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Cost-benefit analysis of native landscapes : a San José Mercury News campus study

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COST-BENEFIT ANALYSIS OF NATIVE LANDSCAPES:

A SAN JOSÉ MERCURY NEWS CAMPUS STUDY

A THESIS

PRESENTED TO

THE DEPARTMENT OF ENVIRONMENTAL STUDIES

SAN JOSÉ STATE UNIVERSITY

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF SCIENCE

BY

KRISTIN MARIE HESS

DECEMBER 2003

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ABSTRACT

COST-BENEFIT ANALYSIS OF NATIVE LANDSCAPES: A SAN JOSÉ MERCURY NEWS CAMPUS STUDY

by Kristin Hess

This study compares the costs of landscaping with native versus non-native plants at the San José Mercury News campus in San José, California. Annual expenses from irrigation, chemicals, plants, labor, and energy were examined for both landscapes over a projected 20 years to determine present value of all costs. Demolition costs of the non-native landscape and implementation of the native landscape are incorporated into the cost-benefit analysis. Wildlife and environmental benefits from native landscapes are addressed non-quantitatively.

The costs of implementation and maintenance of the native landscape in the first four years were higher than the first four years of maintaining the current landscape. However, as the landscape became more self-sustaining, costs associated with the native landscape were significantly reduced. Regardless of higher costs in the first three years, a tremendous cost savings was seen over 20 years with the native landscape, even with the most conservative discount rate.

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INTRODUCTION

Motivation

The Santa Clara Valley in Northern California (Figure 1) was once known as a beautiful countryside of colorful wildflowers and majestic oak trees that awed early settlers. This native vegetation is quickly disappearing due to dramatic population growth and urban sprawl across the valley. In addition, sprawling homes and businesses choose landscape designs that include non-native plants from Europe or the East Coast, where rainfall is more abundant. Historically, the Santa Clara Valley has experienced long, dry summers with cool, wet winters and, over time, the local native vegetation has developed strategies that have allowed them to adapt to these conditions. The replacement of native with non-native vegetation and the increasing urban development threaten the future of California wildlife and puts tremendous stress on the environment.

Native plants cannot compete with most non-natives for water and nutrients, and the typical site will eventually be overtaken by the non-natives. Approximately 2,000 of the 5,027 native plants in California are endemic to the state (Ornduff 1974) and 18 percent are considered rare or endangered (Holland

and Keil 1995), supporting the argument to limit the use of non-natives and encourage the use of natives. The presence of non-natives disrupts natural interactions between all forms of wildlife, including reducing the food supply for animals and interfering with the natural successional process.

These non-native plants are not self-sustaining and often require severe modification of the local environment and intense human labor for their survival. Massive water projects built to import this water have caused habitat destruction in river valleys, damaged aquatic systems, devastated natural fisheries, increased river salinity, and caused irrigation-related pollution, and burdened taxpayers (Reisner 1993).

The traditional landscape is one of the best examples of a water intensive landscape. Originally intended to mask the tall foundations of wealthy, Victorian-style homes on the East Coast (Robbins, Polderman, and Birkenholtz 2001; Henderson, Perkins, and Nelischer 1998), lawns have become the ideal in typical U.S. landscapes. These lawns require intensive use of water, herbicides, fertilizers, pesticides, energy and a great deal of maintenance, while providing few environmental benefits to wildlife.

Fertilizers, based on the principle of biological nitrogen fixation, add nitrogen to the soil to promote fast growth. However, the amount added

through fertilizer is usually many times more than would naturally occur. Much of this excess nitrogen leaches into groundwater and is transported to lakes, rivers and other bodies of water, and ultimately to marine waters, where nitrogen is the limiting factor in plant growth.

Gasoline-fueled equipment, such as the lawn mower and lawn trimmer, is often used in the frequent maintenance of traditional landscapes. Although energy conservation is encouraged throughout the state and the country due to the expense and decreasing supply of resources, consumption continues to rise, contributing to air pollution and occasional oil spills, which harm wildlife and cost taxpayers millions to clean up. By landscaping with native plants it appears much of this environmental damage can be avoided and costs reduced.

Regardless of the obvious implications that native landscapes pose, little research has been conducted on overall cost savings. Although many studies have looked at cost differences of traditional landscapes in comparison to water conserving and low maintenance landscapes, very little research has been conducted concerning traditional non-native landscapes in comparison to native landscapes. Additionally, much of the literature addresses design concepts of native landscapes or the environmental benefits of such landscapes, but fails to include any associated expenses. Interestingly, many professionals claim that

native landscapes do save money in the long term, but these are often unsubstantiated claims due to lack of research. This study will provide a better understanding of the true expenses associated with maintaining a native landscape as opposed to a non-native landscape.

Focus

This research will focus on a particular landscape that is typical of most businesses in the Santa Clara Valley in California, and more specifically, in the city of San José. The San José Mercury News (SJMN) business site is located at 750 Ridder Park Drive in north San José (Figure 2). The property sits on 35 acres near Coyote Creek. Although the site contains many landscaped parcels, this study will focus only on the 63,500 square foot (1.4 acre) front lawn and the associated front areas, including flower pots, flower beds, and trees on the lawn. Figure 3 shows an aerial view of the property with the front lawn area just north of the main building.

Recently, the trees between Highway 880 and the building were cut down, leaving the site completely exposed to all highway traffic. Because it is presumed that native landscapes cost less overall than non-native landscapes due to lower maintenance and water needs, the company is contemplating

converting their site from a traditional, non-native landscape to a native landscape to create a positive public image, help the environment, and possibly save money (Yarnold 2003).

Background

Climate. The climate in San José is Mediterranean with warm, dry summers and cool, wet winters. Annual precipitation is 15 inches (380 mm), mostly as rainfall between the months of November and March (Western Regional Climate Center 2001). Drought conditions are common and many years can pass with little rainfall. Riparian zones, such as Coyote Creek, are found naturally within the city and would often flow through woodland areas. In January the average high temperature is 58° F (14° C) and the average low is 41° F (5° C). The average high temperature in July is 82° F (28° C) and the average low is 57° F (14° C) (Western Regional Climate Center 2001).

Landscape of San Jose. Historically, San José has sustained oak woodlands, chaparral, and grasslands. These communities provide food and/or shelter to 5,000 species of insects, 80 species of reptiles and amphibians, 100 species of birds, 60 species of mammals, making it one of the most productive communities

in the state (Pavlik et al. 1991). The nearby riparian areas provided a source of water to the wildlife.

Today, however, San José is in the center of high-tech Silicon Valley with sprawling industrial parks, businesses, and single family homes covering the city floor. Many roads and freeways have been built to accommodate the residents of San José, where public transportation alternatives are few. Much of the vegetation in the city today is made up of non-native landscapes in city parks, residential homes, and industrial business parks. Generally, these are comprised of turf lawns and other plants that require intense use of water, fertilizers and chemical controls, energy, and labor.

A native landscape has been designed by Middlebrook Gardens, a landscape design company specializing in native plants, which will be implemented if SJMN decides to convert. Hence, expenses for native landscape costs in this study will be based on the proposed native landscape of Middlebrook Gardens.

Research Objectives

The purpose of this study is to evaluate the costs and benefits (savings) of traditional, non-native landscaping methods versus those of native landscaping

on the San José Mercury News business site in San José, California. The objectives of the research are to:

- Determine the costs incurred annually from water use and irrigation system repairs, fertilizer and chemical controls, plants, labor, and energy use over the first three years for the native landscape and over the long-term (20 years) for both landscapes. These costs will be projected 20 years into the future to find the cumulative present value (PV) of the annual costs. From this data, it will be determined which landscape is more cost-effective overall over the course of the 20 year life of the landscape.
- Determine costs to demolish the current landscape and implement the new. Once these costs are obtained, they will be added into the annual expenses of the native landscape to determine if this landscape is more cost-effective even when the additional cost of demolition and implementation are included in the 20 year cost.
- Consider any environmental benefits that will be provided with the implementation of the native landscape. These will not be included in the monetary analysis due to the complexity of the issue. They will be treated non-quantitatively.

RESEARCH

One of the major goals of most landscape projects is to develop as much area of the site as possible with the minimum amount of investment (Austin 1984). In his book *Designing the Natural Landscape*, Austin (1984) explains that costs can be raised or lowered by the use of mechanical irrigation systems, complicated planting techniques, spacing of plant materials, mechanical support for severe slope stabilization, and the size of the planted materials.

Landscape Costs and Benefits

Sustainable Landscapes and Gardens by Groesbeck and Striefel. Groesbeck and Striefel (1995) explain in their book *Sustainable Landscapes and Gardens* that the main costs of any landscape include operational energy costs, material and resource costs, embodied energy costs, human resource costs, and health costs. Operational costs include the day to day landscape maintenance and management; the costs of fuel and energy to mow and maintain lawns; the costs of piping, pumping, electrical equipment, and other equipment needed to apply water and other necessary materials; the costs of extracting and producing chemical herbicide, pesticides and fertilizers; and the costs of transporting and

disposing of yard waste and plastic nursery pots. Resource costs include securing the raw materials needed to make products available; buying water for and applying water to the landscape; displacement and loss of wildlife habitat or open space; water contamination by chemicals or fertilizers; soil erosion; and loss of species diversity. Embodied energy costs, expressed in British Thermal Units (BTUs), constitute the energy required to create, harvest, construct, demolish, and dispose of materials and products used in the landscape. Human resource costs are determined by the time and labor required to maintain and restore the landscape and health costs include the long- and short-term effects on human health that may result from chemical applications and the manufacturing process. All costs comprise the total resource expenditure of a landscape.

Groesbeck and Striefel claim the benefits of any landscape include aesthetics, energy conservation, improved health, and pollution reduction. Aesthetic benefits are derived from the visual and aural beauty of the landscape and the moods and behavior it brings about. Energy conservation benefits occur when landscape elements are used to reduce solar radiation and provide a cooling effect in summer, and divert cold winds and provide shelter in the winter. Health benefits are those that occur because of our enjoyment from and

interaction with landscapes. Pollution reduction benefits occur from trees in the landscape that clean and purify the air.

Groesbeck and Striefel suggest that by planting sustainable landscapes, costs will decrease and benefits will increase. They also state an analysis of the costs and benefits of different kinds of landscapes is difficult, but can be measured.

"Integrating Native Landscapes" by Patchett. In the article "Integrating Native Landscapes" in the September/October 2000 issue of *Land and Water*, Patchett states that native landscapes significantly reduce time spent on maintenance of the landscape. Typical environmental benefits of a native landscape are reduced surface water runoff and downstream flooding, reduced soil erosion, increased groundwater recharge, enhanced regional air and water quality, increased biological diversity of both plants and animals, and increased cost savings. He says that the most significant cost savings come from "a reduction in annual maintenance costs and the opportunity to scale back overall infrastructure needs, which can reduce initial capital development costs" (45). He also states that typical economic benefits of a native landscape include a notable reduction in annual maintenance costs and the opportunity to reduce overall infrastructure needs, thereby reducing initial investment costs. He

proclaims an 80-90 percent annual cost reduction once plants in the landscape are established.

"Water Conservation in Landscaping" by McErlane. McErlane (1989) states in "Water Conservation in Landscaping" that initial costs of a water conserving landscape do not substantially differ from those of a traditional landscape, but there is a significant decrease in the amount of labor, fertilizers, herbicides, and fuel used for mowing and clipping removal in native landscapes when compared to traditional landscapes. He refers to a state funded study in which a California water-conserving landscape consisted of half the amount of turf typically found in a traditional landscape. Fifty-four percent less water was needed, 25 percent less labor, 61 percent less fertilizer, 22 percent less herbicide, and 44 percent less fuel to maintain the landscape.

Nature's Design by Smyser. In her 1982 book *Nature's Design*, Smyser touches on the importance of native landscapes and then gives instruction on how to implement an appropriate landscape for every region of the country. Imported plants often attract exotic insects that can damage or kill nearby native plants and beneficial native insects. Pesticides are not necessary in a native landscape since native plants have evolved to resist local pests, which often damage or kill exotic species. Rather than using pesticides or herbicides to

control pests, she suggests incorporating predatory insects. She asserts that nature and native plants keep a perfect ecological balance and any non-native species will disrupt that balance (Block 2001).

She claims that in native landscapes the need for fertilizers, water and energy is also reduced. However, Diekelmann, and Schuster (1982), claim that all garden costs can be completely eliminated when using natives. Smyser believes a well planned native landscape can reduce energy costs by incorporating shade trees or vines. Common shade trees in California, according to Smyser include toyon (*Heteromeles arbutifolia*) and interior live oak (*Quercus wislizensii*). Insulating vines include California wild rose (*Rosa californica*) and Western virgin's bower (*Clematis ligusticifolia*).

Harvey Mudd College Study. A study at Harvey Mudd College, headed by Beckman and Hamlett, was conducted between 2000 and 2001. A small native garden was designed and implemented, in order to compare expenses spent on a portion of the lawn on campus. They examined water use, fertilizer use, pesticide use, and sustainability of each study area by reviewing bills and records of the college. Implementation costs of the new landscape were obtained by averaging many contractor bids. They projected that by reducing the size of their lawn and replacing non-native plants with natives they would save 73

percent per year on maintenance, water, plant replacements, chemical application, and energy costs. The greatest savings were found in plant replacements (90 percent reduction) and irrigation-related repairs (83 percent reduction).

Xeriscapes

The term xeriscape was coined in 1978 and refers to a landscape design that conserves water and protects the environment (Roche 2000). It is not a native landscape. However many of the same principles apply to a native California landscape. Both require little water, include plants that are adaptable to the region's soil and climate, and often group plants according to water needs. Xeriscapes often include native plants, but typically also include non-natives. In "Xeriscaping Means Never Having to Say You're Sorry," Roche (2000) says that the key to a beautiful, interesting landscape is combining natives and non-natives. Smith and St. Hilaire (1999) contradict Roche's statement in the November issue of *New Mexico Journal of Science*, claiming that landscapers who install xeriscapes are more likely to use native plants. In fact, Smith and St. Hilaire (1999) list some of the benefits of xeriscapes as reduced water expenses,

less time spent on maintenance, and increased use and appreciation of native plant material.

According to Smith and St. Hilaire, the seven principles of xeriscaping are planning for plant placement according to water needs, selecting appropriate turf areas, using an efficient irrigation system, improving the soil, using mulches, choosing appropriate plant material, and using good maintenance techniques.

Roche (2000), Smith and St. Hilaire (1999) and Hart (1993) all stress the importance of planning to create the most efficient xeriscape. Creating shade is an important factor because it helps cool the landscape and reduces water loss (Roche 2000; Brainerd 1973). Plant placement is also an important factor, as this allows for plants that require more water to be grouped together, leading to more efficient use of water and replicating the plant communities found in nature. The use of turf lawn is limited in xeriscapes. However, it is not prohibited in highly traveled areas (Hart 1993; Roche 2000). Smith and St. Hilaire (1999) state that grasses requiring little supplemental irrigation are acceptable, as long as only essential turf areas are maintained and turf grasses appropriate to the area are chosen (Wade 1994). They estimate a 30-60 percent reduction in water use and believe pests and invasive plants are less likely to be introduced in a well-planned xeriscape. However, in "Xeriscaping Provides

Lush Landscapes with Little Water," Hart (1993) estimates a 50-80 percent reduction in water needs. To further reduce maintenance costs, leaf litter should be left on the ground as a soil amendment and volunteer seedlings should be left to mature Roche (2000). This can also be practiced in traditional landscapes, reducing maintenance costs as well.

All authors suggest adding organic matter to shrub and flower beds to increase the ability of the soil to absorb and store water, yet Roche (2000) finds it unnecessary and not economically feasible to use in tree and grass areas. They also suggest using organic mulch to conserve soil moisture, control erosion, and help reduce weeds and soil-borne diseases. Roche (2000) and Smith and St. Hilaire (1999) urge not using rock mulches, which radiate large amount of heat and promote water loss through evaporation. Applying nitrogen fertilizer at the right time and in the proper amount can be beneficial by reducing the water needs and mowing requirements of lawns (Roche 2000). Hart (1993) and Cutler (1999) claim using too much fertilizer can cause plants to become weak.

Turf Lawn and Chemical Costs

Turf accounts for up to 80 percent of irrigation and maintenance costs (Hart 1993). Although water supplies have become scarcer, and in some cases

prices have increased, turf lawns continue to be favored in many traditional landscapes. Yet because of their shallow root systems and minimal pore spaces, water tends to run off the turf rather than permeate the soil, leading to frequent watering throughout the year (McErlane 1989; Fee 1993; Patchett 2000), of up to one and a half inches of water per week (McErlane 1989). According to Alrie Middlebrook, owner of Middlebrook Gardens, a 40 by 20 foot lawn may require 10,000 gallons of water per month in the summer (Middlebrook 2003).

Chemicals used on these landscapes can kill beneficial natural predators and parasites found in landscapes (Coppin, Eisenhauer, and Krannich 2002), contribute to surface water contamination, and cause death in birds (Pimentel and Acquay 1992). Studies have also shown chemical applications in landscapes can cause cancer, infertility, neurological defects, lung, kidney and liver damage, and developmental disorders in children (Goldman and Koduru, 2000; Pimentel and Acquay 1992). According to the California Native Plant Society (CNPS) (n.d.a.) the cleanup of these chemicals leads to additional expenses.

"Lawns and Toxins: An Ecology of the City" by Robbins, Polderman and Birkenholz. In the December 2001 issue of *Cities*, Robbins, Polderman, and Birkenholtz estimate in their article "Lawns and Toxins: An Ecology of the City," that nationwide lawn coverage is between eight and 16 million hectares. In the

U.S., 16 million kg of active pesticide ingredients are sold and used in gardens each year. However, Coppin, Eisenhauer, and Krannich (2002) claim four billion pounds were used in all of the U.S. in 1997. On average, 30 percent of the total 2,4-D, glyphosate, chlorpyrifos, and dicamba used in the U.S. are applied to residential lawns.

Robbins, Polderman, and Birkenholtz further state that toxic chemicals of lawn maintenance are significant contributors to non-point source water quality problems. Additionally, they state that some chemicals may be only mildly toxic to humans, but can be detrimental to the integrity of water resources when leached into the environment. Fertilizer contains a tremendous amount of nitrogen which leaches into water systems and prohibits plant growth. When unregulated, they believe the "application of these chemicals accumulate as systematic costs to society" through environmental degradation (174).

"Environmental and Economic Costs of Pesticide Use" by Pimentel and Acquay. In an article appearing in the November 1992 issue of *BioScience*, Pimentel and Acquay attempted to place an economic value on the environmental damages caused by pesticides. First they determined that spending \$4 billion in pesticide control saves \$16 billion in U.S. crops. They continued by placing an economic value on the environmental costs of

pesticides, based on a number of studies that had previously been published.

Their calculations showed the following. Human pesticide poisonings, including illnesses and death are approximately \$787 million annually. All livestock lost to pesticide contamination, including contaminated meat, eggs, and milk, are an estimated cost of \$29.6 million each year. An annual \$30 million cost was placed on pesticide resistance in pests. Honeybee and related pollination losses caused by pesticides and pollination losses attributed to pesticides were estimated to be \$200 million annually. Other crop and crop product losses were estimated at \$550 million each year. The total annual cost of groundwater and surface water contamination, including monitoring and cleanup costs, totaled \$1.8 billion. Fishery losses totaled between \$10 and \$24 million each year, but they admit this calculation was conservative and believe the actual cost is several times higher. They estimated \$2 billion in birds and bird-related activities were lost annually when including money spent on bird watching and bird hunting. Lastly, the amount spent by federal and state governments each year on pesticide pollution control is about \$200 million. Their final conclusions were that the total yearly environmental and social costs of pesticides were about \$8 billion. The users of pesticides pay approximately \$3 billion. However, the remaining \$5 billion in environmental and public health costs are paid by other members of society.

They end by suggesting that if accidental poisonings, which happen regularly, were included in this study, the actual costs to society would be even greater. A summary of these findings can be found in Table 1.

Environmental Benefits of Native Landscapes

By planting native plants in a city with little open space, food and habitat are provided for wildlife in the center of industrial cities. The native plants and wildlife have a symbiotic relationship, whereby the plants also benefit from the wildlife by pollination, reduced competition, and seed dispersal and regeneration (Pavlik et al. 1991). Although some introduced plants can also provide habitat, it is often for non-native wildlife and provided in less abundance.

"There Goes the Neighborhood" by McKinney. In his article "There Goes the Neighborhood," McKinney (2000) discusses the rapid transformation of the natural landscape by human settlement, which often creates habitat fragmentation by separating natural areas that were once continuous. With urban sprawl, "natural ecosystems are swallowed up and transformed into concrete deserts" (24). While only two to five percent of the total U.S. surface is covered with pavement, over 50 percent of many metropolitan areas are covered

with pavement (McKinney 2000). Plant growth on pavement is nearly impossible due to the difficulty of root penetration, creating a permanent biological wasteland for all wildlife. McKinney (2000) and Essman (1998) suggest planting native vegetation within the city to increase plant and animal diversity and species richness and to create wildlife habitat corridors.

He goes on to describe the idealized lawn as "an attempt to arrest the natural process of ecological succession" (26). In the natural process of succession, areas colonized by grasses would soon be replaced by shrubs and trees, thereby increasing diversity. This process, however, is halted with the urban lawn since an abundance of chemical applications and a tremendous amount of maintenance suppress the growth of later successional plants. Gibson et al. (2000) add to this idea by showing that by allowing natural ecological succession to occur, the diversity of non-native species in an area is reduced and the diversity of native species is increased.

"Urbanization, Biodiversity and Conservation" by McKinney. In his article "Urbanization, Biodiversity and Conservation," McKinney (2002) provides two reasons why the number of non-native plants increases toward the centers of urbanization and the number of natives decreases. First, higher population densities are found here, which is often accompanied by increasing exotic plant

cultivation. Secondly, the increasing amount of disturbed habitat near the urban core encourages non-native growth. He also states that the lowest species diversities of plants and animals are at the urban core of development, where species numbers are less than half of that found in rural areas. Areas near the urban core that have been cultivated with native plants or allowed to continue succession have increased plant diversity as well as arthropod diversity and bird species richness.

Some of the most common plants within the city are what McKinney (2002) refers to as "urban exploiters." These typically non-native plants tend to be ruderal, tolerate high levels of disturbance, colonize industrial and commercial properties, and sprout through pavement. Grasses are the most common of these plants. The typical adaptive traits of these plants include tolerance to high levels of air pollution (such as smog and acidic fog), trampling, and alkaline, compacted, and nitrogenous soils.

"Butterfly Diversity and Human Land Use: Species Assemblages along an Urban Gradient" by Blair and Launer. Blair and Launer (1997) state that over 80 percent of central urban areas are covered with pavement and buildings, leaving less than 20 percent as vegetated area. However, these areas often contain low species diversity and are often eroded from trampling, pollution and invasion or

cultivation of non-native species. This expansion of human habitat creates habitat fragmentation for wildlife. They found in their study that the number of non-native plants increases toward the centers of urbanization and the number of natives decreases. They also found that as a community became more developed, the associated butterfly community decreased proportionately.

"Does Native Invertebrate Diversity Reflect Native Plant Diversity? A Case Study from New Zealand and Implications for Conservation" by Crisp, Dickinson and Gibbs. A study in New Zealand by Crisp, Dickinson and Gibbs (1998) studied the proportions of native and introduced beetle species collected from habitats containing varying proportions of native and introduced plant species. They found a positive trend between the percentage of native beetle species collected and the percentage of native plant species in the area where they were found. The highest percentage of native insect species was found in areas with the greatest native plant cover, while the two areas with the largest proportion of introduced plants had significantly lower percentages of native beetle species.

California Native Plant Society. The California Native Plant Society is a non-profit organization that strives to educate the public about the importance of native plants and encourages their use in cities. Some of the berry-producing

plants they suggest for providing food to wildlife include Mexican elderberry (*Sambucus maxicana*), holly leaf cherry (*Prunus ilicifolia*), California coffeberry (*Rhamnus californica*), brown dogwood (*Cornus glabrata*), toyon, Oregon grape (*Mahonia aquifolium*), and poison oak (*Toxicodendron diversilobum*) (n.d.c.). Plants that attract butterflies and beneficial insects include rabbitbrush (*chrysothamnus nauseosus*), narrow-leaved asclepias (*Asclepias fascicularis*), showy milkweed (*Asclepias speciosa*), St. Catherine's lace (*Eriogonum giganteum*), coffeeberry (*Rhamnus tomentella*), and Lemmon's ceanothus (*Ceanothus lemmonii*). To attract birds, they especially suggest willows (*Salix* spp.), toyon, California coffeeberry, Wood's rose (*Rosa woodsii*), Western serviceberry (*Amelanchier alnifolia*), California fuschia (*Zauschneria* spp.), and blue elderberry (*Sambucus caerulea*) (1999).

Further Research

Further research is needed to identify which native plants are suited for urban landscapes and how much water they require, as well as their resistance to drought conditions (Smith and St. Hilaire 1999). Little information is available regarding native plants new to cultivation in the urban setting (Hart 1993).

Henderson, Perkins, and Nelischer (1998) suggest more research be conducted on people's perceptions of native plant lawn alternatives. People have become accustomed to landscapes with lawn and may therefore prefer them over other possibilities. This may lead to quick rejection of native plant alternatives. Although some research has been conducted and speculation made, it is not entirely clear why native alternatives are so often rejected and lawns so commonly used.

Clearly, more research needs to be done in cost-benefit analysis. Although the results found in this study may be relevant to other sites that have similar characteristics, more research must be done to determine whether similar results will be found in other areas of the state and in areas with different water availability.

It is clear there are numerous benefits to native landscaping, including less maintenance, less water use, and a reduced need for chemical applications. Very little research has been done comparing the monetary costs of traditional non-native and native plant landscapes.

METHODS

Current Landscape

The current SJMN landscape was implemented in 1967. For the past four years, GreenScape has been the landscape contractor for the site (GreenScape is a fictional name used to protect the actual landscape contractor). However, this same company cared for the site under a different name for the previous 11 years. The current landscape consists of a large turf lawn in front of the main building, strips of lawn near the front parking lots, parking lot islands, a par course, and hedges surrounding the main building. This study will address only the large turf front lawn area of the property, including the smaller patches of lawn detached from the large parcel by the walkway to the entrance, and the flower pots located near the entrance of the building. This particular parcel was chosen because it best represents the typical landscape design of most businesses, which includes turf lawn, flowers, and hedges. The total area of this parcel is 1.4 acres. The expansive size of the lawn can be seen in Figure 4. The plants in the landscape and their locations are described below and the layout of the design is shown in Figure 5.

Vegetation. The west side of the lawn contains seven large European olive trees (*Olea europaea*), which are approximately 40 years old (Figure 6). The east side contains seven Southern magnolia trees (*Magnolia grandiflora*), six of which are approximately 40 years old and one that is between five and ten years old (Figure 7).

Below each magnolia tree is a bed of flowers that are seasonally changed twice each year. In the summer, these flower beds are planted with a variety of colors of impatiens (*Impatiens* spp.), and in the winter, with a variety of colors of violets (*Violas* spp.). The species may change each year, but the genus remains the same. This summer (2003), they are decorated with busy Lizzie (*impatiens walleriana*). A photo of a summer impatiens bed under a magnolia tree can be seen in figure 8.

There are two additional flower beds in the landscape. The first is located on the lawn near the entrance of the building, measuring 21 by 11 feet (Figure 9). The second surrounds the SJMN sign on the west side of the lawn and measures 31 by 26 feet (Figure 10). This summer, both flower beds contain blue lobelia (*Lobelia erinus*), scarlet sage (*Salvia splendens*), and African marigolds (*Tegetes erecta*). Again, the species may change every year, but the genus remains the

same. Various species of pansies and violets (*Violas* spp.) and cyclamen (*Cyclamen* spp.) are used in the flowerbeds in the winter.

In addition to the flowers mentioned above, the flowerbed near the entrance of the building also contains six Indian hawthorn (*Rhaphiolepis indica*) bushes, while the flowerbed surrounding the SJMN sign contains eight fortnight lily (*Dietes iridioides*) plants, one heavenly bamboo (*Nandina domestica*) and two Italian cypress (*Cupressus sempervirens*) trees. Each cypress tree stands at opposing ends of the sign. On the westernmost end of the lawn is a small hedge of Formosa firethorn (*Pyracantha koidzumii*) (Figure 11) and on the front of the lawn is a large hedge of escallonia (*Escallonia rubra*) (Figure 12).

There are a total of seven large flower pots in the landscape. Three are square and measure 33.75 inches across. Each is located at various edges of the lawn near the entrance and contains lobelia, salvia, and marigolds in the summer, and pansies and cyclamen in the winter. Figure 13 shows one of these pots with summer flowers. The other four pots are round and located on the stairway entrance to the lobby. The two smaller pots measure 17 inches in diameter, while the other two measure 20.5 inches in diameter. These pots also contain lobelia, salvia and marigolds in the summer, and pansies and cyclamen in the winter. Figure 14 shows the summer flowers in these pots. Summer

flowers in the pots are refreshed every July and January, meaning new flowers are planted to replace those that have died. All plants in the current landscape, the regions from which they come, and their characteristics are listed in Table 2.

Few of the plants in the current landscape are native to California. Most are from Asia, Africa, South America, and Europe. Although the turf lawn consumes a tremendous amount of water, some of the plants require very little, such as fortnight lily and heavenly bamboo. Because they are located in flower beds that receive intense watering, they receive far more water than is necessary for their survival.

The lifespan of each plant varies tremendously. European olive lives between 100-300 years. Italian cypress lives about 50 years, Formosa firethorn about 30 years, escallonia and Indian hawthorn 20 years, and heavenly bamboo lives about 10 years. Fortnight lily lives a short life of only three years (Brickell and Zuk 1996). These plants will generally live their entire potential lifespan if well cared for, needing infrequent replacement.

Most of the plants in the landscape are low maintenance, requiring trimming and pruning only once each year. The flowers require frequent care and maintenance. Because they are annuals (or perennials treated as annuals),

they must be replaced every six months. They also require frequent watering and intense fertilizer application.

Coyote Creek flows through the site, providing riparian habitat for local wildlife and, presumably, a high water table for vegetation on the property. Although a water table test was not conducted, it will be assumed that the water table is high due to the proximity of the property to the creek and by the large size of the redwood trees on the property. The soil is mostly clay due to the nearby creek bed. The creek is currently surrounded by non-native grasses and is not professionally landscaped.

Recycled water. The SJMN landscape is irrigated with recycled water by South Bay Water Recycling (SBRW). Recycled water is wastewater from homes and businesses that has been treated to make it usable in irrigation. The end product is water that is 99 percent pure. Presently, there are no federal laws controlling recycled water use. However, the quality of recycled water at SBWR is tested, monitored and regulated by the U.S. Environmental Protection Agency (EPA), Regional Water Quality Control Board, and the Department of Health Services (South Bay Water Recycling 2002).

Using recycled water benefits the environment in many ways. Because recycled water is produced from municipal wastewater, large amounts of water

are available year-round and the amount of freshwater being imported for landscape use is greatly reduced. Using recycled water also reduces the amount of treated wastewater that is discharged into local water systems from water pollution control plants. In the case of SBWR, less treated waste water is discharged into the San Francisco Bay, reducing the risk of environmental damage to fragile wetlands. Recycled water also tends to be higher in nitrogen, phosphorus, and potassium than drinking water. In many cases, plants can get all required nutrients from recycled water, possibly reducing the amount of fertilizers needed in landscapes (South Bay Water Recycling 2002).

South Bay Water Recycling suggests using some of the many plants that have been successful in landscapes that use recycled water. These include European olive, heavenly bamboo, Indian hawthorn, Formosa firethorn, fortnight lily, toyon, holly leaf cherry, California fescue (*Festuca californica*), and Idaho fescue (*Festuca idahoensis*). These plants are either in the current landscape or the proposed native landscape. Because the water used in the landscape is recycled and may be more abundant than potable water, especially in California, conservation of this resource may not be as much of a concern, especially during drought years (2001).

Glyphosate herbicide. Glyphosate, used in the popular RoundUp, was released for commercial use in 1996 and is now one of the most commonly used herbicides in the world. It is also the most commonly used chemical on the SJMN landscape. The EPA has given the active ingredient in glyphosate category E status, meaning that it shows no evidence for being a carcinogen (1998). The developer of the product, Monsanto Corporation, was granted a Green Chemistry award by the EPA for its environmental soundness. However, a recent study published in *Cancer*, the journal of the American Cancer Society, found the herbicide may be responsible for increased risk of developing Non-Hodgkin's Lymphoma (Hardell and Eriksson 2000).

Energy use. For over a century, car engines have run on a four cycle engine. Lawnmowers, like the ones used by GreenScape, however, still run on the two cycle engine, which is considered extremely inefficient and highly polluting. Two-cycle engines release 25-30% of their oil and gas unburned into the air. They also release toxins when heat causes the fuel to evaporate or when a vehicle's tank is refilled (Lin 1999). Lin claims a lawnmower with a two-cycle engine pollutes as much in one hour as 40 new cars (1999). The advantages of the two cycle engine are that the system is simpler and cheaper to build, since

they do not use expensive fuel injection systems. The engine also produces more power per weight.

Proposed Native Landscape

A native landscape for the SJMN front lawn area has been designed by Middlebrook Gardens in San José, California. The design is based on the natural oak woodland/grassland plant communities historically and naturally found in the Santa Clara Valley. Once the current landscape is demolished, the ground will be graded and mounded to reproduce the natural rolling hills of this region. Following is a description of the proposed native landscape. The layout of the design for this landscape can be seen in Figure 15.

A total of 22 oak trees will be planted in the slopes of the landscape where more water is likely to accumulate. A number of coast live oak (*Quercus agrifolia*) (Figure 16) will be planted. Four single coast live oaks will be planted on the smaller, detached patches of the front lawn area and a small cluster of three coast live oaks on the westernmost corner of the landscape. The remainder of the coast live oak will be strategically placed throughout the landscape. There will be a total of 16 coast live oaks on the site.

One cluster of four black oaks (*Quercus kelloggii*) (Figure 17) will be planted on the east side of the landscape and two valley oaks (*Quercus lobata*) (Figure 18) will be planted near the front of the building. They will be planted away from the other oak trees because they are naturally found in areas with few other oak trees and tend to grow very large. Three California buckeyes (*Aesculus californica*) (Figure 19) will be grouped near the front of the building. Surrounding the young oak trees will be leather oak (*Quercus durata*) (Figure 20), toyon (Figure 21), holly leaf cherry (Figure 22), and a minimal number of madrones (*Arbutus menziesii*) (Figure 23), which will be planted 12 feet from oak trees. These chaparral plants are often found as understory in oak woodlands. Madrone is considered a mixed evergreen woodland tree and is generally found at the edges of oak woodland communities.

Grasses and wildflower seeds will be spread over the lawn area, including red fescue (*Festuca rubra*), purple needlegrass (*Stipa pulchra*), Idaho fescue, California fescue, yarrow (*Achillea millefolium*), checkerbloom (*Sidalcea malviflora*), goldfields (*Lasthenia californica*), creamcups (*Platystemon californicus*), chia (*Salvia columbariae*), sky lupine (*Lupinus nanus*), globe gilia (*Gilia capitata*), farewell-to-spring (*Clarkia amoena*), baby-blue-eyes (*Nemophila menziesii*), meadowfoam

(*Limnanthes douglasii*), golden brodiaea (*Triteleia ixioides*), and golden mariposa (*Calochortus luteus*). Figure 24 shows a native landscape with similar grasses.

Chaparral, including bigberry manzanita (*Arctostaphylos glauca*) (Figure 25), coast silk-tassel (*Garrya elliptica*) (Figure 26), dark star (*Ceanothus integerrimus*) (Figure 27), and coyote bush (*Baccharis pilularis*) (Figure 28), a pioneer species, will be planted on the small hills of the landscape. Coyote bush is a pioneer species and will make up the majority of the plantings in the initial stage. This chaparral will grow quickly and fill in the space during the next 20 years, until the oak trees and grasses have matured. The plantings, especially the coyote bush, will fix the necessary nutrients into the soil, providing for healthy growth of trees and grasses. Figure 29 shows the beginning stage of a commercial area landscaped with chaparral under a mature oak tree. Various sized rocks and small boulders will be placed throughout the landscape.

Five large pots will be brought on the site and planted near the front entrance (Figures 30 and 31). The purpose of the pots is to house plants native to California, but not necessarily to Santa Clara Valley. This prevents their seeds from easily spreading in the ground and allows for better manipulation of their environmental conditions. Soil, for example, may need to be drier or moister for some of these plants, depending on the natural habitat and distribution of the

particular plant. These will include Cleveland's sage (*Salvia clevelandii*), woolly blue curls (*Trichostema lanatum*), mountain pernyroyal (*Monardella odoratissima*), California fuschia (*Epilobium canum*), Chilean aster (*Aster chilensis*), island buckwheat (*Eriogonium arborescens*), sulphur buckwheat (*Eriogonium umbellatum*), bluff lettuce (*Dudleya farinosa*), deergrass (*Muhlenbergia rigens*), spreading rush (*Juncus patens*), and yankee point (*Ceanothus griseus* var *horizontalis*). All plants mentioned above, the regions from which they come, and their characteristics are listed in Table 3.

Seeds and plants will be purchased from local nurseries, within 50 miles of the site. These seeds and plants may or may not be truly genetically native to the Santa Clara Valley, although the species will be the same as that found in the region.

It is expected that this landscape will be self-sufficient after an establishment period of three years. Once at this stage, care and maintenance are reduced to a minimum. The landscape will follow a process similar to that found in nature, with the first 20 years being a transition from chaparral to oak woodland and grassland meadow. The landscape should last as long as the life of the oaks, at least 100-250 years.

Research Design

This study compares the costs of the current non-native and proposed native landscapes by considering expenses incurred by SJMN from water, irrigation system repairs, fertilizers and chemical control applications, plants, labor, and energy. The cost to demolish the current landscape in preparation for the new proposed native landscape is also taken into consideration when comparing costs. These costs are projected 20 years into the future, the life of a typical landscape, to obtain the cumulative PV of costs. The costs of both landscapes will be discounted at five, ten and 15 percent to allow the researcher to effectively determine which landscape is more cost effective over the long-term.

Costs examined in this study are only those that SJMN will face in the future. All costs that have already been spent on the current landscape are sunk costs and of no consideration in this study because they will not affect the decision of SJMN to implement the new or leave the current landscape. Finally, there will be a qualitative review of the environmental benefits of the native landscape in comparison to the current landscape.

Data Collection

The data in this study were collected primarily through interviews with the SJMN Facilities Maintenance Department, Middlebrook Gardens, South Bay Water Recycling, and GreenScape. Interviews were conducted in person, by phone, and via email to obtain expense data and other pertinent information needed to calculate expenses if necessary.

Water and irrigation system repairs. All data for water use at the current SJMN site were collected from SBWR, which has been providing water to the current landscape since 1999. Data regarding the costs and frequency of irrigation repairs were provided by both GreenScape and SJMN through personal interviews, phone conversations, and email.

Frequency of water use for the proposed native site was collected from Middlebrook Gardens. Costs for this frequency of use were calculated by the researcher based on the calculated water output rate.

Fertilizers and chemical controls. The costs of fertilizer and herbicide applications are included in the monthly bill to SJMN. However, the frequency and quantity of fertilizers and all chemical applications to the current landscape were provided by GreenScape via email and personal interviews. Information

regarding the use of fertilizers and chemicals for the proposed native site were provided by Middlebrook Gardens during personal interviews.

Plant replacements. The frequency and quantity of flower and plant replacements were provided by GreenScape in a personal interview and via email. The costs of all flower, plant, and tree replacements for the proposed native landscape were provided by Middlebrook Gardens in a personal interview.

Labor. Labor costs for the current landscape are included in the monthly bill and in the cost of any additional work. The frequency of labor in the current landscape was provided by GreenScape in a personal interview. All anticipated labor costs, as well as frequency of labor for the proposed native landscape, were provided by Middlebrook Gardens in personal interviews and via email.

Energy. Data regarding energy used to maintain the landscape with the use of lawn mowers and trimmers was obtained from GreenScape during a personal interview and via email.

Analytic Methods

In this study, the costs are clearly the annual monetary expenses spent on the landscape. Specific monetary benefits have not been mentioned thus far in

the study and the reader must understand that the benefits quantified for this study are the cost savings incurred from one landscape or another. Other qualitative benefits will be considered later.

Present value of benefits and costs over time. The value of a dollar today is not the same as it will be 20 years from now. Hence, the projected dollar values obtained in this study were translated into present day values in order to present data in monetary terms that are relevant to SJMN today. The values must be discounted in each of the 20 years to get accurate results. The present value calculation for the first year is as follows.

$$PV = C_1/(1 + d),$$

where PV is present value, C_1 is incremental costs in year one, and d is the discount rate. In year two, the equation is as follows.

$$PV = C_2/(1 + d)^2,$$

where PV is present value, C_2 is the incremental costs in year two, and d is the discount rate. In all years following, the same general pattern is used.

The present is defined as the date resources are first committed to the policy, or when the decision is made as to where the resources will go, either to continue the current landscape or to convert to native. Year one begins the day

after the present. In this study, the present is December 31, 2003 and year one begins on January 1, 2004.

By using this approach, which discounts year by year, the researcher assumes all values are incurred on the last day of the year rather than throughout the year. Because the implementation costs are not discounted, the equation also assumes that the implementation costs occur instantaneously, rather than over a short period of time. These approximations can lead to some degree of error in the analysis. This approach, however, is reasonably accurate and has the considerable advantage of convenience.

Sensitivity analysis. The chosen discount rate can greatly influence the outcome of an analysis and lead to different conclusions about the efficiency of a project. A discount rate that is too high will produce too few benefits and, in this case, favor the current landscape. Alternatively, a discount rate that is too low may overestimate benefits, favoring the native landscape. To provide objectivity, the researcher has chosen an average discount rate of ten percent and a high and low discount rate of five and 15 percent, respectively. This will help determine the sensitivity of the present value to these three rates and provide more accurate results for SJMN.

RESULTS

The San José Mercury News pays \$4,500 per month to cover most of the services regularly performed on the entire property. These services include mowing and trimming the lawn and other plants, fertilizing every six weeks, annual herbicide applications, and tree trimming (up to 15 feet) every six months. This monthly cost also includes garbage pickup, which consists of removing flyaway newspapers near the loading dock. Seventy percent of the services are devoted to the front lawn. All costs associated with maintaining the current landscape are described below and summarized in Table 4. Table 7 shows the breakdown of costs in each year over the 20 years as discussed below.

During the first three years after implementation, or after the establishment period of the proposed native landscape, costs are significantly more than the succeeding 17 years. Once the landscape is self-sufficient, costs in all areas are drastically reduced. The expenses involved in maintaining the proposed native landscape are described below and summarized in Table 5. Table 8 shows the breakdown of costs in each year over the 20 years as discussed below.

Implementation of Native Landscape

In order to implement the proposed native landscape, Middlebrook Gardens will demolish the current turf landscape. This will include taking out all vegetation that currently exists on the parcel with tractors and creating mounds and grades from the existing soil to replicate the natural rolling hills of the Santa Clara Valley. The total cost of demolition and grading and mounding is estimated at \$32,400. This includes the energy cost for fuel for the tractor. Expenses and activities involved in demolishing the current landscape and implementing the native are shown in Table 6.

Once the area is prepared, new native plants will be planted. Twenty two oak trees will be planted on the site and three buckeyes, each costing \$40.

The lawn area will be sown with nine pounds of grass and wildflower seed, which average \$18 per pound. The cost for all seeds will come to \$160. Approximately 700 one-gallon plants, each \$15, will be planted on the site at a total cost of \$10,500.

Three pots will be planted with two plants and two pots will have three plants. The pots will cost \$250 each and the plants will total \$200. All expenses for the pots will total \$950.

No chemicals will be used in the implementation of the landscape. The only energy expense included in implementation is that of gasoline needed for the tractor involved in the demolition. This cost however, is included in the total demolition cost.

Because the water table is high, no additional irrigation systems will need to be installed. Often when water tables are low, bubbler systems may need to be installed to soak the young oaks every month. In this case, the irrigation system will remain as is, requiring no additional expenses.

Three-inch Pro-chip mulch, made from recycled wooden palattes, will be added to the new landscape. This will serve as a pest control and water retainer. One thousand three hundred forty five cubic yards of mulch at \$40 per cubic yard will be required for the lawn area, a total estimated cost of \$53,800.

The total cost of implementing the native landscape is \$98,810. In addition, a contingency fee of 15 percent, or \$14,821, and a design fee of 10 percent, or \$9,881, are added to the total cost of the landscape by Middlebrook Gardens. The final, all-inclusive cost of implementation to SJMN of the proposed native landscape is \$123,512. A summary of these costs is shown in Table 6.

Water Use and Irrigation System Repairs Comparison

Current non-native landscape water use. Recycled, or grey water, has been used on the landscape since 1999 and is provided by SBWR. The lawn is watered every day for 10 minutes and in the dry months (generally from June to October), an additional 10 minute daily watering period is necessary. A yearly average of 25 gallons/ft²/yr is used to water the front lawn, which is 63,500 ft². Presently, the cost of this water to SJMN is \$1.2826 for every 100 cubic feet (ccf). At this rate, SJMN spends \$2,721 each year to water the front lawn area. The equation used to calculate this can be found in Figure 32. It is possible that usage could fluctuate from year to year, depending on the heat in the summer and the rainfall in the winter. Therefore, an average of 25 gallons/ft²/yr will be used throughout the 20 year life span.

Proposed native landscape water use. Because initial water needs are very high in the first three years, the proposed native landscape will require the same amount of water currently being used on the landscape for the first two years. The watering schedule will remain the same as the current. In the third year, the amount of water used will be reduced by half, shifting the watering schedule to every other day in the winter and only once a day in the summer. It was calculated that the irrigation system at SJMN puts out 290 gallons per minute

(Figure 33). The total annual cost for water in the first two years will be \$2,721, the same as is currently spent on the non-native landscape. The amount of water used in the third year will be 793,750 gallons and cost SJMN \$1,361.

Once the landscape is established, it will be well-adapted to the local conditions, requiring little human intervention. After the first three years, water requirements will be reduced to only 15 minutes twice each month in the dry months (generally from June to October). Winter and spring months will require no water. At the 290 gallons per minute rate, SJMN would use 43,500 gallons of water each year and pay \$75 annually to irrigate the landscape. The calculation used to retrieve these numbers can be seen in Figure 33. These water needs will remain the same throughout the remainder of the life of the landscape.

In years of drought, either landscape may need additional water. Likewise, in very wet years, the landscape will need less water. Over a long period of 20 years, it is equally likely to see both possibilities occur. Therefore, annual averages will be used in this study.

Current non-native landscape irrigation system repairs. Repairs of \$5,200 have been made to the irrigation system on the front lawn at SJMN over the past five years, due primarily to wear and tear. It is expected that repairs will be made at this same rate for the remainder of the study period. These repairs have been

made periodically over the five year period, rather than all at once. For this reason, the study will assume an average of \$1,040 is spent annually on irrigation repairs so that expenses over time are reported more efficiently.

Proposed native landscape irrigation system repairs. Because the native landscape will be watered less frequently after the first three years, fewer repairs due to wear and tear are expected. However, damage caused by cars or design changes will remain as frequent. Since damage is most commonly due to wear and tear, there is expected to be a significant decrease in overall repair costs after the first three years. Since in the past five years SJMN has spent \$5,200 on repairs, it is assumed that repairs, on average, cost \$1,040 per year. These expenses were assumed for only the first three years of the native landscape. Damage is also frequently caused by lawn mowers, but these repairs are at no cost to SJMN and will not occur once the lawn is removed. These types of repairs are therefore not of concern in this study.

Fertilizers and Chemical Controls Comparison

Current non-native landscape. Fertilizers and herbicides make up six percent, or \$104, of the monthly maintenance cost for SJMN. Because recycled water contains more nutrients than potable water, fewer fertilizers may be

needed than in a landscape not using recycled water, as mentioned above.

However, 200 pounds are applied every six weeks. Plants and flowers receive a treatment of 15-15-15 and the lawn receives a high-nitrogen fertilizer of 27-4-3.

The herbicide glyphosate is used on a regular basis to control weeds.

Every six weeks, 50 pounds of glyphosate is applied in the landscape. For fruit control, 50 pounds of herbicide CT-125 is applied to the landscape once each year. The flower pots do not receive any chemical treatments.

In addition to the fertilizers and herbicides included in the monthly maintenance cost, an additional \$200 is spent every three years on fungicides. This service is not provided by GreenScape; rather, it is contracted out to pest control companies. The next treatment is due in 2005. Also, in the past three years, there has been only one incident of gopher infestation, which cost SJMN \$75. Because this cost is minimal and rodent infestations are rare and sporadic on the SJMN site, they are not of concern to this study.

Proposed native landscape. Chemicals are not used on the proposed native landscape since pests and diseases are extremely rare for plants that have adapted to this area through evolution. The plant becomes more susceptible to disease when its system has been weakened by a form of stress. There are two possible factors that could result in disease or illness of the plant – a predator

from a nearby non-native plant, or severe environmental conditions, such as prolonged drought. Expenses to be considered in such an event would be those necessary to remove the diseased portion of the plant or the entire plant. It is also possible that by simply adding water and relieving the stress of the plant, its ability to resist pests and diseases will be improved. Due to the expected 20 percent attrition rate, the plant would not need to be replaced if removed.

Weeds are kept under control with a thick mulch of three inches. There are no expenses in this category to be analyzed in the study.

Plant Replacement Comparison

Current non-native landscape. Every six months the flowers in each of the flower beds are changed to accommodate the landscape to the seasonal changes of either summer or winter. One hundred twenty flats with 36 jumbo flowers are purchased every six months. Ninety of these are planted in the front lawn area. In July and January an additional four flats of annuals are purchased to refresh the flowers pots. Flowers remaining after refreshing the pots may be used to replace those that have died in other parts of the landscape. The refreshing is done at no additional charge to SJMN. The cost per flat to SJMN is \$35.00, including labor. The total cost to replace the annuals each year is \$6,300

Plants in the landscape are replaced at the end of their lifespan. Typically, five-gallon plants at \$30 each are used for each replacement. Every three years, the eight fortnight lily plants are replaced, a total cost of \$240 every three years. The lifespan of the escallonia and Formosa firethorn are long enough to not need replacing within the next 20 years. Heavenly bamboo is expected to be replaced every ten years and Indian hawthorn every 20 years. Each will be replaced only once in the 20-year life of the landscape, an additional \$60. Plants may also need to be replaced after being killed by an unexpected disease or pest. The olive and magnolia trees are not expected to need replacing within the next 20 years.

Repairs are made to the lawn, on average, semi-annually. However, these costs are so minimal to SJMN that they will not be included in the analysis.

Proposed native landscape. As a common practice, Middlebrook Gardens guarantees all plants within the first year of native landscape implementation and will replace them at no cost to SJMN. There is an expected 20 percent loss rate after the first year, but as plants fill in the landscape, this loss is barely noticeable and plants rarely need replacing. If a plant was to be replaced, the total additional cost would be approximately \$45 per five-gallon plant, as native plants are more costly than traditional plants. For purposes of this study, it is expected that after the first three years, one plant will need to be replaced every

two years, for a total cost of \$450 throughout the 20 year landscape life. All 12 potted plants will need to be replaced about once every three years at \$40 per plant. This will be an additional \$540 every three years.

Trees and grasses will not require replacing. An attrition rate of 20 percent is designed into the plan, with the expectation that not all will survive, due to competition for resources. Planting too many trees may create an unhealthy ecological imbalance within the landscape garden. The strongest trees will naturally survive, while the weaker ones will not. The landscape will create its own balance as it does in nature, and any replacements could cause disruption. Young plantings in an established community would require more water than older plants could tolerate.

Grasses and wildflowers will reseed themselves once the natural lifespan ends. If needed, they could be sewn at the time of cutting. Expenses related to additional sewing of seeds is discussed in the following section.

Labor Comparison

Current non-native landscape. GreenScape keeps a weekly maintenance schedule at SJMN, working with a crew of two men every Wednesday for approximately two and a half hours on the lawn area. Seventy percent, or \$3,150,

of the total \$4,500 bill is devoted to the front lawn area and 55 percent of the total bill is for labor. This translates to approximately \$1,730 of labor devoted strictly to the front lawn area each month. This cost, however, is included in the monthly maintenance cost. Services include mowing and trimming the lawn and other plants, applying fertilizers and herbicides, and trimming trees (up to 15 feet).

There are occasional additional charges for services not included in the regular maintenance schedule. Complete tree thinnings are performed by an arborist every three years, totaling \$1,200 per visit for the entire site.

Approximately one-fourth of the trees on the site are on the lawn area, so one quarter of the bill, or \$300, is for this area. A tree thinning was recently performed and the next is not due for another three years, in 2006. All lawn on the property is aerated every year as well as spread with gypsum for optimum health, an expense to SJMN of \$500 each year. Seventy percent of this labor and resources is devoted to the front lawn. Fifty pounds of gypsum is applied and \$350 is spent annually on this service for only the front lawn area.

Proposed native landscape. Middlebrook Gardens charges \$40 per hour of labor and \$65 per hour for supervisory presence. A supervisor is present one

hour for every two labor hours, or half the time that labor is being performed by the crew.

Hand weeding is necessary for the first three years in the proposed native landscape while the plants become established. Labor will be required once a month for approximately 24 labor hours (three people, eight hours each) to hand-weed the grassland meadow areas until they are established, or for the first three years. This would also involve cutting flowers off the grasses each year, typically in January. A supervisor would also be present for four hours of the eight hour day. Hand weeding the grasses would cost \$1,220 each month, or \$14,640 each year.

Once the grasses are established, their cutting would take place every six months for three labor hours (one person, three hours). A supervisor would be present for one and a half hours. Grass cutting would cost SJMN \$218, every six months, or \$436 every year. At this time, additional seeds can be sewn as a precautionary measure only, since the grass and wildflowers would most likely reseed on their own. Only one half pound of seeds may be necessary and would cost \$18 per pound. No additional labor fee would apply, as reseeding would take place during the cutting.

It is likely that within a five year period, the grasses can get too thick. Every five years, it is expected that eight hours will be devoted to cutting grasses to thin them out (one person, eight hours). This will be a total annual cost, including supervision, of \$580.

Pruning is recommended for the chaparral twice per year for the first three years. This is done by two people for four hours (eight labor hours). A supervisor is present for two of these hours. Each visit of pruning would cost \$450, a total of \$900 each year.

Once the landscape is established, the lifespan of the chaparral plants can be extended three times by coppicing them every four years. This process replicates a fire disturbance and will allow for new growth on each plant. The total time necessary to coppice a parcel of this size is estimated at 12 labor hours (two people, six hours each), with three hours of supervisory presence, which would cost \$675 every four years.

Middlebrook Gardens suggests trimming the trees every five years once they are planted. This would require 16 labor hours (two people, eight hours each) with a supervisor for four hours, a total of \$900 every five years.

It is anticipated that an especially harsh environmental stressor, such as prolonged drought, severe storm, heat wave, and floods will occur every three

years. In such cases, six labor hours (two people, three hours each) may be needed to repair the site. In the case of diseased plants, removal would be done at the time of another regularly scheduled service so as to not require additional labor charges.

Energy Use Comparison

Current non-native landscape. Lawn mowers and trimmers use one half gallon of fuel each week to mow the front lawn. The fuel costs associated with these machines are included in the monthly maintenance costs. Because the irrigation system is fueled by water pressure rather than direct energy, there are no expenses in this category to be analyzed in the study.

Proposed native landscape. Because all labor is done by hand, no energy is used in the maintenance of the proposed native landscape.

Interest Rate Comparison

Interest rates of five, ten and 15 percent were used to discount the annual costs of each landscape. In all rates, the proposed native landscape showed that money would be saved over the 20 year life of the landscape. When using a five percent discount rate over 20 years, Table 9 shows SJMN will spend \$606,164 to

continue maintaining the current landscape, while Table 10 shows the proposed native landscape would cost \$189,581 to maintain, including demolition and implementation. At this rate, the economic payoff would occur at the beginning of year four (Figure 35).

When using a ten percent discount rate, Table 11 shows the current landscape would cost \$416,918 to maintain, while Table 12 shows the native would cost \$180,881 over the 20 period. At this rate the economic payoff would occur in the middle of year four (Figure 36).

Lastly, at a 15 percent discount rate, the current landscape would cost \$329,627 and the proposed native would cost \$175,001 over the 20 years (Tables 13 and 14, respectively). At a 15 percent discount rate the economic payoff would occur at the end of year four (Figure 37). Even at a conservative 15 percent discount rate, the native landscape is still more cost-effective than the current landscape. A summary of these savings can be seen in Table 15.

DISCUSSION

Economic Benefits

At all three interest rates, the native landscape shows significant cost savings over the 20 year lifespan, even when demolition and implementation costs are considered. Table 15 shows that at a five percent interest rate there is a savings of \$416,583; at a ten percent interest rate, a savings of \$236,037; and at 15 percent, a savings of \$134,626. By year four, the landscape has more than paid for itself in savings (Figures 29, 30, and 31), even with the most conservative discount rate. Although expenses for the non-native site are initially very high, after year four the annual cost is minimal.

Environmental Benefits of the Proposed Native Landscape

Less fertilizer and fewer chemicals. The current landscape uses a lawn fertilizer that is especially high in nitrogen. The proposed native landscape will use no chemicals or fertilizers, reducing the risk of nitrogen leaching into groundwater and nearby surface water on the site. Additionally, glyphosate, fungicides, rodenticides, and CT-125 will no longer be used at the site, further reducing the risk of harmful chemicals leaching into groundwater.

Less energy input. The use of fuel will be reduced by one half gallon each week if the native landscape is implemented. This amounts to 26 fewer gallons of fuel each year. This also contributes to a reduction in air pollution.

Food and habitat for wildlife. The plants on the proposed native site will provide an abundance of food for local wildlife, especially birds. Oaks provide food, cover and nesting for over 250 species of birds in California (Francis and Reimann 1999). They support the growth of mushrooms, lichen, galls and mistletoe, which in turn provide food for other creatures. Acorns are perhaps the most common food for animals. With four different oak species on the site, the acorn harvest is likely to last from August through November, providing plenty of food for all creatures to put on fat for the long winter. This comes at a time of year when other plants and grasses are of low nutritional value and often less available.

The oak trees on the site are expected to be home to rodents and mammals such as gray squirrels, ground squirrels, gophers, raccoons, and mice. The western harvest mouse relies on the bark of saplings, while pocket gophers eat the roots of saplings. Ripe acorns are one of the most common food sources among these animals.

The leaves of the tree are larval hosts for many California butterflies. Insects, such as the California oak moth caterpillar, tent caterpillar, and western tussock moth consume large quantities of oak leaves each day. Flowers also provide food for insects and bees that gather pollen from them. Aphids, whiteflies, mites, and leafhoppers suck sap from the leaves and tender shoots. Burrowing insects eat woody twigs and limbs. The many insects associated with the oak tree and its litter feed many insect-eating creatures. Reptiles and amphibians, such as the western fence lizard and California salamander, forage for insects within drier oak woodlands, such as this.

Many birds imbibe sap from phloem beneath the bark, and many forage acorns and bury them in the ground. Each season some of these are not recovered and may sprout in the right environmental conditions. Although insects feed on immature and ripe acorns, birds prefer only the ripe. The branches of oaks provide areas for birds to build nests and for insets to deposit their eggs.

Understory will provide protective thickets for animals to raise their young as well as offer additional food sources. Madrone provides nectar to hummingbirds and the early fall berries are a food source for cedar wax wings, mockingbirds, acorn woodpeckers, Steller's jays, towhees, flickers, and many

others in the area. The madrone is also a host for mushrooms, which would be a significant food source for wildlife. Toyon flowers will attract many insects and the berries attract birds such as robins, thrushes, bluebirds, titmice, wrentits, and red-breasted sapsuckers. The California buckeye will serve as another significant source of nectar for butterflies, hummingbirds, and insects in late spring. It serves as a larval host for some butterflies as well. Flower buds of the buckeye are consumed by gray squirrels.

Chaparral species also support local wildlife. Bigberry manzanita will provide shelter to many local creatures and flowers and berries to birds such as quail, mockingbirds, thrushes, towhees, jays, wrentits, and acorn woodpeckers. The flowers of the coyote bush will attract butterflies, skippers, bees, and many insects. *Ceanothus* spp., such as the dark star suggested for this landscape, provides nectar for butterflies and is a larval host for some. The flowers are especially attractive to bees and birds such as wrentits, thrushes, sparrows, towhees, finches, and juncos. These birds also forage for insects underneath the plant.

The potted plants from other regions of California will be a smaller source of food and habitat only because there are fewer of these plants. However, they do have great wildlife value. Island and sulphur buckwheat are other plants that

will provide nectar to butterflies, beetles, and other insects. The seeds of Cleveland's sage attract hummingbirds and other birds. Chilean aster is a highly valuable source of late summer and early fall nectar for butterflies and birds.

The fibrous roots of California perennial bunchgrasses feed many insects under the ground. These grasses also support butterflies and provide better quality foliage than non-natives. Because these grasses produce less seed than non-native annuals, they tend to attract animals such as voles and harvest mice rather than ground squirrels. Annuals are an additional source of nectar, pollen, and seeds for birds and insects.

The proposed native landscape makes up a plant community that is far more diverse than that of the non-native landscape. More food and habitat are offered, not only because they are native plants, but because there are more of them. Chaparral and oak woodland plants offer a hiding place for wildlife, whereas the turf lawn does not. Additionally, fruit control methods will not be in place, allowing the plant to develop its fruit and provide food. The plants suggested for this landscape create a balanced ecosystem, with animals and plants interacting with one another in symbiotic relationships as in nature. This process encourages the sustainability of the landscape with as little human intervention as possible.

Alternative Management Plan

Middlebrook Gardens proposes an alternative management plan that would incorporate education of the general public and students, as well as give hands-on experience to college students majoring in biology, botany, ecology, environmental studies, or other related fields. Students would donate time to maintain the plants on the site while receiving college internship credits.

Another part of this internship would include guiding public tours of the landscape to educate the public about the natural landscape and the ecology of the Santa Clara Valley. By incorporating this plan, SJMN would save on labor costs and provide an educational experience for students and the public.

Recommendations to SJMN

It is recommended that SJMN implement the native landscape. Although the initial investment for demolition and implementation is significant, the money will be recovered within the first four years. Cost savings will then be noticed every year over the next 16 years. By implementing the Alternative Management Plan as suggested by Middlebrook Gardens, there would be further monetary savings and a tremendous public relations boost as well.

Limitations of the Study

It is difficult to predict the actual costs that may be incurred from the native landscape prior to implementation. Therefore, only predicted costs of the native landscape are compared to actual costs of the non-native. It is possible that unanticipated costs could arise during and after implementation. At the same time, it is possible that costs could be less than expected. These lower costs could be due to lower water needs because of the high water table in the short- and long-term stages, reduced maintenance requirements, fewer plant replacements, and less labor needs than expected, especially in the first two years.

Because this site is located on a riparian zone, it may require less water than a landscape not located on a riparian zone. The water costs for both the native and non-native landscapes may therefore be less than in other similar landscapes. Because of the nearby creek bed, this study is only useful for this property and other properties within a similar proximity to water beds. However, water costs for the non-native landscape would most likely be significantly higher than in the native, regardless of whether a creek bed was nearby.

Some of the expenses for the current landscape were estimated from the larger expense of the entire property. For example, it was estimated that 75 percent of the 120 flats of flowers purchased for the entire site are planted in the front lawn area. It is entirely possible that it is not exactly 75 percent, or 90 flats. However, this was the estimate from GreenScape and is assumed to be quite close to the actual number. The quantity of chemicals and labor devoted to the front lawn areas was also estimated by GreenScape. It is possible that plant replacements will occur more or less often than the time span used in this study, due to living a shorter or longer life than expected.

Lastly, native landscapes often use irrigation systems different from those in traditional non-native landscapes, such as drip and bubbler systems. This study did not include the costs of installing a new irrigation system simply to keep installation costs lower for SJMN. However, if any of the systems more suited for native landscapes were installed, it may have drastically changed the outcome of the study, as irrigation systems can be quite costly.

Further Research

Because SJMN is not interested in money already spent, this study compared only costs that will be incurred from either landscape from this day

forward. It did not consider sunk costs, which would have included implementation costs of the current landscape or any initial costs that may be spent in the early years of the non-native landscape. It would benefit the literature to study the costs of both landscapes from implementation through the 20 year life span. This would provide a more accurate cost-benefit analysis for decision makers with new businesses and vacant lots looking to landscape the property initially rather than replace an existing landscape. Adding the installation costs for a non-native landscape would tip the balance even further in favor of the native landscape, everything else being equal.

As mentioned, native landscapes often use irrigation systems more appropriate to the landscape than a sprinkler system. It would benefit the literature to study the costs of these two landscapes with the different irrigation system as a consideration.

It would be beneficial to conduct a study in which environmental costs are quantified. In such a study, monetary values would be placed on specific losses or gains incurred from non-native or native landscapes. Monetary values may be placed on species diversity or habitat, water quality, energy use and water use.

Lastly, it would be beneficial to the literature to conduct a similar study in an area without a high water table. The results may be drastically different if more water and additional irrigation systems are needed.

SUMMARY AND CONCLUSIONS

It is crucial that native plants be used in landscapes within cities. Not only do they require less water and fewer chemical applications, but they can also save a tremendous amount in maintenance costs. While the current non-native landscape is extremely labor intensive, the native landscape will be nearly self-sufficient within three years, allowing maintenance costs to drastically be reduced. The native landscape clearly shows significant cost savings in all areas, especially after the first three years. Even when considering demolition and implementation costs in the first three years, the native landscape is still more cost effective. If the native landscape were to be implemented, SJMN will begin to see the economic payoff by year four, regardless of the discount rate used.

The native landscape will significantly reduce water use, irrigation repairs, and plant replacement and labor costs. No chemicals or energy will be used to maintain the site, reducing the amount of nitrogen and other chemical leaching into groundwater and surface water. The landscape will also provide food and habitat for local native wildlife, by producing acorns and berries, as well as understory thickets.

Although the initial cost is high, it is recommended that SJMN implement the native landscape and the Alternative Management Plan in order to save money over the next 20 years and beyond. This would also allow for SJMN to be a leader in environmental education.

Further research is suggested for native plant landscapes in other areas with a lower water table. It is also suggested that research be done to compare costs of both landscapes from the implementation stage with more appropriate irrigation systems.

FIGURES

Figure 1. Location of Santa Clara Valley, California. Retrieved from www.neonrose.com.

Figure 2. Map of San José, California showing location of San Jose Mercury News site. Obtained from American Automobile Association, map of Milpitas.

Figure 3. Aerial photo of the San José Mercury News. The front lawn area is the large dark parcel towards bottom of picture in front of building, highlighted in red. Reprinted with permission from the San José Mercury News.

Figure 4. Expansive front lawn turf at San José Mercury News site. Photograph by author.

Figure 5. Sketch of current landscape design on the San José Mercury News front lawn area.

Figure 6. Four of the seven 40 year old olive trees (*Olea europaea*) on the San José Mercury News site. Photograph by author.

Figure 7. One of the seven Southern Magnolia (*Magnolia grandiflora*) trees on the San José Mercury News front lawn area. Photograph by author.

Figure 8. Summer flower bed of impatiens (*Impatiens walleriana*) under a magnolia tree on the San José Mercury News front lawn area. Photograph by author.

Figure 9. Summer flower bed in front of the San José Mercury News building. Contains blue lobelia (*Lobelia erinus*), scarlet sage (*Salvia splendens*), African marigolds (*Tagetes erecta*) and Indian hawthorn (*Raphiolepis indica*). Photograph by author.

Figure 10. Summer flower bed surrounding San José Mercury News sign on lawn. Contains blue lobelia (*Lobelia erinus*), scarlet sage (*Salvia splendens*), African marigolds (*Tagetes erecta*), fortnight lily (*Dietes iridioides*), heavenly bamboo (*Nandina domestica*) and Italian cypress (*Cupressus sempervirens*). Photograph by author.

Figure 11. Formosa firethorn (*Pyracantha koidzumii*) hedge on far west side of San José Mercury News front lawn. Photograph by author.

Figure 12. Escallonia (*Escallonia rubra*) hedge on San José Mercury News front lawn. Photograph by author.

Figure 13. Summer flowers in one of the three square pots by San José Mercury News front entrance. Contains blue lobelia (*Lobelia erinus*), scarlet sage (*Salvia splendens*) and African marigolds (*Tagetes erecta*). Photograph by author.

Figure 14. Summer flowers in one of the four round pots on front entrance stairway of San José Mercury News. Contains blue lobelia (*Lobelia erinus*), scarlet sage (*Salvia splendens*), and African marigolds (*Tagetes erecta*). All scarlet sage has died. Photograph by author.

Figure 15. Sketch of proposed native landscape design for the San José Mercury News front lawn area. Various types of oaks are scattered with understory plants nearby. Chaparral, grasses and some small boulders cover the entire area.

Figure 16. Coast live oak (*Quercus agrifolia*). Reprinted with permission by Charles Webber, California Academy of Sciences, Charles Webber © California Academy of Sciences. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 17. Black oak (*Quercus kelloggii*). Reprinted with permission by Br. Alfred Brousseau, Saint Mary's College, © Br. Alfred Brousseau, Saint Mary's College. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 18. Valley oak (*Quercus lobata*). Reprinted with permission by Charles Webber, California Academy of Sciences, Charles Webber © California Academy of Sciences. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 19. California buckeye (*Aesculus californica*). Reprinted with permission by Beatrice F. Howitt, California Academy of Sciences, Beatrice F. Howitt © California Academy of Sciences. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 20. Leather oak (*Quercus durata*). Photograph by Middlebrook Gardens.

Figure 21. Toyon (*Heteromeles arbutifolia*). Reprinted with permission by J. E. (Jed) and Bonnie McClellan, California Academy of Sciences, J. E.(Jed) and Bonnie McClellan © California Academy of Sciences. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 22. Holly leaf cherry (*Prunus ilicifolia*). Reprinted with permission by Br. Alfred Brousseau, Saint Mary's College, © Br. Alfred Brousseau, Saint Mary's College. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 23. Madrone (*Arbutus menziesii*). Reprinted with permission by Beatrice F. Howitt, California Academy of Sciences, Beatrice F. Howitt © California Academy of Sciences. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 24. California native grasses and wildflowers in a landscape designed and implemented by Middlebrook Gardens. Photograph by Middlebrook Gardens.

Figure 25. Bigberry manzanita (*Arctostaphylos glauca*). Reprinted with permission by Br. Alfred Brousseau, Saint Mary's College, © Br. Alfred Brousseau, Saint Mary's College. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 26. Coast silk-tassel (*Garrya elliptica*). Photograph by Middlebrook Gardens.

Figure 27. Dark star (*Ceanothus integerrimus*). Photograph by Middlebrook Gardens.

Figure 28. Coyote bush (*Baccharis pilularis*). Reprinted with permission by BonTerra Consulting, © 2002 BonTerra Consulting. Obtained from CalPhotos website, the University of California, Berkeley Digital Library Project.

Figure 29. Native plant landscape, in early years, under oak tree. Designed by Middlebrook Gardens. Photograph by Middlebrook Gardens.

Figure 30. Examples of pots used in a Middlebrook Gardens landscape. Similar pots may be used at San José Mercury News site. Photograph by Middlebrook Gardens.

Figure 31. More examples of pots from a Middlebrook Gardens landscape that may be used at San José Mercury News site. Photograph by Middlebrook Gardens.

Lawn size: $1.47 \text{ acre} \times 43,560 \text{ ft}^2/\text{acre} = 63,500 \text{ ft}^2$

Gallons used: $25 \text{ gal/ft}^2/\text{yr} \times 63,500 \text{ ft}^2 = 1,587,500 \text{ gal/yr}$

ccf conversion: $1 \text{ ccf} = 748 \text{ gal}; 748 \text{ gal/ccf} \times 1,587,500 \text{ gal/yr} = 2,122 \text{ ccf/yr}$

Total cost: $2,122 \text{ ccf/yr} \times \$1.2826/\text{ccf} = \$2,721/\text{yr}$

Figure 32. Equation used to calculate turf lawn water expenses for San José Mercury News front lawn.

$10 \text{ min} \times 365 \text{ days} + 10 \text{ min} \times 183 \text{ days (dry months)} = 5,480 \text{ min of water every year}$

$$\frac{1,587,500 \text{ gal/yr}}{5,480 \text{ min/yr}} = 290 \text{ gal/min}$$

Figure 33. Equation used to calculate gallons per minute put out by the San José Mercury News irrigation system.

Watering time: 15 min of water each month x 2 waterings each month = 30 min/month

Gallons used: 290 gal/min x 30 min/month x 5 months (dry months) = 43,500 gal/yr

ccf conversion: 748 gal/ccf x 43,500 gal/yr = 58 ccf/yr

Total cost: 58 ccf/yr x \$1.2826/ccf = \$75/yr

Figure 34. Equation used to calculate native landscape water expenses after the first two years.

Figure 35. Graph of expenses over 20 year life of both landscapes at five percent discount rate.

Figure 36. Graph of expenses over 20 year life of both landscapes at ten percent discount rate.

Figure 37. Graph of expenses over 20 year life of both landscapes at 15 percent discount rate.

TABLES

Table 1. Annual environmental and social costs of pesticide poisoning in the U.S.
as calculated by Pimentel and Acquay (1992).

Occurrence	Annual cost
Human Poisoning	\$787 million
Livestock losses	\$296 million
Resistance in pests	\$30 million
Honeybee pollination losses	\$200 million
Other crop/crop product losses	\$550 million
Groundwater and surface water contamination	\$1.8 billion
Fishery losses	\$10-24 million
Birding losses	\$2 billion
Government spending on pollution control	\$200 million
All other losses	\$2.1 billion
Total environmental and social costs	\$8 billion

Table 2. Plants currently found at the San José Mercury News site.

Year-round Plants and Trees

Scientific Name	Common Name	Origin	Lifespan	Type	Soil	Bloom	Pests
<i>Escallonia rubra</i>	Escallonia	Chile, Argentina	20 years	Evergreen shrub	Fertile, well-drained soil	1/2" pink flowers; summer to early fall	Infrequent
<i>Pyraecantha koidzumii</i>	Formosa firethorn	Taiwan	30 years	Evergreen shrub	Fertile, well-drained soil	Small white flowers in early summer, then 1/4" red-orange berries	Spider mites, lacebug, caterpillars, scale insects, aphids, fireblight dieback, scab, wilt can be problems
<i>Raphiolepis indica</i>	Indian hawthorn	China	20 years	Evergreen shrub	Moist, well-drained, fertile soil	1/2" white flowers with pink-flushed centers; spring, early summer	Prone to scale insects, fireblight, web blight, <i>Entomosporium</i> leaf spot
<i>Cupressus sempervirens</i>	Italian cypress	Mediterranean to Iran	50 years	Evergreen tree	Well-drained soil; tolerates alkaline and acidic soil	Small cones	<i>Coryneum</i> canker, tip and branch dieback, root rot, needle blights are common; bark beetles, scale insects, sawfly, caterpillars can cause problems
<i>Dietes iridioides</i>	Fortnight lily	Africa	3 years	Evergreen perennial	Moist, well-drained; tolerates poor, dry soils	2" white flowers with yellow mark at center of 3 larger petals; spring to summer	Rust and crown and root rot are common
<i>Olea europaea</i>	European olive	Mediterranean	100-300 years	Evergreen tree	Deep, fertile, sharply drained soil	2" white flowers in summer, then followed by fruits	Prone to olive knot, <i>Verticillium</i> wilt, mushroom root rot, lesion nematode, Southern blight; scale insects are common
<i>Magnolia grandiflora</i>	Southern Magnolia	SE U.S.	50-75 years	Evergreen tree	Moist, well-drained; humus rich; acidic to neutral; will tolerate alkaline;	White flowers to 10" mid-summer to fall;	Bacterial leaf spot, spot anthracnose, cancer, dieback, butt rot, powdery mildew, anthracnose, fungal spots, snails, weevils, scale insects, planthoppers, thrips are common
<i>Nandina domestica</i>	Heavenly bamboo	India, China, Japan	10 years	Evergreen shrub	Moist, well-drained	1/2" white flowers in mid-summer, then bright red fruit	Leaf spot, root rot, <i>Verticillium</i> wilt occur

Table 2 - Continued

Summer Flowers							
Scientific Name	Common Name	Origin	Lifespan	Type	Soil	Bloom	Pests
<i>Salvia splendens</i>	Scarlet sage	Brazil	One season	Annual flower	Light, moderately fertile, humus-rich, moist, well-drained soil	Long-tubed bright red flowers 1/2-2" long; summer to fall	Rust, powdery mildew, stem rot, fungal leaf spots are common; whiteflies, mealybugs, aphids, spidermites can be problems
<i>Impatiens walleriana</i>	Impatiens	Africa	Three years	Perennial flower, grown as annual	Humus-rich, moist, well-drained	1-2 1/2" long flowers; summer; pink, white, red on site	Caterpillars are problem; gray mold, impatiens, necrotic spot virus, fungal leaf spots, <i>Rhizoctonia</i> stem rot, <i>Pseudomonas</i> leaf spot, <i>Verticillium</i> wilt occur
<i>Tagetes erecta</i>	African marigolds	New Mexico to Argentina	One season	Annual flower	Well-drained soil; water freely during drought;	Orange to yellow 5" pompon-like flowerheads	Prone to gray mold, bacterial leaf spot, powdery mildew, <i>Alternaria</i> leaf spot, damping off, root rot; leaf miners, spider mites, whiteflies may be problems
<i>Lobelia erinus</i>	Lobelia	South Africa	Three years	Perennial flower, grown as annual	Deep, fertile, moist	1/2" flowers; summer to fall	Rust, smut, leaf spots, slugs may be a problem
Winter Flowers							
<i>Viola</i> spp.	Violets	Africa	Three years	Perennial flower, grown as annual	Humus-rich, well-drained	1-2 1/2" long flowers; summer; pink, white, red on site	Vulnerable to mealybugs, mites, thrips, whiteflies, powdery mildew, stem rot, rhizome rot, nematode invasion
<i>Viola</i> spp.	Pansies	Africa	Three years	Perennial flower, grown as annual	Humus-rich, well-drained	1-2 1/2" long flowers; summer; pink, white, red on site	Caterpillars are problem; gray mold, impatiens, necrotic spot virus, fungal leaf spots, <i>Rhizoctonia</i> stem rot, <i>Pseudomonas</i> leaf spot, <i>Verticillium</i> wilt occur
<i>Cyclamen</i> spp.	Cyclamen	Mediterranean to Iran and Somalia	Three years	Perennial flower, grown as annual	Fertile, humus-rich, well-drained	1/2-1 1/4" long flowers; flower any time of year; white, pink, red	Mice and squirrels may be problems; prone to spider mites, vine weevil, cyclamen mite,

Table 3. Native plants to be used at the San José Mercury News Site.

Oak Woodland

Scientific Name	Common name	Local Distribution	Lifespan	Type	Soil	Flower/Fruit	Pests/ Problems
<i>Aesculus californica</i>	California buckeye	Dry slopes and canyons of foothills, Coast Ranges and Sierra Nevada from Siskiyou and Shasta counties to Kern and Los Angeles Counties	200 years	Deciduous tree	Porous, well-drained; drought resistant	Small cream flowers Feb-Jun; buckeye fruit Aug-Feb	--
<i>Heteromeles arbutifolia</i>	Toyon	Semi-dry brushy slopes and canyons of foothills and mountains of Southern California, north to Humboldt County	50-100 years	Evergreen shrub	Dry, but will accept water in summer with well-drained soil; drought-tolerant	Small, white flowers Jun-July; red berries through winter	May be attacked by insects that cause honeydew and sooty mold; also susceptible to pear blight
<i>Arbutus menziesii</i>	Madrone	North Coast Ranges and Sierra Nevada from Mariposa to Shasta Counties and northward	100-200 years	Evergreen tree or large shrub	Porous, well-drained; drought resistant	White flowers Mar-May; orange berries early fall	Young plants may be susceptible to fungus from soil, from water washing against trunks or from overhead watering
<i>Quercus agrifolia</i>	Coast live oak	Valleys, slopes, Coast Ranges, Sonoma to San Diego Counties	100-400 years	Evergreen tree	Well-drained	Acorn fruit	Crown rot, root fungus if poorly-drained soil
<i>Quercus durata</i>	Leather oak	Klamath to Coast Ranges to San Luis Obispo and the Sierra Nevada from Nevada County to El Dorado County	100 years	Evergreen shrub	Serpentine, nutrient poor	Acorn fruit	Sudden oak, fungus, mold, scale
<i>Quercus lobata</i>	Valley oak	Central Valley and borders, inner Middle Coast Ranges to Los Angeles Counties	400-600 years	Deciduous tree	Rich, loamy, deep alluvial soils; water-tolerant	Acorn fruit	Sudden oak, fungus, mold, scale
<i>Quercus kelloggii</i>	Black oak	Southern San Diego County to Oregon in North Coast, Klamath and Cascade Ranges	100-400 years	Deciduous tree	Coarse, well-drained soils	Acorn fruit	Sudden oak, fungus, mold, scale

Table 3 -- Continued

Scientific Name	Grassland						Pests/ Problems
	Common name	Local Distribution	Lifespan	Type	Soil	Flower/Fruit	
<i>Festuca rubra</i>	Red fescue	Humboldt County to Oregon	3-5 years	Perennial herb	Moist soil	--	--
<i>Stipa pulchra</i>	Purple needlegrass	Throughout California	3-5 years	Perennial herb	Moist soil	--	--
<i>Festuca californica</i>	California fescue	Throughout California	3-5 years	Perennial herb	Moist soil	--	--
<i>Festuca idahoensis</i>	Idaho fescue	Modoc and Klamath Counties	3-5 years	Perennial herb	Moist soil	--	--
<i>Achillea millefolium</i>	Yarrow	Modoc and Klamath Counties	3-5 years	Perennial herb	Moist soil	Small white flowers	--
<i>Sidalcea malvaeflora</i>	Checkerbloom	Unknown	3-5 years	Perennial herb	Moist soil	Reddish-pink or purple flowers	--
<i>Laethenia californica</i>	Goldfields	Unknown	One season	Annual herb	Moderately moist	Small yellow flowers	--
<i>Platystemon californicus</i>	Creamcups	Open, grassy fields, slopes, oak woodlands over most of cismontane California to the edge of deserts	One season	Annual herb	Moderately moist	Small cream flowers	--
<i>Salvia columbariae</i>	Chia	Gravelly slopes, and sandy washes	One season	Annual herb	Dry, lean; water tolerant during periods of active growth	Bright blue flowers; Mar-June; smooth nutlets	--
<i>Lupinus nanus</i>	Sky lupine, Douglas's lupine	Grassy hills, fields, slopes, Coast Range, Santa Cruz to Santa Barbara Counties	3-5 years	Annual herb	Lean soil	Blue; Apr-May	Stem and foliage mildew if too much water and poor air circulation
<i>Gilia capitata</i>	Globe gilia, blue headed gilia	Open slopes, Coast Ranges from Marin County north	One season	Annual herb	Lean soil	Powder blue flowers; April to early summer	--
<i>Clarkia amoena</i>	Farewell-to-spring; herald-of-summer	Bluffs on coast, Humboldt to Marin Counties	One season	Annual herb	Moderately moist	Lavender-pink flowers with cherry-red center; Jun-Aug	--

Table 3 - Continued

Grassland - continued							
Scientific Name	Common name	Local Distribution	Lifespan	Type	Soil	Flower/Fruit	Pests/ Problems
<i>Nemophila menziesii</i>	Baby-blue-eyes	Inner north Coast Ranges from Tehama County south and Sierra Foothills from Butte County south	One season	Annual herb	Tolerant to most soils; water tolerant	Turquoise flowers with white centers	--
<i>Linnanthus douglasii</i>	Meadowfoam	California to Southern Oregon	One season	Annual herb	Moist, well-drained soil	Yellow centers with white on outer petal	--
<i>Triteleia luteoides</i>	Golden brodiaea	Unknown	3-5 years	Perennial herb	Semi-dry, porous, heavy, lean	White flowers with thin petals and small yellow center	--
<i>Calochortus luteus</i>	Yellow mariposa lily; gold nuggets	Mendocino to Santa Barbara Counties	3-5 years	Perennial	Semi-dry, porous, heavy, lean	Yellow flowers; Apr-Jun	--

Chaparral

Chaparral							
Scientific Name	Common name	Local Distribution	Lifespan	Type	Soil	Flower/Fruit	Pests/ Problems
<i>Ceanothus integerrimus</i>	Dark star	Cultivar	6-20 years depending on species	Deciduous shrub	Water-tolerant	Clusters of small blue flowers Mar-Jun	Susceptible to root rot from water-borne molds
<i>Arctostaphylos glauca</i>	Bigberry manzanita	Chaparral, central to southern Coast Ranges	50 years	Evergreen shrub	Semi-dry, porous	Large white flowers Dec thru March; berries	Aphids, scale
<i>Garrya elliptica</i>	Coast silk-tassel	Dry slopes and ridges in chaparral of outer Coast Ranges from Ventura County to Oregon	25 years	Evergreen shrub	Tolerates dry and moist, well-drained	Pale-grey catkins Dec to mid-spring; berries	Aphids, scale
<i>Prunus ilicifolia</i>	Holly leaf cherry	Dry slopes and flats of foothills, in Coast Ranges from Napa County southward	50 years	Evergreen shrub	Porous	Small, white flowers Apr- May; red to black-purple berries	Aphids, scale
<i>Baccharis pilularis</i>	Coyote bush	Dunes and headlands along coast, from Russian River to Point Sur, Monterey County	10-20 years	Evergreen shrub	Heavy or sandy	Small white female flowers;	Aphids, scale

Table 3 -- Continued

Scientific Name	Common name	Potted plants				Pests/ Problems
		Local Distribution	Lifespan	Type	Soil	Flower/Fruit
<i>Salvia clevelandii</i>	Cleveland's sage	Dry slopes, chaparral, from San Diego County to Baja California	3-4 years in pots	Perennial shrub	Rocky soil	Small dark blue, violet Apr-Jul; yellow nutlet
<i>Trichostema lanatum</i>	Woolly blue curls	Dry slopes, chaparral, Coast Ranges near coast, Monterey and San Benito to Orange and San Diego Counties	3-4 years in pots	Shrub	Semi-dry, lean, rocky or sandy	Medium bright blue flowers Apr-Aug intermittently throughout the year; nutlet
<i>Monardella odoratissima</i>	Mountain pennyroyal	Dry slopes in mountain ranges from 3,000 to 10,000 feet elevation	3-4 years in pots	Perennial herb	Rocky soil	White to purple flowers; nutlet
<i>Epilobium canum</i>	California fuchsia	Dry conditions in slopes and ridges	3-4 years in pots	Perennial herb	Dry soil	Long red flowers
<i>Aster chilensis</i>	Chilean aster	Dry conditions in freshwater marsh habitat	3-4 years in pots	Perennial herb	Dry soil	White flowers with yellow center
<i>Eriogonum arborescens</i>	Island buckwheat	Rocky canyons on Channel Islands	3-4 years in pots	Perennial	Porous soil	White to pink flowers Apr-Sep
<i>Eriogonium umbellatum</i>	Sulphur buckwheat	Placer, Siskiyou and Modoc Counties	3-4 years in pots	Perennial	Dry, porous soil	Bright yellow flowers Jun-Aug
<i>Dudleya farinosa</i>	Bluff lettuce	Unknown	3-4 years in pots	Perennial	Dry, porous soil	Yellow flowers
<i>Muhlenbergia rigens</i>	Deergrass	Unknown	3-4 years in pots	Perennial herb	Dry or moist soil	--
<i>Juncus patens</i>	Spreading rush	Unknown	3-4 years in pots	Perennial herb	Dry, porous soil	--
<i>Ceanothus griseus</i> var. <i>horizontalis</i>	Yankee point	Monterey County	3-4 years in pots	Shrub	Semi-dry soil	Flax blue flowers Apr-May

Table 4. Frequency of expenses incurred on current landscape.

Expense	Quantity	Cost to \$JMN	Frequency
Flower replacements	90 flats of 36 flowers	\$35/flat	Every six months
Plant replacements	8 five-gallon fortnight lily	\$30/plant	Every three years
	1 five-gallon heavenly bamboo		Every ten years
	1 five-gallon Indian Hawthorn		Every 20 years
Water	1,587,500 gallons	\$2,721	Every year
Labor	Five labor hours	\$3,150	Every week
Fertilizers	200 pounds		Every six weeks
Herbicides	50 pounds		Every six weeks
Fruit control	50 pounds		Every year
Energy use	½ gallon of fuel		Every week
Tree trimming	—		Every six months
Fungicides	—	\$200	Every three years
Irrigation repairs	—	\$1,040	Every year
Aeration and gypsum	50 pounds gypsum	\$350	Every year
Tree thinning	—	\$300	Every three years

Table 5. Projected frequency of expenses for proposed native landscape.

Expense	Quantity	Projected cost to SJMN	Frequency in first three years	Frequency after first three years
Water in first three years	1,587,500 gallons first two years; 793,750 gallons third year	\$2,721 first two years \$1,361 third year	Every year	--
Water after first three years	43,500 gallons	\$75	--	Every year
Irrigation repairs	--	\$1,040	Every year	--
Plant replacements	1 five-gallon plant	\$45/plant	--	Every two years
Potted plant replacements	12 five-gallon plants	\$45/plant	--	Every three years
Reseeding grasses	½ pound	\$18 per pound	--	Every six months
Hand weeding grasses	24 labor hours; four supervisor hours	\$40/hour; \$65/supervisor hour	Every month	--
Grass thinning	Eight labor hours; four supervisor hours	\$40/hour; \$65/supervisor hour	--	Every five years
Grass cutting	Three labor hours; one and a half supervisor hours	\$40/hour; \$65/supervisor hour	--	Every six months
Pruning chaparral	Eight labor hours; two supervisor hours	\$40/hour; \$65/supervisor hour	Every six months	--
Coppicing chaparral	12 labor hours; three supervisor hours	\$40/hour; \$65/supervisor hour	--	Every four years
Tree trimming	16 labor hours; four supervisor hours	\$40/hour; \$65/supervisor hour	--	Every five years
Cleaning site after storms, drought, etc.	Six labor hours; three supervisor hours	\$40/hour; \$65/supervisor hour	--	Every three years

Table 6. Expenses involved in implementing native landscape.

Expense	Quantity	Unit cost	Total cost
Demolition	Grading and mounding, tractor rental, labor	—	\$32,400
Oak trees and buckeyes	22 five-gallon oak trees; 3 five-gallon buckeyes	\$40/tree	\$1,000
Chaparral and oak woodland plants	700 one-gallon plants	\$15/plant	\$10,500
Flower pots and plants for pots	Five pots; 12 plants	\$250/pot and \$200 for all plants	\$950
6 pounds grass seeds per acre	9 lbs grass seed	\$18/pound	\$160
Three-inch Pro-chip mulch	1,345 cubic yards of mulch	\$40/cubic yard	\$53,800
Subtotal			\$98,810
Contingency	15% of job		\$14,821
Design Fees	10% of job		\$9,881
Total Cost			\$123,512

Table 7. Expenses incurred in each of the 20 years of the current landscape life.

Year	Expense incurred in corresponding year	Annual costs to SJMN	Cumulative total to SJMN
1	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Fortnight lily replacements	\$240	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in first year	\$48,451	\$48,451
2	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Fungicide treatment	\$200	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in second year	\$48,411	\$96,862
3	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Tree thinning	\$300	
	Total cost in third year	\$48,511	\$145,373
4	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Fortnight lily replacements	\$240	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in fourth year	\$48,451	\$193,824
5	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Fungicide treatment	\$200	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in fifth year	\$48,411	\$242,235

Table 7 – *Continued*

Year	Expense incurred in corresponding year	Annual costs to SJMN	Cumulative total to SJMN
6	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Heavenly bamboo replacement	\$30	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Tree thinning	\$300	
	Total cost in sixth year	\$48,541	\$290,776
7	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Fortnight lily replacements	\$240	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in seventh year	\$48,451	\$339,227
8	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Fungicide treatment	\$200	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in eighth year	\$48,411	\$387,638
9	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Tree thinning	\$300	
	Total cost in ninth year	\$48,511	\$436,149
10	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Fortnight lily replacements	\$240	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in tenth year	\$48,451	\$484,600

Table 7 – Continued

Year	Expense incurred in corresponding year	Annual costs to SJMN	Cumulative total to SJMN
11	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Fungicide treatment	\$200	
	Flower replacements	\$6,300	
	Indian hawthorn replacement	\$30	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in 11th year	\$48,441	\$533,041
12	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Tree thinning	\$300	
	Total cost in 12th year	\$48,511	\$581,552
13	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Fortnight lily replacements	\$240	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in 13th year	\$48,451	\$630,003
14	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Fungicide treatment	\$200	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in 14th year	\$48,411	\$678,414
15	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Tree thinning	\$300	
	Total cost in 15th year	\$48,511	\$726,925

Table 7 – *Continued*

Year	Expense incurred in corresponding year	Annual costs to SJMN	Cumulative total to SJMN
16	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Fortnight lily replacements	\$240	
	Heavenly bamboo replacement	\$30	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in 16th year	\$48,481	\$775,406
17	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Fungicide treatment	\$200	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in 17th year	\$48,411	\$823,817
18	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Tree thinning	\$300	
	Total cost in 18th year	\$48,511	\$872,328
19	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Flower replacements	\$6,300	
	Fortnight lily replacements	\$240	
	Labor	\$37,800	
	Lawn aeration and gypsum	\$350	
	Total cost in 19th year	\$48,451	\$920,779
20	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Fungicide treatment	\$200	
	Flower replacements	\$6,300	
	Labor	\$37,800	
	Aeration and gypsum	\$350	
	Total cost in 20th year	\$48,411	\$969,190

Table 8. Projected expenses to be incurred in each of the 20 years of the native landscape life.

Year	Expense incurred in corresponding year	Annual costs to SJMN	Cumulative total to SJMN
1	Demolition and implementation	\$123,512	
	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Hand weeding grasses	\$14,640	
	Pruning chaparral	\$900	
	Total cost in first year	\$142,813	\$142,813
2	Water	\$2,721	
	Irrigation repairs	\$1,040	
	Hand weeding grasses	\$14,640	
	Pruning chaparral	\$900	
	Total cost in second year	\$19,301	\$162,114
3	Water	\$1,361	
	Irrigation repairs	\$1,040	
	Potted plant replacements	\$540	
	Hand weeding grasses	\$14,640	
	Pruning chaparral	\$900	
	Cleaning site after disaster	\$435	
	Total cost in third year	\$18,916	\$181,030
4	Water	\$75	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Total cost in fourth year	\$528	\$181,558
5	Water	\$75	
	Plant replacement	\$45	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Grass thinning	\$580	
	Tree trimming	\$900	
	Total cost in fifth year	\$2,053	\$183,611

Table 8 – Continued

Year	Expense incurred in corresponding year	Annual costs to SJMN	Cumulative total to SJMN
6	Water	\$75	
	Potted plant replacements	\$540	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Cleaning site after disaster	\$435	
	Total cost in sixth year	\$1,503	\$185,114
7	Water	\$75	
	Plant replacement	\$45	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Coppicing chaparral	\$675	
	Total cost in seventh year	\$1,248	\$186,362
8	Water	\$75	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Total cost in eighth year	\$528	\$186,890
9	Water	\$75	
	Plant replacement	\$45	
	Potted plant replacements	\$540	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Cleaning site after disaster	\$435	
	Total cost in ninth year	\$1,548	\$188,438
10	Water	\$75	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Grass thinning	\$580	
	Tree trimming	\$900	
	Total cost in tenth year	\$2,008	\$190,446
11	Water	\$75	
	Plant replacement	\$45	
	Cutting grasses	\$435	
	Coppicing chaparral	\$675	
	Total cost in 11th year	\$1,248	\$191,694

Table 8 – *Continued*

Year	Expense incurred in corresponding year	Annual costs to SJMN	Cumulative total to SJMN
12	Water	\$75	
	Potted plants replacements	\$540	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Cleaning site after disaster	\$435	
	Total cost in 12th year	\$1,503	\$193,197
13	Water	\$75	
	Plant replacement	\$45	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Total cost in 13th year	\$573	\$193,770
14	Water	\$75	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Total cost in 14th year	\$528	\$194,298
15	Water	\$75	
	Plant replacement	\$45	
	Potted plant replacements	\$540	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Grass thinning	\$580	
	Coppicing chaparral	\$675	
	Tree trimming	\$900	
	Cleaning site after disaster	\$435	
	Total cost in 15th year	\$3,703	\$198,001
16	Water	\$75	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Total cost in 16th year	\$528	\$198,529
17	Water	\$75	
	Plant replacement	\$45	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Total cost in 17th year	\$573	\$199,102

Table 8 – *Continued*

Year	Expense incurred in corresponding year	Annual costs to SJMN	Cumulative total to SJMN
18	Water	\$75	
	Potted plant replacements	\$540	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Cleaning site after disaster	\$435	
	Total cost in 18th year	\$1,503	\$200,605
19	Water	\$75	
	Plant replacement	\$45	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Coppicing chaparral	\$675	
	Total cost in 19th year	\$1,248	\$201,853
20	Water	\$75	
	Cutting grasses	\$435	
	Sewing seeds	\$18	
	Grass thinning	\$580	
	Tree trimming	\$900	
	Total cost in 20th year	\$2,008	\$203,861

Table 9. Present value cost of each of the 20 years of the current landscape using a five percent discount rate.

Year	Future dollar value	Discount rate	Present value of annual cost
1	\$48,451	$\$48,451/(1.05)^1$	\$48,451
2	\$48,411	$\$48,411/(1.05)^2$	\$43,910
3	\$48,511	$\$48,511/(1.05)^3$	\$41,892
4	\$48,451	$\$48,451/(1.05)^4$	\$39,845
5	\$48,411	$\$48,411/(1.05)^5$	\$37,940
6	\$48,541	$\$48,541/(1.05)^6$	\$36,225
7	\$48,451	$\$48,451/(1.05)^7$	\$34,436
8	\$48,411	$\$48,411/(1.05)^8$	\$32,777
9	\$48,511	$\$48,511/(1.05)^9$	\$31,227
10	\$48,451	$\$48,451/(1.05)^{10}$	\$29,743
11	\$48,441	$\$48,441/(1.05)^{11}$	\$28,328
12	\$48,511	$\$48,511/(1.05)^{12}$	\$27,011
13	\$48,451	$\$48,451/(1.05)^{13}$	\$25,690
14	\$48,411	$\$48,411/(1.05)^{14}$	\$24,450
15	\$48,511	$\$48,511/(1.05)^{15}$	\$23,334
16	\$48,481	$\$48,481/(1.05)^{16}$	\$22,208
17	\$48,411	$\$48,411/(1.05)^{17}$	\$21,122
18	\$48,511	$\$48,511/(1.05)^{18}$	\$20,154
19	\$48,451	$\$48,451/(1.05)^{19}$	\$19,173
20	\$48,411	$\$48,411/(1.05)^{20}$	\$18,248
Total	\$969,190		\$606,164

Table 10. Present value cost of each of the 20 years of the current landscape using a ten percent discount rate.

Year	Future dollar value	Discount rate	Present value of annual cost
1	\$48,451	$\$48,451/(1.1)^1$	\$48,451
2	\$48,411	$\$48,411/(1.1)^2$	\$40,009
3	\$48,511	$\$48,511/(1.1)^3$	\$36,447
4	\$48,451	$\$48,451/(1.1)^4$	\$33,095
5	\$48,411	$\$48,411/(1.1)^5$	\$30,050
6	\$48,541	$\$48,541/(1.1)^6$	\$27,393
7	\$48,451	$\$48,451/(1.1)^7$	\$24,859
8	\$48,411	$\$48,411/(1.1)^8$	\$22,579
9	\$48,511	$\$48,511/(1.1)^9$	\$20,573
10	\$48,451	$\$48,451/(1.1)^{10}$	\$18,678
11	\$48,441	$\$48,441/(1.1)^{11}$	\$16,979
12	\$48,511	$\$48,511/(1.1)^{12}$	\$15,454
13	\$48,451	$\$48,451/(1.1)^{13}$	\$14,031
14	\$48,411	$\$48,411/(1.1)^{14}$	\$12,746
15	\$48,511	$\$48,511/(1.1)^{15}$	\$11,611
16	\$48,481	$\$48,481/(1.1)^{16}$	\$10,549
17	\$48,411	$\$48,411/(1.1)^{17}$	\$9,577
18	\$48,511	$\$48,511/(1.1)^{18}$	\$8,723
19	\$48,451	$\$48,451/(1.1)^{19}$	\$7,920
20	\$48,411	$\$48,411/(1.1)^{20}$	\$7,194
Total	\$969,190		\$416,918

Table 11. Present value cost of each of the 20 years of the current landscape using a 15 percent discount rate.

Year	Future dollar value	Discount rate	Present value of annual cost
1	\$48,451	$\$48,451/(1.15)^1$	\$48,451
2	\$48,411	$\$48,451/(1.15)^2$	\$36,622
3	\$48,511	$\$48,451/(1.15)^3$	\$31,894
4	\$48,451	$\$48,451/(1.15)^4$	\$27,686
5	\$48,411	$\$48,411/(1.15)^5$	\$24,073
6	\$48,541	$\$48,511/(1.15)^6$	\$20,973
7	\$48,451	$\$48,451/(1.15)^7$	\$18,214
8	\$48,411	$\$48,411/(1.15)^8$	\$15,826
9	\$48,511	$\$48,541/(1.15)^9$	\$13,797
10	\$48,451	$\$48,451/(1.15)^{10}$	\$11,975
11	\$48,441	$\$48,411/(1.15)^{11}$	\$10,406
12	\$48,511	$\$48,511/(1.15)^{12}$	\$9,067
13	\$48,451	$\$48,451/(1.15)^{13}$	\$7,874
14	\$48,411	$\$48,441/(1.15)^{14}$	\$6,846
15	\$48,511	$\$48,511/(1.15)^{15}$	\$5,962
16	\$48,481	$\$48,481/(1.15)^{16}$	\$5,180
17	\$48,411	$\$48,411/(1.15)^{17}$	\$4,499
18	\$48,511	$\$48,511/(1.15)^{18}$	\$3,920
19	\$48,451	$\$48,451/(1.15)^{19}$	\$3,404
20	\$48,411	$\$48,411/(1.15)^{20}$	\$2,958
Total	\$969,190		\$309,627

Table 12. Present value cost of each of the 20 years of the proposed native landscape using a five percent discount rate.

Year	Future dollar value	Discount rate	Present value of annual cost
1	\$142,813	$\$142,813/(1.05)^1$	\$142,813
2	\$19,301	$\$19,301/(1.05)^2$	\$17,507
3	\$18,916	$\$18,916/(1.05)^3$	\$16,335
4	\$528	$\$528/(1.05)^4$	\$434
5	\$2,053	$\$2,053/(1.05)^5$	\$1,609
6	\$1,503	$\$1,503/(1.05)^6$	\$1,122
7	\$1,248	$\$1,248/(1.05)^7$	\$887
8	\$528	$\$528/(1.05)^8$	\$357
9	\$1,548	$\$1,548/(1.05)^9$	\$998
10	\$2,008	$\$2,008/(1.05)^{10}$	\$1,233
11	\$1,248	$\$1,248/(1.05)^{11}$	\$730
12	\$1,503	$\$1,503/(1.05)^{12}$	\$837
13	\$573	$\$573/(1.05)^{13}$	\$304
14	\$528	$\$528/(1.05)^{14}$	\$267
15	\$3,703	$\$3,703/(1.05)^{15}$	\$1,781
16	\$528	$\$528/(1.05)^{16}$	\$242
17	\$573	$\$573/(1.05)^{17}$	\$250
18	\$1,503	$\$1,503/(1.05)^{18}$	\$624
19	\$1,248	$\$1,248/(1.05)^{19}$	\$494
20	\$2,008	$\$2,008/(1.05)^{20}$	\$757
Total	\$203,861		\$189,581

Table 13. Present value cost of each of the 20 years of the proposed native landscape using a ten percent discount rate.

Year	Future dollar value	Discount rate	Present value of annual cost
1	\$142,813	$\$142,813/(1.1)^1$	\$142,813
2	\$19,301	$\$19,301/(1.1)^2$	\$15,951
3	\$18,916	$\$18,916/(1.1)^3$	\$14,212
4	\$528	$\$528/(1.1)^4$	\$361
5	\$2,053	$\$2,053/(1.1)^5$	\$1,274
6	\$1,503	$\$1,503/(1.1)^6$	\$848
7	\$1,248	$\$1,248/(1.1)^7$	\$640
8	\$528	$\$528/(1.1)^8$	\$246
9	\$1,548	$\$1,548/(1.1)^9$	\$656
10	\$2,008	$\$2,008/(1.1)^{10}$	\$774
11	\$1,248	$\$1,248/(1.1)^{11}$	\$437
12	\$1,503	$\$1,503/(1.1)^{12}$	\$479
13	\$573	$\$573/(1.1)^{13}$	\$166
14	\$528	$\$528/(1.1)^{14}$	\$139
15	\$3,703	$\$3,703/(1.1)^{15}$	\$886
16	\$528	$\$528/(1.1)^{16}$	\$114
17	\$573	$\$573/(1.1)^{17}$	\$113
18	\$1,503	$\$1,503/(1.1)^{18}$	\$270
19	\$1,248	$\$1,248/(1.1)^{19}$	\$204
20	\$2,008	$\$2,008/(1.1)^{20}$	\$298
Total	\$203,861		\$180,881

Table 14. Present value cost of each of the 20 years of the proposed native landscape using a 15 percent discount rate.

Year	Future dollar value	Discount rate	Present value of annual cost
1	\$142,813	$\$142,813/(1.15)^1$	\$142,813
2	\$19,301	$\$19,301/(1.15)^2$	\$14,589
3	\$18,916	$\$18,916/(1.15)^3$	\$12,437
4	\$528	$\$528/(1.15)^4$	\$301
5	\$2,053	$\$2,053/(1.15)^5$	\$1,021
6	\$1,503	$\$1,503/(1.15)^6$	\$650
7	\$1,248	$\$1,248/(1.15)^7$	\$469
8	\$528	$\$528/(1.15)^8$	\$173
9	\$1,548	$\$1,548/(1.15)^9$	\$440
10	\$2,008	$\$2,008/(1.15)^{10}$	\$497
11	\$1,248	$\$1,248/(1.15)^{11}$	\$268
12	\$1,503	$\$1,503/(1.15)^{12}$	\$280
13	\$573	$\$573/(1.15)^{13}$	\$93
14	\$528	$\$528/(1.15)^{14}$	\$75
15	\$3,703	$\$3,703/(1.15)^{15}$	\$455
16	\$528	$\$528/(1.15)^{16}$	\$56
17	\$573	$\$573/(1.15)^{17}$	\$53
18	\$1,503	$\$1,503/(1.15)^{18}$	\$121
19	\$1,248	$\$1,248/(1.15)^{19}$	\$88
20	\$2,008	$\$2,008/(1.15)^{20}$	\$122
Total	\$203,861		\$175,001

Table 15. Total savings in present value over 20 year life of landscape at four different interest rates.

Percent interest rate	Current non-native landscape	Proposed native landscape	Total savings
0	\$969,190	\$203,861	\$765,329
5	\$606,164	\$189,581	\$416,583
10	\$416,918	\$180,881	\$236,037
15	\$309,627	\$175,001	\$134,626

WORKS CITED

- Austin, Richard. 1984. *Designing the Natural Landscape*. New York: Van Nostrand Reinhold Company.
- Beckman, Tad and Nancy Hamlett. 2001. Analysis of Current and Regionally Appropriate Landscapes: Prepared for Harvey Mudd College and Three Valleys Municipal Water District: Harvey Mudd College Center for Environmental Studies. Photocopied.
- Blair, Robert and Alan Launer. 1997. Butterfly Diversity and Human Land Use: Species Assemblages along an Urban Gradient. *Biological Conservation* 80 (Apr): 113-125.
- Block, David. 2001. How Nature-scaping Works. *Biocycle* 42 (Dec): 55.
- Brainerd, John. 1973. *Working with Nature: A Practical Guide*. New York: Oxford University Press.
- Brickell, Christopher and Judith Zuk. 1996. *American Horticultural Society: A to Z Encyclopedia of Garden Plants*. New York: DK Publishing.
- California Native Plant Society. n.d.a. *Glossary of Terms*. Retrieved November 13, 2002 from the World Wide Web: <http://cnps.org/activities/terms.htm>.
- California Native Plant Society. n.d.b. *Short Title List of Plants on File*. Retrieved October 1, 2002 from the World Wide Web: <http://www.stanford.edu/~rawlings/plantli.htm>.
- California Native Plant Society. n.d.c. *Birds and Native Plants*. Retrieved March 2, 2002 from the World Wide Web: <http://www.stanford.edu/~rawlings/birds.htm>.
- California Native Plant Society. 1999. *Ideas for Designing with Native Plants*. Retrieved March 2, 2002 from the World Wide Web: <http://www.nccn.net/~cnps/designideas.htm>.

- Coppin, Dawn, Brian Eisenhauer, and Richard Krannich. 2002. Is Pesticide Use Socially Acceptable? A Comparison between Urban and Rural Settings. *Social Science Quarterly* 83 (Mar): 379-394.
- Crisp, Philippa, K.J.M. Dickinson, and G.W. Gibbs. 1998. Does Native Invertebrate Diversity Reflect Native Plant Diversity? A Case Study from New Zealand and Implications for Conservation. *Biological Conservation* 83 (Feb): 209-220.
- Cutler, Karan Davis. 1999. Dry-land Gardening: A Xeriscaping Guide for Dry Summer, Cold Winter Climates. *Organic Gardening* 46 (May): 18.
- Diekelmann, John and Robert Schuster. 1982. *Natural Landscaping*. New York: McGraw Hill Book Co.
- Environmental Protection Agency. 1998. *The Presidential Green Chemistry Challenge Awards Program: Summary of 1997 Awards, Entries and Recipients*.
- Essman, Janet. 1998. Reverting to Nature: Native Plant Landscaping Preserves Local Ecology. *New York State Conservationist* 52 (Jun): 2-7.
- Fee, Sylvia. 1993. Water Wise from Coast to Coast. *American Nurseryman* 177 (Mar): 37-40.
- Francis, Mark and Andreas Reimann. 1999. *The California Landscape Garden*. Berkeley: University of California Press.
- Gibson, D., E. Adams, J. Ely, D. Gustafson, and D. McEwen. 2000. Eighteen Years of Herbaceous Layer Recovery of a Recreation Area in a Mesic Forest. *Journal of the Torrey Botanical Society* 127: 230-239.
- Goldman, Lynn and Sudha Koduru. 2000. Chemicals in the Environment and Developmental Toxicity to Children: A Public Health and Policy Perspective. *Environmental Health Perspective Supplements* 108 (3): 443-450.

- Groesbeck, Wesley and Jan Striefel. 1995. *Sustainable Landscapes and Gardens*. Salt Lake City, Utah: Environmental Resources, Inc.
- Hardell, Lennart and Mikael Eriksson. 1999. A Case-control Study of Non-Hodgkin Lymphoma and Exposure to Pesticides. *Cancer* 85 (Mar): 6.
- Hart, Erin. 1993. Xeriscaping Provides Lush Landscapes with Little Water. *American City and County* 108 (Jan): 66.
- Henderson, Scott, Nathan Perkins, and Maurice Nelischer. 1998. Residential Lawn Alternatives: A Study of Their Distribution, Form and Structure. *Landscape and Urban Planning* 42 (Dec): 135-145.
- Holland, V.L. and David Keil. 1995. *California Vegetation*. Dubuque, IA: Kendall/Hunt Publishing Company.
- Lin, Bruce. 1999. Hydrogen Fuel Cell Scooters for Urban Asia. Master's thesis, Princeton University.
- McErlane, Roger. 1989. Water Conservation in Landscaping. *Journal of Property Management* 54 (May/Jun): 41-42.
- McKinney, Michael. 2000. There Goes the Neighborhood. *Forum for Applied Research and Public Policy* 15 (Fall): 23-27.
- McKinney, Michael. 2002. Urbanization, Biodiversity and Conservation. *BioScience* 52 (Oct): 883-890.
- Middlebrook, Alrie. 2002. Phone Conversation, 17 December. San Jose, CA.
- Middlebrook, Alrie. 2003. Phone Conversation, 11 March. San Jose, CA.
- Neon Rose: Point Reyes National Seashore. 2002. *Bay Area Map*. Retrieved February 7, 2002 from the World Wide Web: <http://www.neonrose.com/area%20map.html>.

- Ornduff, Robert. 1974. *An Introduction to California Plant Life*. Berkeley: University of California Press.
- Patchett, Jim. 2000. Integrating native landscapes. In *Conservation Design Forum, Elmhurst, IL, August 2000*, by Land and Water 44 (Sep/Oct): 44-47.
- Pavlik, Bruce, Pamela Muick, Sharon Johnson, and Marjorie Popper. 1991. *Oaks of California*. Los Olivos: Cachuma Press.
- Pimentel, David and Herbert Acquay. 1992. Environmental and Economic Costs of Pesticide Use. *Bioscience* 42 (10): 750-761.
- Reisner, Marc. 1993. *Cadillac Desert: The American West and Its Disappearing Water*. New York: Penguin Books.
- Robbins, Paul, Annemarie Polderman, and Trevor Birkenholtz. 2001. Lawns and Toxins: An Ecology of the City. *Cities* 18 (Dec): 369-380.
- Roche, Jerry. 2000. Xeriscaping Means Never Having to Say You're Sorry. *Landscape and Irrigation* 24 (Jun): 16.
- Smyser, Carol. 1982. *Nature's design: A Practical Guide to Natural Landscaping*. Pennsylvania: Rodale Press.
- Smith, C and R. St. Hilaire. 1999. Xeriscaping in the Urban Environment. *New Mexico Journal of Science* 25 (Nov): 241.
- South Bay Water Recycling. 2002. Recycled Water Quality Report 2002. Retrieved Aug 9, 2003 from the World Wide Web:
<http://www.ci.san-jose.ca.us/sbwr/downloads/recwatqualrprtfin.pdf>
- South Bay Water Recycling. 2001. Plant Selection. Retrieved Aug 9, 2003 from the World Wide Web:
<http://www.ci.san-jose.ca.us/sbwr/landguidepages/guideplantselect.htm>.
- Wade, Beth. 1994. The Natives are Restful. *American City and County* 109 (Apr.): 54.

Western Regional Climate Center. 2001. *Period of Record Monthly Climate Data*.
Retrieved January 24, 2003 from the World Wide Web:
<http://www.wrcc.dri.edu/cgi-bin/cliirectm.pl?casjos>.

Yarnold, David. 2003. Business meeting, 16 January. San Jose Mercury News,
San Jose, CA.