non-plant objects are an appropriate size, for example, the trees are not too large or small in relationship to the remaining plants and objects in the landscape. There are not plants or objects which block the view of other parts of the landscape, and each part is proportional to the other components. Overcrowding and excessive growth of the vegetation effects composition by making the plant disproportionate to the other plants. In addition, an excessive number of plants or objects the same size which produces "clutter" indicates a lack of composition. In short, the number, size and arrangement of elements of the landscape contribute to composition.

Accent refers to elements which bring attention and emphasis to the landscape. Attributes which accent a landscape include contrasting colors, a variety of textures, objects and plants which are appropriately placed, differing shapes of plants and objects and also elements which are arranged in a pattern. Conversely, a lack of accent is evident when the landscape is barren, has large empty portions or has no objects or plants to break up a large grass area.

Uniqueness refers to how different or creative the landscape is compared with other typical landscapes. It is quality of creativeness which makes the landscape interesting and unusual. Uniqueness may be obtained by using non-plant objects and plants which are different from those commonly used, but in addition, are not odd or bizarre.

on the factor which it was classified. The .35 value was sufficiently close to .40 to account for enough variance to warrant its retention in the final instrument. Thus, the items in the RLRS met standard statistical criteria suggested by Comrey (4).

The item sets were content analyzed to identify the common underlying relationship among them, a name describing this relationship was assigned to cluster. In other words, all the items obtaining a high loading on the same factor measure the same basic construct or attribute of a residential landscape. The four basic attributes of landscapes measured by the RLRS have been defined in Plate I.

It was important to identify relatively independent attributes of residential landscapes for several reasons. First of all, each item is an operational definition for a specific element in the landscape, and the item clusters are related to a basic attribute or principle of landscape design. Thus, when the attribute of Composition, for example, was discussed, the items comprising the measure of Composition define what was meant by Composition and not another basic attribute. Thus, when one element of the set is varied it influences the Composition of the landscape, and has a minimal effect upon the other basic attributes of the landscape.

Computation of RLRS Subscales Scores

A score for each of the RLRS subscales was computed for an analysis of the reliability and validity of the rating scale. The RLRS subscale scores were based upon the items which clustered together into homogenous sets. The subscale score was obtained from a sum of the responses to each item in the set, and computing an average of the scores based upon the number of items which were marked. Thus, the subscale scores excluded items which did not apply to the landscape.

Reliability of the RLRS

The consistency or reliablity of a measurement is important in basic research as well as in practical applications. In other words, when an instrument is reliable, essentially the same values are obtained from one time to another. The reliability of each RLRS subscale was computed with Cronbach's coefficient alpha (5). Cronbach's formula for reliability is not as influenced by a small number of items in a subscale as is, for example, the Kuder-Richardson formula (6). The following reliability coefficients were obtained for the RLRS subscales. Harmony (.84), Composition (.77), Accent (.75) and Uniqueness (.75). The reliability coefficients were considered acceptable in view of the subjective nature of landscape esthetics.

In addition, the inter-rater reliabilities of the RLRS subscales also were computed. The inter-rater reliabilities indicated the consistency of agreement among the raters marking responses to the instrument, and are presented in Table B-2.

Table B-2

Inter-rater Reliability Coefficients for RLRS Subscales
(N=44)

	Harmony			Composition			Accent			Uniqueness		
Rater	B	C	D	B	C	D	B	C	D	B	C	D
A	.31	.53	.51	.64	.77	.71	.69	.61	.71	.33	.37	.40
B		.25	.47		.68	.64		.59	.63		.43	.30
C			.39			.71			.51			.28

The magnitude of the reliabilities indicated that agreement existed among the ratings on each subscale in spite of the background differences of the raters. Also, the following average inter-rater reliability for each subscale were computed: Harmony (.41), Composition (.69), Accent (.62), and Uniqueness (.35).

Next, the inter-rater reliability coefficients were computed for the three overall ratings of the residential landscapes. The inter-rater reliabilities for the three overall ratings are presented in Table B-3.

Table B-3

Inter-rater Reliability Coefficients

for the Three Overall Ratings of the Landscapes

(N=44)

	Beautiful			Unusual			Planned		
Rater	B	C	D	B	C	D	B	C	D
A	.45	.55	.37	.34	.37	.42	.25	.44	.55
B		.43	.38		.38	.30		.33	.35
C			.29			.27			.28

As expected, the inter-rater reliabilities for the overall ratings of the landscapes were lower than for the ratings for the subscales of the RLRS. This occurrence was anticipated because the effect of individual differences among the raters was stronger when rating the overall esthetic quality of the landscape, than when objective elements of the landscape were rated.

The average inter-rater reliability coefficients for the three overall ratings were computed and found to be: Beautiful (.41), Unusual (.35), and Planned (.37).

Another characteristic of a measuring instrument is validity. Content validity was demonstrated by the component factor analysis and indicated the RLRS subscales were internally consistent. The predictive validity of the instrument was examined by determining the association between the subscales of the RLRS and the three overall ratings. The multiple regression analysis indicated how each independent variable, the RLRS subscales in this instance, were associated with each dependent variable in the overall ratings. In addition, the analysis indicated how well the RLRS subscales taken as a whole, were associated with the three overall ratings. In other words, did the RLRS subscales, when taken together, account for a substantial portion of the variance attributed to the overall ratings. The results of multiple regression analyses are presented in Table B-4.

Table B-4

Multiple Regression Analysis of RLRS Subscales with Overall Ratings of Landscapes

(N=176)

Subscale	Beauty	Planned	Unusual
Harmony	.48*	.52*	.02
Composition	.17*	.19*	.02
Accent	.32*	.32*	.07
Uniqueness	.09	.06	.74*
Multiple R Squared	.62	.67	.61

* Significant beyond .95 level

Note in Table B-4 that Harmony, Composition, and Accent all contribute significantly to the overall Beauty of the landscapes. Uniqueness also was a positive contribution but the association was not significant. Also, the same three factors Harmony, Composition, and Accent were significantly correlated with the overall Planning of the landscape, and Uniqueness remained as a small, but positive contributor. However, when the landscape was rated on the quality of Unusual, then Uniqueness was the only significant contributor. The multiple R squares, e.g., .62, .67, and .61 respectively, for the three overall ratings, indicated that a sufficient amount of the total variance was accounted for to establish predictive validity for the instrument.

In summary, the RLRS comprised of items from a broad span of sources, was found to measure the following four attributes of residential landscapes: Harmony, Composition, Accent, and Uniqueness. The factor matrix for the instrument indicated that a high degree of factoral purity was obtained. In addition, the subscales for the RLRS were sufficiently reliable to obtain consistent measures of the landscape attributes. Also the inter-rater reliabilities for the RLRS subscales were high enough to warrant its use as a rating scale. The significant correlation of the RLRS subscales with the overall ratings of Beauty, Planned, and Unique supported the item clusters obtained by the factor analytic and semantic techniques, and established predictive validity for the RLRS.

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Enclosure A

Definitions for the Items in the
Residential Landscape Description Questionnaire

1. contrasting colors in landscape: refers to different combinations of compatible colors and diverse shades of the same basic colors. The elements rated include plant and non-plant objects in the landscape and the colors of the house.

2. a variety of textures in landscape: refers to the smoothness-roughness of plant and non-plant objects in the landscape, for example: rocks, pebbles, shingles, grass, bricks, walls, and plants. Texture also includes vegetation and objects which create different patterns of light and shadow.

3. vegetation blocks view of other parts: refers to excessively large trees, shrubs, desert plants which are growing in front of other elements in the landscape. "Blocking" indicates that the vegetation is inappropriately positioned and prevents observing portions of the landscape. Trimming or removing the vegetation would reduce the blocking effect.

4. landscape fits architectural style: refers to the selection of plants, shrubs, objects which commonly are associated with the architectural style of the house, for example: desert plants and an adobe house, trimmed and shaped bushes with plantation houses, pine trees with shingled houses, etc.

5. landscape in similar to others: refers to the uniqueness of the landscape; it is not different from the majority of landscapes in the region, for example: same native trees, plants, bushes, flowers and landscape plan.

6. concrete areas attractively shaped: refers to the shape and arrangement of sidewalks, driveways, retaining walls, etc. The lines, shapes, curves, blend with other portions of the landscape. "Concrete" includes gravel, rocks and similar non-plant objects used to cover portions of the landscape.

7. landscape textures related to house textures: there is similarity among the size, shape and variety of objects in the landscape with those in the house, for example: gravel in the yard and the gravel on the roof, rocks in a wall and the rocks in the house, smooth grass and an asphalt roof, bricks around trees and a brick house, etc. Patterns of light and shadows match textures in the house.

8. trees too large or too small: refers to the size of the trees. They are too small or large in comparison with the house or compared with other trees and plants. Too large indicates excessive growth or lack of pruning. The size of the tree is out of proportion to other elements in the landscape.

9. landscape colors blend with house colors: the color of plants, trees, objects, etc., are similar to the colors of the house. Bizare contrasts and incongruous colors do not exist in the landscape. The colors in the landscape harmonize with colors in the house.

10. grass area is monotonous: a large area of grass which includes few or no plants, trees, or objects. The grass area has a bland and uninteresting appearance, and lacks plants or objects.

11. <u>landscape has a focal point</u>: refers to the intentional use of plants, objects, or a house entry as a center of attention. The eye is drawn to a specific location, because of the arrangement, size, color or shape of the elements.

12. <u>landscape is cluttered</u>: refers to an excessive number of the same plants or non-plant objects, an incongruous variety of different plants or non-plant objects, or an excessive number of rocks, cacti, flowers, shrubs, trees, etc. of similar size which do not blend together.

13. <u>are empty parts in landscape:</u> refers to an area which needs plants or non-plants to complete the unity of the landscape. An "empty part" would be a portion of the landscape that in comparison to other parts lacks plants or non-plant objects.

14. <u>plant or object doesn't belong:</u> refers to a plant or object which has been placed in an area which makes it very noticeable; but the object doesn't possess attributes in common with that portion of the landscape. The object may be so distracting that little attention is given to the rest of the landscape.

15. <u>landscape looks planned:</u> refers to purposeful arrangement, sequence, combination and design of elements in the landscape. An apparent plan or design was followed to locate elements in the landscape.

16. <u>landscape is balanced</u>: refers to an equalization of separate elements of the landscape. The attention attracted by plants or objects on one side is equalled by the sum of attraction on the other side. Balance is achieved, for example, by color, number, location and size of objects.

17. <u>type of plants go together:</u> there is similarity of color, size, shape, type and texture of the plants: this similarity relates the individual plants together to create a unified effect.

18. <u>eyes follow a pattern:</u> eyes are attracted to parts of the landscape and then move to other portions of the landscape. The eyes follow a sequence of elements in different parts of the landscape. This sequence has a rhythm to it. Objects and plants are used to tie in with other portions and establish a pattern. There is a sufficient variety of plants and objects which attracts the eye to different portions of the landscape.

19. <u>something unusual in landscape:</u> refers to a unique plant or non-plant object which is uncommon and still fits the landscape. Indicates unique, creative, attractive, and attention-getting objects, plants and arrangements.

20. <u>landscape is interesting:</u> attractive and attention-gaining use of size, shape, color, and arrangement of plants and non-plant objects.

21. <u>landscape makes you feel comfortable:</u> stimulates an emotional feeling which is positive, relaxing, familiar.

22. <u>too many plants shaped alike:</u> an insufficient variety of different shaped plants. Needs a wider range of sizes and shapes of plants.

23. <u>landscape is crowded</u>: insufficient space for plants, trees, bushes, etc. Excessive intermingling of vegetation. Too many plants or objects placed close together. Crowded, may be reduced by pruning of plants or elimination of some vegetation entirely.

24. has attractive non-plant objects: refers to the attractive use of bricks, rock, gravel, cement objects, retaining walls, and metal or wooden objects in the landscape. Non-plant objects have elements of color, style, shape, etc., in common with other elements in landscape.

25. has excessive green vegetation: refers to the number of plants, the largeness of the plants, and the excessive amount of growth. Gives a crowded overgrown impression.

26. different from typical landscapes: it is not a typical landscape in general appearance and includes non-native or unusual plants, arrangements, and objects.

27. non-plant objects blend with landscape: refers to non-plant objects which are associated with other parts of the landscape on a basis of color, size, style, shape, etc.

28. landscape is barren: refers to the absence of objects or plants in specific portions of the landscape. Commonly includes lack of verticle vegetation or objects.

29. landscape was creatively designed: refers to the use of unusual and attractive elements in the design of the landscape. Use of native plants and objects in a different way, use of arrangement and combination which create a different effect.

30. colors in landscape harmonize: refers to the use of variety of different colors which blend and are not incongruous. Sufficient variety of colors which are similar enough to go together.

Appendix C

Landscape Questionnaire

C1-5 Address ______________________________

C 6 Type of landscape

(1) Desert
(2) Intermediate
(3) Green

C 7 Condition of lawn

(1) Poor
(2) Average
(3) Good

Landscape Rating

C 8	Not Beautiful	1	2	3	4	5	6	Very Beautiful
C 9	Not Unusual	1	2	3	4	5	6	Very Unusual
C10	Not Planned	1	2	3	4	5	6	Well Planned

C11 Length of residence in home (years)

(1) less than one
(2) 1 - 3
(3) 4 - 6
(4) 7 - 9
(5) 10 - 12
(6) more than 12

C12 Length of residence in Southwest (years)

(1) less than one
(2) 1 - 3
(3) 4 - 6
(4) 7 - 9
(5) 10 - 12
(6) more than 12

C13 What type of climate did you live in before moving to Las Cruces?

(1) Wet
(2) Intermediate
(3) Dry

C14 Your home

(1) Own
(2) Rent

C15 How many people live in your house?

(1) 1	(5) 5	(9) more than 8
(2) 2	(6) 6	
(3) 3	(7) 7	
(4) 4	(8) 8	

C16 Swimming pool or other high-water consuming activity?

(1) Yes
(2) No

C17 Size of Yard

(1) 2,000
(2) 2,000 - 5,000
(3) 5,001 - 9,000
(4) 1/4 Acre
(5) 1/3 Acre
(6) 1/2 Acre
(7) Don't know

C18 When do you apply water?

(1) Morning
(2) Afternoon
(3) Evening
(4) Night

C19 Why do you apply water at this time?

(1) Cooler for working
(2) Children play in water
(3) Adequate water pressure
(4) Conservation of water
(5) Time available
(6) Evaporative cooling
(7) Other ______________________

C20 What type of watering system do you use?

(1) Hose
(2) Flooding
(3) Sprinkler, portable
(4) Sprinkler system
(5) Other ______________________

C21 Are you satisfied with your present watering system?

(1) Yes
(2) No

C22 If not, how would you change it?

(1) Install fixed system
(2) Reduce size of area
(3) Change shape of area
(4) Change slope of area
(5) Balance water pressure and delivery
(6) Increase pressure
(7) Other ______________________________

C23 How often do you water in summer? (times per week)

(1) 1	(5) 5
(2) 2	(6) 6
(3) 3	(7) 7
(4) 4	(8) less than 1

C24 How long does the water run per setting? (hours)

(1) 1	(5) 5
(2) 2	(6) 6
(3) 3	(7) 7
(4) 4	(8) less than 1

C25 How do you determine when to water your landscape?

(1) Regular schedule (list interval if stated ________)
(2) Depends on temperature
(3) When plants look like they need it
(4) Depends on rainfall
(5) Follow neighbor
(6) Other ______________________________

C26 Highest water monthly consumption in 1973

(1) 0 - 20,000 gallons
(2) 20 - 40,000 gallons
(3) 40 - 60,000 gallons
(4) more than 60,000 gallons
(5) Don't know

C27-30

______________________________ Actual maxiumum monthly water consumption in 1973 (gallons x 1000)

C31 What % of water you consume is put on landscape?

(1) 0 - 10
(2) 11 - 20
(3) 21 - 30
(4) 31 - 40
(5) 41 - 50
(6) 51 - 60
(7) 61 - 70
(8) 71 - 80
(9) 81 - 90

C32-35

______________________________ Total water consumed in 1973 (gallons x 1000)

C36-39

______________________________ Water consumed for landscape (gallons x 1000) in 1973

C40-42

______________________________ Percent total water applied to landscape

C43-45

______________________________ Domestic water usage in 1973 (gallons x 1000)

C46 How many hours a week do you work in the yard?

(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) 8
(9) more than 8

C47 Do you feel you could lower your water usage and still keep your landscape alive and healthy? (in those areas where you regularly water)

(1) Yes
(2) No

C48 Would you take advantage of an educational program directed toward maintaining landscape and conserving water?

(1) Yes
(2) Maybe
(3) No

C49 How would you evaluate the importance of green in a home landscape? Make your mark on the ladder at left.

Very Desirable

Not Important