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Xeriscape guidelines adapted to residential gardens in Cyprus

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XERISCAPE GUIDELINES ADAPTED TO RESIDENTIAL GARDENS IN CYPRUS

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Table of Contents

List of Tables

List of Figures

Abstract

One of the major problems that my country, Cyprus, faces is water scarcity. In the last five to ten years, the problem has become more serious because of a series of droughts that have left the island with limited water. As a result, Cypriots keep their gardens to a minimum or they abandon their gardens due to water shortage. This attitude of Cypriots toward their gardens was the inspiration of this thesis topic. The idea of Xeriscape and the seven guidelines of Xeriscape that were first introduced and organized by the Denver Water Department in Colorado are directly related to water conservation and landscaping, which is the focus of this thesis. First, I researched books, articles, and the Web on related topics with water conservation and landscaping in the United States and in Cyprus. After that, I did interviews with professional and non-professional Cypriots on related topics with water conservation in gardens. Based on this research and interviews, I tested the Xeriscape guidelines, which originated with the Denver Water Department, to see how they work in Cyprus. I used two sites of Cyprus as case studies to evaluate these guidelines. According to this testing of guidelines on case studies, I adapted the Xeriscape guidelines to Cyprus. The cultural environment of Cyprus, which is different than in the United States, affects how I adapted the guidelines. Also, the natural differences in Cyprus affect the application of the guidelines. In addition, graphic and other informative data are included in my own guidelines to provide a more detail explanation of important terms related with Xeriscape.

Introduction

I.1 Background of the Topic

This thesis will illustrate how Xeriscape guidelines can be adapted to residential gardens in Cyprus, a Greek island situated in the Eastern Mediterranean Sea. "Xeriscape" means water conservation through creative landscape, which comes from the Greek word "xeros," meaning "dry" and from the word "scape" from the word "landscape." This idea of Xeriscape originated with the Denver Water Department. Xeriscape encourages the use of native plants, of drought-tolerant plants, and other related principles, such as the use of mulches, efficient irrigation systems, soil analysis, and maintenance.

Cyprus has a mild climate, with long, dry summers and short, mild winters. Its water supply is both inadequate and irregular, with an average annual rainfall of 500mm (20in), leaving the island quite dry**.** A water shortage, one of the major problems of Cyprus, has become more obvious in the last five years because of drought conditions. After discussing with my father the water shortage in Cyprus, he told me, "Your thesis topic should deal with water conservation in residential garden design because we Cypriots die for our gardens, but we do not know how to deal with them." My thesis will provide a source of information for citizens about residential garden design that promotes water conservation measures.

I.2 Statement of the Problem

The design of residential gardens in Cyprus is very interesting because gardens are part of people's everyday lives. Climatic conditions are conducive to cultivating gardens, and the island setting provides an extremely safe environment, allowing people to sit outside until late at night while eating and relaxing. Cypriots use outdoor spaces for their daily activities such as drinking

coffee in the morning and relaxing in the afternoon. They also use outdoor spaces to play with their kids and to barbeque, usually on the weekends.

Currently, most Cypriots are forced to keep their gardening to a minimum or do not garden at all because of the drought of the last five years. Many have the perception that the water shortage limits their options for having an attractive garden. Many Cypriots are disappointed that their gardens are dying during these drought years. Furthermore they think that it is impossible to have an attractive garden while at the same time conserving water. However, a Xeriscape model shows how proper selection and use of plants that require minimal irrigation can result in a suitable garden. This type of landscape can be attractive and interesting using different colors, shapes, and textures of native and water-conserving plants. Despite popular misconceptions, Xeriscape gardens are not just brown, with rocks and cactus**.**

Even though the Ministry of Agriculture, private landscape designers, and horticulturists are more familiar than most people in Cyprus with designed landscapes that conserve water (Xeriscape), there are no organizations that focus exclusively on this idea. The Forestry Department of the Ministry of Agriculture is the only governmental department that focuses on the use of plants and water conservation issues. This department conducts educational campaigns about the use of native plants of Cyprus. Although the public in Cyprus has become more sensitive to the environment and to garden design during the last five years, they have limited knowledge of water conservation in landscaping. Due to the drought, more people are asking professionals how to maintain their gardens because sustainable garden design is more complex than before. People must be familiar with the selection of plants that require less water, with plants that are adapted to the environment, and also with the way to zone the plants to save energy.

One of the phrases that came into widespread use in the last half of the 1980s is "sustainability," a term that is closely related to the principles of Xeriscape. The World Commission on Environment and Development (WCED) defines sustainability as " meeting our needs today without compromising the ability of future generations to meet their own needs." Natural systems provide models for sustainability that create no waste. For example, a single tree can provide the same cooling effect as a 10-room-sized air conditioner, running 24 hours a day with no waste (Lyle 3). Xeriscape that promotes water conservation and native plants is an essential part of sustainable development in Cyprus.

I.3 Scope

Xeriscape guidelines adapted to residential gardens in Cyprus, focusing on two case study sites. Conceptual designs and Xeriscape design recommendations are presented for two residential gardens. The gardens that I use to investigate the guidelines are selected to represent the main geographical areas of Cyprus: the mountains and the coastal plain. This will give people an idea of the alternatives possible in garden designs. In addition, the guidelines adapted to Cyprus will provide Cypriots the opportunity to design their own garden that conserves water.

I.4 Objectives

- To test the Xeriscape guidelines developed by Denver Water Department in two case study sites in Cyprus.
- To adapt specific Xeriscape guidelines to residential gardens in Cyprus.

I.5 Methodology

First, I reviewed the literature on related topics: humanity, nature, environment, the hydrological cycle, Xeriscape, Mediterranean climate, Mediterranean Garden Society, Cyprus's climate, geology, bioclimatic zones, flora, native plant communities and hydrology. Due to the lack of research on garden design in Cyprus, I interviewed 15 professionals and 10

nonprofessionals about water issues, environment, horticulture, agriculture, nurseries, and landscape design. The nonprofessionals included a broad range of people of different ages, professions, and interests. The information I was seeking from the interviews was very important. It helped me to become more familiar with the topic, it gave me real numbers about precipitation, temperature, water supply and demand that I could not find in books, and it gave me information about the history of gardens in Cyprus, the role of gardens in Cypriots' lives, water conservation in residential garden design, and the attitudes of Cypriots toward Xeriscape.

After I collected this important background information, I investigated how to adapt Xeriscape guidelines for residential gardens in Cyprus. First, I became familiar with the Xeriscape guidelines through research in books, articles, and on the Internet. Second, I tested the original Denver guidelines by applying them to two sites in Cyprus. Based on the case study information, and on my experience and knowledge of Xeriscape, I adapted the Xeriscape guidelines to Cyprus. While testing the Xeriscape principles on the sites in Cyprus, I felt that more detailed explanations and graphics was needed in order for the guidelines to be followed more easily by the public. In addition, during my evaluation of the guidelines on these two sites, I realized that geographical and cultural differences of Cyprus should be incorporated into the guidelines for Cyprus.

I.6 Timeliness of Research

This thesis is valuable because it organizes information on water conservation and landscape design in Cyprus in a useful and systematic way. Other reasons are as follows: designing garden sites that save water helps to reduce water consumption nationwide. Secondly, sustainable gardens and water conservation can be more easily achieved through informed landscape design. The third reason is that Xeriscape is an environmentally sound concern

because it conserves water and supports native plants. Fourth, landscaping and water conservation in gardens help to enhance the character of the place. Lastly, the idea of water conservation in residential garden design is economically suitable because it helps reduce water utility costs.

Chapter 1. General Principles of Water Conservation

The first area of importance to discuss is the relationship of humans with nature and the environment. After dealing with people and nature, and explaining the effect of people on the environment, we will talk about the concept of sustainability, which today is a very commonly used term and is concerned with environmental soundness. The third area, related to the hydrological cycle and the resultant flow of water, will explain the shortage of this important natural resource. The next area concerns landscaping and water conservation in the United States to introduce to Cypriots a similar situation in the United States.

1.1 Sustainability

Humans are currently experiencing a period of time that is marked by increasing conflict between human activities and environmental constraints. Acid rain, depletion of the ozone layer, increased levels of carbon dioxide, and the depletion of rainforests are among the environmental problems that are widely known to be attributed to human activities all over the world.

This conflict of humans with the environment creates an unbalanced relationship between nature and human beings. For a better survival of humans, for the human environment to become sustainable, people have to change some of those patterns and should try to reestablish their connections with nature. In the middle of 1980s, when the word "sustainability" came into widespread use, people realized their struggle with the environment and nature**.** They realized that they must turn to sustainable development. In sustainable development, the effort is to make full use of basic landscape processes – even more complete use than nature herself makes. According to the World Commission on Environment and Development, which defines sustainability as "meeting our needs today without compromising the ability of future generations to meet their own needs" Lyle adds "Nature is the perfect model for sustainability; it

produces no waste. So, we must attempt to model our somewhat linear processes after the efficient cyclical processes of nature." (Lyle 3). Having nature as a model, we must reduce, reuse, recycle, and properly manage materials in order to protect human health and the environment. Human society must use resources like energy, water, land, and materials in a sufficient way. It must try to eliminate waste, create a healthy environment, and support conservation. When people focus on these environmental improvements, then they will move toward the period of time that humans and nature will in a balance, which is necessary for our survival.

Xeriscape is one of the concepts that has nature as a model and is part of sustainability. Xeriscape principles sustain resources and preserve the earth by supporting native plants and by using landscape principles that conserve water. Plants adapted to the conditions of the local environment can live on water and nutrients available there and will also support the region's character. Water conservation in landscaping is important and is part of people's concern with the environment. Before I introduce landscape design and water conservation, one should consider the hydrological cycle, which will explain the shortage of this natural resource.

1.2 Hydrological Cycle

Water is the most important and probably the most widely known substance on Earth. It is a key component in determining the quality of our lives and makes up 50 to 90 percent of the weight of living things. In addition, around 70 percent of the earth's surface is covered by water in oceans, seas, lakes, rivers, and swamps. Water is a scarce resource that, unless there are droughts and floods, most of us do not think about much (Robinette 11). The water cycle (hydrological cycle) provides a model for understanding the global plumbing system. Understanding the global system is essential to water conservation because in order to conserve

water, we should know how to keep the water cycle as close to its natural form as possible. Not only should the water cycle be understood but also the meaning of condensation, precipitation, and evaporation.

The water cycle is the endless cycle that water travels through on our planet (like a never-ending spiral). Landscape plants and all plants are an important component in that cycle because they help to speed up and implement the process. In this cycle, water can be found as a liquid (water), as a solid (snow, ice), and as a gas (water vapor). The change of a substance from a gas to a liquid is called condensation. On the reverse side, the change of a substance from liquid to a gas is called evaporation. Moreover, the water that falls to earth from the sky as rain, snow, sleet, or hail is called precipitation and is a direct result of condensation (Robinette12). (fig. 1.1).

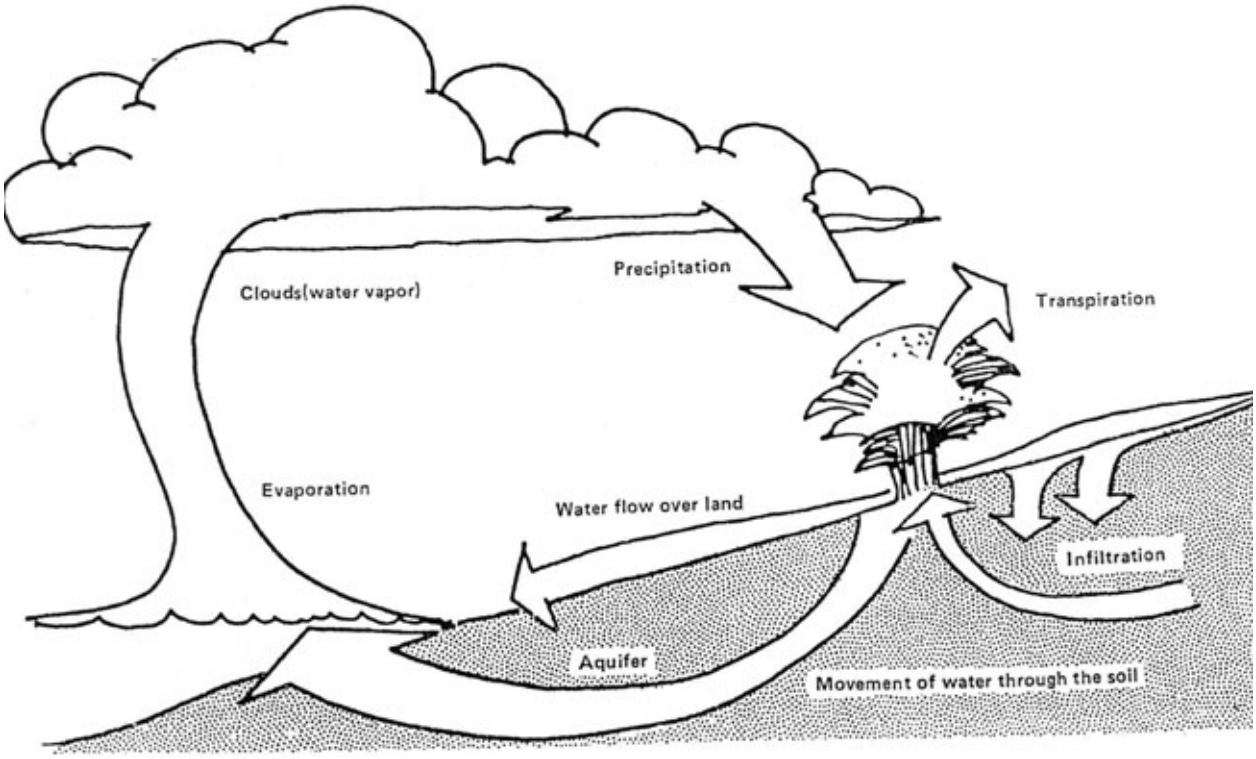


Figure 1.1 - Water Cycle. (Figure: Robinette12.)

In simple words, water is pulled out of plants, the soil, lakes, rivers, and oceans and is transferred into a gas or into droplets. After that, water falls back to earth in the form of rain, snow, sleet, or hail and when it arrives on earth, it goes back to rivers, lakes and oceans. Then the circle starts again.

The role of plants is very important to the water cycle. Plants work like water pumps. When moisture reaches the soil, the roots transfer the moisture (water) through the trunk and stems into leaves and then into the air. A mature plant with many big leaves pumps out more water than a small plant with fewer smaller leaves. The water that is pumped out from the leaves to the air should be replaced by rainfall or irrigation. This is the reason why when there is a water scarcity, we select plants that do not use a lot of water. They can survive even if a lot of water is not available to be replaced back to the roots (Robinette 13.) (fig.1.2).

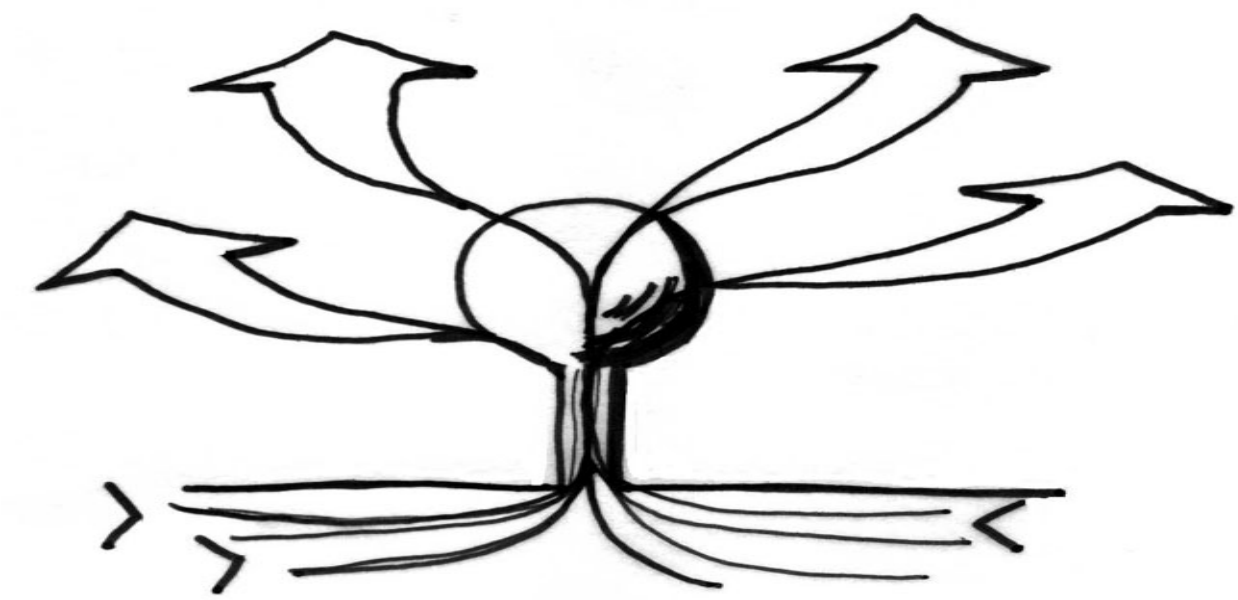


Figure 1.2 - Plant cycle. (Figure: Robinette 13.)

Keeping the water cycle as natural as possible and trying not to disturb it with our activities is very critical for our survival. The reality is that we have already broken that natural

cycle, and we have an unbalanced relationship with nature. For example, humans created this unbalanced relationship by importing plants that do not naturally grow in the area. As a result, these plants have needs different from those the nature provides them. In addition, water consumption increased in the twentieth century due to water competition in different areas, leaving people with limited water resources. (fig. 1.3).

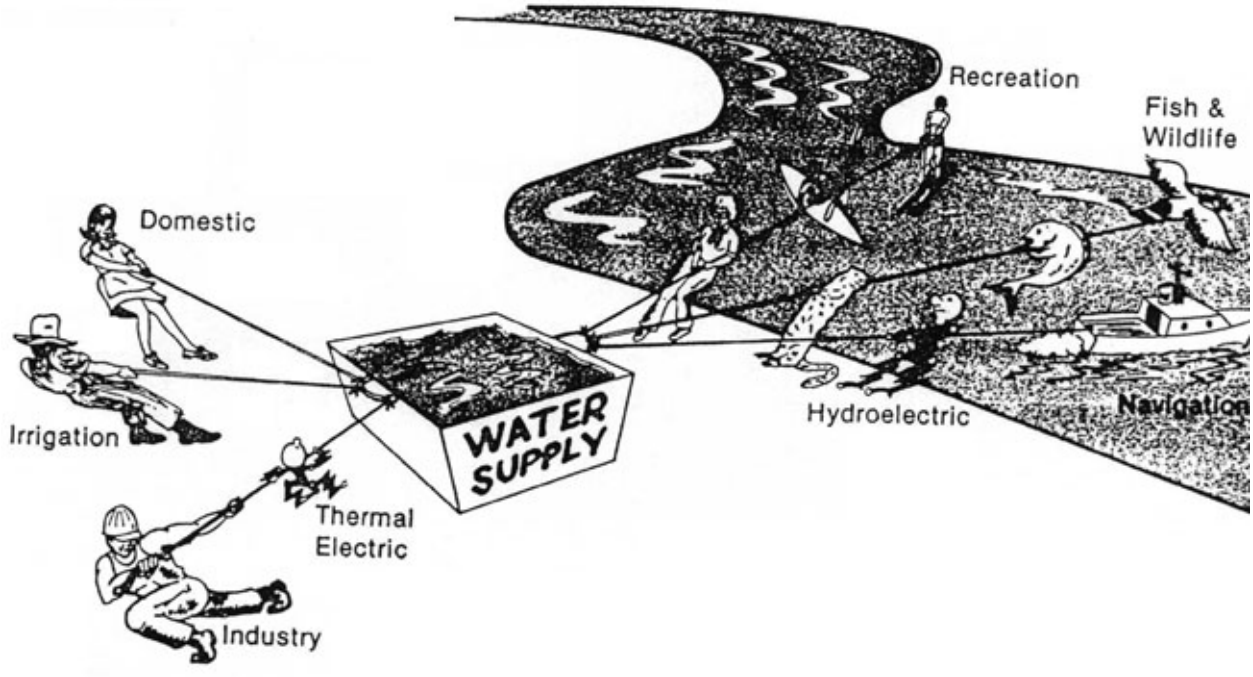


Figure 1.3 - Water competition. (Figure: Robinette16.)

In Figure 1.3, we see how people are fighting for water to satisfy their different needs. In our world today, water competition is one of the major concerns of society and puts limitations on the landscape elements. It seems obvious that water use for landscaping and plants should be restricted rather than water for drinking, cooking, and bathing (Robinette 16).

This serious problem of water competition makes people more environmentally aware than before, and it prompts them to start to conserve water. For example, in arid zones of the United States, Australia, Africa, the Middle East, and the Mediterranean where water problems

are apparent, people are becoming more aware and are starting to conserve water in many ways, such as using less water to wash dishes, taking showers instead of baths, doing only fully loaded laundry, and watering plants with a container instead of with a water hose. Even though people are more aware than before, usually they follow the "hydro-illogical cycle." (fig. 1.4).

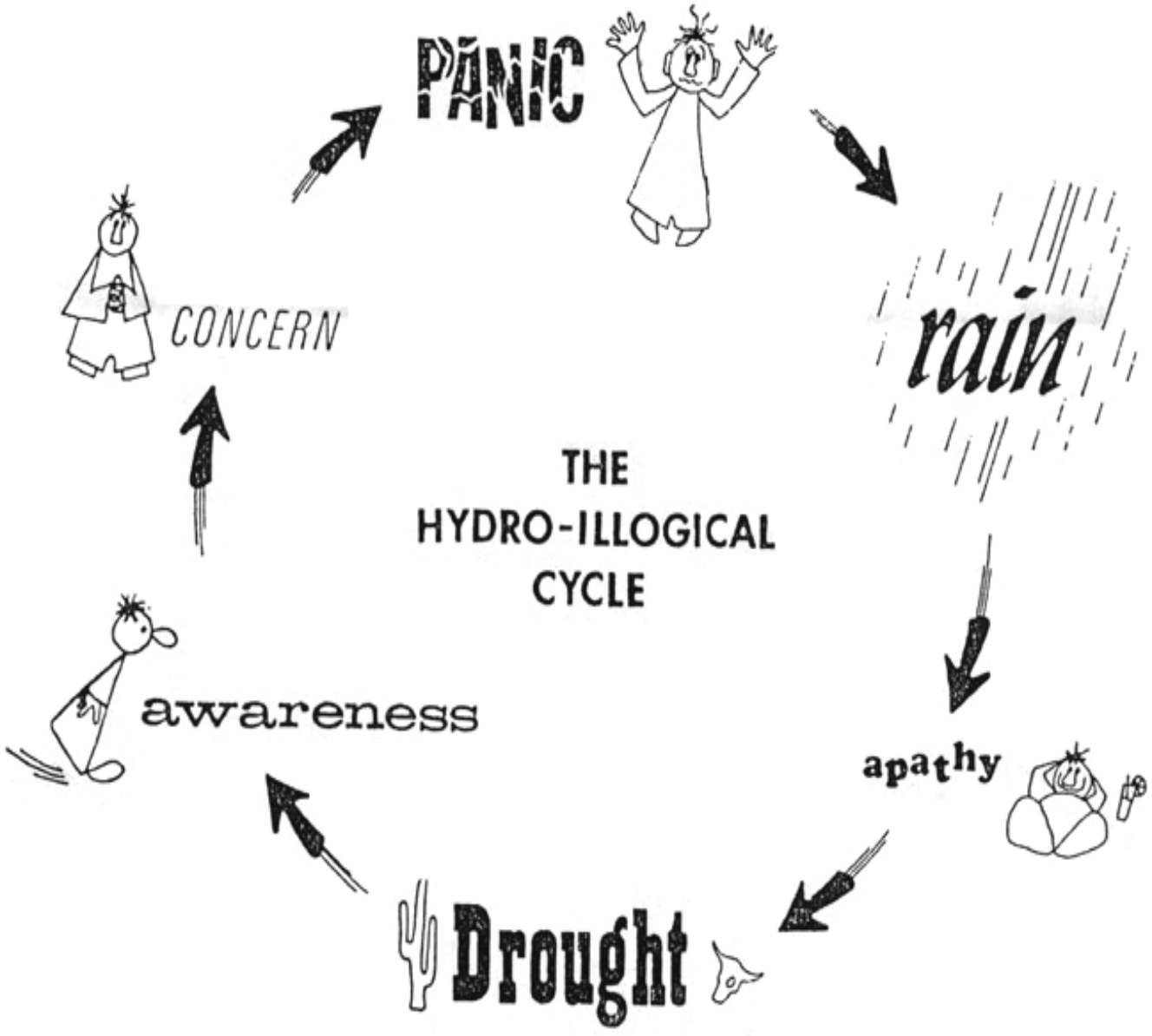


Figure 1.4 - Hydro-illogical Cycle. (Figure: Robinette 66.)

Figure 1.4 expresses perfectly people's behavior concerning with water conservation (hydro-illogical cycle). This cycle explains the illogical behavior of people: when there are drought years, people conserve water but when the good years come, they easily forget those bad years and start to consume or waste water in large quantities (Robinette 66).

1.3 Landscaping and Water Conservation in the United States (Xeriscape)

In the next 25 years, close to one third of the world's population will experience water shortage (Deen 1). Based on International Institute research, the problem of water shortage threatens global peace. The Libyan leader Muammar Qaddafi has warned that the next Middle Eastern war would be over dwindling water supplies. Also, Egypt has threatened to go to war to protect its water supplies. In addition, the executive secretary of Beirut, Hazem El-Biblawi, has said that water would replace oil as one of the major political and economic issue of the Middle East in this century. Research on water scarcity has been studied on a country-by-country basis. The Institute of International Water Management divides the countries into four categories. The first category, which includes Afghanistan, Egypt, Saudi Arabia, Pakistan, Israel, Jordan, Iran, Iraq, Kuwait, Tunisia, Singapore, and South Africa, are the countries with the least water available. By the year 2025, they will not have enough water to support agriculture, industry, household use, and the environment. The second category is countries mostly from sub-Saharan Africa that have sufficient water resources but which have to double their efforts to conserve water in all possible ways. The other two categories, which are North America and Europe, will have less pressure on water supplies, with a moderate need to increase water development efforts (Deen 1).

Before the early 1980s, Americans who were practicing landscape water conservation were the exception rather than the rule. In the twentieth century, in most of the places in America

and in areas that are facing water scarcity, as in Arizona, Texas, Nevada, Colorado, and California, water conservation started to be part of people's lives. Now water conservation in landscaping is starting to be the rule rather than the exception. Dealing with this major threat of water scarcity forces people to be more environmentally concerned. Water conservation is one of the ways people are showing their concern for the environment. In the energy crisis of the 1970s, gas-guzzling cars were replaced by fuel-efficient cars. Today, in the Southwestern states with low precipitation and water competition, landscape designers and planners are forced to replace the water-loving trees, shrubs, and annuals with Xeriscape plants (History of Xeriscape 1.)

- **The Origins of Xeriscape**

The Associated Landscape Contractors of Colorado (ALCC) and the Denver Water Department started the idea of water-conserving gardens in Colorado in 1981. By mid-1981 a team of professionals from green and blue (water) industries assembled to focus on water for landscape purposes. The team included a local landscape architect, a horticulturist from Colorado State University, a Fellow of ASLA, a horticulturist consultant, and a conservation manager from Denver Water. They refer to the term "Xeriscape" as the whole idea of their program. The introduction of the Xeriscape concept was specifically for popularizing landscape water conservation and to positively involve and educate as many people as possible about the importance of water to humans and other life forms. The mission of the team was to create educational demonstration gardens to show the beauty possible through this concept and to create a wide-reaching and on-going public involvement and education program. Nancy Leavitt, an environmental planner for Denver Water, coined the word "Xeriscape" for the garden and the educational program, which includes the seven water-saving principles of Xeriscape (Department of Agriculture 1).

The seven water-saving principles of Xeriscape devised by the Denver Water Department are:

1. Planning and Design
2. Soil analysis
3. Practical Turf Areas
4. Appropriate Plant Selection
5. Efficient Irrigation
6. Use of Mulches
7. Appropriate Maintenance

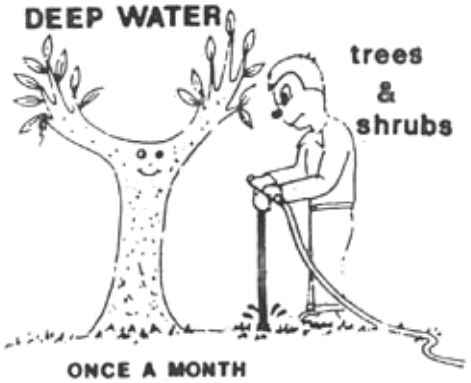
Landscape professionals say of Xeriscape that the application of its principles can reduce water use in the landscape by up to 80%. The first Xeriscape garden was dedicated at Denver Water in May of 1982, and in 1985 the growth of the concept was so significant that the National Xeriscape Council, Inc., a non-profit organization, was forced to fill many requests for information. In 1996, the non-profit organization Xeriscape Colorado Inc. celebrated the existence of 32 Xeriscape gardens in Colorado. Positive media coverage spawned interest in spreading the idea of Xeriscape in a number of states, such as California, Colorado, Texas, Florida, Georgia, Nevada, Arizona, and New York and in other countries like Israel and Spain (History of Xeriscape 3). During the last period of drought in the late 1980s and early 1990s, the crisis of atmosphere created a great demand for Xeriscape information. As the founder of the National Xeriscape Council mentioned, the Xeriscape movement grew on its own out of necessity (Weber 30). Xeriscape`s concept has as a slogan, " Keep it on tap for the future." They try to make the idea of Xeriscape attractive to people and easy to understand. Chris Call, a Water Denver expert on Xeriscape guidelines, explained to me that guidelines were designed in a way

that people can easily follow them. She said that the guidelines couldn't include scientific data that the public cannot follow. For example, for testing their type of soil, they explained to the public a simple way to test their soil. They ask them to get a soil and to form a ball. If the soil can form a ball then it is clay. If the soil cannot, then it is sand. In addition, she explained to me that it was their intent to make the guidelines very general so that they can be applied in any location of the world. Figure 1.5, prepared by the Cooperative Extension Service of Colorado State University show ways to save water in the landscape.

Moreover, the term "Xeriscape" conjures up different perceptions. Gene Bussell an ASLA planner, stated," I was uncomfortable at first with the term Xeriscape, which conjures up images of desert conditions and cacti. Xeriscape principles break down the concept of water-efficient landscape in a way that the public can easily understand" (Thompson 56). Xeriscape has been a misunderstood concept and its results are contrary to some people's conceptions. When I introduced the idea of Xeriscape to people in Cyprus, their first response was " Do you mean that my garden would look like a desert?" Xeriscape designs can be very attractive, with abundant color. Xeriscape can also be used on sites next to the ocean where there are problems of salt-water intrusion into local water supplies. According to John Arend, senior land planner for Evans Group, the ITT Admiral Corporation and the Evans Group designed an 80% Xeriscape at the Hammock Dunes project using salt-tolerant plants for the ocean-front location (McLeister 83). Another important effort of Xeriscape is the encouragement of naturalistic landscaping with native plants (fig1.7). Using native plants supports the environment and helps with the restoration of the sense of place. In the article "Letting the Desert be the Desert," Steve Martino, an ASLA member, said, " First I started to beg and trick people into using native plants." Today,

Figure 1.5 - Water conservation in landscaping. (Figure: Robinette 55.) (Fig. Con'd.)

DEEP WATER



ONCE A MONTH

MULCHES CONSERVE WATER

Organic Matter

improves the

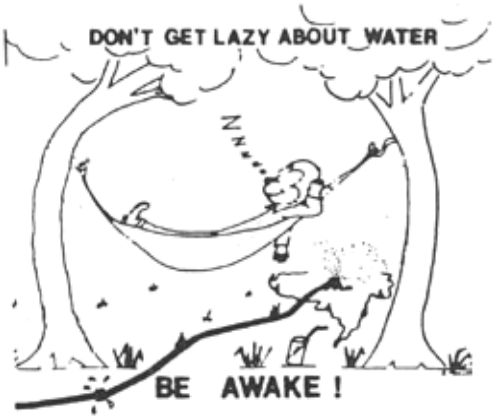
WATER EFFICIENCY of your soil.

COMPACTED SOILS

waste water through run-off

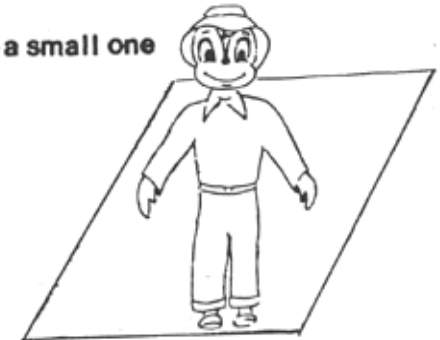
WATER ONLY

when the plants "TELL" YOU



BE AWAKE !

....a small one



CAN YOU GET BY WITH LESS?

people have discovered the savings in maintenance costs that can result from native plant use. These days, homeowners are beginning to value gardens that stress the environment as little as possible. Moreover, he talked about the importance of native plants by saying, “Why play another region’s music when the song of one’s own region is so lovely?” (Fisher 81). Also, Cypriots expressed their concerns about the use of native plants. However, when I showed them

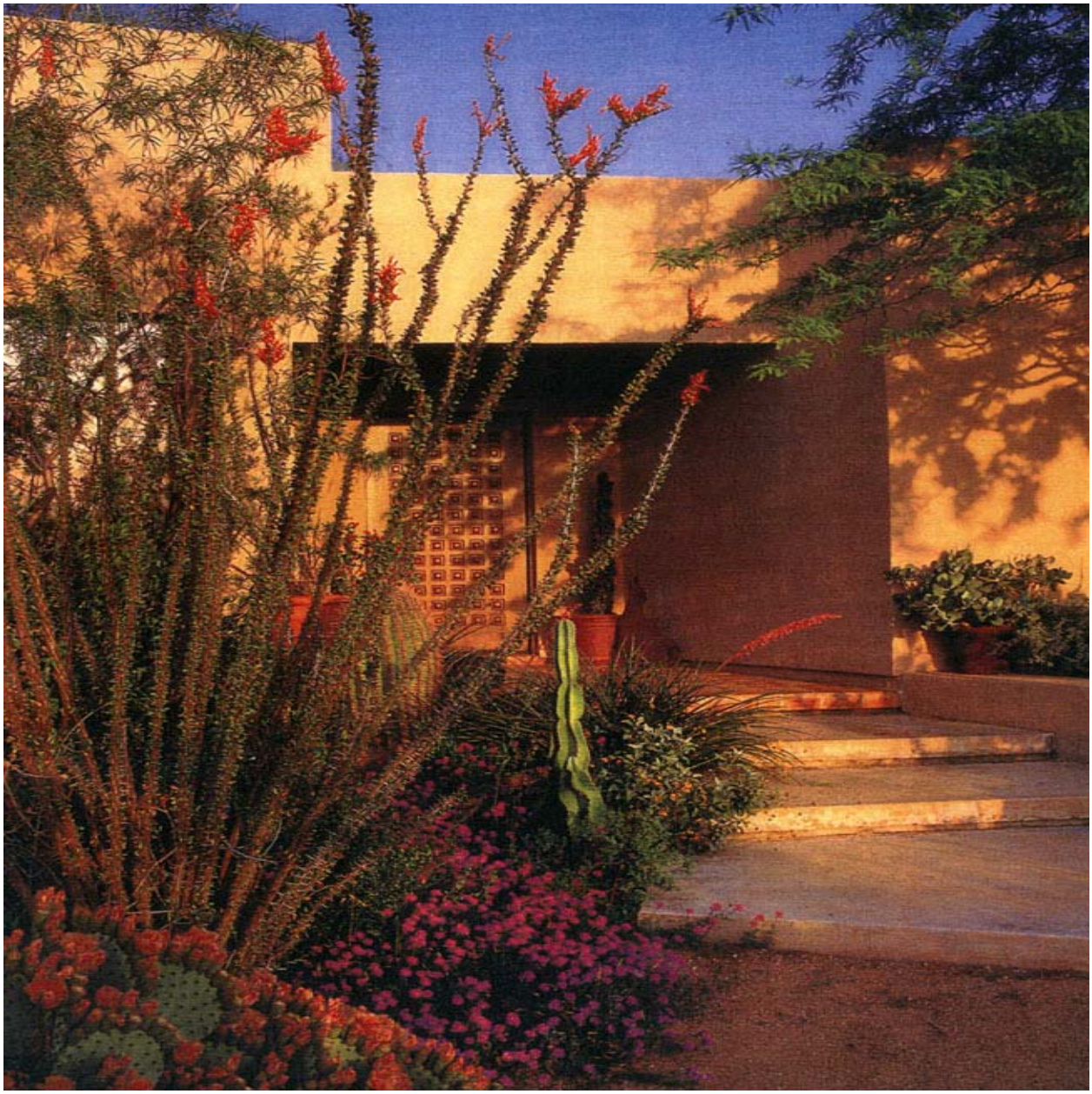


Figure 1.6 - Colorful Xeriscape gardens. (Photo: Garden design May 1990.)

Figure 1.7 - Xeriscape garden with naturalistic look. (Photo: Garden design June 1991.)

photos of Xeriscape gardens, their attitudes were very positive. In another article "Xeriscape offers attractive solution to water shortages," it is mentioned that if inexpensive native plants are used, the dollar figures are about the same as using more traditional landscaping. But if mature desert trees are brought in (at $1000 a piece) the figure can go up substantially. The main idea with Xeriscape is to enhance the density of the native plants and place a small zone of grass (20 to 30-ft portion on a one-acre lot). Les Leininger, assistant vice president in the services of McMillin Co., says that this company spends 20% to 30% more money for more native plants so people would not be scared by their sparse appearance. He said that this expenditure is worthwhile because the long-term benefits outweigh the costs. Also, separate water meters on

the four models at Bonica Long Canyon showed the two Xeriscape yards produced 25% to 40% savings in water, which represents a saving of $5 month per month (McLeister 84). Table 1.1 demonstrates how much water could be saved without major changes in lifestyle. This table shows a comparison of water use among three Denver Water single-family residential accounts.

Table 1.1-Comparison of water use among three Denver Water single-family residential accounts

	Average Denver Water Residential Account	Residential Account With Moderate Conservation[1]	Residential Account With Maximum Conservation[2]
high summer water use	780 gallons/day	560 gallons/day	359 gallons/day
low winter water use	221 gallons/day	199 gallons/day	181 gallons/day
annual water use	152,052 gallons	109,477 gallons	69,939 gallons
annual water bill	$192.00	$135.00	$82.50
annual sewer bill	$157.68	$142.02	$129.18
gals per toilet flush	4.5 gpf	2.5 gpf	1.6 gpf
gals/minute showering	4.0 gpm	2.5 gpm	2.5 gpm
gals per laundry load	45 gallons	45 gallons	20 gallons
type of landscape	90% of yard is Kentucky bluegrass lawn, remainder is flower beds & shrubs. 2 mature trees	65% of yard is tall fescue lawn, remainder is xeric flower beds, shrubs & ground-covers. 2 mature trees	35% of yard is buffalograss lawn, remainder is xeric flower beds, shrubs groundcovers. 2 mature trees
hours per week on landscape maintenance	1 1/2 hours wk, + 5 hrs once/year	1 3/4 hours wk, + 4 hrs once/yr	1 1/2 hours wk, + 1/2 hr once/yr
method of irrigation	automatic sprinkler system - no rainfall or soil moisture sensor installed	automatic sprinkler system w/soil moisture sensor	manual irrigation (hose dragger)
total water applied during 26-week growing season	82,108 gallons	59,118 gallons	37,767 gallons

Table by Denver Water Department

The first account is based on data from Denver Water. The other two are hypothetical. For comparison's sake all accounts were assumed to be demographically identical, with 2.71 people in the household and 4,000 sq ft of landscape. It also compares the landscape maintenance (Denver Water Conservation Master Plan 8). In conclusion, the Xeriscape idea has been popularized and useful in some of the states of America and in some countries of the world by the support of all kinds of media. What we expect now is to have more attention to the idea of Xeriscape in more countries and particularly on the part of the ones facing the critical issue of water scarcity. Now, I will set the background for similar efforts in Cyprus by introducing the geographical and cultural aspects that close related with water conservation and landscaping.

Chapter 2. Cyprus

2.1 Introduction

- **Mediterranean Climate**

Cyprus is located in the Mediterranean Sea and therefore has a "Mediterranean" climate with short, cool, wet winters and long, dry summers. Worldwide there are five climate areas characterized as "Mediterranean": the area surrounding the Mediterranean Sea, the South African Cape, Southern and Western Australia, Central Chile, and much of California. (See the following figure with Mediterranean climates.)

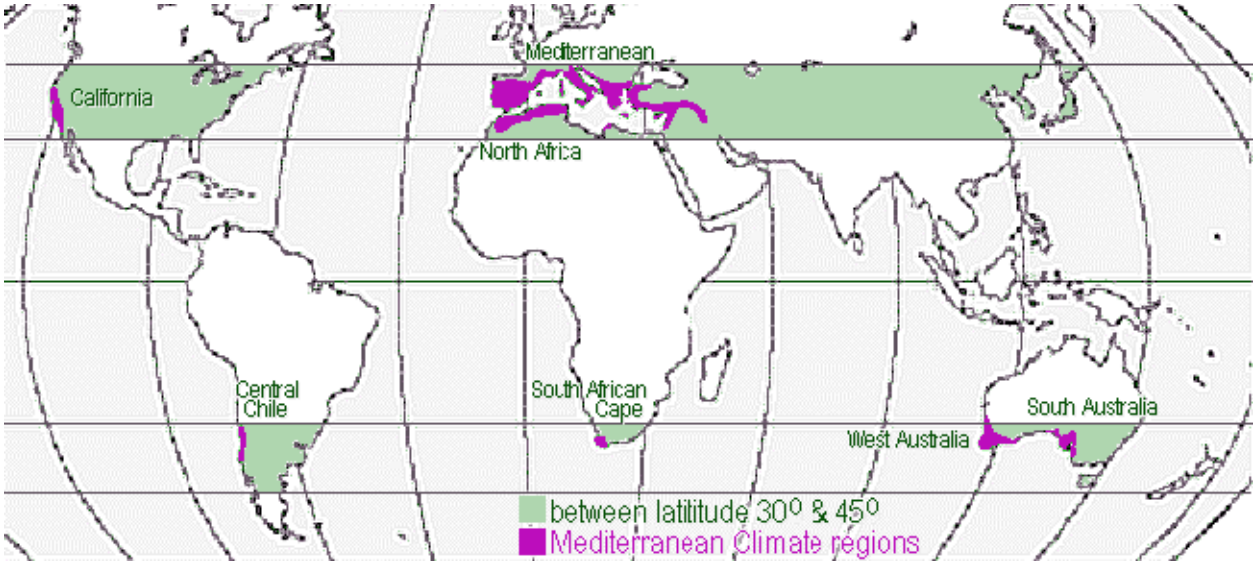


Figure 2.1 – "Mediterranean" climates in the world. (Figure: MGS web site.)

Temperatures may vary considerably. Some areas have hard frosts in winter, others barely any frost at all; in some, summers are unbearably hot and dry, others mild and foggy. Plants native to these areas are genetically programmed to withstand these specific conditions. One common form of adaptation is a summer dormancy period, as the arid summers are the most difficult season to survive.

In total, the five areas with Mediterranean climates comprise only about 2% of the earth's landmass. The largest of them is the Mediterranean itself, with about 60% of the world's "Mediterranean" climate, followed by Southern and Western Australia, which together equal about 22%. The remaining three are: California (10%), Chile (5%), and South Africa (3%). It is interesting to note that this last and smallest "Mediterranean" climate is itself the richest of the six floristic kingdoms of the world, with a diversity of 1,300 species. The next closest is the South American rainforest with 400 species (MGS 1). As a result, gardeners in these areas of the world enjoy a diversity of native plants in addition to the beautiful and interesting plants of other similar climates, which sometimes become naturalized. Working with the natural forces that shape these unique regions of "Mediterranean" climates, one can create astonishing beauty while requiring minimal maintenance through climate-appropriate plantings.

- **Facts about Cyprus**

Cyprus has a population of approximately 750,000 people and is the largest island in the Mediterranean, after Sardinia and Sicily. It is located on the eastern edge of the sea, some 60 km (37 miles) from Turkey to the north and 90 km (56 miles) from Syria to the east. (See the following figures of Mediterranean and Cyprus.) The island is approximately 0.6 times the size of Connecticut and has a total area of 9,250 sq km (3,571 sq miles), of which 3,355 sq km (1,295 sq miles) are in the Turkish Cypriot area. The population of the island is divided as follows: 85.1% of the population are Greek Cypriots, 11.7% Turkish Cypriots, and 3.2% foreigners residing in Cyprus. The capital of the island is Nicosia (Lefkosia), with a population of 198,000. Limassol, Larnaca, Paphos, Famagusta, and Kyrenia are the major towns of Cyprus. Its geographical position is largely responsible for the climate, which, to many visitors, seems to

divide the year into nine months of summer and three of spring. Standing at the crossroads, as it were, of Europe, Asia, and Africa, the country has been viewed over the centuries as a

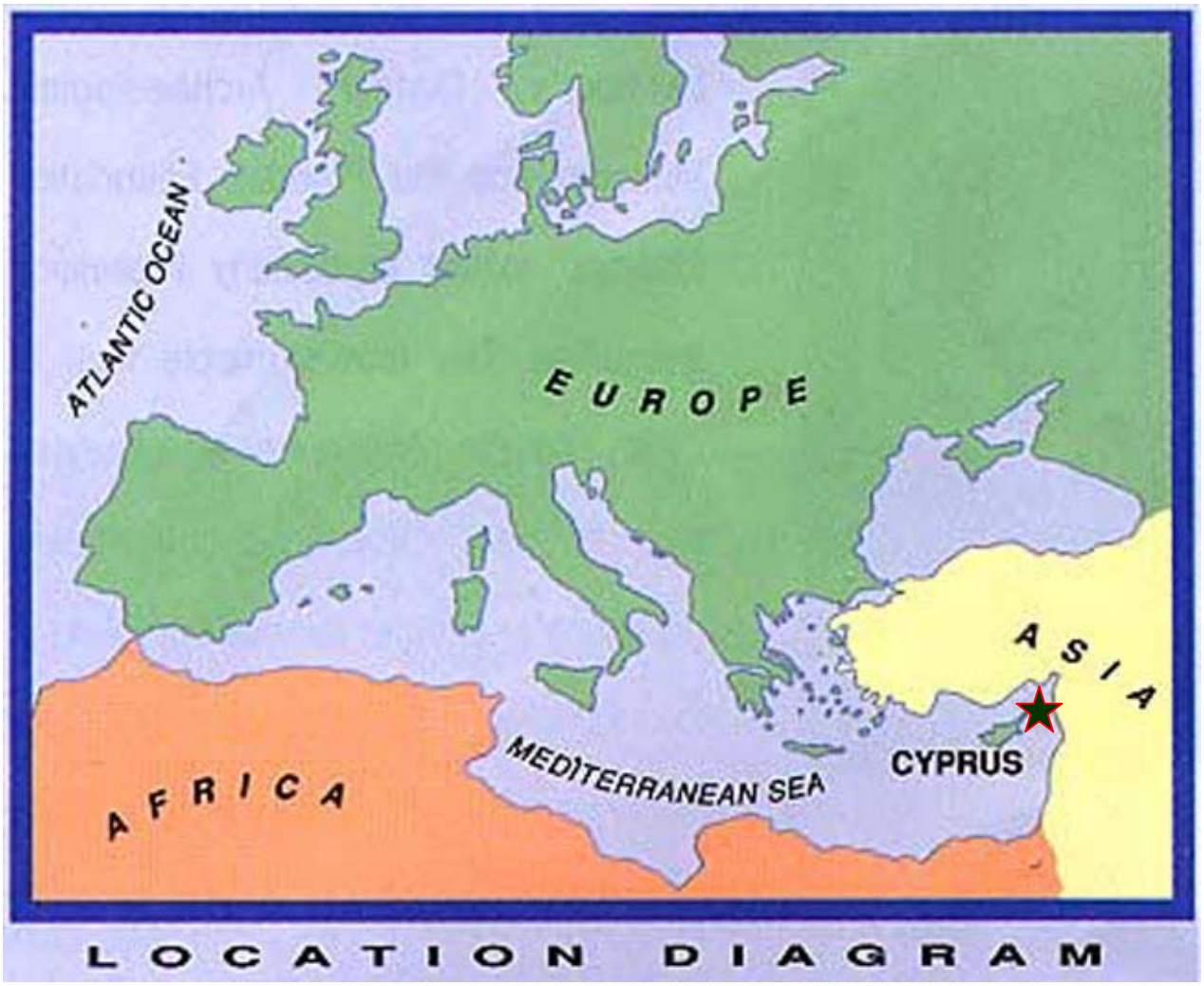


Figure 2.2 - Map of Mediterranean. (Figure: Cyprus Organization web site.)

strategically important stronghold by a long succession of conquerors. Cyprus, although a small country, has a rich cultural heritage and a known history that dates back over 10,000 years. Some believe that the name "Cyprus" is derived from the Latin word for cooper, "Cuprus." The island's trade in copper once made it one of the busiest commercial centers in the Mediterranean. The island of Cyprus is known internationally as an extremely popular holiday destination for

Figure 2.3 - Map of Cyprus. (Figure: Cyprus Organization web site.)

European and Middle Eastern countries, thanks to its excellent warm climate, wonderfully hospitable people, first-rate accommodations, delicious cuisine, and its safe, friendly environment (Kyriakou 6).

What is special about Cyprus is its diverse natural and cultural environments. I have never visited a place where the landscape changes so dramatically from a mountain to coastal scenery in less than 15 miles distance. During the spring season, visitors to Cyprus can ski in the mountains and on the same day swim at the beach. The diversity of cultures is special, too. In a village, visitors can savor the traditional way of life. In urban areas, they can see how Cypriots

live a modern life while keeping their traditions. In addition, in tourist areas, people can experience the influence of tourism on our small island.

- **History**

According to mythology, Cyprus is the birthplace of the goddess of love and beauty, Aphrodite (Venus). The island is both an ancient land, with an eleven thousand year-old history and civilization, as well as a young independent republic since 1960. (See the following pictures.) Cypriots feel strongly about their history and unique culture, and they try hard to keep them alive. The history of Cyprus plays an important role in people's lives and behavior.

Figure 2.4 - Tombs of the King. (Photo: Kyriakou, 1987.)

2.2 Environmental Factors

2.2.1 Geology

Cyprus is dividend into three geological zones: the Kyrenia range to the north (Pendadaktylos), the Troodos massif to the south, and the Mesaoria plain separating the two. The Troodos range is a region of high relief rising to 1,951 meters (6,401 feet) on Mount Olympus. The forests, which cover the Troodos massif, combined with its steep slopes and precipices and narrow valleys and crevices, help create beautiful scenery. The Troodos is covered with pines, dwarf oaks, cypresses, and cedars. The Kyrenia range rises up to 1,024 meters (3,360 feet) at Kyparissovouno. It is a picturesque area with hills, slopes, and valleys free of folding and other tectonic features. This range is made of a succession of mostly allochthonous sedimentary formations, ranging from Permian to Middle Miocene in age. The central plain, which is the Mesaoria, has a low relief not exceeding 180 meters (591 feet) near Nicosia. This plain is composed of flyschtype rocks carried by rivers from the Troodos and Kyrenia ranges. The Mesaoria plain is formed of a succession of upper cretaceous to pleistocene sedimentary rocks. Cyprus is almost surrounded by coastal valleys. In the north is the Kyrenia valley, with its narrow dent elated coasts; in the west are the Paphos and Chrysochou valleys; in the east is the Famagusta valley. The soil is alluvial and fertile, suitable for agriculture (PIO 11). (See the following figure with the geology of Cyprus.) The geology of Cyprus explains why Cyprus is a unique place with its diverse landscape. One of my favorite scenes is the drive from the village Drousia to Polis. The experience is unique because the sea can be seen through the mountains.

The Ministry of Agriculture, Natural Resources and Environment is responsible for the rational management and sustainable use of natural resources as well as being the coordinating ministry for the protection of the island's environment. Cyprus has endorsed the principles of sustanable

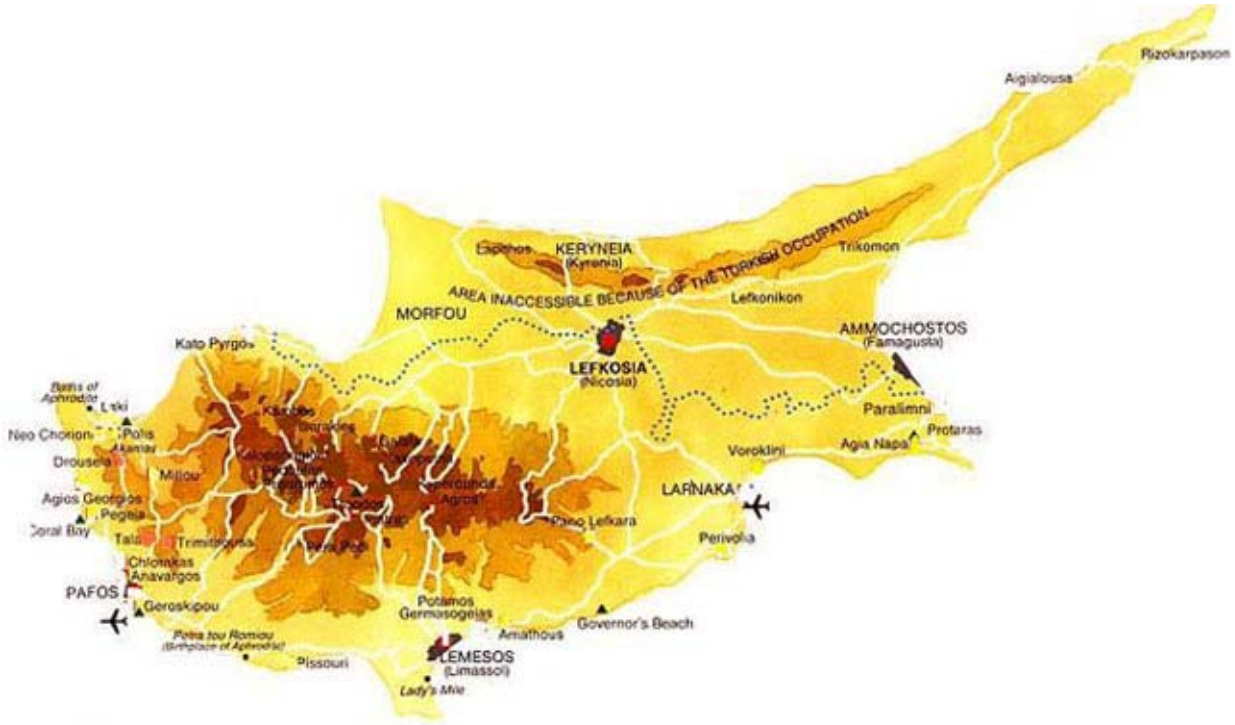


Figure 2.5 - Map of the geology of Cyprus. (Figure: Cyprus Organization web site.)

development, which are economic development, environmental stewardship, and equitable opportunities. In this process, the country is guided by the principles adopted at the Rio Conference and the European Union's respective policies.

The setting up of national parks and nature reserves is now receiving attention. There are six national forest parks, two in the coastal area, three around Nicosia, and one at Troodos. Two nature reserves are also located at Troodos. Worth mentioning also is the work initiated for the preparation of the ecological chart of Cyprus. The basic objective of this effort is to survey, study, and map all the basic characteristics and parameters of the natural, biological, and cultural resources, to identify the pressures threatening them, and to put forward suggestions and programs for the protection and enhancement of the ecological and cultural endowment of the island (PIO 252). I believe that the introduction of the idea of Xeriscape in Cyprus will support this objective of the government and can also support the principles of sustainable development.

Cyprus' endorsement of the European Union will make sustainable development part of our lives.

2.2.2 Climate

Cyprus has an intense Mediterranean climate with hot, dry summers from the middle of May to the middle of September with an average temperature of 32 C (90 F), rainy and rather changeable winters from the middle of November to the middle of March with an average temperature of 16 C (61 F); and the intervening transitional seasons of autumn and spring. Summer is a season of high temperatures with cloudless skies, but the sea breeze creates a pleasant microclimate in the coastal areas. Summer temperatures are high in the lowlands, even near the sea, and reach particularly uncomfortable readings in the Mesaoria. From ancient times Cyprus was called the "Island of Sun" because the sun shines for 340 days a year. On the other hand, winters are mild with some rain and snow in the Troodos Mountains (usually starting before Christmas). The average rainfall from December to February is about 60% of the average annual total precipitation for the island as a whole, which is 500 mm (20 inches). The higher mountain areas are cooler and moister than the rest of the island. They receive the heaviest annual rainfall, which may be as much as 1,000 mm (39 inches). Frost also occurs in the higher districts, which are usually blanketed with snow during the first months of the year. The average daytime temperature is around 16 C (61 F). This season brings some much-needed rain to this land in which water shortage is a huge problem. In addition, relative humidity of the air is on average between 60% and 80% in winter and between 40% and 60% in summer with even lower values over island areas around midday. Sunshine is abundant during the whole year, particularly from April to September, when the average duration of bright sunshine exceeds 11 hours per day. Winds are generally light to moderate and variable in direction. Strong winds may occur

sometimes, but gales are infrequent over Cyprus and are mainly confined to exposed coastal areas as well as areas at high elevations. The climate of Cyprus is considered one of the healthiest in the world, and infectious diseases are practically unknown (Climate of Cyprus).

2.2.3 Flora of Cyprus

With a total of 1,910 taxa (species, subspecies, and varieties), 139 of which are endemic, Cyprus is an extremely interesting place for nature lovers and because of its diversity of flora, it is a botanist's paradise. The term "endemic plant" means all plant taxa which grow naturally in Cyprus and nowhere else in the world. The endemic plants of Cyprus include 73 perennial herbs, 21 annual herbs, 19 sub shrubs, 14 shrubs, and only one tree, the Cyprus Cedar (*Cedrus brevifolia*). Its isolation as an island has led to the evolution of many species with strong endemic flowering elements. At the same time, being surrounded by big continents, it incorporates botanological elements of the neighboring land masses**,** such as the Western Mediterranean (France, Italy, Spain) and the Eastern Mediterranean (Greece, Israel, Syria and Turkey). Cyprus is big enough to have a varied topography (mountains, inlands, and coastal areas), which goes along with a varied climate. Its geographic position, its size, and these variations in habitat result in a rich and diversified flora. Cyprus's flora is as rich as that of other Mediterranean countries but is much richer than that of countries of central and northern Europe (Tsintides 10,15).

Because the flora of Cyprus is diverse, important, and special, Cypriots must protect and try not to impact it in a negative manner. Cyprus's flora is a valuable heritage, and its conservation is an imperative duty for all its citizens. The character of the island is marked not only by the people and the buildings but also by the flora of the place; so we must try to keep that special character rather than trying to change it. Cyprus is a small, beautiful island that

combines all the kinds of landscape, a feature that is uncommon in other places in the world or on that scale. One of the most important attributes of a place is its character that has been achieved by its history, its culture, and the people that live in that place. It is the special character of a place that makes people love traveling from one place to another. What is the reason of traveling from one place to another to see new places if all the places of the world are the same? Cypriots should feel proud of this natural wealth, and also they should feel equally proud of the measures taken to conserve this precious heritage.

2.2.4 Bioclimatic Zones

The bioclimate of Cyprus is the classification of the island in zones based on its flora and its climatic conditions. According to the research by Vaso Pandela, the island is divided in eight bioclimatic zones:

1. Semiarid Hot (Precipitation<400mm [15.8’’] and an average minimum temperature of the coldest month >6 C [43F]).
2. Semiarid Mild (Precipitation<400mm [15.8’’] nd an average minimum temperature of the coldest month 3-6 C [43F]).
3. Hot Arid (Precipitation 400-600mm [15.8-23.6’’] and an average minimum temperature of the coldest month >6 C [43F], altitude 0-300 meters [0- 984ft]).
4. Mild Arid (Precipitation 400-600mm [15.8-23.6’’] and an average minimum temperature of the coldest month 3-6 C [37-43F], altitude 300-400 meters [984-1313ft]).
5. Semi Wet Mild (Precipitation 600-900mm [23.6-35.4’’] and an average minimum temperature of the coldest month 3-6 C [37-43F], altitude 400-900 meters [1313-2953ft]).

6. Semi Wet Cool (Precipitation 600-900mm [23.6-35.4’’] and an average minimum temperature of the coldest month 0-3 C [32-37F], altitude 900-1150 meters [2953-3775ft]).
7. Cool Wet (Precipitation>900mm [35.4’’] and an average minimum temperature of the coldest month 0-3 C [32-37F], altitude 1150-1500 meters [3775-4921ft]).
8. Cold Wet (Precipitation>900mm [35.4’’] and an average minimum temperature of the coldest month <0 C [32F], altitude>1500 meter [4921ft]).

(fig. 2.6 with the bioclimatic zones of Cyprus). This research on bioclimatic zones was done by the Forestry Department of Cyprus with the collaboration of an important scientist, Vasos

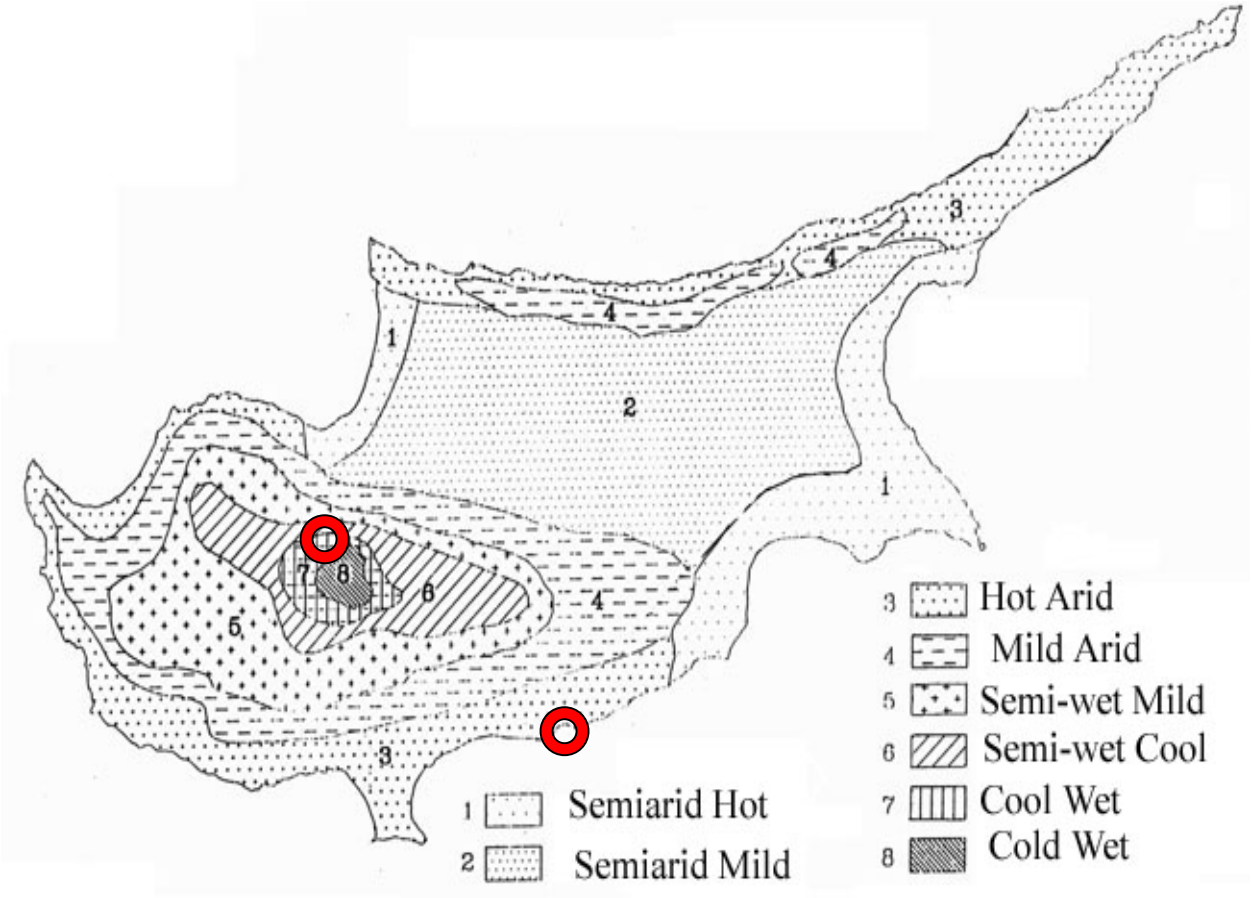


Figure 2.6 – Map of bioclimatic zones of Cyprus and of the case studies. (Figure: Vaso Pandela.)

Pandelas. This map is an important contribution toward the natural wealth of Cyprus. According to this map, Cypriots can specify the climatic conditions of their site, which will help them to decide about the right plant selection. The right plant selection will help preserve the natural vegetation of each area. (Ministry of Agriculture 14).

2.2.5 Natural Vegetation and Native Plant Communities of Cyprus

The country's diverse geomorphology has allowed the development of a wide variety of vegetation. This includes forests of hardwood, evergreen, and broadleaved trees such as *pinus latepensis, cedar, cypressus* and *oak*. According to Eratosthenes, a Greek botanist of the third century B.C., most of Cyprus, even Meaoria, was heavily forested in antiquity, and considerable remnants of those forests survive on the Troodos and Kyrenia ranges. Locally, at lower altitudes, about 17% of the whole island is classified as woodland (PIO 13). Garigues and Maquis also cover a considerable part of the island and in reality they are of anthropogenic origin. They result from the destruction of forest followed by periodic burning and overgrazing, leading to soil erosion and a subsequent reduction of ecosystem productivity. Where the soil is not seriously eroded and other ecological factors are favorable (slope, aspect, moisture availability), the succession order garigue>maqui>pine forest is followed, and eventually the forest is re-established. But sometimes the soil is very eroded so that the garigue and maqui seem to be the final vegetation community, although in most cases there is a very slow development of the garigue to maqui and of maqui to pine forest (Tsintides 12).

The natural habitats of Cyprus can be classified into six large groups: pine forests, garigues and maquis, rocky areas, coastal areas, wetlands, and cultivated areas. Pine forests are found throughout the entire altitudinal spectrum from sea level at Akamas and Episkopi to the Troodos Mountains. The pine forest can be subdivided into two broad climatic zones: the Brutia

Pine zone (*Pinus brutia* Terone) and the Black Pine or Troodos Pine zone (*Pinus nigra* Arnold spp. Pallasiana). The second zone, which is the gariques and marquis, covers the entire altitudinal range of Cyprus. Garigues and Marquis is subdivided into the following three categories: the Garigue on dry, eroded soils, the Garigue on moderately eroded soils, and the Maquis with evergreen *Sclerophyllos* shrubs mixed with subshrubs, herbs, and isolated trees. The third area, the rocky areas, comprises a variety of individual habitats with rocky outcrops at low or high altitudes, on limestone shaded/moist sites or sunny/warm and dry slopes. The vegetation on rocky sites is sparse, as is expected. Typical species are *Sedum* spp., *Umbilicus* spp., *Arabts* spp., *Ptilostemon chamaepeoce*, and *Gagea* spp. The next area is the coastal areas, which includes a narrow belt 50-150 meters (164-492 feet) in width along the coast. Typical plants are: *Limonium* spp., *Echium angustifolium*, *Medicago marina*, *Crithmum maritimum, Centaurea aegialophia,* and *Verbascum sinuatum*.

Figure 2.7 - Pine Forest. (Photo: Tsintides.)

Figure 2.8 - Garigue on dry eroded soils. (Photo: Tsindites)

Figure 2.9 - Garigue on moderately eroded soils. (Photo: Tsintides.)

Figure 2.10 - Rocky areas. (Photo: Tsintides.)

Figure 2.11 - Coastal area. (Photo: Tsintides.)

Other areas are the wetlands, which cover a smaller area than the other groups. They include mainstream beds, salt lakes, and small marshy areas near water springs, water dams, and artificial lakes. Representative species are: *Platanus orientalis, Alnus orientalis, Laurus nobilis, Nerium oleander, Rubus sanctus, Arundo donax* and *Mentha* spp. (fig. 2.12).

Figure 2.12 - Wetlands. (Photo: Tsintides.)

The next area is the cultivated land and the other small areas. These areas include agricultural land, edges of such land, and other disturbed land. It is estimated that this group of habitats hosts *Urtisa* spp. *Dioica* and *Oriopordom cyprium* (Tsintides 10-15). (fig 2.13).

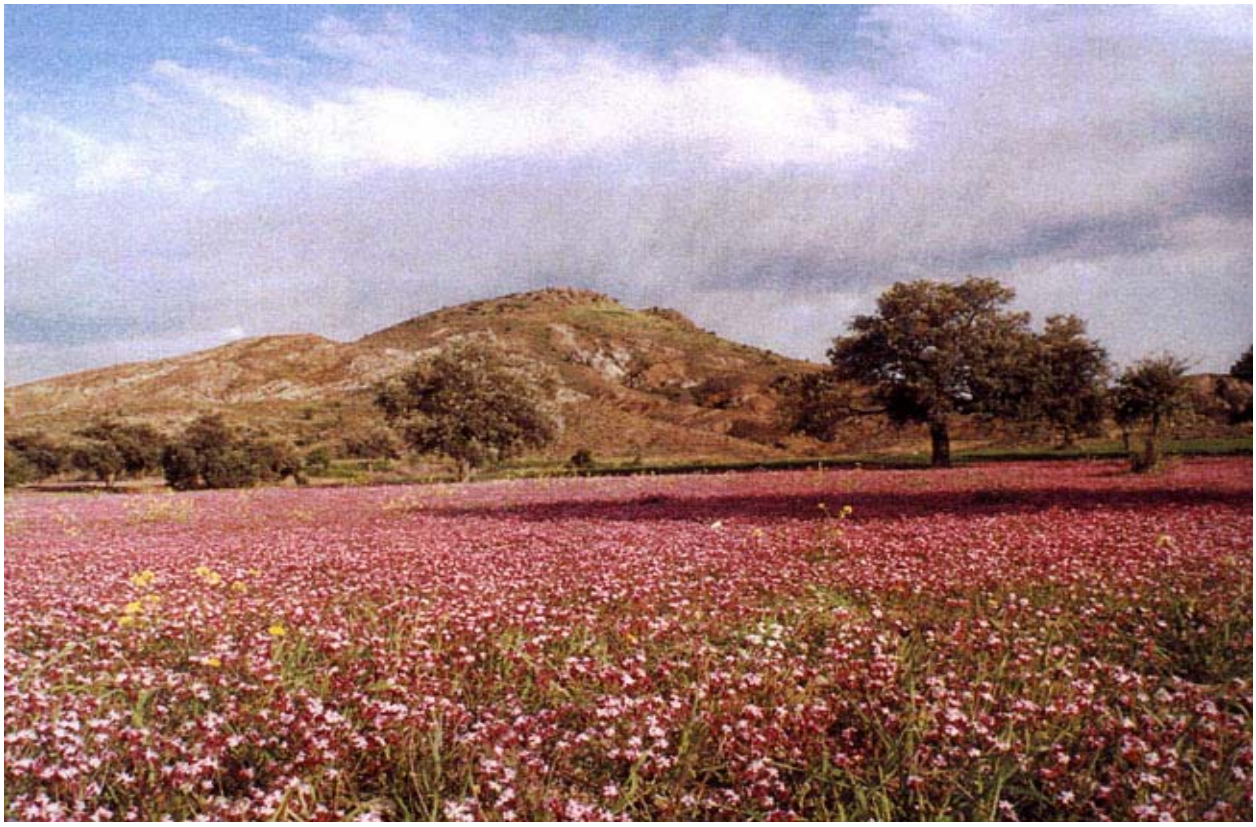


Figure 2.13 - Cultivated area. (Photo: Tsintides.)

It is essential to be knowledgeable about the natural vegetation of Cyprus and of its communities while designing a garden in Cyprus. I believe that it is critical to design a garden that enhances the special character of Cyprus that most visitors fall in love with. As a designer, my rule of thumb is to consider the character and the flora of the area that surrounds the site before making any decisions.

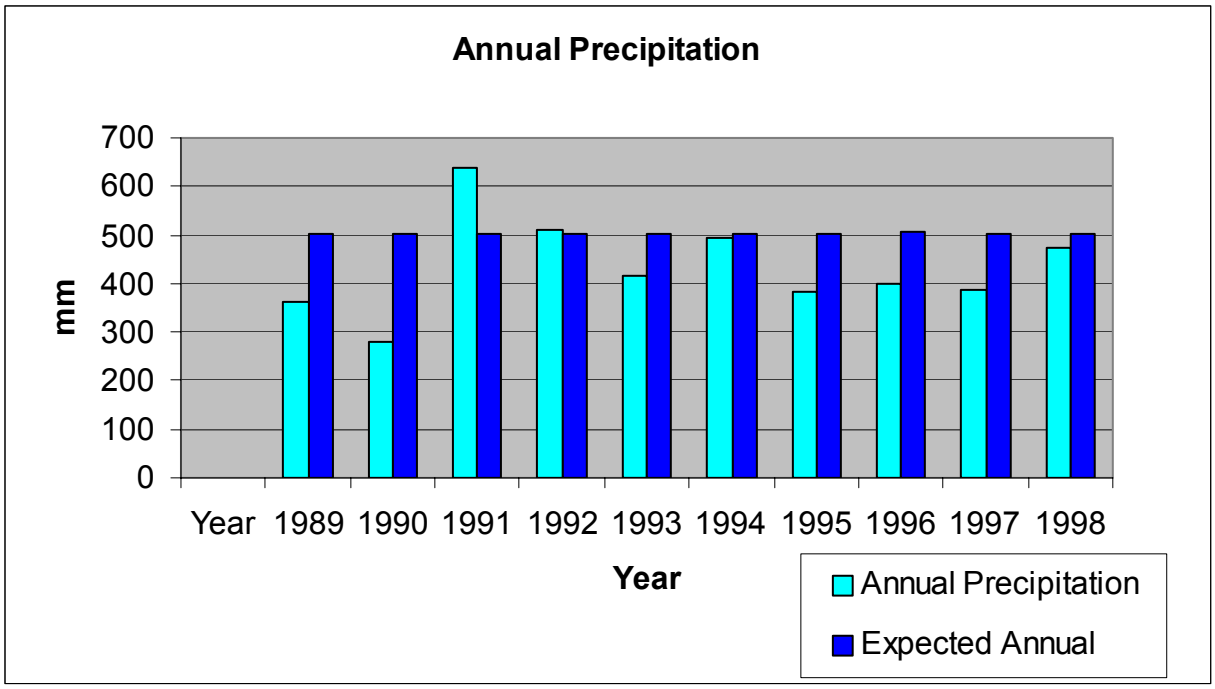
2.3 Hydrology in Cyprus

Throughout its history, Cyprus has been confronted with the problem of water shortage. However, in the last ten years, Cyprus has faced the problem of water shortage even more dramatically not only because of increasing water competition in agriculture, industry, tourism, and household use**,** but also because Cyprus has witnessed a series of years of drought. This

drought has created major problems for the supply of drinking water, as well as for the water used for agriculture.

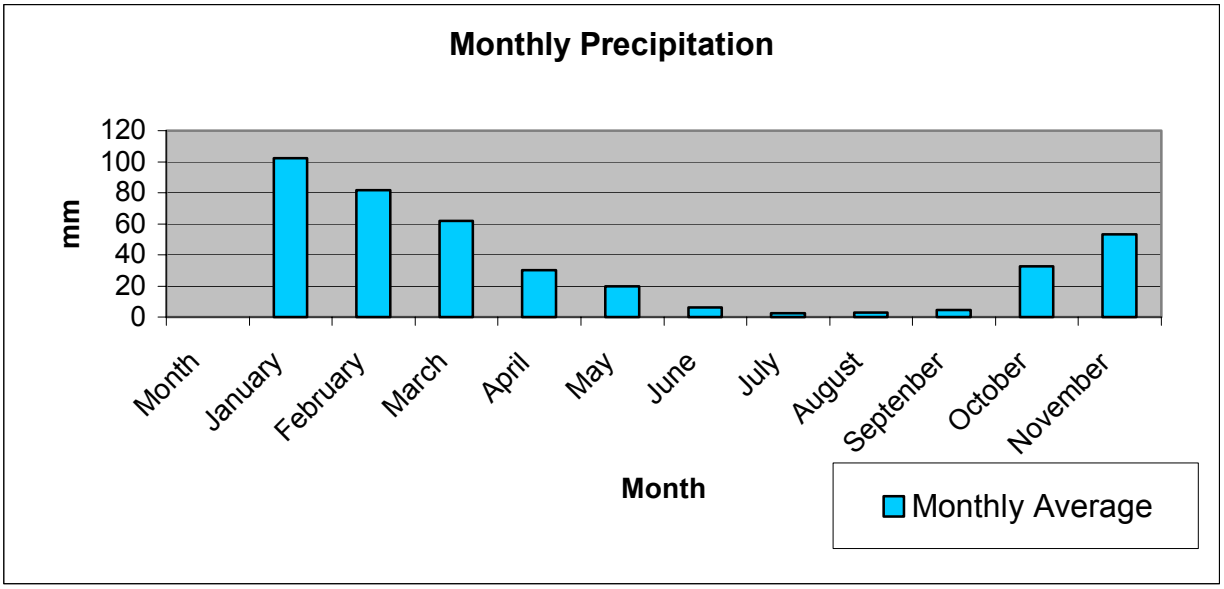
During the twentieth century, climatic conditions have changed in Cyprus. The two major variables that affect the climate are precipitation and temperature. The current trend of decreasing precipitation and rising temperatures has contributed to making the last 20 years the hottest of the twentieth century. The average annual precipitation in the first 30 years of the twentieth century was 559 mm (2.2 inches) but in the last 30 years has decreased to 464 mm (1.82 inches), creating an average decrease of 17% between the beginning of the century and now. Furthermore, the average precipitation for the last ten years is 22% lower than the average precipitation for the period from 1901 to 1930. The following figure shows the annual precipitation between the years 1989 to 1998 (Apostolides 63).

Table 2.1 - Annual precipitation (Table by author.)



This table shows that during the period of 1989 to 1998, the annual precipitation was low and much lower than the expected annual precipitation except during the year of 1991, when the precipitation went up to 630 mm (3 inches). The next table shows the average precipitation for each month. As it shows, the period between June to September is very dry (Apostolides 64).

Table 2.2 – Monthly precipitation.



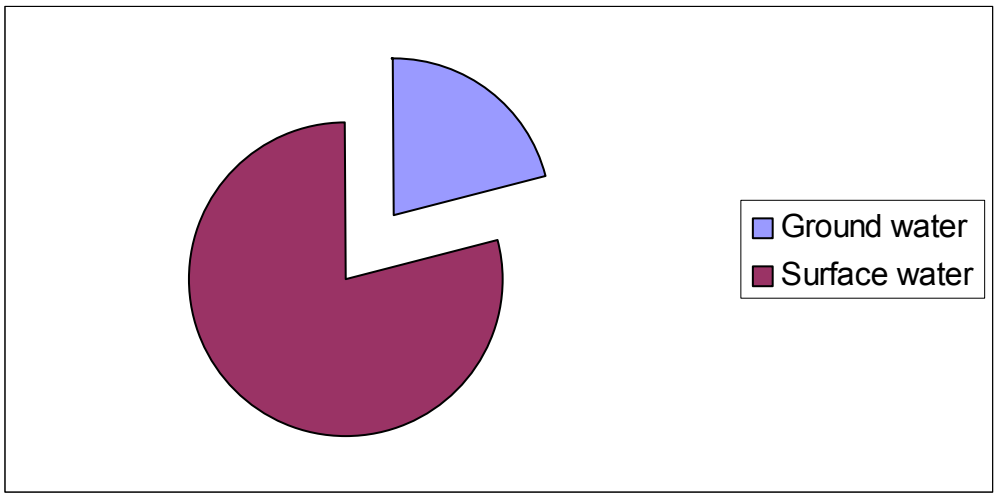
(Meteorological Service 1)

The average annual temperature of Cyprus is increasing in the twentieth century. Between 1976 and 1998, the average increase of temperature in cities was 0.035 C per year and 0.015 C per year in suburban areas. Research predicts that our climate will be hotter and dryer, following the same climatic conditions that are happening in the Middle East and Eastern Mediterranean (Apostolides 63-64).

Unfortunately, because of the reduction in rainfall, the quantities of water available both for drinking and irrigation have not been adequate. As a result, the government gives utmost priority towards the optimum utilization of all the island's water resources. Since the

groundwater is reliable, clean, and low in cost, water resources development in Cyprus initially focused on groundwater, and until 1970 groundwater was the main source of water for both drinking and irrigation. As a result, almost all aquifers were seriously depleted because of over pumping. Seawater intrusion was subsequently observed in most of the coastal aquifers. (See the following table with the relationship of groundwater and surface water.)

Table 2.3 - Relationship of groundwater and surface water in Cyprus. (By author.)



The Water Development of Cyprus identified the water shortage problem in time, and in consultation with international organizations, prepared a long-term plan for solving the problem. The first step involved the construction of a large number of dams. Dams were created to gather rainwater and runoff water from the mountains to be used mainly for irrigation. By the time of the independence of Cyprus in 1960, the island had 16 dams. The dams had a storage capacity of 6 million cubic meters (211.9 million cubic feet) by 1960. By the year 2000, the capacity of dams reached 300 million cubic meters (10,594 million cubic feet). This was truly an impressive achievement when compared to other countries of the same size and level of development as Cyprus. Even though this investment in dams increased dramatically, the water capacity of the

dams has been reduced in the last ten years by 40% because of the low precipitation (Apostolides 11).

Other steps that were taken by the government were the construction of large projects like the Khrysokhou irrigation project and the Southern conveyor project. Also, the government turned its attention to other non-conventional sources, such as the use of recycled water for irrigation, recharge, and amenity purposes, the desalinization of brackish water, the efficient use of available water, including better pricing and conservation measures and the preservation of water quality.

Furthermore, in order to eliminate the dependency of the towns and tourist centers on rainfall to satisfy the increasing water demand, the government has decided to proceed with the construction of seawater desalination plants. By January 22, 2001, every household was expected to have a continuous supply of good-quality drinking water on a 24-hour basis, and that the water rationing measures would finally be terminated. This new way of increasing the water supply would allow people to use water for the most important things, such as cooking, washing, taking a bath, and sometimes watering their plants. Desalination of seawater was first introduced in Cyprus on a large-scale basis in April 1997, with the operation of the Dhekelia plant. The plant operates on a Built, Own, Operate, Transfer (BOOT) basis, and the desalinated water is presently sold to the government (PIO 212).

Not only is water quantity a problem but water quality is also a problem in some areas of Cyprus. Fertilizers, sewer systems, salt water, and boron reduce the quality of water and make soil and water analysis a necessity before making any design decisions.

While facing the problem of water shortage, it is very important to see some real numbers about the water consumption in Cyprus so we can figure out where and how Cypriots can

conserve water. In Cyprus, according to a research that is done by the Water Development Department, water consumption is divided into three main categories: agriculture (70%), household and tourism (20%), and industry (10%). To consider water conservation in residential gardens in Cyprus, it is important to know total water consumption as well as the average water consumption at each household. The average water consumption in a house is as follows: 21 % shower, 8% tap, 28% toilet, 13% kitchen, 7% laundry, 14% landscape, and 9% car wash. As can be shown from the above information, water consumption of 14% for landscape is a high number that explains why water conservation in gardens in Cyprus is important (World Water Day). (fig. 2.14). Climatic conditions and water resources are explained to inform people about the major causes of water scarcity in Cyprus. An important part of the solution of the problem is diagnosis. If Cypriots understand how serious water scarcity is, then it is easier to follow water conservation measurements. The numbers on hydrology show that water scarcity is a big issue in Cyprus. However, the interviews that I had with professional and non-professional Cypriots expressed more dramatically that this problem has became a part of most people's lives in Cyprus. One promising solution is desalinated seawater. One of the articles in a Cypriot magazine says that desalinated seawater can solve the problem of water shortage. This may be true, but the use of desalinated seawater will not eliminate the need for other water-conservation measures. Desalinating seawater costs a great deal of money, which the government may not be able to afford. The government plans to increase the price of water, which has stayed at the same levels for the last ten years. Water conservation not only reduces water bills but also supports our environment and the character of places. Based on my observations, the government put great effort in finding new ways to conserve water. People have become more aware than before, but they can do more.

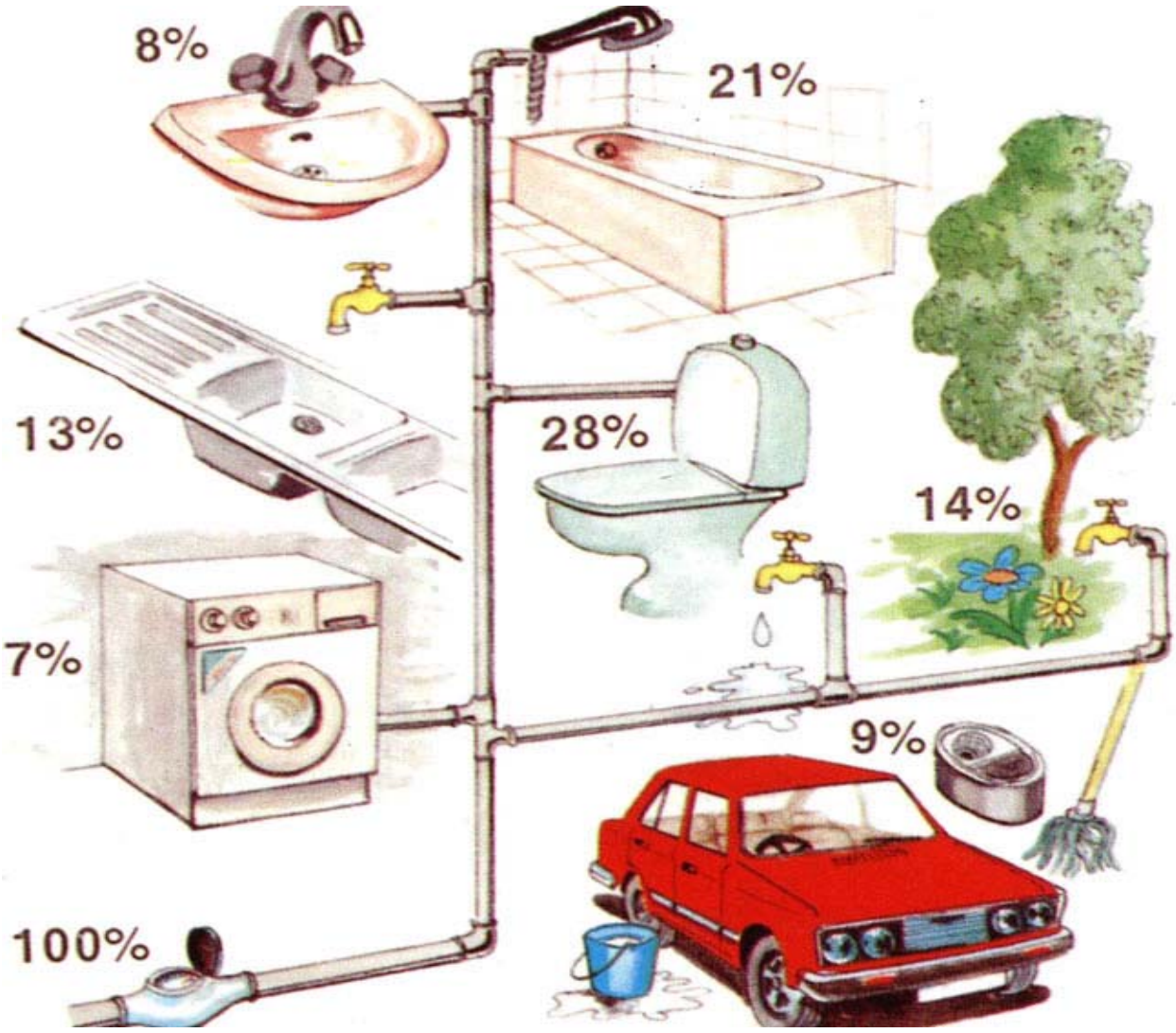


Figure 2.14 - Water consumption in a household. (Figure: Water Development department of Cyprus.)

Chapter 3. Gardens in Cyprus

3.1 Landscaping and Water Conservation in Cyprus (Xeriscape)

Cyprus is one of these countries with a critical water scarcity. The problem of water shortage and drought was always there for the island, but in the last five to ten years it has become more serious than ever before. In Cyprus there has always existed water conservation to some degree, but due to the long period of drought, the participation of the public in water conservation has risen dramatically.

The departments of the government that are directly concerned with the problem of water are the Water Development Department and the Water Board Department. These departments have cooperated more and more for the last ten years to increase the awareness of the people of water conservation by using multi-method approaches and by conducting an educational campaign. One of the methods used during the worst years of drought from 1994 to 2000 was the rotation system of water supply. Most households were supplied water two to three days a week or even less. As a result, people used water for the most important needs, like drinking, cooking, and for taking baths. The maintenance of gardens was one of the first things to be cut off when managing a small amount of water in a household. Although Cypriots have a tendency to have rich, plentiful gardens, the lack of water forced them to decrease or even totally abandon the concept of a garden at their homes. These measures were strict, but they worked because they helped improve the attitude of Cypriots towards conserving water. During the last two years, the government has discontinued this rationing because they have solved part of the problem with desalinated seawater.

Another part of the educational campaign for water conservation is the incentives that are offered by the government. The government offers $150 when people are digging a well and

$150 extra if people connect it with the toilet units. The Water Development Department and the Water Board Department that developed it insist that this method of connecting the machine with the toilets is saving 28% of the water that is consumed in each household. These days a lot of the people have machines at home that help them to keep their landscape in good shape, but there are not many people who connect this machine with the toilets. Maybe people are not aware of this method or they are afraid of the installation in an existing house. Another method that is fully successful is the encouragement of the public to use specially designed plastic bags that are attached to the toilet units and help to conserve water. These bags are distributed free from the Water Development Department and the Water Board Department and can be easily installed by the public. These bags are saving a lot of the water that would be wasted by the toilet units. Moreover, in the summer of 2001, free water containers were given to the public, who answered a questionnaire associated with water conservation (Andreou 4).

In addition to this campaign for water conservation, the government encourages the idea of grey water (desalting of brackish water) by offering $350 per house and an additional 20% off with the installation in the second house of the owner. The Water Development Department and the Environmental Service, which are under the control of the Ministry of Agriculture, Natural Resources and Environment, started the idea of the grey water in 1997. The application of grey water for water conservation can save up to 35% of drinking water. It is easy to install and maintain, and the quality of water that results is good enough to use for the landscape and for toilets (Kambanellas 50). Even though the whole idea seems easy to follow and worthwhile to do, for some reason, the public is not properly informed. The government, architects, and civil engineers should make people more aware of such important information that can conserve the limited water in our country.

In general, the Water Board Department and the Water Development Department supply the public with new information about water conservation and about related information on water shortage through leaflets that are included in water bills. Other actions that are taken to support the water conservation campaign is the Worldwide Water Day by the United Nations, which falls on March 22 every year. On this day the public is informed about the importance of water, about the water shortage, and about guidelines for conserving water. Other campaigns include organized professional conferences on water conservation and lectures to schools on how to conserve water. Not only are lectures done at schools, but also informative leaflets are distributed to students to get them involved from a young age in caring about water conservation. It is also important to mention that the government has successfully provided irrigation systems that are used for agriculture, and they are considered some of the best in the world. Also, low interest loans are offered for agriculture.

Not only were incentives given to help the water conservation campaign, but also some rules were set about water consumption. For example, the Water Board Department established a limitation for water consumption in each household. The maximum water consumption in a household was set at 40 tons for the same price, but if a household exceeds that amount, it is charged $1.5 per extra ton consumed. One of the future plans is to increase the price of water, which has not been changed for the last ten years. Another rule that is set by the government is that it is forbidden to use the water hose of drinking water to wash verandas or cars, or to water the landscape (Andreou 5). (fig.3.1-3.2).

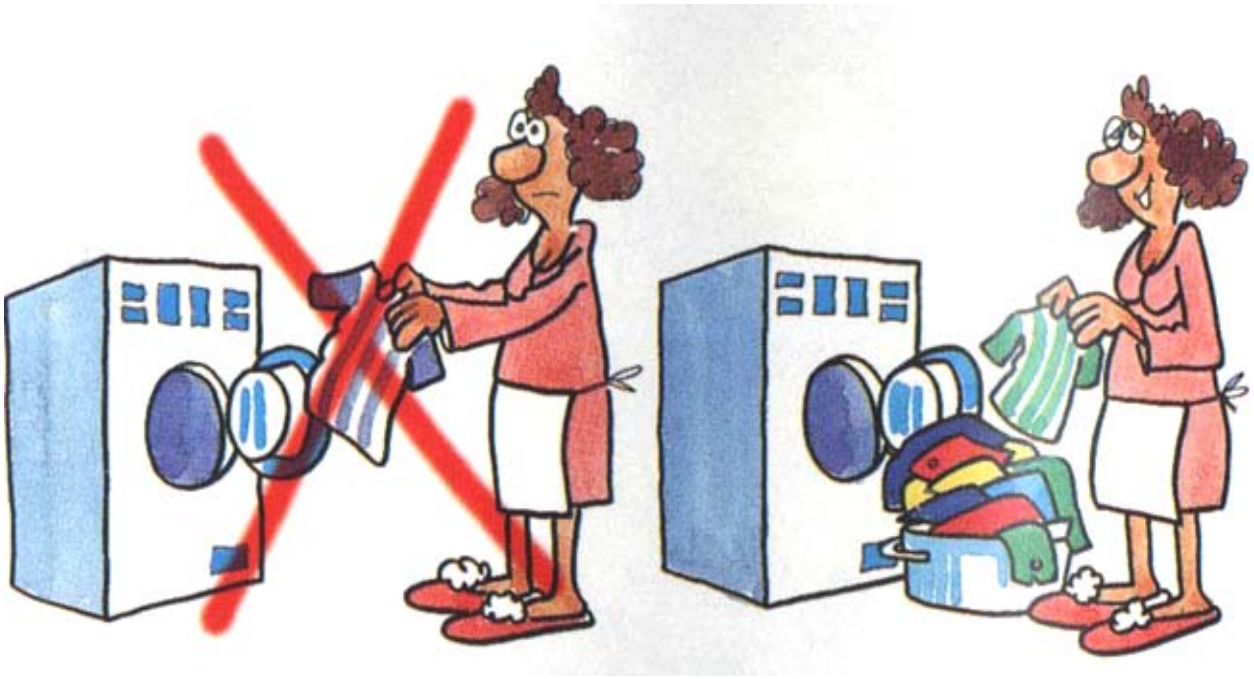
Figure 3.1 - Using a water container. (Figure: Water development department.)

Figure 3.2 - Washing the car. (Figure: Water Development department.)

As a result, the public has become more cooperative in conserving water. At home, Cypriots use less water to wash the dishes, they fully load their washers when doing laundry, they use the groundwater for watering the landscape instead of drinking water, and some people-- whether or not they intend to conserve water--use fewer water-loving plants, more native plants, and an advanced irrigation system in their yards. On the other hand, there are always

people who do not conserve water. For instance, the old ladies who still wash their clothes by hand (frequently and not fully loaded), because this is how they are used to doing it and nobody can change their customs. Or some of the housekeepers that clean the veranda floor with the water hose instead of the mop, and some of the young people who still take a bath instead of a shower because they like to go against the rules of the house. One of the interviews with a young woman in her late twenties explained why she does not care about water conservation and is still taking a bath: " The reason that I do not care to conserve water is that I was studying abroad during the bad years of drought and I did not experience what other people did with the water supply rotation of 2 to 3 days per week." (fig. 3.3).

Figure 3.3 – Water conservation at home. (Figure: Water Development Department.) (Fig. Con'd.)



It can be concluded that the public of Cyprus has become more aware than before but they can do more to conserve water. Cypriots need more incentives to change their attitudes and behavior.

A lot of things are mentioned about water conservation in general in Cyprus but not a lot is mentioned about gardens. In Cyprus, there are no organized groups that focus only on water conservation in gardens, such as Xeriscape in the U.S. One of the departments of the government that is focusing more on water conservation in gardens is the Department of Forestry, which it is under the Ministry of Agriculture. This Department of Forestry puts a lot of effort into helping the public to understand the importance of our native plants and the idea of creating a garden that conserves water. The Forestry department supports its effort of water conservation by organized lectures that are done for the public, professional landscapers, and nurseries. A recommended plant list and guidelines are offered by this department to help the people be more familiar with

using the right plants at the right place. Not only do they provide the public with the list of plants, but also they are selling to their nurseries most of the plants that are included in the list, which are in a very low price range. Another goal mentioned at this department is that they plan to prepare demonstration gardens in which they can show how to design gardens while conserving water. The only kind of water conservation garden now it is the botanical garden in Nicosia, which has mostly native plants and is currently under construction. (fig.3.4).

Figure 3.4 - Botanical garden in Nicosia. (Photo by author.)

In addition, educational campaigns for schools are organized by this department to help the teachers pass along the message that water conservation and native plants are important. Free native plants are offered to schools with the idea that students can learn about them at their schools. In this way, they will become more aware of the native plants of Cyprus and become more concerned with the problem of water shortage. Moreover, school gardens become

demonstration gardens for the public to show how creative gardens can be with the use of water conservation plants and native plants of Cyprus.

Another department that got involved with the awareness of kids about water conservation is the Environmental Service. It published a story in which the hero explains how his life is involved with conserving water. This department makes it clear that future generations should be involved with the problem of water shortage from an early age. Educational campaigns for water conservation convey their message through TV, radio, by distribution of leaflets and posters, and by other means of communication. The public is familiar with the general campaign on water conservation but is not very familiar with the educational campaign that is introduced by the Forestry department regarding native plants.

While gathering information on water conservation in gardens in Cyprus, I observed that it took time and a lot of effort to put the information together. Interviews, articles, and my own observations were the main sources to sort the information. Even though Cypriots are more aware than before with water conservation, they are not familiar with water conservation in gardens. When I visited the Forestry Department and we exchanged information on my thesis topic and on their contribution to the flora of Cyprus, they were so excited that we had a common goal to protect our natural heritage. I realize that there are Cypriots who put a lot of effort in protecting the flora of Cyprus, but they are not organized so that their message can pass through to the public.

3.2 Garden Culture of Mediterranean and Cyprus

The typical Mediterranean garden conjures images of blue skies, sun-baked courtyards, and long, lazy lunches under vine-covered pergolas. The key ingredients are light, warmth, simplicity, and relaxation. It has a “laid back” image, which is an attractive style contrasted with

the pace of modern life. The predominant colors are white, earthy shades, and blue. The main hard landscape materials are stone, concrete, and ceramics, which are earthy, durable materials. Timber is also occasionally used for pergolas. Plants are hardy and drought tolerant, often with silver-grey foliage typical of dry climates, such as lavender, olive, rosemary, and pencil pines (Gardening News 1). In addition, containers are popular, with geraniums and roses in them. One of my grandmother's gardening practices was to put geranium containers in every single step of her stairways. Typically, Mediterranean gardens do not have lawns; instead ground surfaces are paved or covered with gravel. Walled gardens and courtyards are popular for relaxing and entertaining. Pergolas or verandas provide overhead shade, a necessity for this climate. Grape vine is one of the most common climbers for overhead that provides good shade and fruits. However, a lot of people do not prefer it due of its high maintenance when it loses its leaves. Also, simple water features often are used for their cooling effect. A lot of times people asked me, "Do you live in these beautiful white houses on the beach, which are full of lavenders?" This perception of people that associate Greek style with white houses and blue color show that these special characteristics are important to be preserved.

Homer, Solomon, Xenophon, Plato, and many other writers of antiquity were among the first to leave us with references to Mediterranean gardens of their day. Homer described gardens, which included votive symbols, trees, and sacred wellsprings, as sacred places because of the presence of the gods. Gardens were the places that gods gathered to have fun by dancing, drinking wine, and relaxing. The idea of the garden as a place for relaxing and getting together emerged first in Hellenistic Greece. Greek people keep strong this tradition of using the outdoor space most of the time to eat and relax. In addition, gardens were described as very beautiful, reflecting the harmony achieved between humanity and nature. Also, early descriptions show

that cypress, oaks, and carob are typical of the Mediterranean gardens. Fruit trees like citrus, as well as grapes and thyme, were very common too. Homer wrote in the Odyssey: "And there grow tall trees blossoming, pear-trees and pomegranates, and apple-trees with bright fruit, and sweet figs and olives in their bloom…one part is being dried by the heat, a sunny plot on level ground, while other grapes men are gathering. These were the splendid gifts of the gods in the palace of Alcinous" (Sievenking 2). Homer's description of the palace of Alcinous emphasized the use of fruit and olive trees in a Mediterranean garden. Based on my observation, gardeners in the Mediterranean region could not imagine their gardens without the existence of fruit trees. Furthermore, Greeks were the first to learn the art of gardening. In addition, Romans used words of Greek origin to describe the art of gardening as "topiaria," which means pruning leaves and bushes into artistic shapes. Another description of gardens that was given by Greek philosophers such as Plato is the importance of shadiness that is essential to the Mediterranean climate. Plato wrote, "There, there is both shade and a gentle breeze and grass to sit down upon… for this plane tree is very wide-spreading and lofty, and the height and shadiness of this agnus castus are very beautiful, it makes the spot as fragrant as possible" (Sievenking 3). In the Mediterranean region gardens fit the surrounding place and nature and had the advantage of wind and sun.

Philosophers' descriptions show that Mediterranean gardens and those of Greece/Cyprus are very similar to the gardens of the present time. Photos that I took in Cyprus conjure the images that philosophers described like the use of olive and fruit trees. Mediterranean gardens have a naturalistic look that imitates nature and gives a sense of place. In the book The Mediterranean Gardener, the author Hugo Latymer gave a very nice description of the Mediterranean landscape: "The only gardeners on a Mediterranean hillside for example are sheep, the only fertilizer, their droppings, the only irrigation the rain. But we find many

marvelous plants: gnarled olive trees a thousand years old, deep green twisted carob trees, citrus, bloom, rosemary and thyme"(Latymer 20). In another book Gardens Around the World the author Elizabeth Schuler said about the Greek landscape, "Grace grows wild in this country. This is the nature of the country to leave it grow naturally…Even the ruins of Mycenae have no garden but the marjoram turns the wilderness into a sea of blossom, and the Verbascum thrives around Agamemnon's grave" (Schuler 125).

Even though Greek and Cypriot gardens have a naturalistic look and use the native plants, people have been using imported plants, too, that change the special character of our landscape. It has been the trend of the twentieth century to use imported plants and make our landscape look like Hawaii and Miami, because people have admiration for foreign things. However, in the last years, Mediterranean people have become more concerned with their cultural heritage and landscape and have started to realize that the use of traditional and native plants is important. As a result, people are going back to their origins and back to nature. They do what their ancestors did. They do not have to give plants extra water of the rain, or do they have to use extra fertilizer, rather they let plants grow naturally. This idea of going back to nature and the idea of Xeriscape do not rule out the possibility of achieving an attractive garden. When I explained to my mother the idea of Xeriscape, she said to me, "This idea is going back to my mother that she used only native plants, and they looked very attractive even without using fertilizer." People, who were sensitive to water conservation in a landscape and felt that human society did not continue important landscape traditions that our ancestors did and kept a balance with nature, decided to organize this idea of Xeriscape and to make the whole idea more easily understood by the public.

- **Mediterranean Garden Society**

The Mediterranean Garden Society (MGS) is a non-profit association and that is important to be aware of, which acts as a forum for anyone with a special interest in the plants and gardens of Mediterranean climate regions. The MGS started with a small membership in Greece in 1994. Although the roots of the society are firmly in the Mediterranean soil, the members are happy to count among other member gardeners and plants people from areas such as California, Australia, and South Africa that have similar climates to the Mediterranean region. Up to now there are members in forty countries around the world. The central role of the MGS is to facilitate the exchange of information and experiences. There are many aspects to Mediterranean gardening, and unlike gardeners in temperate Europe and North America, gardeners in the Mediterranean region do not have a strong tradition of horticultural techniques to fall back on and most gardening literature is not applicable in the Mediterranean area, so they focus more on their own hard-won experiences (MGS).

3.3 Gardening Trends in Cyprus Since 1960

Before 1960, back to the time of Socrates, Cypriots were more concerned with their cultural heritage and landscape. People appreciated nature and had a balance with it. The way that Greek theaters were built explains how Greeks appreciated and had a balance with nature. Structures fitted the landscape and the surrounding area rather than imposing them on nature. As a result, ancient people appreciated natural vegetation and maintained this special character that is called the Mediterranean landscape and gardens. After that, gardens in the Mediterranean and Cyprus changed. People changed that special character and had a major effect on nature. They imported plants that destroyed that special character of the area that our ancestors had conserved and maintained for thousands of years. Even though people imported plants and imitated other

landscape styles, in the late-twentieth century with the concept of sustainable development, and due to the long series of droughts, people are becoming more concerned with the environment. They began to appreciate their traditional landscape and to move into Mediterranean-style gardens with more native drought-tolerant plants that enhance the landscape, conserve water and reduce water bills.

In Cyprus, gardening trends since 1960 show how people have changed gardening behavior due to their way of life. Since 1960, several changing circumstances, including the British colonial influence, followed by Cyprus independence, then the Turkish invasion, preoccupied the citizens.

In 1960, the newly formed government of the Republic of Cyprus inherited an economy which exhibited most of the structural weaknesses of underdevelopment. During these difficult years, Cypriots had other priorities than to put effort into gardening. Between 1960 and 1974, the government focused its attention on the upgrading of the economic and social infrastructure, on the restoration of confidence in the economy, on the improvement of the standard of living of the population, and on the upgrading of social services. As a result, Cypriots built new houses and put more effort into landscaping. In 1974, as the war with Turkey occupied half of the island, Cypriots faced new problems. People who lived on the northern part of the island had to move to the southern part to start new lives and to look for new houses and jobs. All these problems that the public suffered in Cyprus to 1984 made them focus on the aspects of life that would help them survive. They focused on sustainable development by producing their own fruits, nuts, and vegetables. Olive, orange, lemons and fig trees, along with grapes, were the most common plants that one could find in the Cypriot household. In addition, some people produced their own olive oil and wine. As a result, up to this period of time, they did not pay too much attention to the

aesthetics of their garden but focused on gardening that sustained energy and enhanced the character of Cyprus by using traditional trees. (See the following pictures with traditional gardening.)

Figure 3.5 – Olive trees. (Photo by author.)

Between 1985 to 1990, the economic crisis was over, and people were not suffering as before. They worked hard and they overcame most problems brought on by being independent and at the war in 1974. The main reason Cypriots overcome their problems is that tourism brought a lot of money to the island in a very short time. From 1973 to 2000, tourism increased from 264,000 to 3 million people. The extremely low cost of living in Cyprus made Europeans select Cyprus as one of the best and cheapest tourist destinations in this period of time. A lot of Cypriots rely on tourism as their second job. As a result, Cypriots built more luxurious houses and hotels and started to spend more money on landscape design.

Figure 3.6 – Lemon trees. (Photo by author.)

In addition, a lot of Cypriots started to study abroad in Greece, the United Kingdom, and in the United States and brought back "new ideas." More landscape professionals/horticulturists entered the market and introduced "new ideas" and imported more plants. As a result, a massive trend of using imported plants instead of the natives occurred in these years by careless or insufficiently knowledgeable people about the native plants of Cyprus. According to research done by the Forestry department in Cyprus, in the period of 1990 to 1994 they planted 200,000 gold gress at a cost of $450,000. By 1997, 60% of these plants had died due to diseases and due to the climatic conditions in Cyprus. (See the following pictures with gold gress trees, grassy areas and other imported plants.)

Figure 3.7 – Gold gress trees. (Photo by author.)

Figure 3.8 – Use of cultivated lawn. (Photo by author.)

Figure 3.9 - Imported plants. (Photo by author.)

Figure 3.10 - Dry gold gress. (Photo by author.)

Even though these imported plants looked fine at the beginning, they cost a lot of money and they needed a lot of water and maintenance to survive in Cyprus. Also, these imported plants, which were mostly imported from the Netherlands, changed the character of Cyprus. People forgot their roots, their cultural heritage, and their special landscape that foreigners admired. They felt that olive trees, fruit trees, and thyme were out of fashion. After that trend was established, between the years of 1990 and 1992, the Forestry department did research in Nicosia to count the use of imported plants versus native plants. The result was that 90% were imported and only 10% were natives. When they figured out these depressing results, this department, in order to increase the use of native plants, organized an educational campaign. Seminars were held for schools, horticulturists, and landscapers. The goal was for people to realize to the advantage of using native plants instead of imported plants. TV, radio, leaflets, and the Internet were some of the means of communication to promote this idea.

By 1995, when there began a long drought that lasted for five years, people started to change, not only because of the educational campaign but also due to the lack of water. Their options during the drought years were to abandon their gardens or to use more drought-tolerant plants. Even though people were not accustomed to having professional landscapers design and implement their gardens, the series of drought years forced people to seek advice from professionals. By 2000, the government and the people had become much more environmentally concerned than before. For example, the green spaces and parks designed by government professionals include native plants or plants adapted to Cyprus. The highways all over the island are planted mostly with *Nerium oleander*, which needs a low quantity of water. Also, the roundabouts are carefully planted with native plants or plants that are adapted to Cyprus. As a result, in the last couple of years, gardening in Cyprus has helped to enhance the character of the

island rather than to create a foreign image that does not belong here. (Kyriakou 2001). (fig. 3.11- 3.13).

Figure 3.11 - Water conservation garden. (Photo by author.)

Figure 3.12 - Water conservation garden. (Photo by author.)

Current gardening trends include the public becoming more environmentally concerned than before and realizing that their gardens can survive only by using native plants or by using extreme quantities of water that we do not have on our island. Now not only do people realize the importance of sustainable development, they also understand the importance of going back to their roots that their ancestors were proud of. So the public began asking professionals for advice. In conclusion, the government and specifically, the Forestry Department, helped a lot by reintroducing the plants native to Cyprus. This department can help but it cannot do everything to change the situation. Nurseries, landscape designers, and horticulturists must help to break this cycle of using imported plants. In Cyprus the supply of native plants in nurseries is very limited. If the public is convinced and ready to use the plants but plants are not available from nurseries, then the goal cannot be achieved.

Figure 3.13 - Water conservation garden. (Photo by author.)

3.4 The Importance of Gardens in Cypriots' Lives

Gardening in Cyprus is not a recent phenomenon. It has its roots back to the period of Solomon and Homer. From their descriptions, gardens were important and became part of people's lives. Gardens were a way to have a bond with nature. In holy places in Greece and Cyprus, gardens were important and part of community ceremonies. For example, in Athens *Laurus nobilis* and *Pistacia lentiscus* were planted around the albas of the gods of Olympus. In Greece gardens usually look naturalistic and enhance the character of the place. Gardening was also important by producing products like grapes and wine and by providing shade, which is essential in the Mediterranean climate, which is very hot. (See Figure 2.10.)

The way our ancestors used their gardens had a tremendous impact for our generation. In Cyprus, people use gardens to barbeque, to relax, and for children to play. Cypriots feel that it is our culture and our custom to eat outside, to relax, and have fun as the Greek gods did. In addition, gardens are important too because they provide a cooler atmosphere during the hot weather that makes the inside space uncomfortable. On the other hand, the use of air-conditioning units is common in Cyprus but they are high in cost and people are used to living without them. Usually people have a single air-conditioning unit in their bedrooms to save money rather than to put single units in all rooms. Only retail stores have central units. Gardens in Cyprus are not only important because they provide a place to meet, relax, eat, and to have shade and cool air, but they are also important due to the safe environment that Cyprus provides, which lets people sit outside until early in the morning. (fig. 3.15). An important gardening custom that makes Cypriot gardens look different that the gardens in the United States is the use of a fence in all sides of the house. Based on my observations, almost all houses define

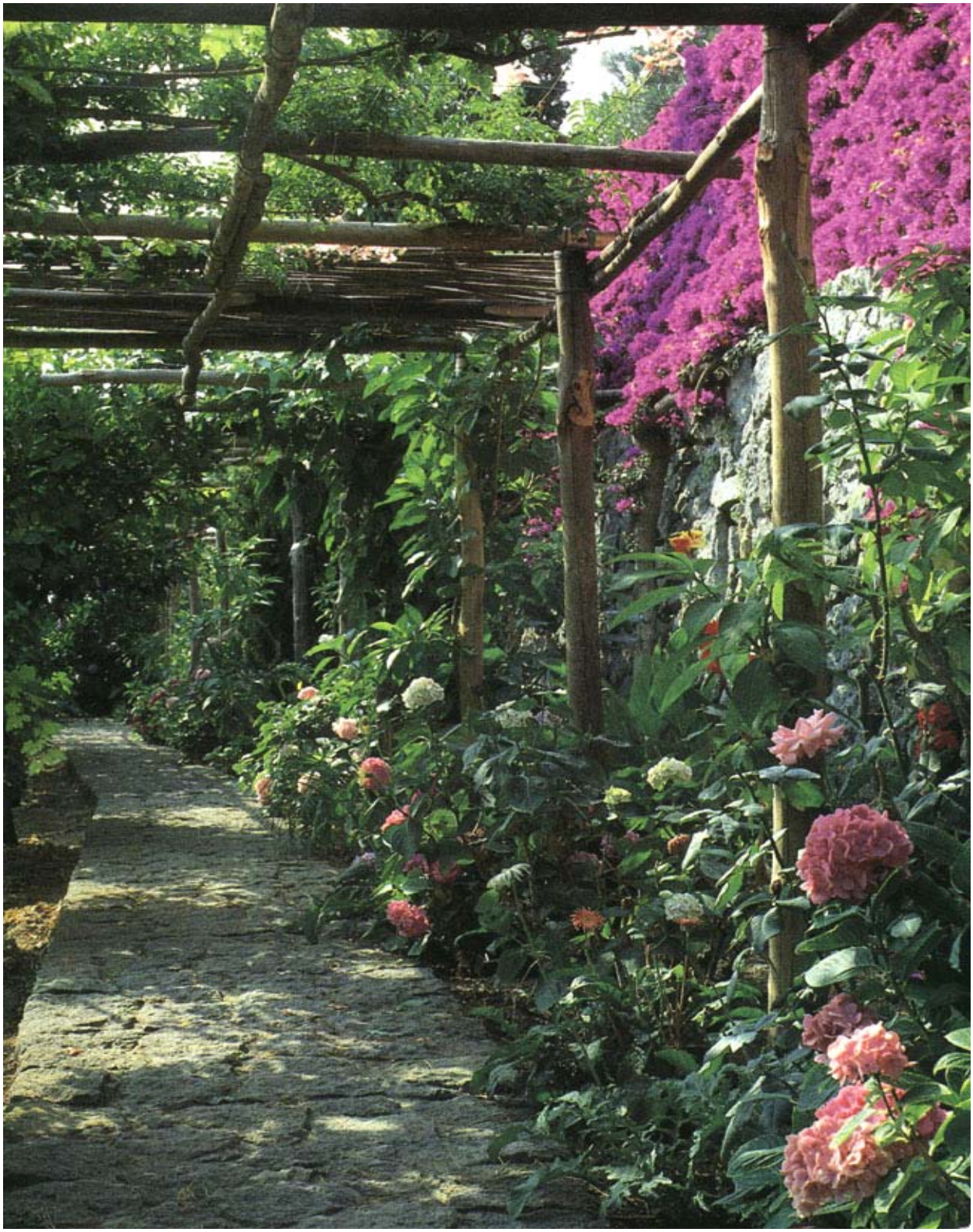


Figure 3.14 - Use of pergolas and vines. (Photo: Latymer 11.)

Figure 3.15 - Eating outside is a part of the culture. (Photo by author.)

their property line with a fence or a gate. Cypriots use also the fence to protect the garden from dogs. In general, it is used more for a cultural custom that creates a feeling of security. Even though Cypriots use the fence, I believe that most Cypriots feel that it is not good manners to be isolated from neighbors. In our culture neighbors could be part of the family because they live next to you. Creating privacy areas next to neighbors means that you like to have a distance from them. Moreover, according to my experiences, most Cypriots are too much concerned with their privacy in sitting outside. A lot of people like to sit at the front porch while having a dinner with friends. However, this does not mean that Cypriots are less likely to have privacy areas in their gardens.

Furthermore, gardens in Cyprus are not just important due to our culture and customs, rather they are important for the following reasons: green spaces reduce the noises of urban places, plants filter the dirt and clean the air, gardens help for the aesthetic engagement of outdoor space, and finally they help to increase our quality of life.

Figure 3.16 - The garden enhances the character of the place. (Photo: Latymer 21.)

In addition, the appropriate plant selection that includes native plants of Cyprus and drought-tolerant plants adapted to Cyprus can make the outdoor experience more enjoyable. These plants help to conserve the traditional landscape and the naturalistic look, and maintain the cultural

heritage of Cyprus because these plants are better adapted to the climate and the geomorphology of Cyprus. Second, they do not need a lot of water to survive and they need less maintenance, like pruning, weeding, and proper fertilizing. Also, they match with the surrounding environment, which helps to preserve the character of the island.

Chapter 4. Xeriscape Guidelines Developed by Denver Water Department

According to books and articles written on water conservation in landscaping, the seven principles of Xeriscape are fundamental when designing a residential garden that conserves water. The Denver Water Department in Colorado, in order to make garden designs that conserve water easier and more practical, put together the Xeriscape principles. When I tested these guidelines on the two sites in Cyprus, I was provided with very useful information that helped me to adapt the guidelines to Cyprus. The experience that I gained by using these guidelines to prepare conceptual diagrams for each site helped me to identify if I need to elaborate the guidelines with general information and also to verify what type of information I need to provide to make the guidelines adapted to Cyprus. The following guidelines are the original Xeriscape guidelines that were created by the National Xeriscape Council.

The seven principles of Xeriscape are:

- Planning and Design
- Soil Analysis
- Practical Turf Areas
- Appropriate Plant Selection
- Efficient Irrigation
- Use of Mulches
- Appropriate Maintenance

Planning and Design Envisions the creation of a water-efficient landscape design. First, we should draw a base plan of our yard with the existing conditions, trees, shrubs, and grass

areas and structures, which provides direction and guidance. Slope and grade changes should be considered in this plan, too. It is recommended to use a plan in a 1:10 or 1:8 scale. Second, we consider the amount of money we want to spend to complete this garden, and the maintenance we want to do. Third, we create zones of high, medium, and low water use so that we group plants with similar needs together in beds. In addition, proper grading is important to allow water to soak into the soil and is used by plants with the greatest need of water. Moreover, terracing and retaining walls can be effective in correcting steep slopes. Plants that are in high water zones can be placed in front and close to the house. Also they can be placed in low-lying drainage areas or in the shade of other plants. Drought-tolerant plants can be better collected on the side of prevailing winds to the northwest side of the garden, providing shelter for less tolerant plants (Fig. 4.1-4.9 are provided by www.ces.uga.edu web site)

Figure 4.1 - Planning and design

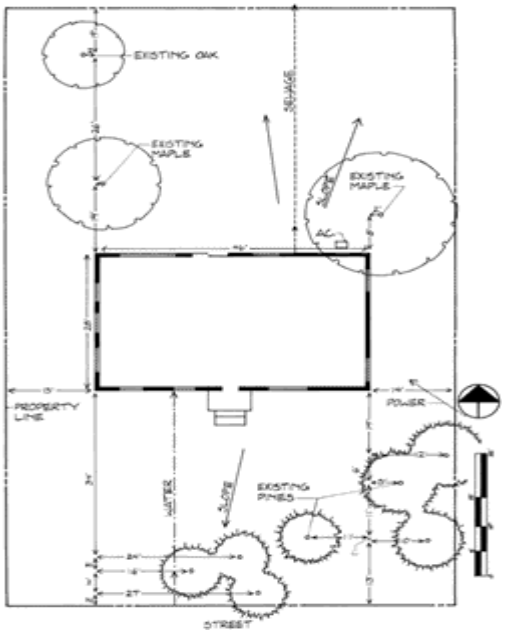


Figure 4.2 - Example of base plan

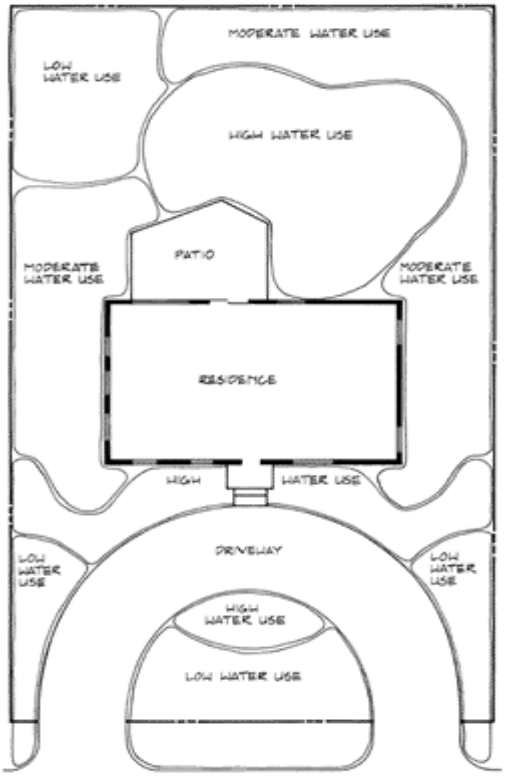


Figure 4.3 – Water-need zones

Soil Analysis A soil analysis is important to help determine whether soil improvement is needed for better water absorption and improved water-holding capacity. Sandy soils drain easily and quickly after a rain, and they have low moisture-holding capacity and low nutrient capacity. Clay soils are capable of holding a great quantity of water but in rainy conditions often lack oxygen and have poor drainage. Both of these soils can be improved by the generous addition of organic matter. Organic matter can consist of compost, well-rotted manure, or peat moss. One should spread a layer of organic matter 7.6-10 cm (3-4 in.) thick on the surface of the soil to be improved and then thoroughly incorporate the organic matter into the existing soil. However, incorporating organic matter is not necessary for large turf grass areas and is not economically feasible. Also, for native plants, soil amendment may not be necessary, but it is necessary to loosen the soil.

Figure 4.4 – Soil analysis

Practical Turf Areas It is recommended not to use impractical turf areas such as long and narrow areas or odd-shaped areas. It is inconvenient for irrigating systems. It is suggested that turf grasses be used as a planned element in a landscape. Buffalo grass and blue gramma grass are the recommended type of grasses for Xeriscape gardens in the Southwest U.S. Buffalo grass may cost more than other turf grasses but the cost is becoming more competitive. Also, it is

recommended to reduce the size of the lawn and try to apply water infrequently and thoroughly. If residents have no lawn, they do not have to cut, fertilize, or water it. In addition, they do not have to pay for a lawn mower, fertilizer, and most important, for water.

Figure 4.5 – Use of lawn

Appropriate Plant Selection. A good plant selection includes plants that they are in balance with the natural environment and are adapted to the region's soil and climate. These plants will also help to enhance the character of the landscape. Native plants and drought-tolerant plants have lower water demands, fewer pest problems, and less fertilizing needs.

Figure 4.6 – Plant selection

Efficient Irrigation By simply using efficient irrigation, we can instantly save 30 to 50% on our water bill. An irrigation system is the way we provide plants the right amount of water at the right time. There are two irrigation systems: sprinkler irrigation and drip irrigation. Hose-end sprinklers and permanent underground systems are the common types of sprinkler irrigation systems, which are most water efficient when we water between late evening and mid morning.

Figure 4.7 - Efficient irrigation

Usually the permanent sprinkler system is more water-efficient than the hose-end sprinkler. For grass, low-pressure, low-angle sprinklers irrigate best. The second irrigation method, drip irrigation, offers increased watering efficiency and plant performance when compared to sprinkler irrigation. Drip irrigation allows safer use of "salty water" in the landscape and garden. If you water by hand, one should avoid oscillating sprinklers and other sprinklers that throw water high in the air. It is better to water deeply and infrequently to develop roots. The best time to water is between 9 p.m and 9 a.m. **6.**

Use of Mulches Use mulch wherever possible. Good mulch conserves water, reduces the weed population, prevents soil compactions, and keeps soil temperature more moderate. In addition, mulches give a finished look and increase the visual appeal of a garden.

Figure 4.8 – Use of mulches

Mulches can be organic materials such as pine bark, compost and woodchips or inorganic materials such as lava rock, limestone or permeable plastic, a non-plastic sheet. Inorganic mulches should be applied at least two inches deep and rarely need replacement.

Appropriate Maintenance. Maintenance preserves the beauty of the Xeriscape landscape. The first year or two, the landscape will require a fair amount of weeding but as plants mature, the maintenance labor reduces over time. In addition, pruning, weeding, proper fertilizing, pest control, and irrigation system adjustments conserve water (Water Denver Colorado).

Figure 4.9 – Appropriate maintenance

The following illustrations, from the Denver Water Department web site and popular publications, show examples of the range and effect of Xeriscape gardens.

Figure 4.10 - Xeriscape garden before the construction. (Photo: Water Denver web site.)

Figure 4.11 - Xeriscape garden after the construction. (Photo: Water Denver web site.)

Figure 4.12 - Xeriscape garden before the construction. (Photo: Water Denver web site.)

Figure 4.13 - Xeriscape garden after the construction. (Photo: Water Denver web site.)

Figure 4.14 - Xeriscape garden after the construction. (Photo: Water Denver web site.)

Figure 4.15 - Xeriscape garden after the construction. (Photo: Water Denver web site.)

Figure 4.16 - Xeriscape garden with cactus. (Photo: Garden design, May, 1995.)

5. The Case Studies

5.1 Introduction of the Sites

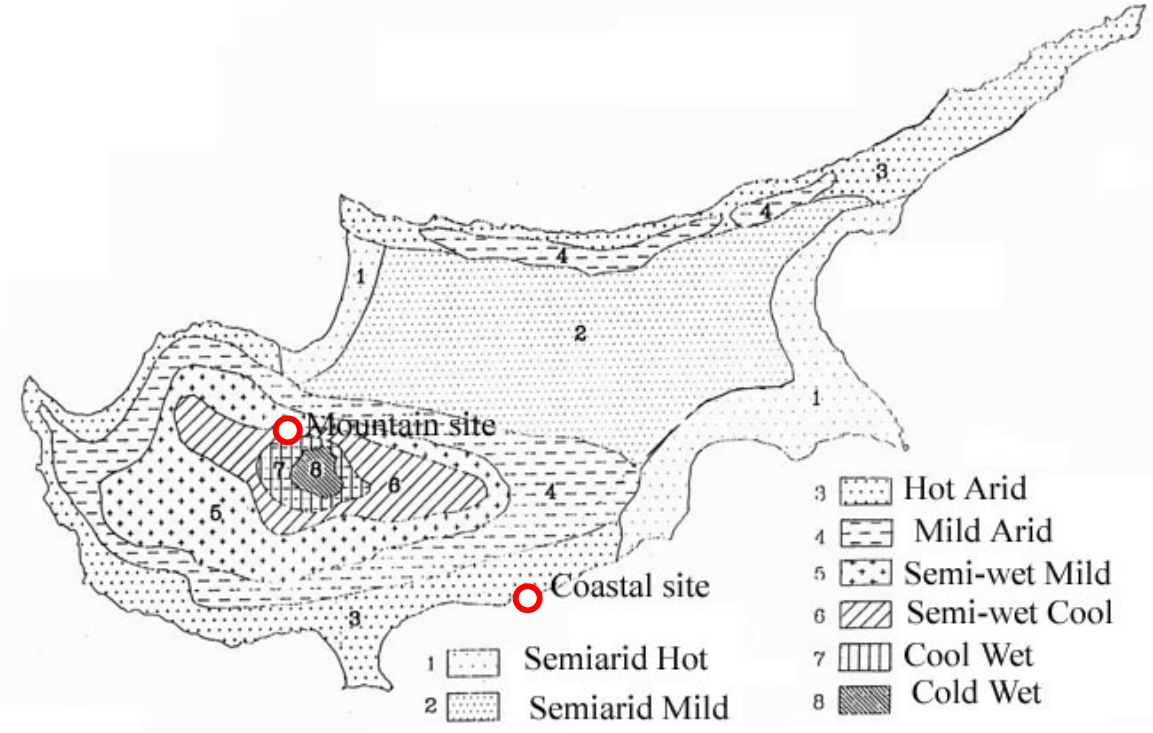


Figure 5.1 - Location map of the sites. (Figure by Vaso Pandela.)

Applying the Denver guidelines to the two sites that I selected as case studies is part of the process of adapting the guidelines for Cyprus. The two residential gardens in Cyprus test how to apply the guidelines in two sites that differ in geographical position and that represent two important geographic extremes, the coastal plain and mountains of Cyprus. Gardens in mountain and coastal areas of Cyprus will belong to two different bioclimatic zones, resulting in different precipitation, temperature, altitude, and flora. Also, slope, wind, soil, and water are different due to the geographical position of each site. These differences result in different design decisions and plant selection for each case study. In addition, the microclimates of each residential case study garden and the way the architects sited the houses create different microclimates that must be taken into consideration when designing the outdoor spaces.

A base map with the existing conditions of each residential site is provided as background for the case studies. Next, an inventory base map with existing conditions, microclimates, the bioclimatic zones, and other important factors of the site is provided for each of the residential gardens. Then, a conceptual diagram is prepared for each garden, based on the inventory of each site that was done before and based on Xeriscape guidelines adapted to Cyprus. This diagram indicates recommended zones of plants, which range from low to high water needs, recommended location of structures and general recommendations that can help owners to make the right designing decisions.

- **Case Study #1 Papaphilippou Residence**

House on the Beach

Figure 5.2 – House on the beach. (Photo by author.)

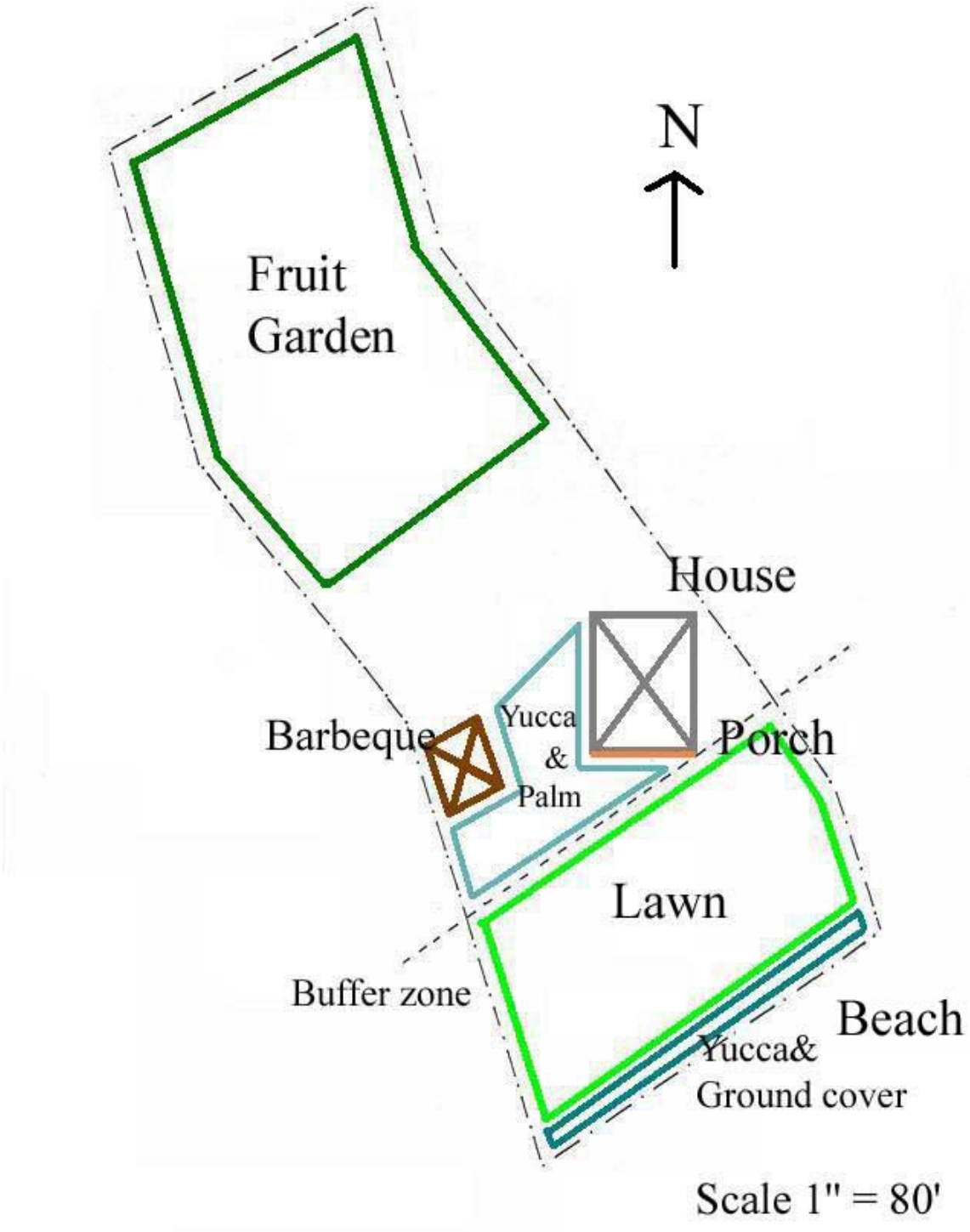


Figure 5.3 – Beach house base map with existing conditions.

The Papaphilippou family owns the house, which is located in the village of Agios Theodoros, south of Cyprus (Bioclimatic zone 3) (fig. 5.1). It is a two-story house

on the beach with big windows having unspoiled scenery of the beach on the southern side. The family uses the house mostly on the weekends. The owners of the house, who love gardening, did the installation of the landscape themselves. They have already planted a fruit garden at the northern side, palm and other drought-tolerant plants in the areas close to the house, and a lawn mainly on the southern side. In the future, they plan to have a swimming pool. They did not put a limitation on budget. The total area of the site is 50,400 sq ft. The house is close to 5,000 sq ft. The house, based on existing zoning regulations, can occupy at most ten percent of the property, due to environmental factors.

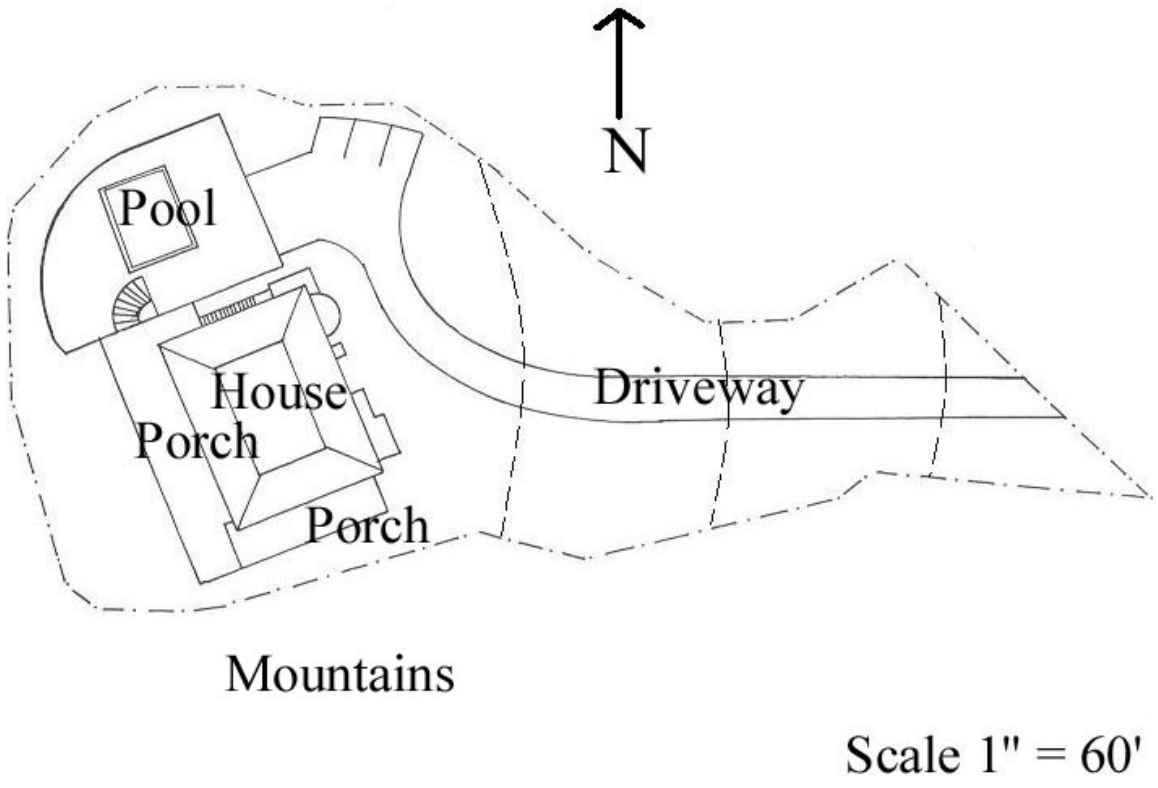


Figure 5.4 – Base map with existing conditions of the house on the mountain.

Also, as seen in Figure 5.3, the dashed line indicates the buffer zone for the beach, which means that beyond this line you cannot build structures. This garden can be successfully transformed into a Xeriscape garden because its programmatic requirements

meet the two important intents of Xeriscape, which are low maintenance due to infrequent visits of the owners, and second, the importance of enhancing the character of the beach.

- **Case study #2 Aggelide Residence**

This house (fig .5.3) is located in the village of Evrychou, which is northwest of Cyprus, very close to the Troodos Mountains (Bioclimatic zone 6). The site is located inside the village but in an area very close to the old village of Evrychou. The house will be constructed in a couple of years. The site plan was provided by the architect. The Aggelides family lives in England at this time, but they plan to move to Cyprus soon. They like the fact that their garden is minimal in maintenance due to their frequent travels outside of the country. The house will be two-story and will have a swimming pool. They love the site because of the diversity of views. They have also expressed the desire to have a vegetable and fruit garden. The site does not have any zoning regulations that affect design decisions. They did not put a limitation on the budget. The total area of the site is 23,400 sq ft; the house is close to 3,600 sq ft. The diverse views of the site will be taken into consideration when designing the garden. This site can also be turned into a successful Xeriscape garden because of the owners' requirements; they wish to conserve water and to enhance the native character of the area.

5.2 Inventory and Conceptual Diagrams of the Case Studies

House on the Beach

In figure 5.5, I refer to the existing uses of the site, the microclimates, and other important factors of the residential garden on the beach. Based on the bioclimatic zone of

the site, which is zone three, the normal precipitation is close to 16 to 24 inches. The average minimum temperature of the coldest month is 43 F and the altitude range from 0-984 ft. The site slope close to zero percent; it is located at the same elevation as the beach. On the northwestern side of the lot there is a fruit garden; on the northwestern side of the house there is a barbeque area and a garden with palm and drought-tolerant plants.

Figure 5.5 - The fruit garden. (Photo by author.)

On the south side, a front veranda has nice scenery of the beach. Palms and other drought-tolerant plants are planted close to the veranda. The southern side has lawn, and the area next to the beach is planted with yucca and groundcover. The views, sun, wind, and slope are important factors that were taken into consideration in designing decisions. The view from the house to the southern side, the beach, is the most important view. (See fig. 5.9) The other views look to open fields. (fig. 5.10).

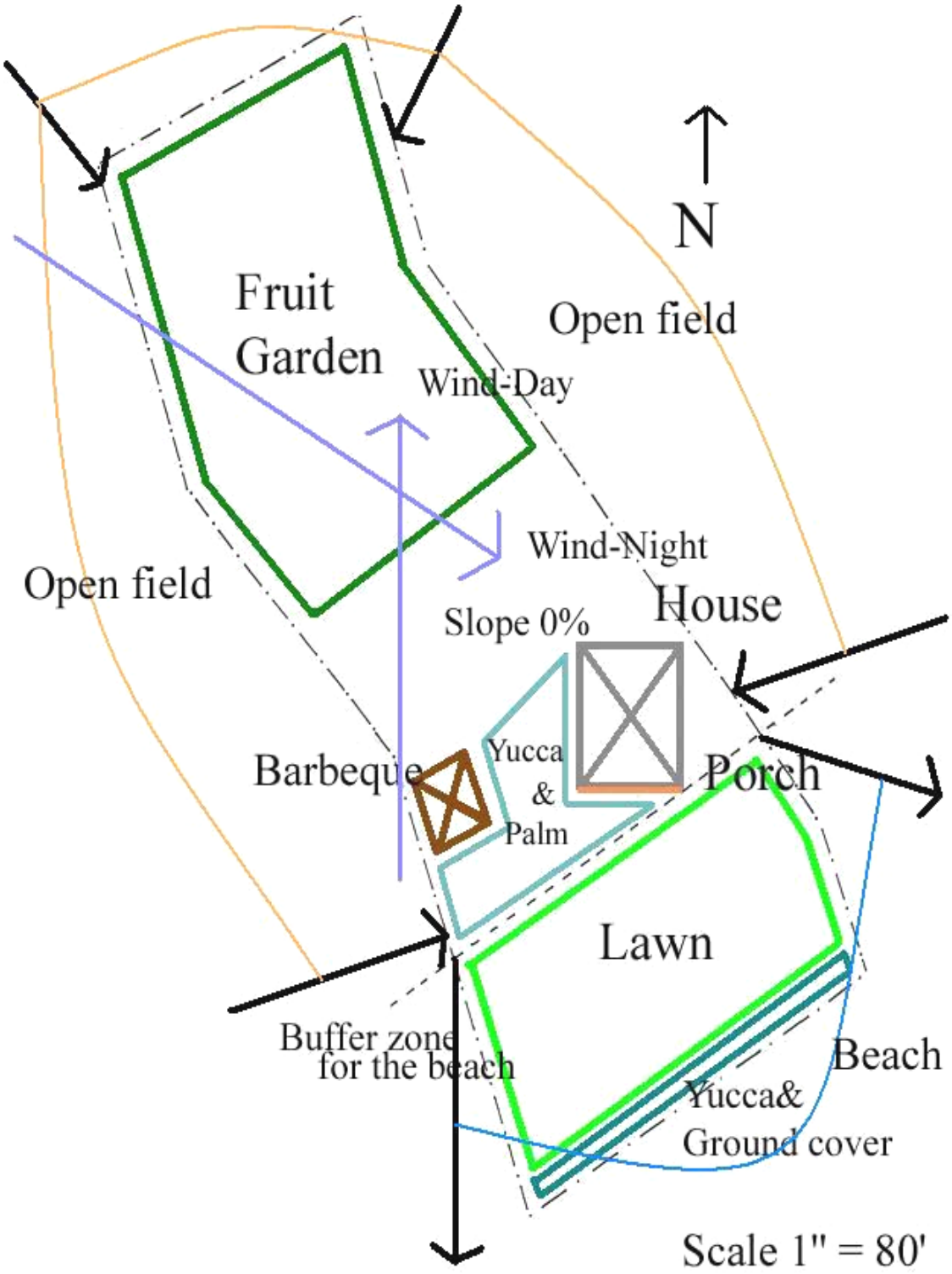


Figure 5.6 – Inventory base map of the house on the beach

Figure 5.7 - The barbeque area. (Figure by author.)

Figure 5.8 - The area from the beach to the house. (Photo by author.)

Figure 5.9 - View from the house to the beach. (Photo by author.)

Figure 5.10 - View from the house to the open field. (Photo by author.)

Due to the limited structures on the site, the area is almost always sunny; the northeastern and some of the southeastern corner of the house get afternoon shadow, which the house creates. During the day, the wind blows from south to north and at night, from northwest to southeast. The minimum wind run in the site is 1.8 m/s, the maximum is 8.4 m/s, and the average is 4 m/s. The site is flat, and the slope is close to zero percent. After the inventory plan, the next important step is to test the soil and water of this site.

A mechanical and chemical analysis of the soil of the site was done by the Ministry of Agriculture in Cyprus (Appendix 5.1, 5.2). Based on the analysis the composition of the soil is clay because the percentage of clay is higher than 35%. This composition of soil which is 37% clay, 39% silt, and 24% sand is considered fairly good. This means that the drainage and water absorption are fairly good and its holding capacity is very good. Due to the climatic conditions of the site, which receives low precipitation (16 to 24 inches), a composition of soil with 24% sand, which means it does not have perfect absorption, is not a big problem. Fertilizers can be added to help the absorption of this soil. This analysis shows that the pH is 8.7, which is considered high, but for Cyprus conditions this level of pH is acceptable. Based on the chemical analysis of the soil of this site the level of potassium is considered low (50 ppm). The normal level is above 200 ppm. Potassium helps for drought hardiness, and nitrogen helps for extent of root penetration, but results in loss of color. In addition, the salinity of this soil is 993 ppm, which is considered a low level. However, the level of free lime is high, 23%. Soils high in free lime tie up major and minor elements making them less available to the plant. A fertilizer can improve the level of free lime in this soil. As a result, this site has a fairly good soil that does not face any serious problems. However, fertilizers that contain acid,

humus, carbonate, and potassium can improve this soil. Plants should be selected based on the soil analysis.

Water for the site comes from a dam, the Kalo Chorio Dam. Based on water analysis of the site that was done by the Ministry of Agriculture in Cyprus, the water quality does not present any problem (see Appendix 5.5). The level of boron is only 0.1, which is considered very low. The level of salinity is also at good levels because it is lower than 1000 ppm. The level of conductivity is also low, 0.5 ppm (higher than 0.75 is considered low in salinity).

- **Design Concept for the House on the Beach**

After preparing the inventory map, and identifying the type of soil and quality of water of the site, I have reviewed guidelines four to ten. As a result, I have come up with the following conceptual map and recommendations for the site:

- **Area A** It is recommended that on the northwestern side drought-tolerant evergreen trees should be planted to provide privacy, shade to the site and to the fruit garden, and shelter to the site from the prevailing winds. It is better to plant double row of trees to be effective in summertime. Area A close to the house can be planted to provide privacy and shelter from wind but it should be planted loosely to let some prevailing winds blow to the house, which will be needed due to the high humidity of this site located on the beach. The existing barbeque area should be moved close to the house for convenience.
- **Area B** The fruit garden should be moved to the northeastern side of the property. The fruit garden has medium water needs, so it should be shaded by

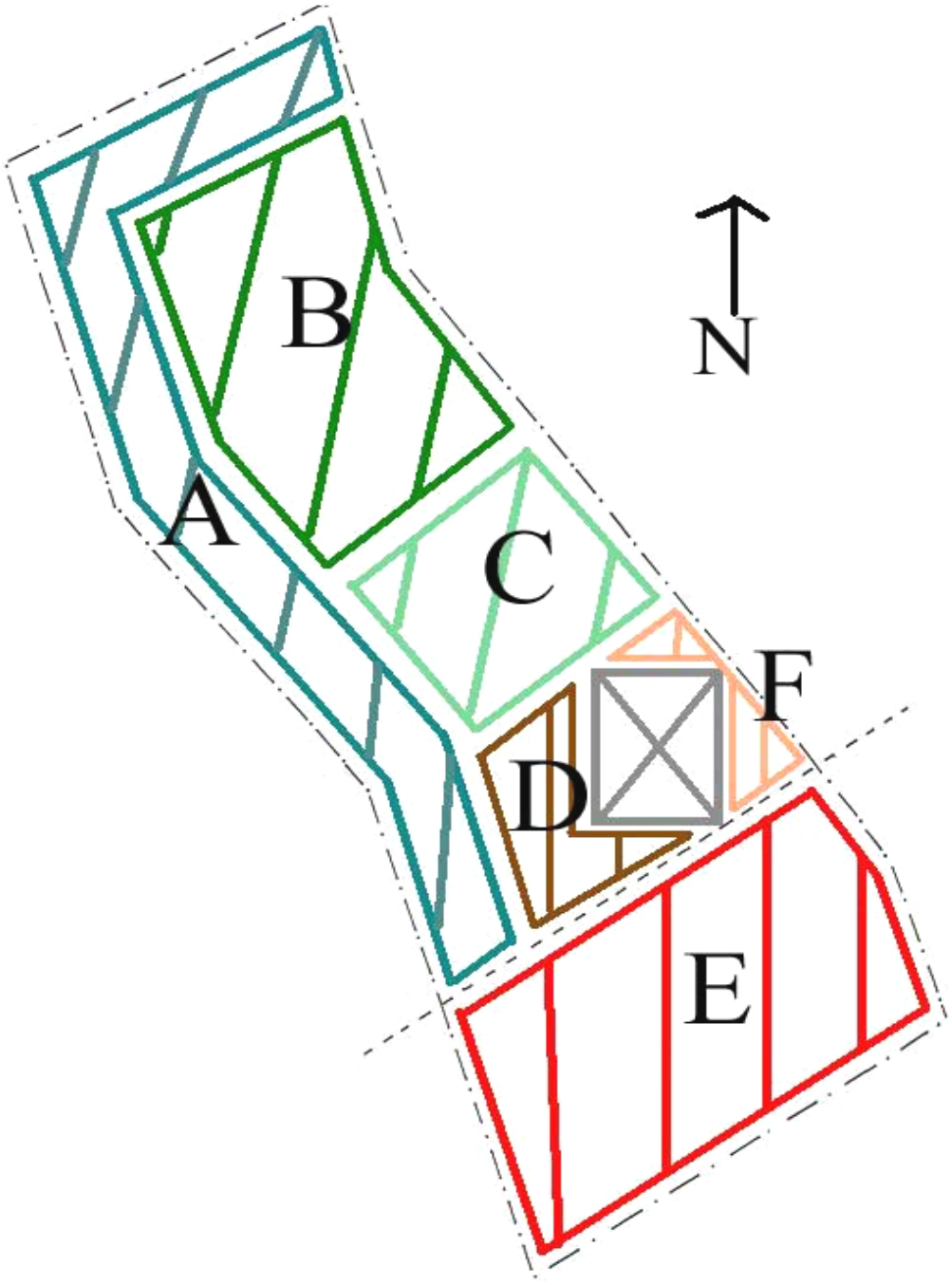


Figure 5.11 - Conceptual diagram of the garden on the beach

drought-tolerant plants (from the plants in area A). Also, this garden, for convenience reason should be moved closer to the house. Owners will love to have the fresh fruits as close as possible. The existing irrigation can be kept and it can be moved with the fruit garden.

- **Area C** This area is suitable for medium water-need plants that benefit from the shade of evergreen trees on the western side. This area can be used as a backyard garden and also partially block the view on the eastern side of area C. Also, part of this area should provide parking space.
- **Area D** This is the area close to the house that needs better connection with the indoor space. Also this area can be a good spot for the pool and for an overhead structure with vines, which should be built away from the buffer zone. A pool in this area will have privacy, shade from plants in area A, and a connection with the view of the beach. It is recommended to use evergreen vines so that leaves do not get into the pool. In addition, plants close to the pool area should be selected to be low maintenance for the pool and not to attract unwanted insects. Also, high water-need plants can be placed in a compact area close to the house, as with plant containers.
- **Area E** The size of the lawn, which takes most of the front area, should be reduced and replaced with a mixture of St. Augustine and Bermuda grass that will conserve water and create a nice green mat of lawn all year around. The size of existing lawn does not save water or energy, and also it does not enhance the character of the beach. This area should be used to encourage the views to the beach. This is the major element of the whole site. Low drought-tolerant plants

can be used at this spot that gets the most sunshine. Plants should be carefully selected to enhance the special character of the site, which focuses on the beach. The combination of native shrubs and the small scale of the proposed lawn will create a friendlier entrance to the whole garden. In addition, the use of stones, sand, and other related elements can be used to bring the beach into the site.

- **Area F** This is the area that gets the most shade. As a result, a patio and a barbeque area can be located here. It is important to have the patio and barbeque area close to each other and close to the house. In addition, the way that winds blow on the site supports the location of the barbeque area because the smoke of the barbeque moves in the direction opposite the house, which will be the eating area. The size and the location of the gardens do not address issues concerning neighboring structures because the site is located next to open fields.

Recommendations

- Be aware that blocking winds and views can have disadvantages, too. Select the right material and size that can be attractive, can provide privacy, and that can let some likely winds come in the site. Also, there are types of fences that create different effects from inside to outside. Structures and plant materials can help for creating a different atmosphere on a garden-like enclosure or disclosure, which is important for our cultural traditions in Cyprus. In my opinion, a combination of both can make the garden an interesting place to be at different times and for different occasions. However, as I stated before, this site does not face any issue of blocking views for privacy but the owners may desire the feeling of enclosure.

- Due to the fact that the site is flat, it is recommended to create saucers around the roots of trees so that run off water can get into plants. In addition, areas A, D, and F can be regraded to bring runoff water to areas B and C, in which plants are higher in water needs. This idea to hold runoff water in the site will help the composition of soil that has low water absorption. Area E can be regraded to provide water to the proposed lawn area.
- The soil of the site could be improved by the addition of fertilizer that contains acid to help the absorption of nutrients because the soil is very alkaline. Humus fertilizer is suggested in coastal areas, which is as low as 1-2 %. Also the addition of fertilizer that contains potassium and carbonate can improve the soil because the analysis shows that their levels are low. Also, a fertilizer that helps the level of free lime should be considered.
- It is suggested to install an irrigation system in most of the site due to the rare visits of the owners. It is recommended to use gray water for watering the landscape but it is better not to water the fruit garden and playground areas. Other areas can be watered with the use of gray water and the installation of a drip system. A sprinkler system can be used for the lawn area. The wakki device can also be used in locations when drip irrigation is impractical. Their use can be increased based on the owner's recommendations. A water source needs to be close to the house to water high water-needs plants, which should be in a compact area. These can be watered with a wakki device or a water container. Remember, the use of a water hose for watering the landscape is against the law.

- Use of mulch is recommended in most of the site in order to conserve water and to control weeds. However, plant areas that are not irrigated and are high in sun exposure should be covered with mulch to hold moisture and to help roots to grow. Organic mulches are not recommended in areas that are subject to fires, for instance, in areas D and F, which are close to patio areas where people can throw cigarettes. As I stated before, the right selection of mulch will enhance the character of the beach setting.
- Papaphylippou owners should start their Xeriscape garden in the fall. They should be aware that they will spend more money and time in the first couple of years but after that, maintenance costs and labor will be reduced. The owners should be aware of the plant list (table 6.1) that provides information on water needs, bioclimatic zones, and other important information. Feel proud of the garden that enhances the character of the beach in Cyprus and uses Cypriot native plants. Be aware that even if we have more water due to desalination of salt water, Xeriscape gardens are valuable because they are more environmentally friendly, enhance the special character of Cyprus, and reduce water bills.
- **House on the mountains**

In figure 5.12, I analyze the existing site and the microclimates of the site. Based on the bioclimatic map, the site belongs to zone 6. The normal precipitation is 24 to36 inches, the average minimum temperature of the coldest month is 32 to 37 F, and the altitude is range from 2953 to 3775 ft. The existing site does not have any structure because the house is not yet under construction. An important characteristic of the site is that it has open views in 360 degrees. Not only are all the views open, they are also

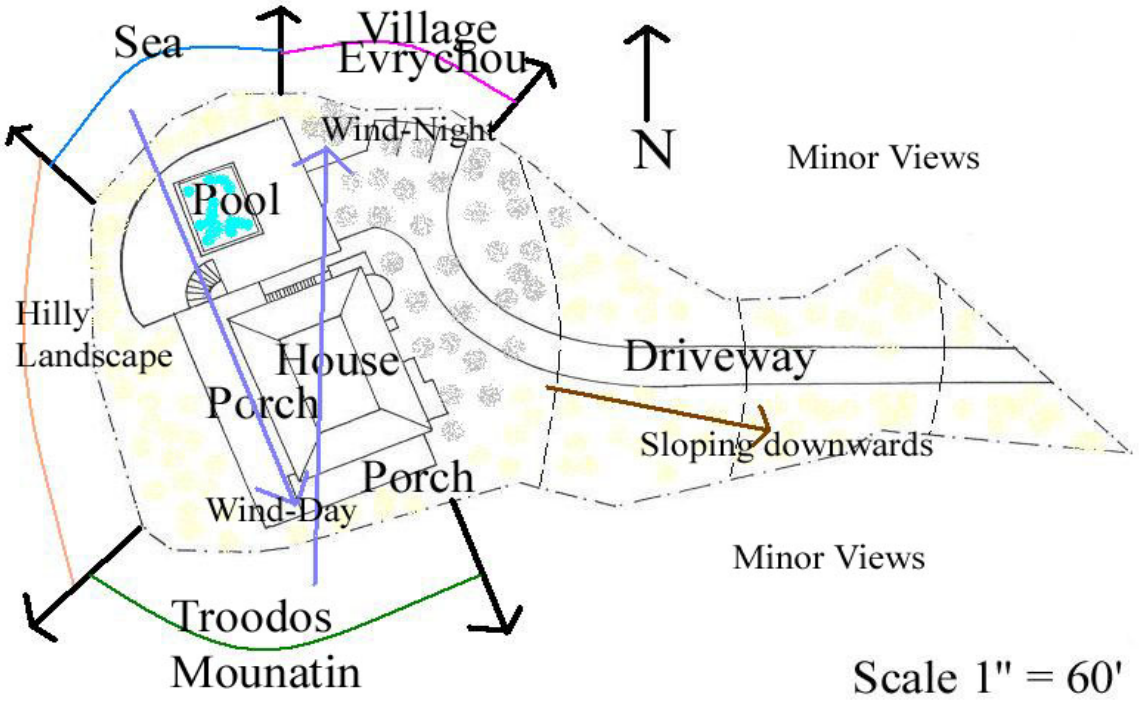


Figure 5.12 - Inventory base map of the house on the mountain. (Figure by author.)

Figure 5.13 - View of the sea. (Photo by author.)

diverse, which makes the site uniquely attractive. On the northwestern side is a view of the sea. (fig. 5.13.) On the west side is the view of a hilly landscape whose colors are brownish green. (fig. 5.14). On the southern side is a view of the Troodos Mountain, the

Figure 5.14 - View of hilly landscape-West. (Photo by author.)

scenery of which is colors of dark green. (fig. 5.15). From the southeastern to northeastern side, the view is to the same hilly landscape as before. Finally, on the north side is a view of the village Evrychou in brown and white colors that remind the viewer that there is civilization nearby. (fig. 5.16).

Figure 5.15 - View of Troodos Mountain. (Photo by author.)

Figure 5.16 - View of the village Evrychou. (Photo by author.)

Other important characteristics of the site are the wind, sun, and slope. Winds blow from the northwest to southeast during the day, and at night, they change to the

opposite direction. In addition, the northeastern area of the house is under shade. The other areas have moderate sunshine because there are not a lot of structures on the site based on the size of the site. Slope also plays an important role on this site located close to the mountains, because the site gets much more precipitation than other areas of Cyprus. The slope and runoff water on the site should be reconsidered to keep the water on the site. We can see that the site is sloping downwards on the southeastern site.

A mechanical and chemical soil analysis of this site was done by the Ministry of Agriculture in Cyprus (Appendix 5.3, 5.4). Based on these analyses and according to Figure 4.12, this type of soil has 31% sand, 31% silt, and 38% clay. The composition of the soil is considered clay because clay is higher than 35%. This is considered very good composition of soil because it holds moisture and at the same time has good drainage and water absorption. In mountain areas, a higher percentage of clay helps the conditions because precipitation is higher than in a coastal area. This analysis shows that pH is 7.4, which is considered a good level based on the type of soils in Cyprus that have much higher pH. Based on the analysis, the level of soil salinity is 762, which is considered low. In addition, the level of potassium is only 68 ppm, which is considered low. The normal level of potassium is above 200 ppm. A fertilizer that contains potassium and carbonate can be added to the soil. Moreover, this soil contains 8% free lime, which is not considered a high level. In addition, this soil is high in humus because the soil is located in the mountain areas where humus is as high as 7-8%. Generally, this type of soil is considered very well and does not present any serious problems for the plants.

The Ministry of Agriculture also did a water analysis of the site (appendix 5.6). The water quality of the site shows that water salinity is very low and that it is suitable

for every crop. The total number of anions is 367 ppm and cations is 118 ppm, which is much lower than 1000 ppm, the acceptable level of salinity. Moreover, the electrical conductivity of 0.69 is also low. In addition, the level of boron is 0.17, which is fairly low and does not cause any serious problem to the plants.

- **Design Concept of the House on the Mountain**

After I analyzed some of the important factors that affect the site and got the soil and water analysis, I came up with the following recommendations and conceptual diagram of the site on the mountain:

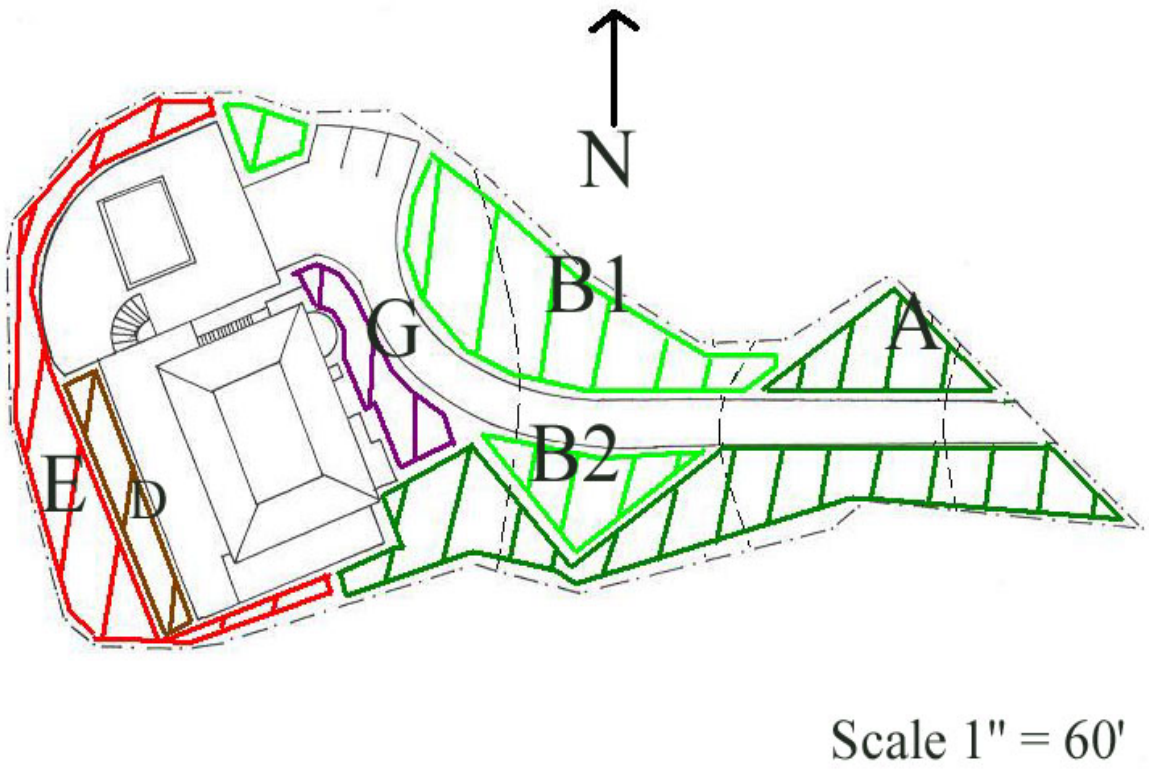


Figure 5.17 - Conceptual diagram of the house on mountain.

- **Area A** Evergreen drought-tolerant shrubs and trees will grow well in this area, which receives a lot of sunshine. Also, these plants can be used as a buffer zone

for the house, which will create necessary privacy. In addition, they will provide shelter from the prevailing winds for the plants with higher water demands. Due to the fact that the site is located in a mountain area and receives much more precipitation than other areas, area A should be considered to provide runoff water to area B. This can be achieved by creating a small-scale terrace to area A. Terraces will also enhance the character of the site, which is surrounded by mountains. Also, it will help to keep the runoff water on the site, rather than to bring it to neighbors' sites.

- **Area B1** The northeastern side receives some shadow from the two-story house and would be an appropriate area for a fruit garden that needs a medium amount of water. Also this location is convenient to the house. Terraces on this site will help to slow down the water.
- **Area B2** This area is the location of medium water-need plants that receive some shade and runoff water from plants in area A. These plants should tolerate sun. This can also be used for a small-scale area of lawn. A mixture of St. Augustine and Bermuda grass can create a nice green carpet all year around.
- **Area D** This is a suitable location for an overhead structure with vines. Low plants on the western side do not provide the essential shade; as a result, pergolas in this area will provide the necessary shade and will also encourage the views, which are very important. Evergreen vines are suggested to provide shade all year around because this area is high in sun exposure.
- **Area E** This is an area in which low drought-tolerant plants will grow well because it gets a lot of sunshine. Low plants will encourage the views to the sea,

the hilly landscape, and the mountain. It is recommended to encourage the landscape of each area on this side of the garden (sea, hills, mountain). This will help to enhance the special character of each area. This area should be regraded to keep runoff water in area E.

- **Area G** The area close to the house gets the most shade, which makes this area suitable for plants that have higher demands for water. In this area, runoff water should be retained rather than to provide it to other areas. Plants in this area can be watered with a water container or an irrigation system. This area can be the oasis of the whole garden.

Recommendations

- It is recommended not to block the views with an unattractive fence or tall trees. The views on this site give a special character to the garden. A partial screening block of views could be implemented on the eastern side where the views are minor in order to create the feeling of enclosure. This site does not involve issues of blocking views for privacy because the site is isolated. The nearest house is more than 2000 ft away. The property line can be defined by the right selection of structure or plant material.
- Soil and water of the site do not present any problems. Fertilizer of potassium and carbonate can be added to the soil to improve it.
- It is recommended to install an irrigation system for the high and medium water-need plants. Low water-need plants do not need an irrigation system because the site receives needed precipitation (area E). Drip irrigation can be installed for most of the plant areas except the lawn area that needs a sprinkler system. Grey

water can be used for irrigation of the landscape, but it is not recommended for the fruit or vegetable gardens. The wakki device can be used for plants that other irrigation systems will not reach or on terrace areas where drip irrigation might be difficult to install.

- Use of mulches is encouraged on the site but they should be selected to look naturalistic and to blend with nature. Stones of the beach and sand are not recommended because they do not enhance the character of the mountain. Organic mulches should be used with caution to avoid fires. Inorganic mulches are encouraged.
- Owners should be aware of the plant list that provides plants suitable for bioclimatic zone 6, and to get advice on the right plant selection based on their water and soil analysis. It is suggested to plant the Xeriscape garden in the fall. This new garden will be higher in maintenance cost and labor in the first couple of years but later will decrease. It is not recommended to buy large sized plants that cost a lot of money because the precipitation on the mountain areas is high enough to help the plants to grow fast. Be proud of this garden that enhances the character of the surrounding area of the site and the character of mountain in Cyprus and uses Cypriot native plants. Be aware that even if we have more water due to desalination of salt water, Xeriscape gardens are valuable because they show environmental concern, preserve the character of Cyprus, and reduce water bill.

- **Summary**

Even though the two case studies are not far in distance, there were a lot of differences that affected my design decisions, when applying Xeriscape guidelines to the two sites. The two sites belong to different bioclimatic zones; the site on the coast belongs to zone 3 and the site on the mountain to zone 6. As a result, the coastal site gets higher temperature, lower precipitation and has a lower altitude than the site in the mountain. The slope of the coastal site is close to zero percent, and the other site has steep slopes. The mountain site has a steeper slope, so I advise to create terraces to control runoff water in order to keep it on the site and to enhance the character related to the mountain. On the other hand, the coastal site has 0% slope so I do not recommend terraces but to regrade areas to keep water on the site. Furthermore, the coastal site gets lower precipitation and higher temperature, so I suggest irrigating most of the zones, but on the mountain site I do not recommend an irrigation system on lower water-need zones because the site receives higher precipitation.

The character of each case study differs, too. The character in the coastal area should enhance the character of the coastal site because it is located on the beach. The case study in the mountain enhances the character of the surrounding area. These sites will have different type of mulches, which are based on the character of each site. For example, sand and stones (beach) match with the coastal style. Another characteristic of the sites is the view. The Mountain site has important views that should not be blocked, and coastal sites should focus on the major view that is to the beach. Other views to open fields should be blocked for privacy and for creating needed shade. I propose lower sized plants on the mountain site that will encourage the views, and I propose tall trees on most

of the coastal site to block the views to open fields. In addition, the type of soil in the coastal region is more alkaline than the mountain site, and its soil composition contains less sand. Use of fertilizers that contain acid should be added to the coastal site to reduce the alkalinity of the soil. However, the soil of the mountain does not need any major improvement. Also, the location of structures and the sun and shade exposure are different from site to site. Important factors that differ from coastal to mountain areas illustrate how each case study should be handled based on the geographic location and also based on other factors, which affect the sites.

Even though these case studies are different, they have some similarities. Both sites are required by the owners to have a fruit garden and pool, and there are no limitations on budget. In addition, neither site has a major problem with soil and water analysis. Lastly, owners of both sites require low water and maintenance due to their rare visits to the site. In addition, their sites must enhance the character of the area. These are the main objectives of a Xeriscape garden.

The application of the guidelines to the above sites provides important information I will use to adapt the Xeriscape guidelines to Cyprus. First, based on this experience, the problems that I faced helped me to elaborate my guidelines to make them easier to follow. Second, this process helped to identify numerous cultural and natural factors that affect the adaptation and application of guidelines in Cyprus. A more detailed explanation will be provided in the next chapter, which will explain the process of adapting the guidelines of Denver to Cyprus and will also explain each guideline in detail.

Chapter 6. Xeriscape Guidelines Adapted to Residential Gardens in Cyprus

6.1 The Attitude of Cypriots Toward the Idea of Xeriscape

Previously, I talked about landscaping and water conservation in Cyprus, which explains what is happening in Cyprus from the governmental point of view, like the rules and regulations, the incentives, and the educational campaign. Now, I will talk about the attitudes of Cypriots toward their gardens that are associated with the drought of the last five years and toward the idea of Xeriscape in Cyprus.

As I stated before, "water conservation" is one of the most widely used phrases in Cyprus. Since the lack of water is a problem that affects everyone, the ideology of water conservation becomes part of most people's lives.

A lot of things were told about water conservation in general but not about gardens. The first reason that this happened in Cyprus is that Cypriots are not used to having professional landscape designers for their gardens. As a result, they prefer to do their gardens by themselves, leaving them to use their limited knowledge of water conservation and landscaping. Most of the people that conserve water in their gardens are those that are doing it without realizing it. This means that by luck they have in their gardens mostly cactus or native plants that stay alive during drought because these plants do not need much water. Second, the organizations that deal with water conservation in gardens, like the departments of the government that deal with water, the ones that deal with the environment, the nurseries, and landscape designers, are dealing with it as a minor aspect of their organizations. For example, most of the nurseries are not offering native plants because they insist that Cypriots do not like them. The supply of native plants in Cyprus should be increased by the nurseries so that they are available to people who are willing to use them.

The drought of the last five years has forced Cypriots to keep their gardens to a minimum or abandon them altogether. Even though "water conservation" is one of the most widely used phrases in Cyprus, most of the public in Cyprus repeatedly mentioned to me that they could not even think of the existence of a garden while there is a serious water shortage. Based on my observations, I find that Cypriots associate the idea of a garden with a green lawn and colorful plants and believe it cannot happen when there is water scarcity. During my interviews with professionals and non-professionals about landscaping and water conservation, I asked them to give their opinions of the idea of Xeriscape and its implementation in Cyprus. Most of the people in Cyprus are not familiar with the term Xeriscape, but most of the professional people are familiar with the general idea of water conservation in gardens. On the other hand, the public had no clue what Xeriscape is about; they understood that the idea is associated with cactus and xerophytes but they cannot understand the idea of using native plants. It looks strange for them to use cactus and xerophytes in a garden because they have negative attitudes toward these kinds of plants and cannot see cacti as major elements of a garden. They mention cacti are not safe plants for kids. Furthermore, they said that they do not like their gardens to have the look of a desert or even the naturalistic look. Cypriots are used to planting mostly imported plants in their gardens and cannot see the creative use of drought-tolerant or native plants.

Even though they expressed these negative feelings, their attitude changed completely when I showed them illustrations of Xeriscape gardens. They were very impressed by Xeriscape gardens and they seem very excited for this idea to be implemented in Cyprus. A professional interviewee said that the Xeriscape idea looks like the best solution for gardens in Cyprus because it conserves energy and water, it reduces the water bill, enhances the character of Cyprus, and it also protects the environment.

People suggested that demonstration gardens could be effective while promoting this idea in Cyprus, because the public would like to see how creative landscapes could be achieved while conserving water. Moreover, interviewees said that Cypriots would like the idea of designing their own yard that conserves water if it seems easy to apply and if it is low in cost. In addition, others expressed the feeling that the public of Cyprus would like incentives in order to follow the idea. Another interesting suggestion was made about a competition with a Xeriscape garden that conserves the most water.

Cypriots are different from other nationalities; their difference in culture affects how Cypriots can adapt the idea of Xeriscape to our island. Cypriots are different in their concern for the environment and the conservation of water. For example, European countries have more water than Cyprus does, but they are used to conserving water. Also they are more concerned about the environment than we are. For instance, British people wash their car using a container but Cypriots use the water hose to do the same job.

European countries are more likely to obey the law than we do in Cyprus. Our culture is less sensitive to the environment than we should be. One of the interesting interviewees said, " The mentality here in Cyprus is like we do the opposite thing of what we have to do." It is not easy to explain why Cypriots are less likely to obey the law and to do what they have to do but one of the main reasons that it is true is that Cyprus has been most of the time under the control of other nations, which affects the way they see life. Even though Cypriots are different and less concerned with the environment than other nationalities, they have become more environmentally concerned the last ten years. In addition, they look excited about following this idea of Xeriscape because they have found a solution for their gardens, which they were forced many times to abandon due to lack of water. However, it is suggested that people like to see

illustrations, pictures of nice gardens in order to be interested, and to follow the idea of landscaping while conserving water.

6.2 Xeriscape Guidelines for Residential Gardens in Cyprus

The guidelines that I came up with are originally from Xeriscape principles, but I adapted them to be compatible with Cypriot conditions and to be more representative to Cypriots. When I tested the Xeriscape guidelines with case studies, they helped me to develop the following process. The first step was to elaborate general information. For example, I included figures on wind, slope (guideline#2), sun (guideline#6), and more detailed information and figures of soil (guideline#3). This information was added to my guidelines to have a better understanding by the public of the guidelines and to reduce the process of adapting the guidelines to a garden. While I was testing the case studies, I had difficulty in understanding how to deal with wind, slope, and sun without looking to illustrations and graphics of each of these principles. In addition, I figured that it was important to elaborate soil analysis and water analysis in order to understand how to handle each type of soil and problematic water, which helps the process of selecting the right plants.

In Cyprus, the profession as a landscape architect is new, so people in this profession are facing important issues. For example, when I gathered information for each case study, I could not get grading maps of each site. In order to get grading information, I would have to do a survey of each case study, which is not the intent of my thesis. Another important issue of the profession is that the public is not familiar with a garden design that conserves water. As a result, the Xeriscape guidelines adapted for Cyprus must be easy to follow by the public.

After I included this information, the second step of the process was that I recognized that Denver guidelines are generic. As a result, in order to apply these generic guidelines in Cyprus,

they should be closely related to factors of Cyprus that are different. Even though Cyprus and Denver, Colorado, share a similar problem of water shortage and they look to the idea of Xeriscape as a great solution for their problem, there are cultural and natural differences that were considered while adapting the Cypriot guidelines. Cultural factors include the traditions and customs in Cypriot gardens and the role of the government toward water conservation. Cultural differences were experienced through the application to the two case studies, and examples are provided through the guidelines. The culture of Cyprus is not easy to explain in a few sentences. However, it was built through the history of Cyprus, which is 11,000 years old. Cypriots feel proud of their long history and they try hard to keep it alive. Their traditions and customs are strong enough that it can be difficult to change them. As a result, customs affect the way that people in Cyprus use the outdoor space and think about their gardens. For example, use of materials, privacy in the garden, the use of fences, and the time to use the outdoor space are different than in the United States. The Xeriscape idea was interesting to Cypriots because it enhances the character of Cyprus through the use of native plants that are important to preserve. A list of plants native to or adapted to Cyprus is provided in the guidelines. Also, the role of the government toward water conservation measurements affects the guidelines in Cyprus. Government limitations, rules and regulations, and incentives are taken into consideration through the guidelines. When I applied the guidelines to the two sites, I took into consideration the use of gray water, the law that forbids to the use of water hoses to water the landscape, and the use of desalting water.

Other than cultural differences, there are natural differences that affect the application of guidelines. However, a major natural difference that affects the guidelines is water analysis. In Denver Colorado the quality of water is not an issue. In Cyprus, there are areas, as I stated

before, where the water quality is very bad. Even though the two case studies did not face any problem with quality of water, I decided that is important to include a separate guideline that refers to water analysis.

The geology of Cyprus, in which the landscape changes so dramatically from mountain to coastal, affects design decisions. Climatic factors, the vegetation of Cyprus, soil, slope, water, and wind are important factors that are diverse within the island and should be taken into consideration when designing a garden in Cyprus. One landscape designer of the Forestry Department said, "It is not easy to design in Cyprus, because the conditions change dramatically in very short distances. For example, you have a different vegetation on one side of the same mountain than on the other side due to the diversity of soil, water, sun, and wind." When I tested the two sites, I used the bioclimatic map of Cyprus that helped me to make important decisions. The map of bioclimatic zones of Cyprus should be part of the Xeriscape guidelines adapted to Cyprus because people can designate the bioclimatic zone of their site, which will specify the temperature, precipitation, the altitude, and the flora of each site. This map can help in the right plant selection. Furthermore, the map of the soil of Cyprus that can define the composition and pH of soil from one location to another should be included in the guidelines to help the design decisions.

Based on the experience I gained by testing the guidelines in two case studies in Cyprus and on the knowledge I have about the topic, I adapted the guidelines to residential gardens in Cyprus. I believe that when guidelines are directly related to Cypriot conditions, and easy to follow by the average person, then people are more willing to follow them. The following are the Xeriscape guidelines adapted to Cyprus:

1. **Planning and Design.**
2. **Winds and Slope.**
3. **Soil Analysis.**
4. **Water Analysis.**
5. **Eliminate Large Turf Areas.**
6. **Zoning of Plants and Plant Selection.**
7. **Support the Role of Government.**
8. **Efficient Irrigation Systems.**
9. **Use of Mulches.**
10. **Appropriate Maintenance.**

1. Planning and Design. The base plan can be prepared to specify the existing conditions of the site and to locate the geographical position of the residential gardens based on the map of bioclimatic zones that was prepared by Vaso Pandela (see Figure 2.6). In addition, rules and regulations for the site are important to be mentioned and can be found at the Ministry of Transportation Development in Nicosia. It is important to consider if it is located in the city, in a village, in the coastal area, or in a mountain in order to enhance the special character of the area. Furthermore, budget and maintenance are necessary factors to consider for a good design. After that, an inventory base map should be prepared to define views, slope, sun, and wind and other important factors that affect the site. An explanation of wind, slope, and sun is provided later on. If the site is not flat, a surveyor can get a grading map, and a landscape architect can give recommendations on grading decisions. If there is a wild spot, it should not be cleared until it is certain that there are not certain plants that can be used for the design. In Cyprus, we have a

special and diverse of native flora that people under estimate for a garden design. A good example of a native plant is lavender. Its purple flower, its thin texture, and gray color can provide a different atmosphere to the garden. Lighting lavender plants creates a special effect in our garden. It is recommended that designs could be built around existing pines, olives, and pistachios. Today, people are buying huge olive trees at a very high cost.

2. <u>Winds and Slope.</u>

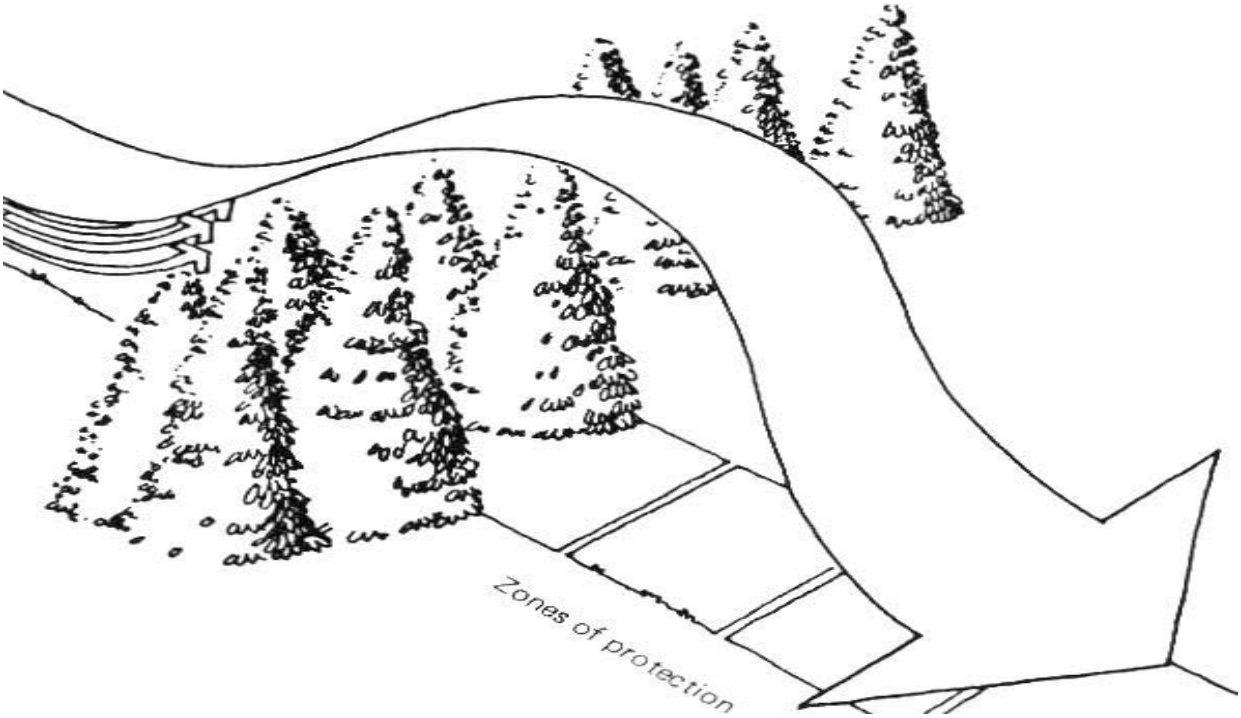


Figure 6.1 – Wind direction (Figure: Robinette 111)

Important factors that should be considered in an inventory map are the wind and slope of the site. Wind is important while conserving water because the concept is that by reducing wind speed, less of the available water will be transpired out of plants into the atmosphere. Figure 6.1 shows the direction of wind. Evergreen windscreens are effective for a longer period of time than deciduous windscreens during the year but unless they are arranged in multiple rows, they cannot be as effective during the important drier summer months (Robinette 111).

Another important factor that affects designing decisions while conserving water is the slope of the site and how the grade of the site can help for conserving water. Traditional landscape areas have been graded to drain areas off the site as quickly as possible. In seeking to conserve water or to use available water more efficiently, it may be necessary to regrade to allow water to percolate into the soil rather than running off. (fig. 6.2). (Robinette 124).

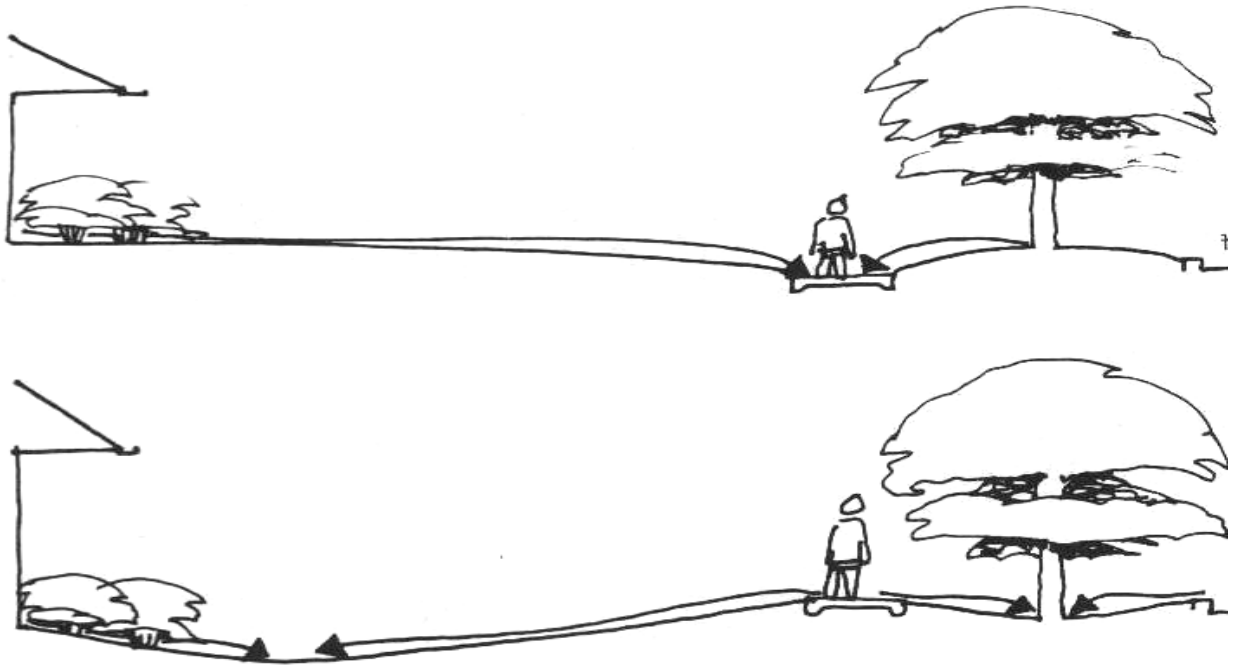


Figure 6.2 – Regrade the landscape to conserve water (Figure: Robinette 124)

A good strategy for hillsides is terracing, which is almost as old as cultivation itself. Many houses on the Mediterranean coast have sections built originally with dry stonewalls. For example, at the village Lofou, which is a preserved village, terraces were built with dry stonewalls a thousand years ago, and people created the terraces for cultivation and to slow down the water (fig. 6.3). These type of terraces look attractive and create places for nice planting. So they need to be maintained. On lower terraces, wooden arbors can be erected to support sun-loving climbers that provide cool, shaded areas for walking or sitting. As I stated before, we Cypriots love to sit outside under the shade of arbors with climbers.

Figure 6.3 - Use of stones for terraces. (Photo: Latymer 22.)

3. <u>Soil Analysis</u>. A chemical and mechanical soil analysis must be done to identify the type of soil. Soil analysis can be done by the Ministry of Agriculture and Natural Resources at the Department of Agriculture in Nicosia. A mechanical analysis of soil will identify the composition of the soil, which is the proportion of sand, silt, and clay. A chemical analysis will identify nutrients capacity. Soil needs to be improved to have a better water absorption and holding capacity. This can be achieved by the addition of organic matter. Some of the following information can be provided with soil analysis at the laboratory but it is explained in detail so that we can have a better understanding of the results of the analysis.

Figure 6.4 can help to identify the composition of the soil. This table shows a three-sided grid with each side representing the content of a particular particle on a scale from 0% to 100%. To locate the exact point on the grid, you should first calculate the percentage of sand, silt, and clay in the total sample without including the organic matter in the total (the percentage of sand, silt, and clay will be provided in the analysis at the laboratory). If it is near the edge of two areas, then it will behave with a mix of the characteristics of both soil types. Another general approach to identify the composition of soil is using the following statement: if clay is higher than 35%, the composition of the soil is clay; if clay is between 20 to 30 % and silt less than 40%, then the composition of the soil is clay loam; and if clay is less than 20% then the soil is considered sandy.

After the texture of the soil is identified, the nutrients and availability of plant food at different pH levels will be measured. Figure 6.5 shows how the main foods of nitrogen, phosphate, and potash are made more or less available at different pH levels. The availability of iron, manganese, and boron is also depicted. PH is a measurement of the acidity or alkalinity of soil. When pH is between 4.5 to 7.0, then soil is acid, between 7.0 to 8.7 is alkaline, and when it is 7.0, it is neutral or basic. Figure 6.6 shows the type of soils in Cyprus. It shows that in forest areas of Cyprus like in the Troodos Mountains, the pH is between 7.0 and 8.0, but in the other areas, the pH is higher than 8.0. As a result the soils in Cyprus are alkaline. The map of the soil in Cyprus (fig. 6.6) shows that soils are clay loam and clay. Clay soils are capable of holding a great quantity of water but in rainy conditions often lack oxygen and have poor drainage. However, due to the low precipitation in Cyprus, these types of soils are considered fairly good.

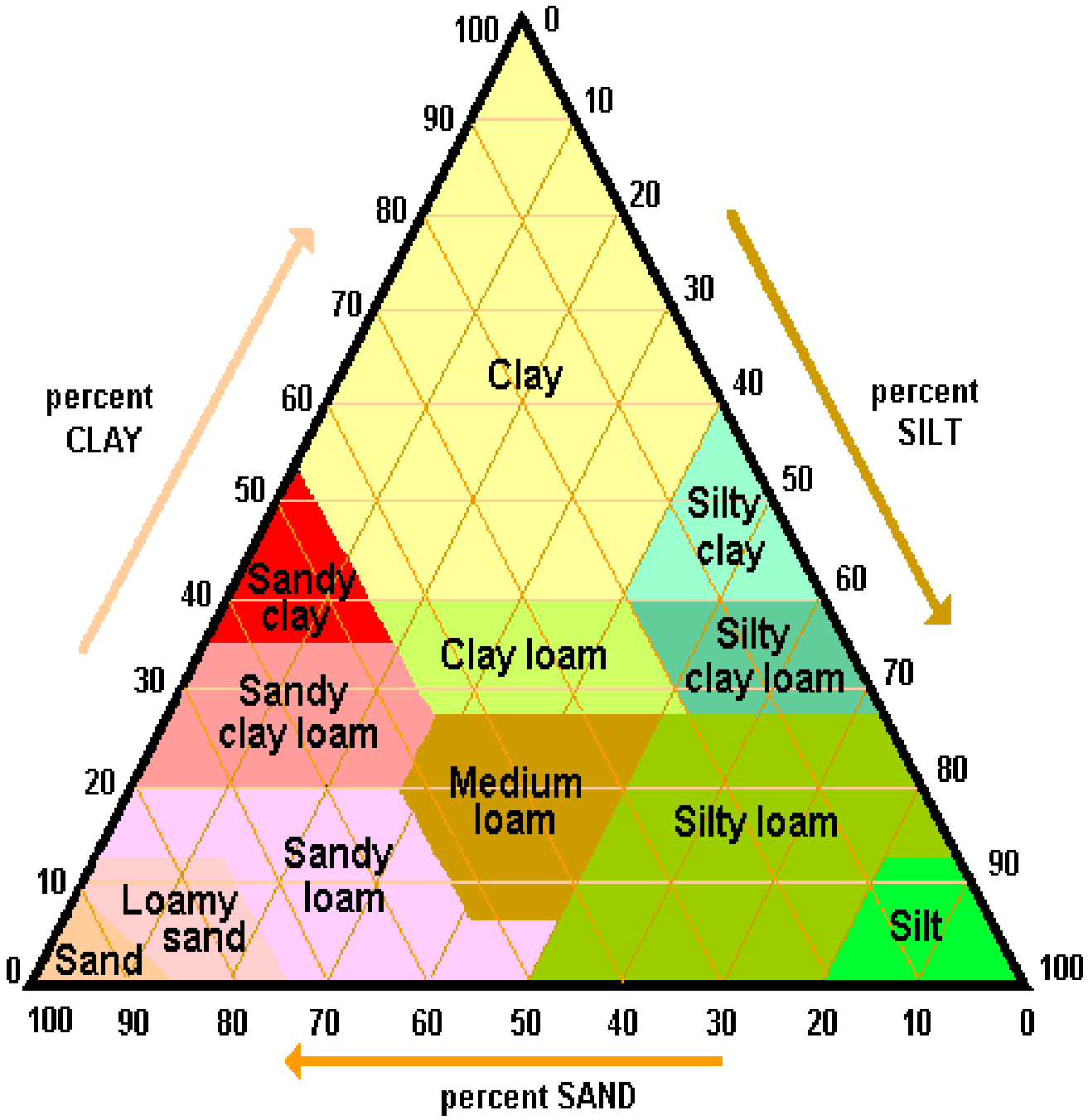


Figure 6.4 - Composition of soil. (Figure: www.pda.org.uk)

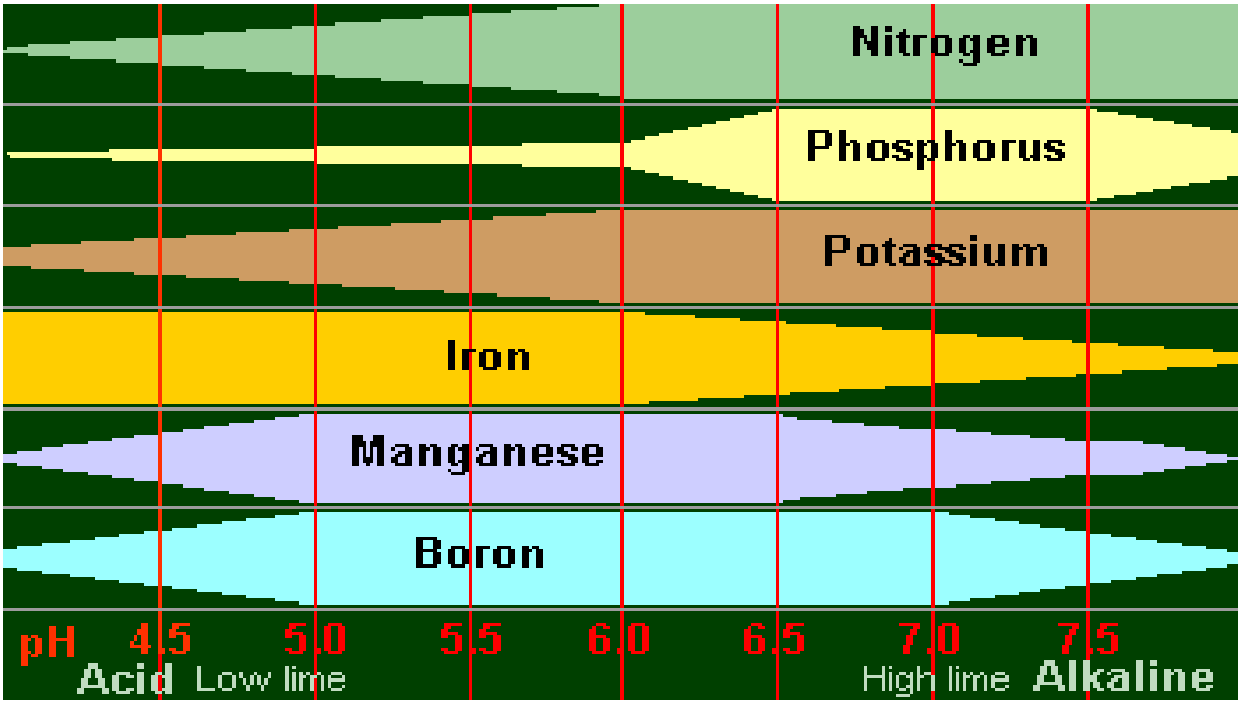


Figure 6.5 – Availability of food for soil. (Figure: www.pda.org.uk)

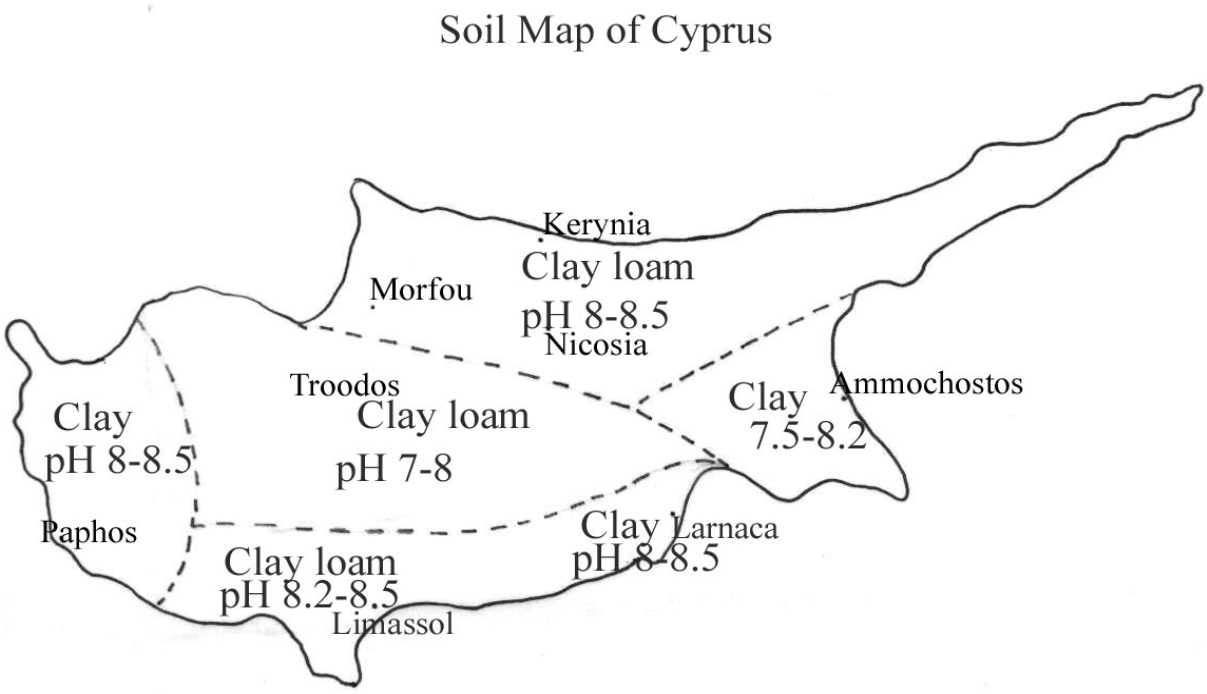


Figure 6.6 - Soil of Cyprus. (Figure by author)

These soils are alkaline because they are high in calcium and magnesium. Plants native to Cyprus are not so sensitive to these soils with high pH but when pH become as high as 9, then it creates problems to the plants. Figure 6.5 shows that soil with high pH are low in availability of iron and manganese but they are high in availability of potassium and nitrogen. Potassium is considered low when it is lower than 200 ppm, and it is normal when it is between 200 and 500 ppm. In addition, in mountain areas of Cyprus, nutrient humus is 9% but in other areas this nutrient is as low as 1 to 2%, fertilizer that contains humus can be added in these areas to improve the soil. Another important factor in soil analysis is level of salinity, which is considered high when its total number of anions is higher than 1000 ppm. However, we should remember that a lot of plants native to and adapted in Cyprus can survive in high salinity and in high ph. In addition, most of these plants have low water needs because they survive in conditions of Cyprus where precipitation is very low. We have to consider that they need more water in the first years that we plant them in order to create their first roots. The Forestry Department of Cyprus and local nurseries could specify the plants that are suitable with the water and soil analysis of each of the gardens. (Chomata tis Kiprou 1).

4. <u>Water Analysis.</u> A water analysis must be done to define the quality of water in Cyprus because the island has areas with problematic water. Water analysis can also be done by the Department of Agriculture. After the water analysis, water can be identified as suitable for all types of plants or as suitable with certain plants. There are areas of Cyprus that water is high in salinity and in boron. Appendix 6.1 through 6.5 provide list of plants that are tolerant to salinity and boron. Boron can be found in high concentrations in the groundwater of Cyprus, especially in the central part of the island. Boron in high concentrations is of major concern due to its toxicity to both animals and irrigated plants. The origin of the phenomenon is usually explained

as remains of seawater. When boron is higher than 0.7 ppm, it causes tip burn to sensitive plants like lemon, orange, avocado, apple, peach, and grape trees. Plants that can tolerate boron between 1.0 to 4.0 ppm are mostly vegetables. Also olive and yucca trees can grow in water that is high in boron. Another important concern with water is salinity. It is the term used when referring to the presence of soluble salts in soil or water. High salinity exists when soluble salts are between 1000 and 1200 ppm. In addition, level of salinity can be defined by electrical conductivity. Salinity exists in water when electrical conductivity is higher than 0.75. Plants sensitive to high salinity are lemon, orange, desidious trees, strawberry, onion, carrot, potato plants, and roses. Examples of plants that can better survive in salinity are tomatoes, grapes, olive, pomegranate, and fig trees. (Georgiou 2002)

5. <u>Eliminate Large Turf Areas</u>. Even though turf areas look nice, Cypriots should eliminate large turf areas. I believe that Cypriots associate an attractive garden with the largest and greenest turf area. (fig. 6.7) This is fine, because a lawn is an important element in a garden that functions as a recreational and a visual element. People in Cyprus must realize that a garden with a minimum lawn and with a combination of native shrubs and groundcovers can be as attractive as with the use of the traditional large area of lawn. Also these Xeriscape gardens look nicer in our country due to the climatic conditions and at the same time they will save energy, time, and money. We have to realize that Cyprus provides a special naturalistic style, which in winter is green and then a yellowish brown during the long summertime. It is almost impossible to have a natural and beautiful lawn the whole year around in Cyprus due to the climate, which is too hot and dry. An alternative solution to lawn that can be creative too is the use different texture and color of gravel or dirt that enhance the character of each site.

Even though I do not recommend use of lawn in Cyprus, people should better use small scale lawn, a native lawn, and a type of lawn that conserve as much water as possible. Based on research that was done by the Forestry Department, choices of suitable grass for Cyprus are: *Stenotaphrum secunatum* (St. Augustine grass) and *Cynodom dactylon* (Bermuda grass). Both of these are high in tolerance of salt, electrical conductivity 8 to 16 ds/m. St Augustine grass is a broad-leaved grass that spreads by runners and quickly makes a thick, springy mat. It is probably the most trouble-free summer ground cover, as it needs little water. Bermuda grass is a creeping, fine-leaved grass that, with only moderate watering, looks green and healthy in summer.

In addition, the lawn area can be replaced by a patio/deck, which can be used for relaxation or for taking meals in fine weather. The location of a patio should be determined by the sun, the use, convenience, and accessibility. It should be considered that the barbeque area is located close to the eating area but in the right location that the smoke of the grill does not get in the way of the people. Patio materials should be considered for the high sun exposure and for low maintenance. Drought-tolerant vines and climbers can be used for shading the patio. It is better to plant evergreen vines and climbers on an overhead arbor to reduce maintenance. People in Cyprus use grape vine on an overhead. Grapes provide good shade but they need maintenance when their leaves fall. However, these leaves can be used as mulch for other planting areas. Also, the location of the patio should be taken into consideration to be away of the neighbors' bedrooms. Cypriots have customs to use the outdoor space late at night, and they also talk loudly. (fig. 6.8). However, it is not recommended to use concrete in most of the outdoor space because the size of the lawn is reduced. I realize that a lot of Cypriots prefer to pave most of the outdoor space with concrete because they do not have to worry about the maintenance of plants. Concrete is not aesthetically attractive because it does not give a finished look, and it also retains

heat that is not desirable in the climate of Cyprus. Concrete can be used in areas like the driveway.

Figure 6.7 - Impractical size of lawn. (Photo by author.)

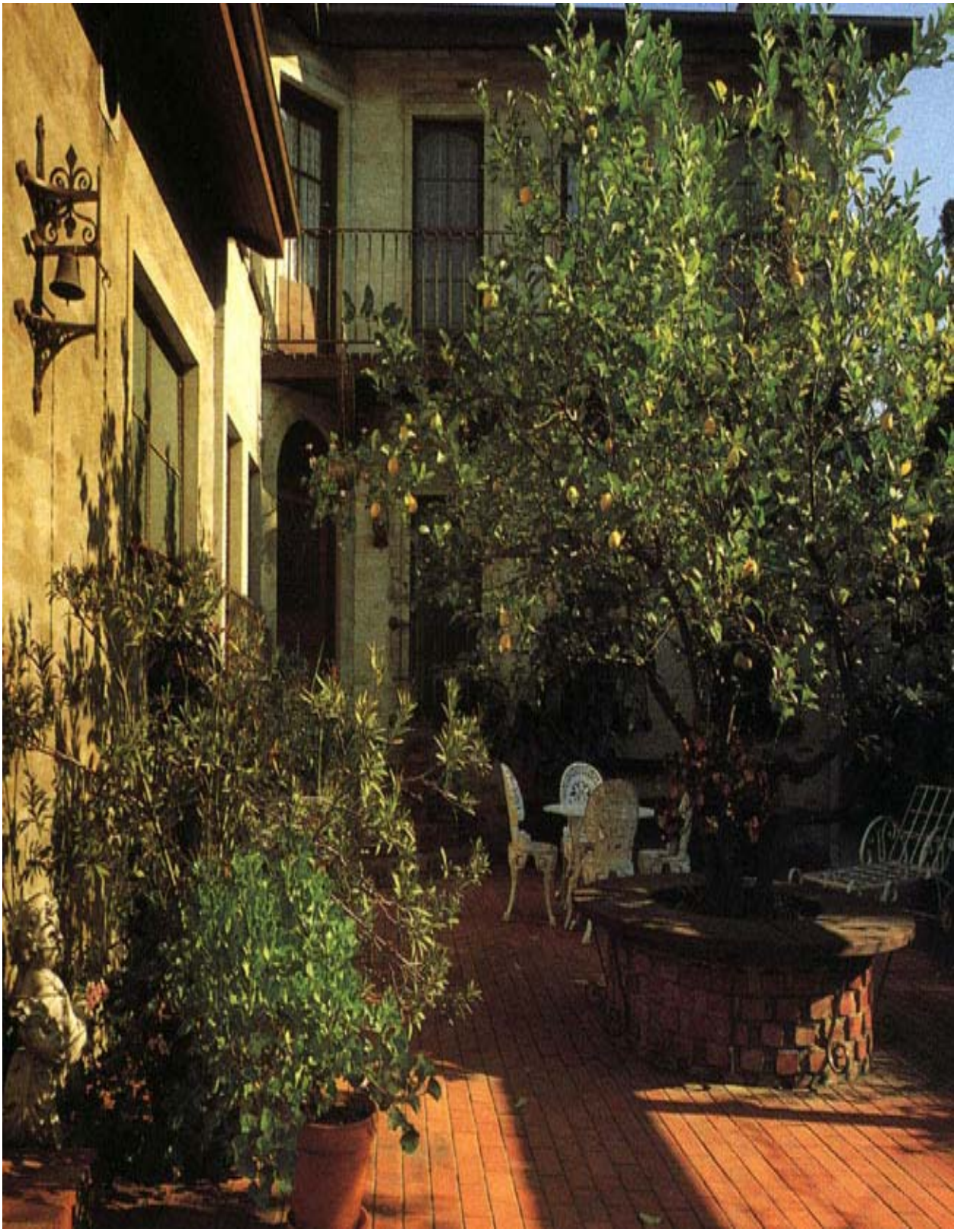


Figure 6.8 - A Greek style patio. (Photo: Latymer 31.)

6. <u>Zoning of Plants</u> and <u>Plant Selection</u>. Gardens can be classified from low to high water-need zones. These zones will help to conserve water and to have a more uniform outcome in term of aesthetics and maintenance. High water-need plants can be placed in low-lying drainage areas, near downspouts or in the shade of other plants. When water does not collect naturally, place the high-water-need plants in areas that are accessible to water. Dry, sunny areas far from a hose are perfect for low water-use plants. It is important to regrade areas to hold runoff water to the site. Growing plants according to water and sunlight requirements ensures that they will flourish in an optimal environment. Figure 6.9 illustrates the sun's path at a latitude of 36 degrees north, which is close to the latitude of Cyprus, which is approximately 35 degrees. Figure 6.10 indicates seasonal sun patterns.

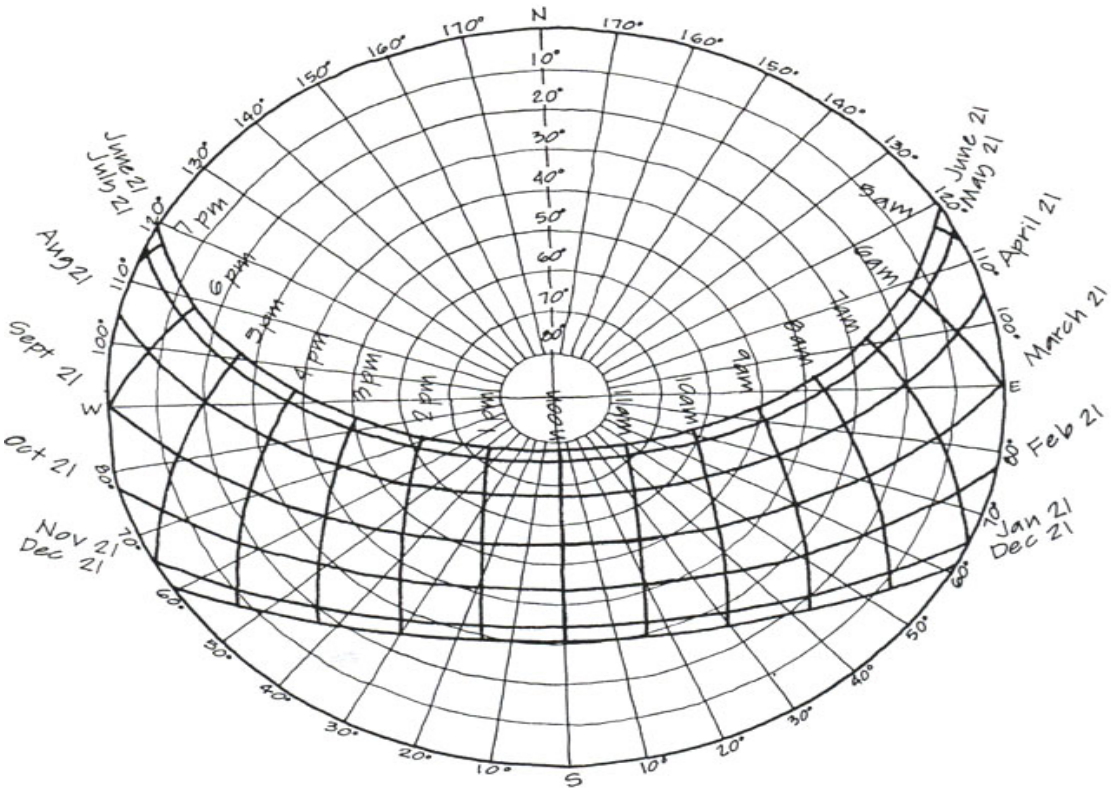


Figure 6.9 - Sun path diagram 36 degrees latitude. (Figure: Brown 17.)

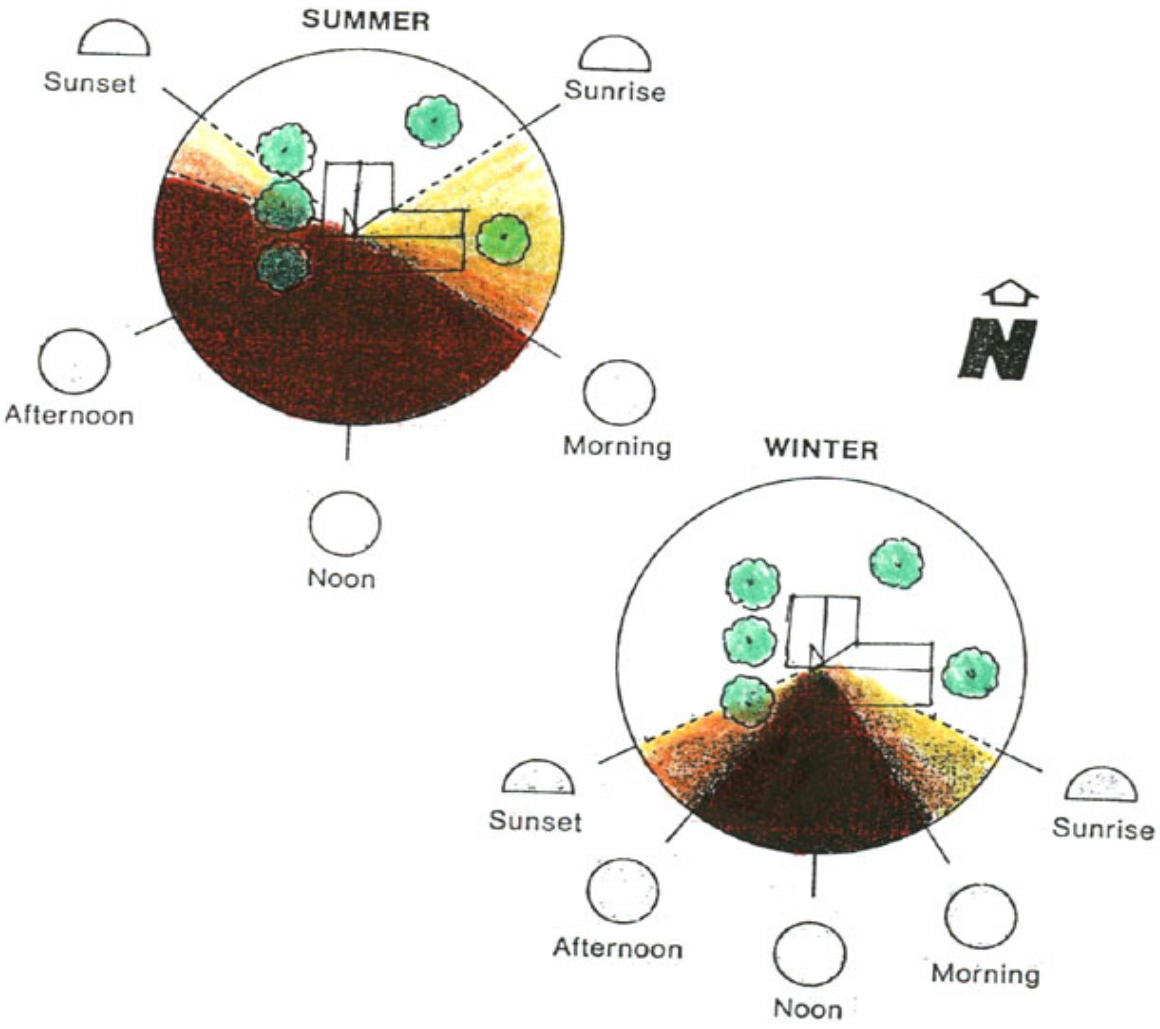


Figure 6.10 - Seasonal sun path. (Figure: Brown 7.)

The summer sun is high in the sky and appears to pass directly over this home. The hot sun, shown by the darker color, is what requires moderation with shade-producing plants. The winter sun appears low in the sky and shines for a much shorter time than in the summer. The northern exposure of this home receives no direct sunshine. The following diagram provides a general conceptual idea for a residential garden design, which takes into consideration the water-need zones. It is a hypothetical site with zero percent slope, in which winds move from northwest to southeast. Figure 6.11 is an example that gives you an idea of how to divide the garden in zones and how to take into consideration some variables. This is not a base to begin any design.

Structures on the site, water accessibility, slope, winds, and other important factors make each site have different designing decisions.

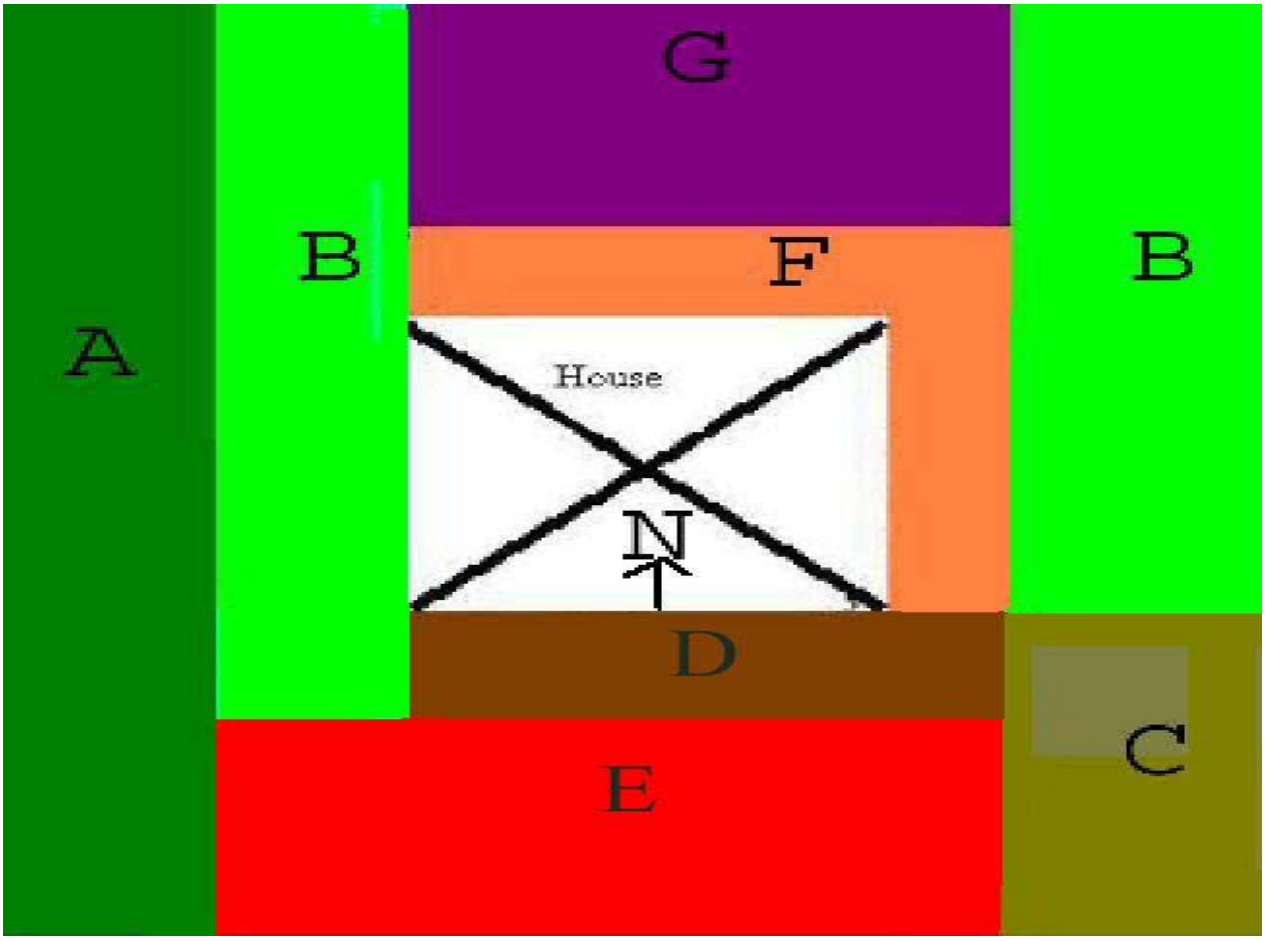


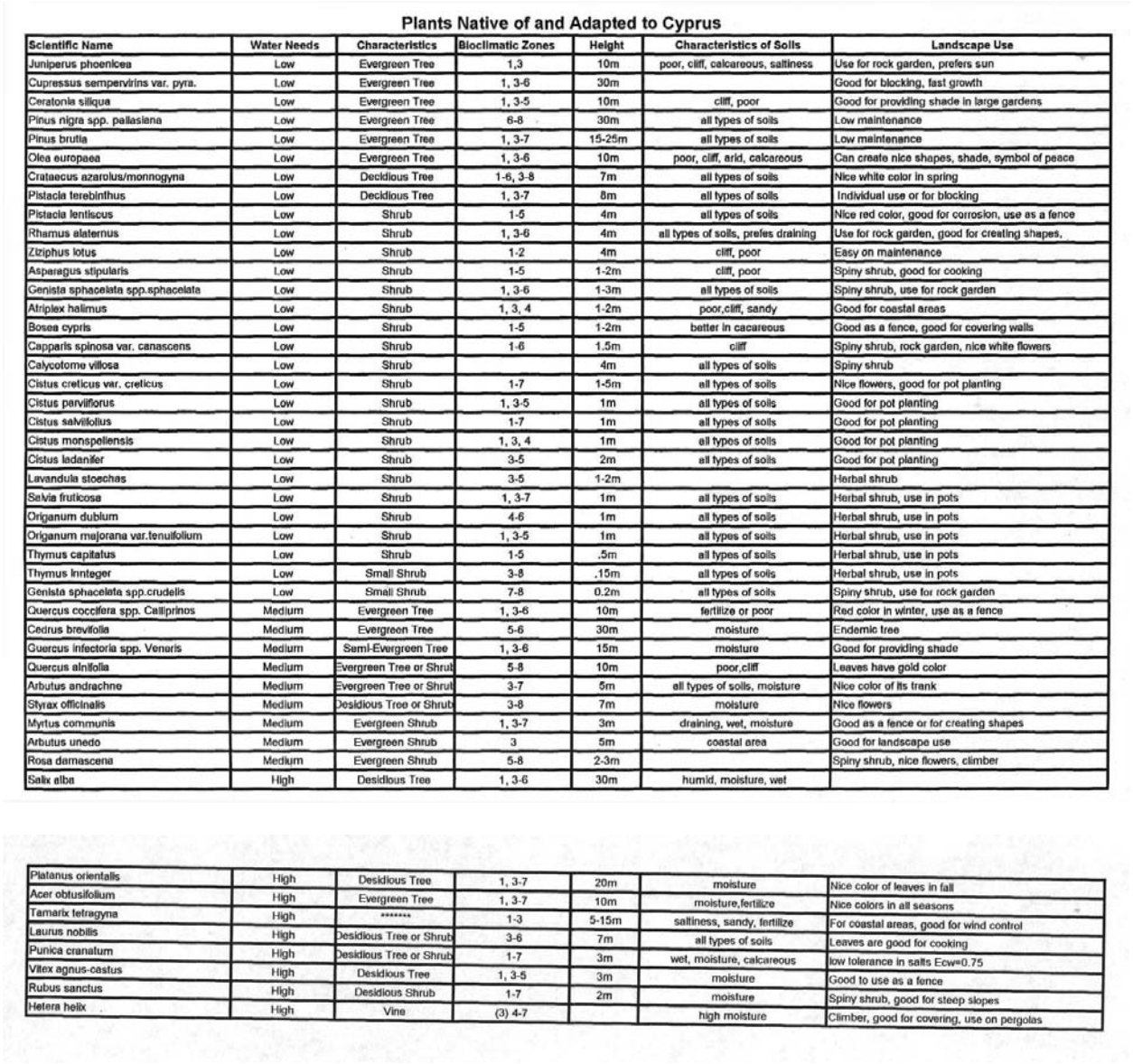
Figure 6.11 - Conceptual diagram

- **Area A** The hot sun, mostly in summertime, requires modification of area A with shade-producing plants. Due to intense afternoon sun angles, it is desirable to conserve as much moisture as possible by planting tall trees, such as Italian cypress (*Cupressus sempervirens).* The gardens will be protected from drying winds, and the trees' shade will keep the summer temperature down and reduce evaporation. The Italian cypress is narrow and tall, so one can garden beneath it.

- **Area B** This area becomes a place for plants with medium water needs. These plants can grow well under the shade of evergreens, which are in area A. They can grow well, too, at the northeastern side since the sun provides midday shadows.
- **Area C** This area becomes hot in summer and in winter, too. Deciduous shade trees with low water needs will cool the area in summer and will permit the warming of the area in winter when the leaves fall.
- **Area D/E** These two areas become the hottest parts of the garden all year around due to the angle of the sun. Area D needs good overhead protection for summer. If porches don't have a roof, a good solution can be vines, which will provide shade in summer and sun in winter. Area E is the right place for drought-tolerant plants that survive in hot spots.
- **Area F** This is the best location of the patio for Mediterranean climates. The patio on the eastern side benefits from late afternoon shadows, and the patio on the northern side benefits from midday shadows. A patio close to the house benefits from the shadow of the house, the convenience of being next to it, and the possibility of its being a part of the indoor space. Consider the patio to be away from areas that would bother neighbors.
- **Area G** This area, which is the shady northern exposure, is the location of the plants with higher water needs. These plants should be placed close to the water hose and in a small scale.

It is recommended to use in a garden 80% native plants of Cyprus and plants that are adapted in Cyprus, and the remaining 20% to be other plants (Kyriakou G. 2001). The Forestry Department prepared the following plant list, which includes native plants of Cyprus and plants adapted in Cyprus.

Table 6.1 Plants Native of and Adapted to Cyprus



Plants Native of and Adapted to Cyprus

Scientific Name	Water Needs	Characteristics	Bioclimatic Zones	Height	Characteristics of Soils	Landscape Use
Juniperus phoenicea	Low	Evergreen Tree	1,3	10m	poor, cliff, calcareous, saltiness	Use for rock garden, prefers sun
Cupressus sempervirins var. pyra.	Low	Evergreen Tree	1, 3-6	30m		Good for blocking, fast growth
Ceratonia siliqua	Low	Evergreen Tree	1, 3-5	10m	cliff, poor	Good for providing shade in large gardens
Pinus nigra spp. pallasiana	Low	Evergreen Tree	6-8	30m	all types of soils	Low maintenance
Pinus brutia	Low	Evergreen Tree	1, 3-7	15-25m	all types of soils	Low maintenance
Olea europaea	Low	Evergreen Tree	1, 3-6	10m	poor, cliff, arid, calcareous	Can create nice shapes, shade, symbol of peace
Crataecus azarolus/monnogyna	Low	Deciduous Tree	1-6, 3-8	7m	all types of soils	Nice white color in spring
Pistacia terebinthus	Low	Deciduous Tree	1, 3-7	8m	all types of soils	Individual use or for blocking
Pistacia lentiscus	Low	Shrub	1-5	4m	all types of soils	Nice red color, good for corrosion, use as a fence
Rhamus alaternus	Low	Shrub	1, 3-6	4m	all types of soils, prefes draining	Use for rock garden, good for creating shapes,
Ziziphus lotus	Low	Shrub	1-2	4m	cliff, poor	Easy on maintenance
Asparagus stipularis	Low	Shrub	1-5	1-2m	cliff, poor	Spiny shrub, good for cooking
Genista sphacelata spp.sphacelata	Low	Shrub	1, 3-6	1-3m	all types of soils	Spiny shrub, use for rock garden
Atriplex halimus	Low	Shrub	1, 3, 4	1-2m	poor,cliff, sandy	Good for coastal areas
Bosea cypris	Low	Shrub	1-5	1-2m	better in cacareous	Good as a fence, good for covering walls
Capparis spinosa var. canascens	Low	Shrub	1-6	1.5m	cliff	Spiny shrub, rock garden, nice white flowers
Calycotome villosa	Low	Shrub		4m	all types of soils	Spiny shrub
Cistus creticus var. creticus	Low	Shrub	1-7	1-5m	all types of soils	Nice flowers, good for pot planting
Cistus parviflorus	Low	Shrub	1, 3-5	1m	all types of soils	Good for pot planting
Cistus salvifolius	Low	Shrub	1-7	1m	all types of soils	Good for pot planting
Cistus monspelliensis	Low	Shrub	1, 3, 4	1m	all types of soils	Good for pot planting
Cistus ladanifer	Low	Shrub	3-5	2m	all types of soils	Good for pot planting
Lavandula stoechas	Low	Shrub	3-5	1-2m		Herbal shrub
Salvia fruticosa	Low	Shrub	1, 3-7	1m	all types of soils	Herbal shrub, use in pots
Origanum dublum	Low	Shrub	4-6	1m	all types of soils	Herbal shrub, use in pots
Origanum majorana var.tenuifolium	Low	Shrub	1, 3-5	1m	all types of soils	Herbal shrub, use in pots
Thymus capitatus	Low	Shrub	1-5	.5m	all types of soils	Herbal shrub, use in pots
Thymus inmteger	Low	Small Shrub	3-8	.15m	all types of soils	Herbal shrub, use in pots
Genista sphacelata spp.crudelis	Low	Small Shrub	7-8	0.2m	all types of soils	Spiny shrub, use for rock garden
Quercus coccifera spp. Calliprinos	Medium	Evergreen Tree	1, 3-6	10m	fertilize or poor	Red color in winter, use as a fence
Cedrus brevifolia	Medium	Evergreen Tree	5-6	30m	moisture	Endemic tree
Quercus infectoria spp. Veneris	Medium	Semi-Evergreen Tree	1, 3-6	15m	moisture	Good for providing shade
Quercus alnifolia	Medium	Evergreen Tree or Shrub	5-8	10m	poor,cliff	Leaves have gold color
Arbutus andrachne	Medium	Evergreen Tree or Shrub	3-7	5m	all types of soils, moisture	Nice color of its trank
Styrax officinalis	Medium	Desidious Tree or Shrub	3-8	7m	moisture	Nice flowers
Myrtus communis	Medium	Evergreen Shrub	1, 3-7	3m	draining, wet, moisture	Good as a fence or for creating shapes
Arbutus unedo	Medium	Evergreen Shrub	3	5m	coastal area	Good for landscape use
Rosa damascena	Medium	Evergreen Shrub	5-8	2-3m		Spiny shrub, nice flowers, climber
Salix alba	High	Desidious Tree	1, 3-6	30m	humid, moisture, wet	
Platanus orientalis	High	Desidious Tree	1, 3-7	20m	moisture	Nice color of leaves in fall
Acer obtusifolium	High	Evergreen Tree	1, 3-7	10m	moisture,fertilize	Nice colors in all seasons
Tamarix tetragyna	High	*******	1-3	5-15m	saltiness, sandy, fertilize	For coastal areas, good for wind control
Laurus nobilis	High	Desidious Tree or Shrub	3-6	7m	all types of soils	Leaves are good for cooking
Punica cranatum	High	Desidious Tree or Shrub	1-7	3m	wet, moisture, calcareous	low tolerance in salts Ecw=0.75
Vitex agnus-castus	High	Desidious Tree	1, 3-5	3m	moisture	Good to use as a fence
Rubus sanctus	High	Desidious Shrub	1-7	2m	moisture	Spiny shrub, good for steep slopes
Hetera helix	High	Vine	(3) 4-7		high moisture	Climber, good for covering, use on pergolas

The list (table 6.1) divides plants according to the bioclimatic zones of Cyprus and provides useful information for plant water needs and the aesthetics of each plant. See the following diagram that summarizes the plants' water use zones. Additional plant lists are available from MGS and other sources that include plants for Mediterranean climates (MGS web site). After you have followed steps one through five, you could create your own diagram of water-need zones. Then, a plant selection can be bought from a nursery based on this diagram. It

is recommended to get the advice of professional people for the plant selection. The Forestry Department has the following locations of nurseries: Athalassa, Fasouri, Stavros Psokas, and Prodromos.

7. <u>Support the Role of Government</u> The last principle is to support the government campaign toward water conservation in your garden. This can be achieved by the following ways: use of gray water, follow the law of water hose in a landscape, understand the role of desalinated water, and realize the increase in the price of water. Based on rules and regulations on the use of gray water in a landscape, it is considered one of the safest methods to water the garden, and it is environmentally friendly. It is recommended to use drip and mini sprinklers with the use of gray water. Not only is the quality of gray water in Cyprus a very good for the plants but it also contains nutrients for the plants as well. Specific regulations on the use of gray water, such as the use of fruit from the trees or other factors should be taken into consideration. Gardeners should label the landscape that is watered with gray water for safety reasons. Information on gray water can be found at the Water Development department in Nicosia (Fotiou 9).

In a Cypriot garden, it is not recommended to water the landscape with a water hose because the law forbids it. Efficient irrigation systems or the use of water containers are recommended. Another governmental measure for water conservation that would affect Cypriots is the increase in the price of water. Moving toward the idea of a Xeriscape garden in Cyprus will help to reduce water bills', which in may couple of years double.

It is true that in Cyprus by January 2001, people believed that the problem of water shortage was not an issue any more. I believe the problem of water shortage is reduced due to the desalination of salt water and that now Cypriots are more likely to water their gardens. However,

the use of desalted water should not stop people from conserving water. Even though Cyprus has a new source of water, the island does not stop to face the problems of drought. Furthermore, this new source of water is not low in cost but is very expensive for the government. People pay for this water through indirect ways or with an increase in their water bills. The Xeriscape idea not only helps to enhance the character of Cyprus by using native plants, but it also conserves water and reduces water bills.

8. <u>Efficient Irrigation Systems.</u> The use of efficient irrigation systems will provide water at the right place and at the right time without consuming extra water. For a Mediterranean climate, it is better to use first the drip system because is the best way to save water and, secondly, the mini-sprinkler system. Drip and mini-sprinklers are also suitable for the use of gray water. Low-level systems such as the drip system or permanent water tubes are more economical of water and less encouraging to weeds. But if these systems are left on for one hour or more, they will wet the soil area around the jet. On the other hand, high-level watering systems such as sprinklers reduce the effort of watering a large garden or a large lawn area. However, sprinklers water trees and shrubs unevenly. In addition, they need special installation when the area is not flat, which costs a lot of money. (fig. 6.12-6.13).

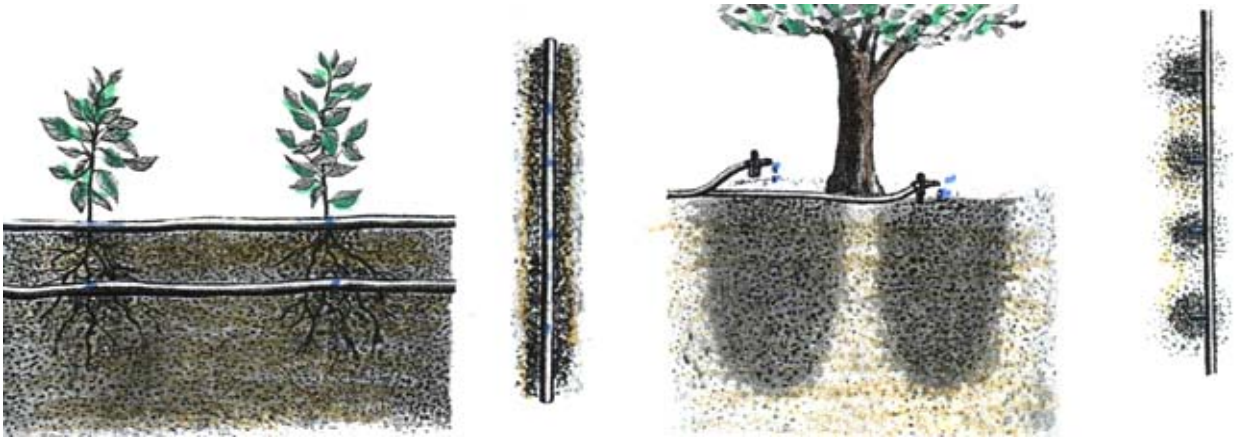


Figure 6.12 - Drip Irrigation. (Figure: Latymer 143.)

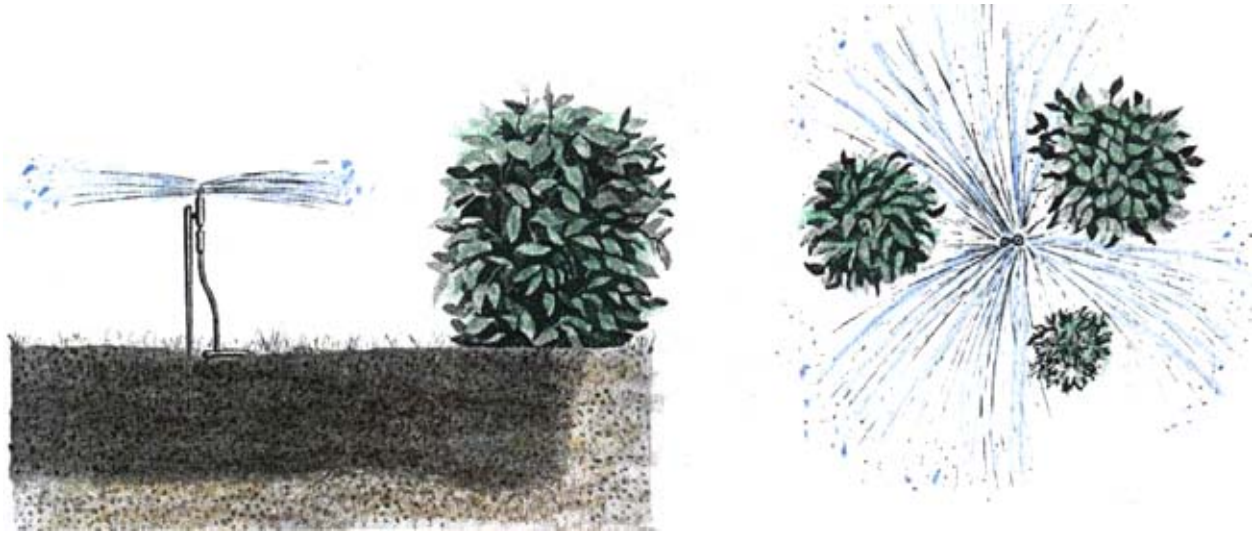


Figure 6.13 - Sprinkler systems. (Figure: Latymer 144.)

Furthermore, an engineer in Florida designed an irrigation device (wakki water-er) suitable for Mediterranean climates. It can be used to irrigate new transplants in an otherwise unirrigated or minimally irrigated garden. Wakki-Water-er is 30 times more efficient than a sprinkler and saves hours of standing with a hose. You attach the patent pending Wakki-Water-er to the garden hose, push the sturdy spike into the ground, turn it on and direct the specially designed adjustable nozzles at the base of each shrub. It is easy to use, convenient, and flexible in design. It saves hundreds of gallons per hour, and encourages healthier, deeper roots on the shrubs. Cypriots can try to use wakki device than to use a water hose that wastes more water and it is also against the law. The people who designed this efficient irrigation device found out that this device is over 30 times more efficient than a sprinkler. Based on their experience, a sprinkler delivered to the targets 10.1 gallons in 43 minutes, which is 0.23 gallons per minute. However, the Wakki device delivered 21 gallons in 3 minutes, which is 7 gallons per minute (fig. 6.14). (www.wakkiwater).

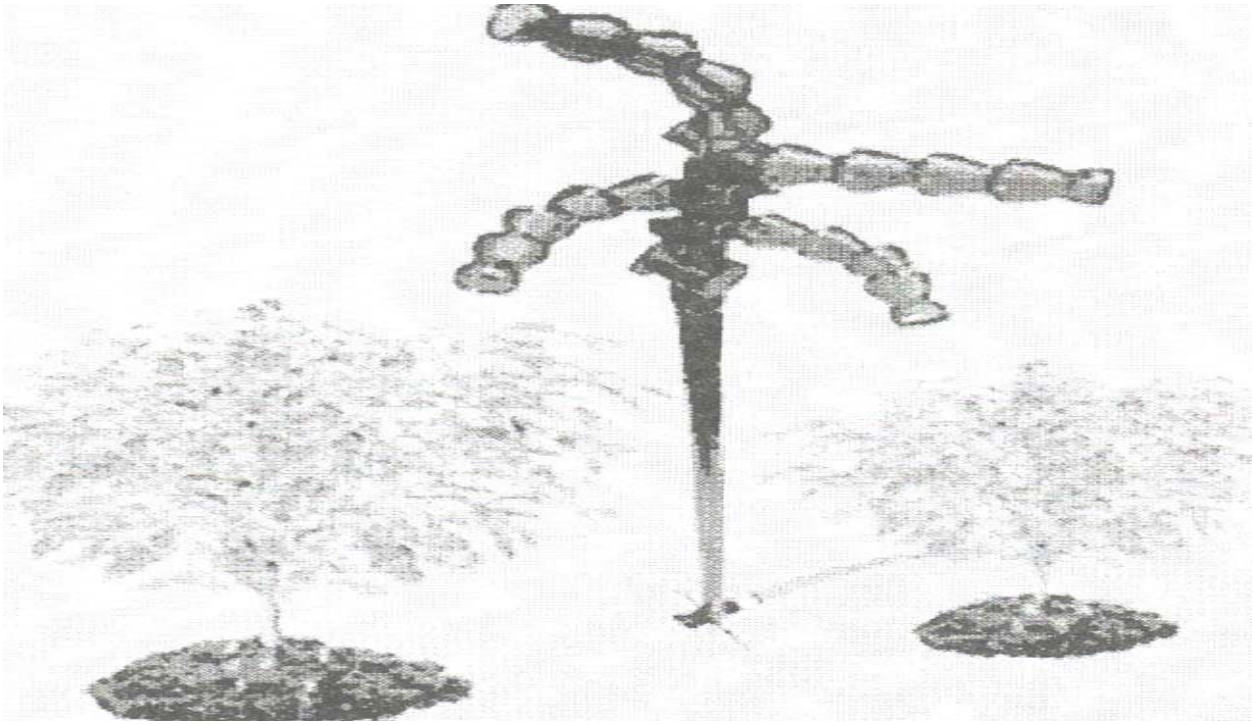


Figure 6.14 - Wakki device. (Figure: www.wakki.water web site.)

Using efficient irrigation systems in a landscape can also support the government campaign toward water conservation. Cypriots must realize that for water conservation reasons, it is forbidden to water the landscape with a water hose. As a result efficient irrigation systems will be considered. Irrigation wholesalers, nurseries, or landscape designers in Cyprus can easily and successfully do the installation of an irrigation system in a residential garden.

9. <u>Use of Mulches</u> Even though the use of mulches is not very common in Cyprus, it is recommended to use mulches but with caution. The use of mulches reduces the heat in the soil, controls weeds, helps to conserve water, minimizes evaporation, slows erosion and also gives a finished look. In Cyprus, due to the fires that are so common during the summertime, type of mulches should be carefully selected. It is recommended to use inorganic mulches rather than organic ones. Some organic mulches can be a hazard. Inorganic mulches, like rocks, crushed stone, sand, decomposed granite, and pumice, can be used. Inorganic mulches rarely need

replacement. They are good in windy spots but they retain heat. Plastic bags can also be used. They hold water, they are easily transportable, and holes can be punched into them, allowing water into the soil. Mulches can also be used to enhance the surrounding area of the site. Mulch used in the Troodos area should be different than ones used in coastal areas.

10. <u>Appropriate Maintenance</u> Cypriots are recommended to do the appropriate maintenance to their gardens to avoid undesirable results. These types of gardens that conserve water will need more water and maintenance during the first two years, but after that will be easy to take care of. Maintenance will be reduced every year. It is true that the landscape can look empty in the first couple of years, but plants will eventually grow and will look very attractive. A higher budget can be spent to buy larger native plants to create a nicer Xeriscape garden from the first couple of months. Early fall is the time to concentrate on, the time for most of the planting and some fertilizing, as well as the pruning of those trees and shrubs that have not been watered during the summer. In addition, the use of plant containers is recommended for planting, which limits the area of soil that needs to be watered and then cuts down on water consumption. In the Mediterranean regions, potted plants are very popular and can be the furniture of the outdoor space (Water Denver Colorado web site, Latymer 17, 20, 23, 34, 46).

Figure 6.15 - Use of plant containers. (Photo: Latymer 46.)

Conclusion/Implications

The purpose of this thesis was to adapt Xeriscape guidelines to residential gardens in Cyprus. The objective of this thesis was met by applying the Xeriscape guidelines to two case studies in Cyprus that vary in geographic location. Each case study provides conceptual diagrams and recommendations. The case studies helped me to elaborate the Xeriscape guidelines originated by Denver Water, and to provide in the guidelines specific information on Cypriot conditions, such as natural and cultural factors.

When I reviewed the Denver Water Xeriscape guidelines, I realized that these guidelines are generic and can be adapted to any location, including Cyprus. Even though it is the intent to be general, I investigated the original principles to consider specific Cyprus requirements of slope, wind, soil and sun angles. However, there are not enough explanations and graphics on how these principles work. My guidelines include figures on correcting a slope, wind pattern, composition of soil, and sun direction at different time of the day with informative explanations that one could rely on when designing a garden that conserves water. This information was very useful for my considerations on each of the case studies.

The next step was to investigate ways to adapt guidelines to Cyprus. These guidelines, as I stated before, does not include information that was very important in the process to design a garden that conserves water in Cyprus. For example, a major gap is the emphasis on water quality analysis. A quality water analysis should be included in each design to verify if water quality is suitable for plant selection. For instance, if water contains a high quantity of boron, then lemon trees could not survive. Guideline number four on the Xeriscape guidelines, adapted to Cyprus, explains how water analysis could affect plant selection. Water analysis was not

included in the general guidelines because water quality is not an issue. However, water quality is a big issue in Cyprus.

After that, I realized that there are natural and cultural factors that affect the guidelines. Major factors that are included in the guidelines to apply them to Cyprus are: map of bioclimatic zone, map of soil in Cyprus, information on water quality such as its boron content and salinity, a list of plants native of and adapted to Cyprus, types of grasses for Cyprus, methods of irrigation, and recommendations of mulches. Examples of cultural factors that affect the principles of Xeriscape are: attitude of people toward lawn, patio, privacy in garden, use of materials such as concrete and mulches, and also the effect of government limitations. The character of the site, the rules and regulations of each site, and maintenance are included, too. A major problem that I faced while I gathered information of natural factors in Cyprus is that there is a lack of research related to my thesis topic in Cyprus. An interesting way that I gathered related information on my thesis was through interviews with professional and non-professional Cypriots that related to water issues. In addition, my father, who is a horticulturist, make a contribution through his experience and his connections at the Ministry of Agriculture to provide me with all related information and to clarify all possible questions I had through our long-distance discussions on the phone. Another major problem while adapting Xeriscape guidelines to Cyprus is how to connect the cultural differences of Cyprus. Culture is very difficult to be explained in general so I found that specific examples could help. Cultural examples through the guidelines and case studies were based on my own experiences and knowledge on this topic.

Applying Xeriscape guidelines to two case studies became an interesting step and an important contribution to my thesis. The guidelines that were tested with two sites in Cyprus by preparing the conceptual diagrams and recommendations for each site, provided very useful

information that helped my process to adapt the guidelines to Cyprus. Also, testing the guidelines into two real sites help me experience important factors and problems that a Landscape Architect should be aware of while designing a gardens that conserves water in Cyprus. An important step to develop the case studies was the idea to select two case studies that represent two important geographic locations, the coastal and mountain plains in Cyprus. Even though the case study on the coastal area is only forty miles in distance from the site in the mountains, there are a lot of differences that affect my decisions while adapting Xeriscape guidelines in Cyprus.

Writing this thesis has been a great opportunity to increase my knowledge of water conservation and landscape design in Cyprus and organize information of this topic in a useful and systematic way, which was not done before. I am also so pleased that I have had the experience of collecting information in Cyprus and learning, where to get information and whom to contact, which was the most difficult, time-consuming but worthwhile step. Also, it has been an experience to begin trusting my own innate abilities.

- **Areas of Future Study**

An interesting alternative for future study might be to test the guidelines in more residential gardens in Cyprus to identify more opportunities for designing a garden in Cyprus that conserves water. In addition, a step further than testing the guidelines on cases studies can be to provide a design of each of the case studies. This will help Cypriots to see how a Xeriscape garden in Cyprus would look. Also another possibility for future study could be to provide Xeriscape guidelines specific for major geographic locations of Cyprus. This will help better to make the right selection at the right place and time in Cyprus and avoid the unfortunate results of using plants that do not fit in the area.

I hope this thesis has given the reader enough information and stimulated enough interest to adapt Xeriscape guidelines to Cyprus.

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Appendix 1 Mechanical Analysis of Soil Case Study #1

MINISTRY OF AGRICULTURE AND NATURAL RESOURCES
Department of Agriculture

№ 001402

DATA SHEET

MECHANICAL ANALYSIS OF SOIL

File No.: ..8./02... Lab No.: 1/02 Date: 22/1/02 Analyst: Z. Michael
Submitted by: Soil & Water... Site: ..Zygi..... Date: ..21./1./02....

LABORATORY RESULTS

LOCATION	DEPTH cm	PARTICLE SIZE DISTRIBUTION					pH	$CaCO_3$ %
		% SAND			SILT %	CLAY %		
		COARSE	MEDIUM	FINE				
Zygi	0-15	3	8	13	39	37	8.7	22.5
(Saint	15-30	4	7	13	33	43	8.5	23.5
Theodoros)	30-60	4	7	14	35	40	8.5	29.5
	60-90	3	7	17	38	35	8.4	33.5

(Form Agr. 294)

Chemist: [signature]

Appendix 2 Soluble Salts in Soil Samples Case Study #1

MINISTRY OF AGRICULTURE AND NATURAL RESOURCES
Department of Agriculture

№ 000791

SOLUBLE SALTS IN SOIL SAMPLES
DATA SHEET

File No.: 8/02 Lab.No.: 1/02 Analyst: Z. Michael Date: 22/1/02
Submitted by: Water & Soils Locality: Zygi Date: 2/1/02
Remarks:

LABORATORY RESULTS

SAMPLE CHARACTERISTICS			pH	ANIONS / mg/l				CATIONS / mg/l			
No.	Locality	Depth		Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}
		cm									
	Zygi	0-15	8.7	72	345	Nil	576	220	50	136	22
	(Saint	15-30	8.5	72	240	-u-	576	170	28	140	24
	Theadoros)	30-60	8.5	215	101	-u-	576	250	20	128	14
		60-90	8.4	143	134	-u-	480	180	16	148	12

(Form Agr. 295)

Chemist:

Appendix 3 Mechanical Analysis of Soil Case Study #2

MINISTRY OF AGRICULTURE AND NATURAL RESOURCES
Department of Agriculture

№ 001403

DATA SHEET

MECHANICAL ANALYSIS OF SOIL

File No.: 8/02 Lab No.: 5/02 Date: 6/3/02 Analyst: Z. Michael
Submitted by: Water & Soils Site: ..... Date: 19/3/02

LABORATORY RESULTS

LOCATION	DEPTH	PARTICLE SIZE DISTRIBUTION					pH	$CaCO_3$ %
		% SAND			SILT %	CLAY %		
		COARSE	MEDIUM	FINE				
Eutrychau	cm 0-30	4	12	15	31	38	7.4	8.0

(Form Agr. 294)

Chemist:

Appendix 4 Soluble Salts in Soil Samples Case Study #2

MINISTRY OF AGRICULTURE AND NATURAL RESOURCES
Department of Agriculture

№ 001053

SOLUBLE SALTS IN SOIL SAMPLES

DATA SHEET

File No.: 8/02 Lab. No.: 5/02 Analyst: Z. Michael Date: 6/3/02
Submitted by: Water & Soils Locality: Evrychou Date: 19/3/02
Remarks: ---

LABORATORY RESULTS

SAMPLE CHARACTERISTICS			pH	ANIONS / mg/l				CATIONS / mg/l			
No.	Locality	Depth		Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}
		cm									
---	Evrychou	0-30	7.4	215	67	Nil	480	260	68	40	22

(Form Agr. 295)

Chemist: [signature]

Appendix 5 Water Analysis Case Study #1

WASTEWATER ANALYSIS

Source of sample: [illegible] Γεωργίου / Κάτω χωριό
Sample collected by: ....
Date collected: 16.2.01

	1.	2	3	4	5
pH	7.95	8.10	7.95	7.95	7.75
Conductivity μc/cm	0.50	0.95	0.50	0.50	0.48
Chloride (Cl) mg/l	36	18	36	18	36
Sulphate (SO4) mg/l	48	273	24	129	17
Carbonate (CO3) mg/l	NIL	NIL	NIL	NIL	NIL
Bicarbonate (HCO3) mg/l	192	192	192	144	192
Nitrate (NO3) mg/l	24	16	25	17	18
Nitrite (N02) mg/l					
Sodium (Na) mg/l	21	42	22	22	22
Potassium (K) mg/l	NIL	NIL	NIL	NIL	NIL
Calcium (Ca) mg/l	36	92	52	44	44
Magnesium (Mg) mg/l	33	38	24	27	26
Boron (B) mg/l	0.1	0.1	0.1	0.1	0.1
Total N %					
Ammonia (NH3-N) mg/l					
BOD5 (Total) mg/l					
BOD5 (filtered) mg/l					
COD (Total) mg/l					
COD (filtered) mg/l					
SS mg/l					
VSS mg/l					
P mg/l					
H2S mg/l					
Fe mg/l	0.08	113	0.58	0.48	0.22
Zn mg/l	0.02	0.29	0.02	0.02	0.02
Mn mg/l	NIL	16	NIL	NIL	NIL
Cu mg/l	NIL	0.50	NIL	NIL	NIL
Pb mg/l					
Cd mg/l					
Ni mg/l					
Cr mg/l					

Agricultural Chemist

Appendix 6 Water Analysis of Case Study #2

MINISTRY OF AGRICULTURE,
NATURAL RESOURCES AND ENVIRONMENT
DEPARTMENT OF AGRICULTURE

WATER CHEMICAL ANALYSIS

File No. ..... Date: 18/01/02

Submited by: M. Mavrommati.
Owner ...Andreas Georgiou.
Address: ...Evrichou...
Location: ... Varkatzis.

Date: .....
Registration No. .....
Type of Analysis: .....

RESULTS

Electrical Conductivity dS/m ..0.69..... pH ...7.8.....

ANIONS	mg/L	meq/L	CATIONS	mg/L	meq/L
Chlorides(Cl^-)	71	2.00	Sodium (Na^+)	80	3.48
Sulfates(SO_4^{2-})	–	–	Potassium (K^+)	4	0.10
Carbonate($CO3^{2-}$)	0	0	Calcium(ca^{2+})	8	0.40
Bicarbonate(HCO_3)	288	4,74	Magnesium(Mg^{2+})	26	2.20
Nitrates(NO_3^-)	8	0.12	Boron (B)	0.17	
TOTAL	367	6.8		118	6.18

Analyst .....Agric. Officer ..... Date: .....

REMARKS

Water of very low salinity, suitable for every crop.

for Director Dept. of Agriculture

02040403
G/SS

ΧΡ. ΦΩΤΙΟΥ

Appendix 7 Salt Tolerances of Ornamentals

	Low tolerance (EC_w = 0.75 to 1.5 dS/m)*	Moderate tolerance (EC_w = 1.5 to 3.0 dS/m)	High tolerance (EC_w > 3.0 dS/m)
least tolerant	*Acacia longifolia* (Sydney golden wattle)	*Juniperus chinensis* (Hollywood juniper)	*Araucaria heterophyllea* (Norfolk Island pine)
	Cotoneaster horizontalis (Rock cotoneaster)	*Melaleuca quinquenervia* (Cajeput tree)	*Arctotheca calendula* (Cape weed)
	Leptospermum laevigatum (Australian tea tree)	*Raphiolepsis indica* (Indian hawthorn)	*Baccharis pilularis* (Coyote brush)
	Pachysandra terminalis (Japanese spurge)	*Agave attenuata* (Thin-leaved agave)	*Coprosma repens* (Mirror plant)
	Photinia fraseri (Fraser's photinia)	*Casuarina equisetifolia* (Horsetail tree)	*Cortaderia selloana* (Pampas grass)
	Pinus halepensis (Aleppo pine)	*Hakea suaveolens* (Needle bush)	*Delosperma 'alba'* (White trailing iceplant)
	Rhamnus alaternus (Italian buckthorn)	*Phormium tenax* (New Zealand flax)	*Drosanthemum hispidum* (Lavender pink iceplant)
	Strelitzia reginae (Bird of paradise)	*Pittosporum phillyraeoides* (Desert willow)	*Gazania aurantiacum* (South African daisy)
	Vinca minor (Dwarf running myrtle)		*Lampranthus spectabilis* (Trailing iceplant)
	Limonium perezii (Sea lavender)		*Phyla nodiflora* (Lippia)
	Punica granatum (Dwarf pomegranate)		*Myoporum laetum* (Myoporum-shrub)
	Crassula argentea (Jade plant)		*Myoporum parvifolium* (Myoporum-ground cover)
	Festuca ovina cv. Glauca (Blue fescue)		*Pittosporum crassifolium* (Evergreen pittosporum)
	Juniperus scopulorum cv. Moffetii (Moffets juniper)		
	Felicia aethiopica (Felicia)		
most tolerant			

Source: work done in solution culture by Dr. Roy Branson, Extension Specialist, and Richard Maire and Lyle Pyeatt, Farm Advisors, UC Cooperative Extension.

Appendix 8 Tolerances of Ornamentals Shrubs and Ground Covers to Salinity in Irrigation Water

	Low tolerance* (EC_w = 0.75 to 1.5 dS/m)†	Moderate tolerance (EC_w = 1.5 to 3.0 dS/m)	High tolerance (EC_w > 3.0 dS/m)
least tolerant	*Trachelospermum jasminoides* (Star jasmine)	*Pittosporum tobira* (Pittosporum)	*Nerium oleander* (Oleander)
	Feijoa sellowiana (Pineapple guava)	*Viburnum tinus* cv. Robustum (Viburnum)	✓ *Pyracantha crenatoserrata* cv. Graberi (Pyracantha)
	Ilex cornuta cv. Burfordii (Burford holly)	*Ligustrum lucidum* (Texas privet)	*Rosmarinus officinalis* cv. Lockwood de Forest (Rosemary)
	✓ *Rosa* sp. cv. Grenoble on Dr. Huey Root (Rose)	Lantana camara (Lantana)	*Cordyline endivia* (Blue dracaena)
	Hedera canariensis (Algerian ivy)	*Buxus microphylla* cv. Japonica (Boxwood)	*Euonymus japonica* cv. Grandifolia (Euonymus)
	✓ *Hibiscus rosa-sinensis* cv. Brilliante (Hibiscus)	*Xylosma congestum* (Xylosma)	*Carissa grandiflora* (Natal plum)
	Nandina domestica (Heavenly bamboo)	*Platycladus orientalis* (Arborvitae)	✓ *Bougainvillea spectabilis* (Bougainvillea)
		✓ *Dodonaea viscosa* cv. Atropurpurea (Dodonaea)	
		Elaeagnus pungens (Silverberry)	
		Juniperus chinensis (Spreading juniper)	
most tolerant		*Callistemon viminalis* (Weeping bottlebrush)	

Source: L. Bernstein, L. E. Francois, R. A. Clark. 1972. Salt tolerance of ornamental shrubs and ground covers. *Journal of the American Society for Horticultural Science*. 97 (4): 550-56.

* Listed in decreasing order of sensitivity. EC_w values shown are associated with generally satisfactory appearance and up to 25% decrease in top growth.

† EC_w means electrical conductivity of irrigation water. Assumptions include the following: $EC_e \times 2 = EC_{sw}$, EC_e = electrical conductivity of soil saturation extract representative of the more active part of the root zone. EC_{sw} = electrical conductivity of the soil water. $EC_w \times 3 = EC_{sw}$, $\frac{1}{2} EC_{sw} = EC_e$, $EC_e = \frac{2}{3} EC_w$. All values are expressed as decisiemens per

Appendix 9 Salt Tolerance of Ornamental Shrubs, Trees and Ground Cover

Common name	Botanical name	dS/m
Very Sensitive		
Star jasmine	*Trachelospermum jasminoides*	1–2
Pyrenees cotoneaster	*Cotoneaster congestus*	1–2
Oregon grape	*Mahonia Aquifolium*	1–2
Photinia	*Photinia x Fraseri*	1–2
Sensitive		
Pineapple guava	*Feijoa Sellowiana*	2–3
Chinese holly, cv. Burford	*Ilex cornuta*	2–3
Rose, cv. Grenoble	*Rosa sp.*	2–3
Glossy abelia	*Abelia x grandiflora*	2–3
Southern yew	*Podocarpus macrophyllus*	2–3
Tulip tree	*Liriodendron Tulipifera*	2–3
Algerian ivy	*Hedera canariensis*	3–4
Japanese pittosporum	*Pittosporum Tobira*	3–4
Heavenly bamboo	*Nandina domestica*	3–4
Chinese hibiscus	*Hibiscus Rosa-sinensis*	3–4
Laurustinus, cv. Robustum	*Viburnum Tinus*	3–4
Strawberry tree, cv. Compact	*Arbutus Unedo*	3–4
Crape Myrtle	*Lagerstroemia indica*	3–4
Moderately Sensitive		
Glossy privet	*Ligustrum lucidum*	4–6
Yellow sage	*Lantana Camara*	4–6
Orchid tree	*Bauhinia purpurea*	4–6
Southern Magnolia	*Magnolia grandiflora*	4–6
Japanese boxwood	*Buxus microphylla var. japonica*	4–6
Xylosma	*Xylosma congestum*	4–6
Japanese black pine	*Pinus Thunbergiana*	4–6
Indian hawthorn	*Raphiolepis indica*	4–6
Dodonaea, cv. atropurpurea	*Dodonaea viscosa*	4–6
Oriental arborvitae	*Platycladus orientalis*	4–6
Thorny elaeagnus	*Elaeagnus pungens*	4–6
Spreading juniper	*Juniperus chinensis*	4–6
Pyracantha, cv. Graberi	*Pyracantha Fortuneana*	4–6
Cherry plum	*Prunus cerasifera*	4–6
Moderately Tolerant		
Weeping bottlebrush	*Callistemon viminalis*	6–8
Oleander	*Nerium oleander*	6–8
European fan palm	*Chamaerops humilis*	6–8
Blue dracaena	*Cordyline indivisa*	6–8
Spindle tree, cv. Grandiflora	*Euonymus japonica*	6–8
Rosemary	*Rosmarinus officinalis*	6–8
Aleppo pine	*Pinus halepensis*	6–8
Sweet gum	*Liquidambar Styraciflua*	6–8
Tolerant		
Brush cherry	*Syzygium paniculatum*	>8
Ceniza	*Leucophyllum frutescens*	>8
Natal plum	*Carissa grandiflora*	>8
Evergreen Pear	*Pyrus Kawakamii*	>8
Bougainvillea	*Bougainvillea spectabilis*	>8
Italian stone pine	*Pinus pinea*	>8
Very Tolerant		
White iceplant	*Delosperma alba*	>10
Rosea iceplant	*Drosanthemum hispidum*	>10
Purple iceplant	*Lampranthus productus*	>10
Croceum iceplant	*Hymenocyclus croceus*	>10

pecies are listed in order of increasing tolerance based on appearance as well as growth reduction. Data compiled from References [7, 14, 21]
alinities exceeding the maximum permissible κ_e may cause leaf burn, loss of leaves, and/or excessive stunting.
laximum permissible κ_e is unknown. No injury symptoms or growth reduction was apparent at 7 dS/m. The growth of all iceplant species
reased by soil salinity of 7 dS/m.

Appendix 10 Relative boron tolerances of plants

	Sensitive (0.5 to 1.0 mg/L boron)	Somewhat tolerant (1.0 to 2.0 mg/L boron)	Tolerant (2.0 to 10.0 mg/L boron)
least	Lemon	Lima bean	Carrot
tolerant	Grapefruit	Sweet potato	Lettuce
↑	Avocado	Bell pepper	Cabbage
	Orange	Tomato	Turnip
	Thornless blackberry	Pumpkin	Onion
	Apricot	Zinnia	Broad bean
	Peach	Oat	Gladiolus
	Cherry	Milo	Alfalfa
	Persimmon	Corn	Garden beet
	Kadota fig	Wheat	Mangel
	Grape (Sultanina & Malaga)	Barley	Sugar beet
	Apple	Olive	Palm *(Phoenix canariensis)*
	Pear	Ragged robin rose	
	Plum	Field pea	Date palm *(Phoenix dactylifera)*
	American elm	Radish	
	Navy bean	Sweet pea	Asparagus
	Jerusalem artichoke	Pima cotton	Ather *(Tamarix aphylla)*
	Persian (English) walnut	Acala cotton	
most	Black Walnut	Potato	
tolerant	Pecan	Sunflower	

Source: USDA Technical Bulletin 448.

Appendix 11 Boron Tolerance Limits for Ornamentals

Common name	Botanical name	Threshold (g/m^3)
Very sensitive		
Oregon grape	*Mahonia Aquifolium*	<0.5
Photinia	*Photinia X Fraseri*	<0.5
Xylosma	*Xylosma congestum*	<0.5
Thorny elaeagnus	*Elaeagnus pungens*	<0.5
Laurustinus	*Viburnum Tinus*	<0.5
Wax-leaf privet	*Ligustrum japonicum*	<0.5
Pineapple guava	*Feijoa Sellowiana*	<0.5
Spindle tree	*Euonymus japonica*	<0.5
Japanese pittosporum	*Pittosporum Tobira*	<0.5
Chinese holly	*Ilex cornuta*	<0.5
Juniper	*Juniperus chinensis*	<0.5
Yellow sage	*Lantana Camara*	<0.5
American elm	*Ulmus americana*	<0.5
Sensitive		
Zinnia	*Zinnia elegans*	0.5–1.0
Pansy	*Viola tricolor*	0.5–1.0
Violet	*Viola odorata*	0.5–1.0
Larkspur	*Delphinum sp.*	0.5–1.0
Glossy abelia	*Abelia x grandiflora*	0.5–1.0
Rosemary	*Rosmarinus officinalis*	0.5–1.0
Oriental arborvitae	*Platycladus orientalis*	0.5–1.0
Geranium	*Pelargonium X hortorum*	0.5–1.0
Moderately sensitive		
Gladioli	*Gladiolus sp.*	1.0–2.0
Marigold	*Calendula officinalis*	1.0–2.0
Poinsettia	*Euphorbia pulcherrima*	1.0–2.0
China aster	*Callistephus chinensis*	1.0–2.0
Gardenia	*Gardenia sp.*	1.0–2.0
Southern yew	*Podocarpus macrophyllus*	1.0–2.0
Brush cherry	*Syzygium paniculatum*	1.0–2.0
Blue dracaena	*Cordyline indivisa*	1.0–2.0
Ceniza	*Leucophyllum frutescens*	1.0–2.0
Moderately tolerant		
Bottlebrush	*Callistemon citrinus*	2.0–4.0
California poppy	*Eschscholzia californica*	2.0–4.0
Japanese boxwood	*Buxus microphylla*	2.0–4.0
Oleander	*Nerium Oleander*	2.0–4.0
Chinese hibiscus	*Hibiscus Rosa-sinensis*	2.0–4.0
Sweetpea	*Lathyrus odoratus*	2.0–4.0
Carnation	*Dianthus Caryophyllus*	2.0–4.0
Tolerant		
Indian hawthorn	*Raphiolepis indica*	6.0–8.0
Natal plum	*Carissa grandiflora*	6.0–8.0
Oxalis	*Oxalis Bowiei*	6.0–8.0

Species listed in order of increasing tolerance based on appearance as well as growth reduction.
Boron concentrations exceeding the threshold may cause leaf burn and loss of leaves.

Vita

Elli George Georgiou was born in 1975 to George and Vera Georgiou in Nicosia, Cyprus. She graduated from Archbishop Makarios III High School in Nicosia, Cyprus, in 1993, and enrolled at the University of New Orleans in New Orleans (UNO), Louisiana. After receiving a Bachelor of Science degree in marketing in 1999 from UNO, she moved to Baton Rouge, Louisiana, and began graduate school at Louisiana State University in Baton Rouge, Louisiana. Elli anticipates an August 2002 graduation with a Master of Landscape Architecture degree. After graduation, Elli plans to become a licensed landscape architecture and open her own design practice.