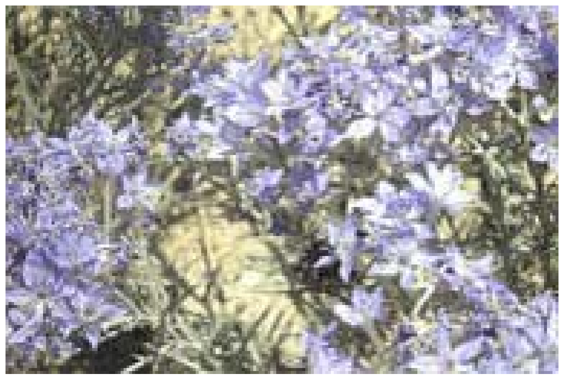
SANTA ANA RIVER WOOLLY STAR

REPORT OF BIOLOGICAL STUDIES FOR THE PRESERVE MANAGEMENT PROGRAM, YEARS 4 THROUGH 9

(County of San Bernardino Contract Agreement No. 99-638)



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SECTION 1.0 INTRODUCTION

This report documents methods and results of on-going biological studies on the Santa Ana River woolly star (*Eriastrum densifolium* ssp. *sanctorum;* hereafter referred to as woolly star), which updates the 2002 report, entitled *Santa Ana River Woolly Star: Report of Biological Studies for the Preserve Management Program, Years 4 through 8,* with data collected during 2003 and subsequent analyses. These studies are required as part of implementation of the Management Plan for the species (Chambers Group 1993). The Management Plan was prepared pursuant to mitigation requirements outlined in the 1989 Biological Opinion issued by the U.S. Fish and Wildlife Service for the Santa Ana River Mainstream Project. A list of documents that have resulted from this project can be found in Appendix A and include the following type of documenst: publications in peer review journals, unpublished technical reports, master's theses, and doctoral dissertations.

The on-going woolly star biological studies are divided into two main categories: 1) population and habitat monitoring, and 2) habitat renewal and population expansion. The studies were designed and implemented with the intent of providing information directly relevant to the preservation of the woolly star, a mitigation requirement for the Santa Ana River Mainstream Project. As new information evolves from these studies, it is recognized that future studies and management approaches might need to be modified over time in order to fulfill the intent of the Management Plan and mitigation requirements. This approach is known as adaptive management, and allows for the most effective management practices to emerge from research efforts.

As set forth in the Management Plan, population monitoring was undertaken by selecting study sites that included naturally occurring populations of woolly stars for observation over time. Sites differed by soil composition, where the amount of silt and clay varied, a factor that indicates different stages of succession (maturity of the vegetation community) within the Riversidian Alluvial Sage Scrub community. The purpose of this study was to observe various age classes of naturally occurring woolly stars over time in order to predict future trends in woolly star populations.

The habitat monitoring component of the Management Plan is intended to address broad-scale changes in the Santa Ana River Wash over time, which could provide indications of future changes in extent and distribution of woolly star habitat.

The habitat renewal and population expansion components of the Management Plan are intended to develop optimal methods of increasing habitat and populations in the event that the population studies and/or habitat monitoring indicated future decline in woolly star populations or habitat. A subcomponent of the study addresses seed viability over time, as determined through carefully controlled laboratory conditions.

SECTION 2.0 METHODS

SECTION 2.1 Population and Habitat Monitoring

Study Sites

The study was conducted at five sites located along the Santa Ana River Floodplain in southwest San Bernardino County, California. The five sites were located within an area bounded by San Bernardino International Airport to the west, the San Bernardino Mountains to the east, Greenspot Road/Fifth Street to the north, and the Redlands Airport and the Santa Ana River to the south. The sites were previously identified by Burk et al. (1988) and are referenced in the Management Plan. The study sites are differentiated from each other by their successional age, which was determined prior to this study by soil samples collected from the sites and by historic flood data.

Plot Establishment

The methods for these studies are described in detail in the Management Plan and are similar to those used in other demographic studies, including Bierzychudek (1982), Maschinski et al. (1997), and by Schmalzel et al. (1995). Fifty permanent demography plots were established on five study sites (10 plots per site). Two of the sites (1 and 2) represent a young stage of succession. Two sites (4 and 5) represent an older stage of succession. The fifth study site (site 3) represents an advanced stage of succession. The plots are each 4.5m by 2.0m and were permanently established by installing four cement markers for each plot (Figure 1, Typical Demography Study Plot). The study plots were further divided into six subsections, each measuring 1.5-meters by 1.0-meter. The markers were placed at the 1.5-meter and 3.0-meter positions along each of two long edges of each plot, with the purpose of marking at least one corner of each of the six subsections. The markers were used to locate the plots as well as allow a fixed location for the digital camera tripod. The plots were selected randomly within areas containing high densities of woolly star. The plots did not all have the same orientation since space was often limited and the presence of large shrubs often obstructed plot placement.

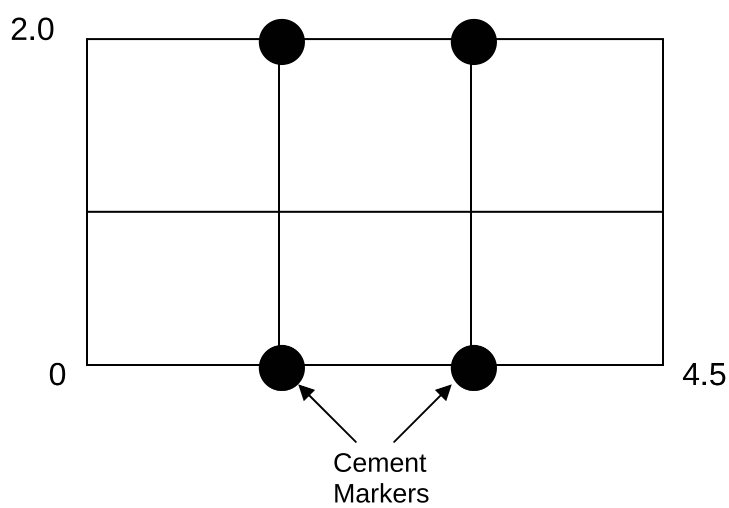

Figure 1 - Typical Demography Study Plot. This diagram represents a typical demography study plot. A total of 50 permanent plots were established among the five sites (ten per site). Each plot is 4.5-meters by 2.0-meters and is further subdivided into six subsections. Permanent cement markers were placed to mark at least one corner of each subsection in order to provide a means for locating plots during future studies.

Field Data Collection

For the woolly star, previous observations indicated that the majority of plant mortality occurs in late summer and early fall when temperatures are highest and when water is most scarce. Therefore, for each year of the study, data collection began as early as late fall, allowing for the majority of plant mortality (especially seedlings) to occur. For the first two seasons of the study, data collection began as early in the fall as possible since the process was very lengthy, and the majority of the growing was needed to complete data collection before plant mortality began again. As better field equipment became available and the methodology of data collection was perfected, collection became more efficient, and the time necessary to collect data decreased. This allowed for data collection to begin later in the growing season for the remainder of the study.

Throughout the study, a photographic record has been kept for each plot by using a digital camera. During the first season, a Kodak DC 40 digital camera was used, however, due to inadequacy of features of the Kodak camera, an Olympus 320L camera has been used for successive seasons. The camera was mounted above the plots using a camera tripod and an aluminum boom arm. Because the camera was not able to capture an entire plot with one photograph, each plot was subdivided into six, 1.5m by 1.0m sections. The camera-mounted tripod was moved around the plot to take photographs of each subsection. The cement markers that were created to locate the plots also provided a guide for the tripod to be positioned properly for each use. To position the tripod, a measuring tape was extended along each of the long edges (4.5 meters) of the plot, with the center of the cement markers occurring at 1.5-meter and 3.0-meter points on the measuring tape. The cement markers were placed at the corners of the third and fourth subplots. This procedure allowed the tripod to be properly positioned properly for each use.

Each plot was photographed to obtain fixed coordinates of individual plants for each season of the study. To ensure accurate and consistent identification, Individual plants were marked with circles of fluorescent flagging placed around the base of the plant to locate them easily in the digital images. As the plots were photographed, a sketch was made in the field of each plot depicting the approximate location of plants, and a temporary identifying number was given to each plant.

The majority of plant mortality occurs in late summer and early fall when temperatures are highest and when water is most scarce. For the purpose of this study, it was not necessary to know how many seedlings germinated the previous fall-spring since the majority of these seedlings don't survive the dry, hot summer months (Wheeler 1991). Seedlings were included in the study only after they survived their first summer and established themselves. As the plots were photographed, a sketch was made in the field of each plot depicting the approximate location of plants, and a temporary identifying number was given to each plant. In the first season, all plants within plots (living and dead) were marked and photographed. Dead plants were noted in the event that an individual could be dormant for a season and have new growth in successive seasons. For the remaining seasons of the study, only the live plants were marked in the photographs. If a plant appeared dead during the study, its status was noted and then watched in successive seasons to see if it resumed growth.

Newly germinated seedlings were not marked (and therefore not counted) during data collection. Since the majority of seedlings will not survive the dry, hot summer months (Wheeler 1991), these individuals were added to the study in the following season if they survived their first summer. Therefore, in any given season, individuals that were new to the study since the previous season were added to the study as "seedlings".

Determining Life Stage Of A Woolly Star Individual

After identifying numbers were assigned to the plants, the life stage was recorded for each plant, to be used later in the creation of population matrices. Choosing a life stage for this study proved to be difficult. Previous demography studies conducted by Bierzychudek (1982), Maschinski and Rutman (1993), and by Schmalzel et al. (1995), used characteristics such as crown diameter, height, and basal diameter to determine life stages for populations. Physical characters such as these could not be used with consistency for woolly star due to the highly variable growth patterns of individuals. Therefore, a life stage was selected that could be more reliably determined and that better correlated with the age of woolly star individuals. The branching pattern of individual plants was chosen as the life stage indicator for this study.

In the case of a seedling, the seedling begins as a single shoot. This shoot may develop additional shoots near the base of the plant (major branches) during the first season or it may remain as a single, main shoot. Seedlings may flower in the first season but also may not depending on environmental conditions and the time of the year in which they germinate. By the end of the summer, the old, vegetative material withers away, and the plant appears to be dead, but is just entering the summer-deciduous period. Provided that the plants survive the summer months, then at the start of the next season, individuals begin generating the new “major branches”. At a given point in time, by starting at the base of a plant, and studying the relative thickness of branches on an individual, it can be determined with consistency how many levels (i.e., stages) of “major branching” a plant has gone through in its lifetime. During the flowering period, a plant at a higher branching stage will have more new growth shoots overall, and therefore will likely have more flowering heads. Therefore, as individuals, plants at higher branching stages have the potential to contribute more to the fecundity of the population.

It was observed that as plants get older, new shoots are not always produced. This may be dependent on the environmental conditions of that season or the age of the plant. Some plants in this study did not produce any new growth at all (shoots or leaves) in a given season. When observed, these plants appeared dead but may only have been dormant. During this study, several plants were observed that appeared dead in one season but produced new growth in successive seasons. This would produce a problem with associating plant stage with age. However, for the purpose of this life stage based study, a lack of branching in a season is not important. The branching stage relates to the ability of an individual to contribute to future generations of plants. A plant in a higher branching stage would produce more new shoots each season for several years, thus potentially producing more flowers and therefore acquiring a greater chance for contribution to fecundity.

Field data collection began as early in the fall as possible, following summer plant mortality. Because data collection began early in the growing season, many of the plants had not yet begun to exhibit new shoot growth, and new seedlings were not yet visible. As a result, the study was designed to use the old growth from the previous season, instead of the new growth of that season, in determining the life stage of individuals. In addition, for seasons two through six, plants that were new to the plots were identified as “seedlings” since they were the plants that germinated in the previous season and survived the summer mortality, thus correlating with the old growth used to determine the life stage.

Plot Photographic Analysis

After plot photography, the images were transferred to a computer and manipulated to ensure correct orientation and size. A coordinate system was then created for each plot USING NIH Image soft ware, allowing for each plant to receive a unique set of coordinates (in meters). Using these coordinates, each plant could be independently tracked for the course of the demography study. Each plant was also given its own unique identification number based on the site number, plot number, and the season in which it first was first photographed.

Life Stage Data Analysis And Population Matrices

Population matrices were created for each site based on the Management Plan and those created by Bierzychudek (1982), Maschinski and Rutman (1993), and by Schmalzel et al. (1995). In this study, the general matrix model was derived from the Lefkovitch (1965) model, and was based on life stage rather than age, due to the fact that the ages of woolly star individuals could not be determined without destroying the plants. Furthermore, previous work by Lefkovitch (1965), Vandermeer (1978), and Kirkpatrick (1984) has shown that the growth plasticity of plants as well as the indeterminate growth form often makes the age structure a poor predictor of future population states. Since woolly star individuals are highly variable in size and growth form, age would not have made a good indicator. As previously discussed, the life stage chosen to study was the branching stage of an individual.

Population matrices were created using parameters based on the change in branching stage between seasons. Table 1 shows the general matrix format. The first row of the matrix represents fecundity and is based on the proportion of individuals in each stage class in a given season (x), relative to the number of seedlings present in the following season (x+1). The parameters in the remaining rows represent either the probability of an individual moving from one life stage to the next between consecutive growing seasons, or the probability of an individual remaining at the same life stage between consecutive growing seasons. For example, $P_{1,2}$ is the probability that a plant will move from stage 1 to stage 2 between consecutive growing seasons, and is calculated as the proportion of the number of individuals in stage 1 at year x, versus the number of individuals in stage 2 at year x+1. Population matrices were created for this report using data from seven consecutive growing seasons (fall 1997 through spring 2003). Using the matrices, population growth rates were estimated for each site using RAMA AGE/STAGE computer software. Furthermore, expected time to extinction was projected for the entire population.

Table 1. General population matrix used for the demography study.

	0	1	2	3	4	5
0	$P_{0,0}$	$P_{1,0}$	$P_{2,0}$	$P_{3,0}$	$P_{4,0}$	$P_{5,0}$
1	$P_{0,1}$	$P_{1,1}$	$P_{2,1}$	$P_{3,1}$	$P_{4,1}$	$P_{5,1}$
2	$P_{0,2}$	$P_{1,2}$	$P_{2,2}$	$P_{3,2}$	$P_{4,2}$	$P_{5,2}$
3	$P_{0,3}$	$P_{1,3}$	$P_{2,3}$	$P_{3,3}$	$P_{4,3}$	$P_{5,3}$
4	$P_{0,4}$	$P_{1,4}$	$P_{2,4}$	$P_{3,4}$	$P_{4,4}$	$P_{5,4}$
5	$P_{0,5}$	$P_{1,5}$	$P_{2,5}$	$P_{3,5}$	$P_{4,5}$	$P_{5,5}$

In addition to the population growth rates, additional data analyzed included the number of plants per plot at each site, the average mortality rates for each site, and the distribution of branching stages for each site, each over the course of the study. Statistical analyses were performed for data collected at each site. A generalized linear model Analysis of Variance (ANOVA) was conducted for each set of data analyzed. Probability values (p-values) were generated to determine if significant differences exist between sites and between seasons, and to establish trends for the range of woolly star populations.

Habitat Monitoring/Aerial Photography Analysis

In 2002, the Army Corps of Engineers provided a digital ortho-rectified, color aerial photographs of the study area at a scale of 1 inch = 100 feet, taken in 1998. The resolution of these photographs was survey-grade and far greater than the aerial photographs available at the time the Management Plan was prepared. The aerial photographs of the study site were taken after the high storm flows had subsided in the Upper Santa Ana River associated with the previous rainy season's El Nino phenomenon. Records indicate that since the time the aerial photographs were taken, the study site has experienced normal to below normal rains. Therefore, the geomorphology observed in the digital aerial photographs of the study site are indicative of a system that had recently experienced high surface water flows, but that has been relatively stable since that time. High surface water flow indicators such as recent braiding that consists of reworking of sediments into sandbars, scouring of seasonal channels, and other sedimentary structures were noted on the aerial photographs within and adjacent to the study site. The relative freshness of these indicators helped determine the boundaries of the active and inactive stream channels, and their associated terraces that support early, intermediate, or late successional stages of Riversidian Alluvial Fan Sage Scrub. The aerial photographs were georeferenced and imported into a geographic information system (GIS) ArcINFO Desktop software. Polygons for the above referenced features were constructed and annotated showing age and status of terraces and the stream channel. Acreages were calculated using ArcInfo. The areas analyzed were those within the boundaries of the Mitigation Study Area (Figure 2).

The land formations analyzed within the Mitigation Area consisted of channels and river terraces of various ages. The stream channels studied were determined to be primary, indicating evidence of a frequently active channel, or secondary, indicating evidence of a relatively inactive channel. The criteria used to determine whether a channel was active were observation of standing or flowing water, lack of vegetation in channel showing recent scour, fresh or recent sandbar formation, down cut banks, terraces, and recent stream braiding.

Terraces that showed no signs of recent inundation by flooding (i.e. were observed to support at least sparse vegetation) were evaluated to determine their stage of development. Criteria used to determine the stage of development of the terraces within the Mitigation Area were density of vegetation and general density of long-lived woody species such as junipers (based on percent cover: Early = 0-30%; Intermediate = 30-60%, and Late = 60-100%), color of soil (Early = white/granitic weathering absent; Intermediate = tan/oxidized soil, with some weathering varnish present; Late = yellow, weathering varnish present), and proximity and elevation of terrace in relation to current floodplain (with terraces aging as the distance from active channels increases).

The channel features or terrace polygons were then determined to be non-disturbed or disturbed. The criteria used for determining disturbance were frequency of roads, construction or fire prevention brush clearing, fire damage, flood engineering, and other signs of human impact. If a feature area was populated by more than 10 percent of any of these impact criteria it was labeled as disturbed.

SECTION 2.2 Habitat Renewal and Population Expansion

The field site is located north of the Sunwest mine, 0.85 km south of Greenspot road and 0.2 km east of Orange Street, San Bernardino County (N 34^{o} 05.957', W 117^{o} 10.840', elevation 391 m). Based on historical flood records, soil analysis and vegetation type, both Wheeler (1991) and Burk et al. (in press, 2002) reported that the field site has not experienced major changes in geomorphology since the floods of 1862 (Aqua Manza flood) and 1867.

Plot Design

A randomized complete block design was used to establish 35 experimental plots 14 January 1999 (Figure3). These plots were placed near declining woolly star populations because that habitat represents the stage in succession that will eventually need restoration intervention. Each of five blocks contained seven 4m x 7m experimental plots. As prescribed in the Management Plan, each experimental plot was randomly assigned one of six soil manipulation treatments or an unmanipulated control. Treatments included: 1) Cleared. Vegetation was removed manually at the soil surface to avoid disturbance of the substratum. 2) Cut. The top 20 cm of substratum was manually removed, thus eliminating accumulated micro-organics, silts and clays, to expose sand and to prevent establishment of competitive annuals/perennials. 3) Diked. Vegetation was initially cleared at the soil surface. Soil was removed manually resulting in four parallel trenches (one trench per meter), each measuring 70 cm wide and 50 cm deep. 4) Sand fill-10 cm. Vegetation was cleared at the soil surface. Washed sand (>2 mm particle size-gravelly sand USDA soil classification), obtained from a local sand mine, was placed atop the plots to a depth of 10 cm. Sand fill manipulations were used to mimic natural sand deposition that would occur following a major flood event. 5) Sand fill-20 cm. Procedure same as above. Washed sand was placed atop the plots to a depth of 20 cm. 6) Sand fill-30 cm. Procedure same as above. Washed sand was brought to randomly selected plots to a depth of 30 cm.

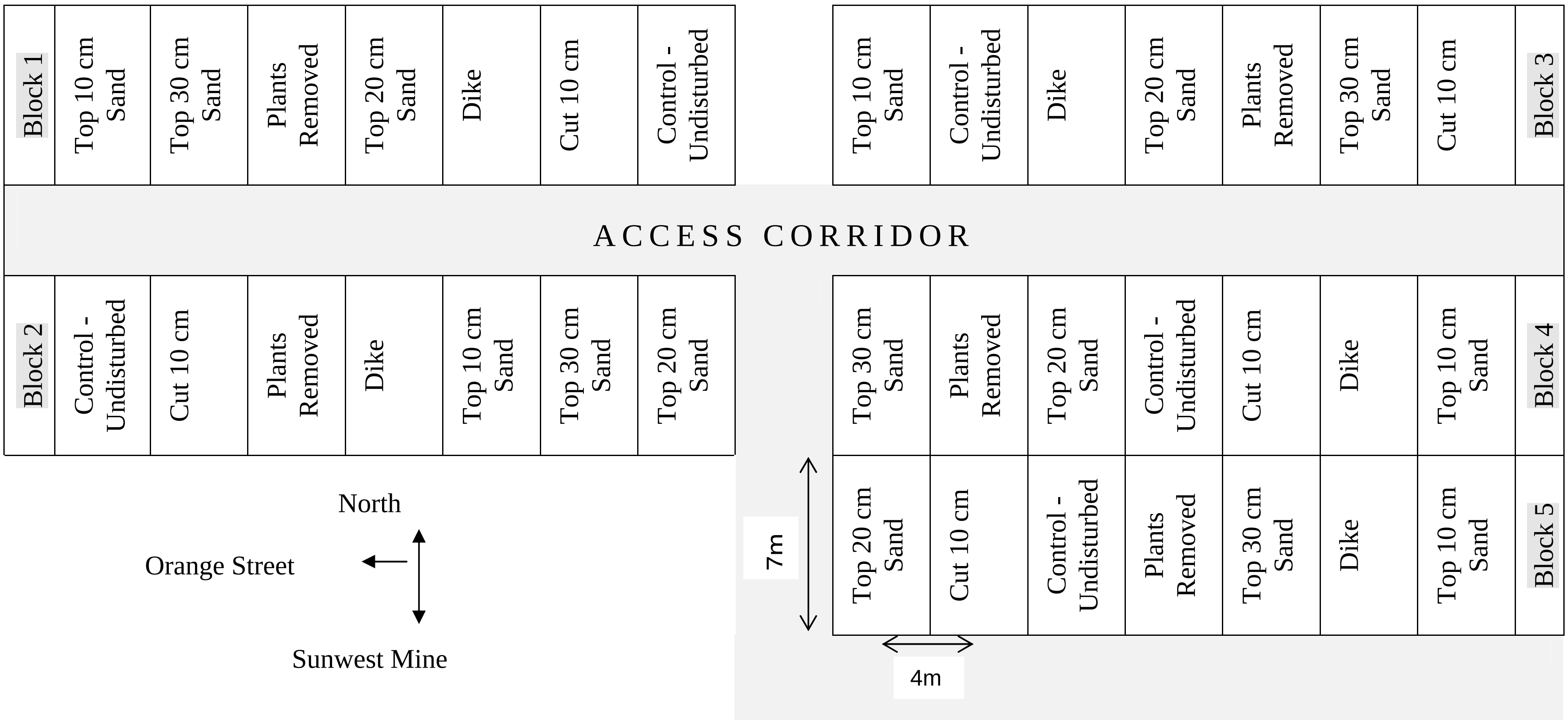

Figure 3. Randomized complete block design of experimental restoration plots established January 1999.

Environmental Variables Measured

Throughout the study, on-site precipitation was monitored using an All Weather metric rain collector. This rain collector was anchored to a wood post such that the top of the rain collector extended 2 cm above the wood post and measured 1m from the substratum surface. Rainfall accumulation was recorded within the same week of a precipitation event. Air temperature was obtained from a weather station located at the San Bernardino Flood Control District, San Bernardino County.

Germination and Seedling Survivorship

Field Data Collection

Germination and survivorship were quantified using three subplots randomly placed along the perimeter of each experimental plot. Each subplot, measuring 0.56 m in diameter, was constructed of 0.32 mm vinyl microtubing and anchored to the ground using galvanized wire pegs. Annually, vegetative overgrowth along the 1m perimeter of each experimental plot (excluding the control) was removed, and new subplots were randomly placed to maintain a consistent microsite for germination. Although the substratum of each treatment plot was manually disturbed each year, it was impossible to assure the removal of naturally dispersed seeds. Each subplot was seeded with 50 seeds that were collected from woolly star plants at the field site. In the first year subplots were seeded 1 December 1999 and in the second year subplots were seeded 6 November 2000 prior to winter rainfall. Germination was recorded at the stage in which the cotyledons initially appeared at the soil surface (J. Burk-personal communication).

Seedling emergence and survivorship data were collected three times throughout a season (one year) to monitor the effect of seasonal changes on each variable: February, approximately one month after a rainfall event that would induce germination (28.4 mm of rainfall-Wheeler, 1991); April, at the conclusion of the rainy season; and September, after summer, the driest part of the year, when seedlings are drought stressed. Data were replicated for a second year. Seedlings were identified using a Hastings 10x hand lens and temporarily marked with PVC rings (2 mm - height/1.5 cm- diameter). *E. densifolium* ssp. *sanctorum* seedlings were positively identified by the presence of two green, spine-tipped cotyledons with woolly pubescence. All plots were photographed using a D-320L Olympus digital camera to obtain a permanent record of emergence/survivorship. Photographing at the seasons end (September) was delayed because I could not discern whether seedlings were dead or dormant. Final seedling identification occurred following a significant rainfall event (~ 28.4 mm) that stimulated woolly star to resume growth (branching/leafing out).

Calculations

Total germination. The total number of seeds that germinated on each experimental plot was determined by calculating the average number of seeds that germinated for each group of subplots. A three-way analysis of variance was used to detect differences in total germination by block, treatment (including control), and year.

Percent germination. To study seasonal changes in germination, the percentage of seeds that germinated in February (Equation 1) was compared to the percentage of seeds that germinated in April (Equation 2):

Equation (1) $\%\ \text{Germination}_{(Feb)} = (a / 50) \cdot 100$

Where a = the average number of seeds that germinated in February for each group of subplots, and 50 is the number of seeds sown per subplot.

Equation (2) $\%\ \text{Germination}_{(Apr)} = (b / 50 - a) \cdot 100$

Where b = the average number of seeds that germinated in April for each group of subplots, a = the average number of seeds that germinated in February for each group of subplots, and 50 is the number of seeds that were initially sown per subplot.

The percent germination data for each year studied was averaged. A one-way analysis of variance was used to detect differences between the mean proportion of seeds that germinated in February and April.

Total Survivorship. To determine total survivorship, the percentage of seedlings that survived in each subplot was calculated (Equation 3):

Equation (3): $\%\ \text{Survival} = (x / y) \cdot 100$

Where x = the number of seedlings that survived per season (1 year), and y = the total number of seeds that germinated per season.

The total percentage of seedlings that survived on each experimental plot was found by calculating the average percent survival of seedlings in each group of subplots. The total survivorship data for each year studied was averaged. A one-way analysis of variance was used to determine differences in total survivorship by treatment (including control).

Percent survivorship: early and late germination. The percent survival of early (Equation 4) and late (Equation 5) emerging seedlings was initially calculated for each subplot:

Equation (4): $\%\ \text{Survival}_{(early)} = (c / d) \cdot 100$

Where c = the number of early emerging seedlings that survived a season (1 year), and

d = the total number of seeds that emerged early.

Equation (5): % Survival $_{(late)}$ = (e / f) $\cdot$ 100

where e = the number of late emerging seedlings that survived a season, and f = the total number of seeds that emerged late.

The average percent survivorship of seedlings that emerged early and late was calculated for each group of subplots. Survivorship data collected for two years was averaged. A one-way analysis of variance was conducted to detect differences between the average percent survivorship of seedlings that germinated early rather than late.

Seedling Establishment

Seedlings that had persisted for at least one year, post germination, were recorded as established. Establishment plots were located in the center of each experimental plot and measured 2 m x 4.5 m. The corners of each establishment plot were marked with 0.61 m sections of rebar that were nailed into the ground. Each establishment plot was initially seeded in 1999 with approximately 1000 *E. densifolium* ssp. *sanctorum* seeds that were collected from plants located within the primary field site. Seeds were mixed with 0.5 L of sterilized sand and broadcast using a Scott’s Handy Green II seeder. Establishment plots were seeded again in 2000 in an effort to establish populations on each plot. At the conclusion of this study, the number of plants that had established on each plot were marked, counted, and photographed using a D-320L Olympus digital camera to obtain a permanent record.

MDS Ordination

A multivariate, non-metric multidimensional scaling (MDS) analysis (Primer v5 PRIMER-E Ltd., Clarke and Gorley 2000) was used to measure the similarity in soil texture between soils sampled from each experimental soil condition and soil that was collected from an early succession and late succession site. Early and late succession soils were collected and classified prior to this study by Burk et al. (1988). The early succession site was located approximately 2.7 km from the field site, and soils characterized as late succession were collected from within the same field site in which the experimental design was established.

Soil Analysis

In order to assess whether or not soil certain soil properties were associated with results of the habitat renewal experiment, soil samples were randomly collected from three of the four corners of each experimental plot to prevent disturbance of the seedling emergence subplots. Soil subsamples were collected from the top 7 cm using a 13 oz. metal cylinder inserted into the ground. Soil subsamples extracted from each experimental plot were mixed and brought back to the laboratory in paper bags. All samples were analyzed for particle size distribution (A20 N- USDA system for soils, using screening and hydrometer setting rates), soil fertility, and micronutrient analysis (A01) by the Soil and Plant Laboratory, Inc. of Orange, California.

Analysis of Plot Data

Data analysis was conducted using Minitab statistical software, release 13. Each data set was tested for equal variance and normality. When necessary data were log or arcsine transformed. All data were tested with Analysis of Variance (ANOVA) or with non-parametric tests when data failed to meet the assumptions of ANOVA.

Seed Viability Trials

Seeds were stored in lots of 6 0 in 0.75 cm x 3.85 cm shell vials loosely stoppered with paper tissue that allows air circulation but prevents seed escape from the vial. Each seed vial was placed inside a 1.2 cm x 7.5 cm glass vial sealed airtight with a synthetic rubber stopper. Both the seed and external vials are labeled. Half of the external vials also contain 1 g silica gel that was dried to constant weight at 100°C then held in desicator jars to cool before placing it in the vials. When all vials were prepared they were stored upright in racks at –35°C, 18°C, +3°C or +24°C. Seeds were placed in the assigned temperature conditions on 20 April 1999.

On 4 December 2002, a vial of seeds was removed from each storage treatment. The seeds were divided into 5 replicates of 10 seeds, and placed in the germination modules to determine germinability. The germination modules consist of a 2.5 cm section of schedule 40 PVC pipe covered at one end with a 2 mm mesh screen and secured with silicon rubber to a 4.5 cm section of PVC to allow holding in test tube racks. Each module was filled with 2 cm of washed field sand. Modules were placed in two test tube racks of 20 modules per rack. The 40 modules, each containing 10 seeds placed on the surface of the sand, were positioned under a constant gentle mist that leached the seeds with >30 mm of water over a period of 33 hours in a greenhouse isolation chamber set to cool to about 20°C. Racks were rotated after 12.5 hours to increase uniformity of leaching. After 33 hours the two racks containing the germination modules were placed in separate semitransparent white plastic bags tied with a twist tie. The racks were then placed in a growth chamber with 12 hours of light and 12 hours of dark at 16°C.

The seeds remained in the growth chamber for 8 days when germination was recorded. As determined in May 1999, a period of 11 days was sufficient to allow germination of most seeds. Thus, the modules were removed on 16 December 2002 for a total of 11 days in the growth chamber and a final germination count obtained.

SECTION 3.0 RESULTS

SECTION 3.1 Population and Habitat Monitoring

This section provides the most recent information on the population and habitat monitoring, updating the 2002 report. Appendix B provides the branching stage data for each plot of each site. Appendix C provides summary tables of the number of plants for each plot of each site. Appendix D provides summary tables of the mortality rates for each site and for each transition period between growing seasons. Appendix E provides summary tables of the branching stage distribution for each site and for each season.

Population Matrices & Estimated Growth Rates

Tables 2 through 6 provide the population matrix and estimated population growth rate (lambda) for each site. Based on the branching stage data collected for the first six seasons, each site has a population growth rate of less than 1.0, indicating that the population at each site is declining. Table 7 provides the estimated growth rates for each site, as well as the projected time to extinction for each site based on the growth rate. Extinction times were estimated using the number of woolly star individuals per ten plots at each site as the initial abundances. If calculated using actual numbers for each site, extinction times are expected to be higher than what are reported below. Site 4 exhibited the highest growth rate over the six years, whereas Site 2 exhibited the lowest growth rate. Based on statistical analyses, there was no significant difference between the five sites with respect to their average growth rates.

Table 2 - Population matrix for Site 1 (Lambda = 0.807)

	0	1	2	3	4	5
0	.069	.19	.16	.22	.45	
1	.478	.04				
2		.572	.329			
3			.373	.418		
4				.264	.558	
5					.162	.25

Table 3 - Population matrix for Site 2 (Lambda = 0.725)

	0	1	2	3	4	5
0	.061	.13	.15	.11	.16	
1	.503	.175				
2		.616	.363			
3			.345	.393		
4				.196	.346	
5					.103	.313

Table 4 - Population matrix for Site 3 (Lambda = 0.781)

	0	1	2	3	4	5	6
0	.067	.14	.14	.11	.11	.09	.08
1	.550	.158					
2		.733	.396				
3			.354	.388			
4				.308	.416		
5					.178	.289	
6						.067	.25

Table 5 - Population matrix for Site 4 (Lambda = 0.901)

	0	1	2	3	4	5
0	.043	.54	.60	.59	.61	
1	.536	.137				
2		.427	.229			
3			.344	.273		
4				.215	.436	
5					.097	.167

Table 6 - Population matrix for Site 5 (Lambda = 0.735)

	0	1	2	3	4	5
0	.069	.17	.16	.13	.16	
1	.519	.114				
2		.593	.318			
3			.344	.313		
4				.258	.544	
5					.075	.083

Table 7 - Summary of growth rates and extinction times per site

Site	Population Growth Rate	Extinction Time
1	0.807	9 years
2	0.725	6 years
3	0.781	9 years
4	0.901	11 years
5	0.735	7 years

Plants Per Site

Table 8 provides the number of woolly star individuals per site (per 10 plots) and for each season. For all sites, the total number of plants declined dramatically during the course of the study, which reflects the declining growth rates estimated for each site. All sites declined sharply between the third and fourth seasons, and maintained low numbers through the seventh season. Relative to the other sites, Site 4 had a large increase in plant numbers between the second and third seasons, and then exhibited massive mortality into the fourth season. Statistical analyses revealed significant differences between the five sites with respect to plant numbers, although there did not appear to be any correlation with the successional age of the sites. However, Site 3 (by far the oldest site), has consistently declined in numbers over the seven years, in contrast to the other four sites, which have had fluctuating numbers in response above-normal and below-normal seasons of rainfall. Figure 3 graphically depicts the trends in population numbers at the five sites.

Table 8 - Number of Woolly Star individuals per site (per 10 plots) for each season

Site	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003
1	105	100	130	66	67	42	27
2	184	180	168	77	59	65	24
3	107	99	94	48	43	36	22
4	64	111	197	34	46	23	8
5	143	148	162	72	68	52	27

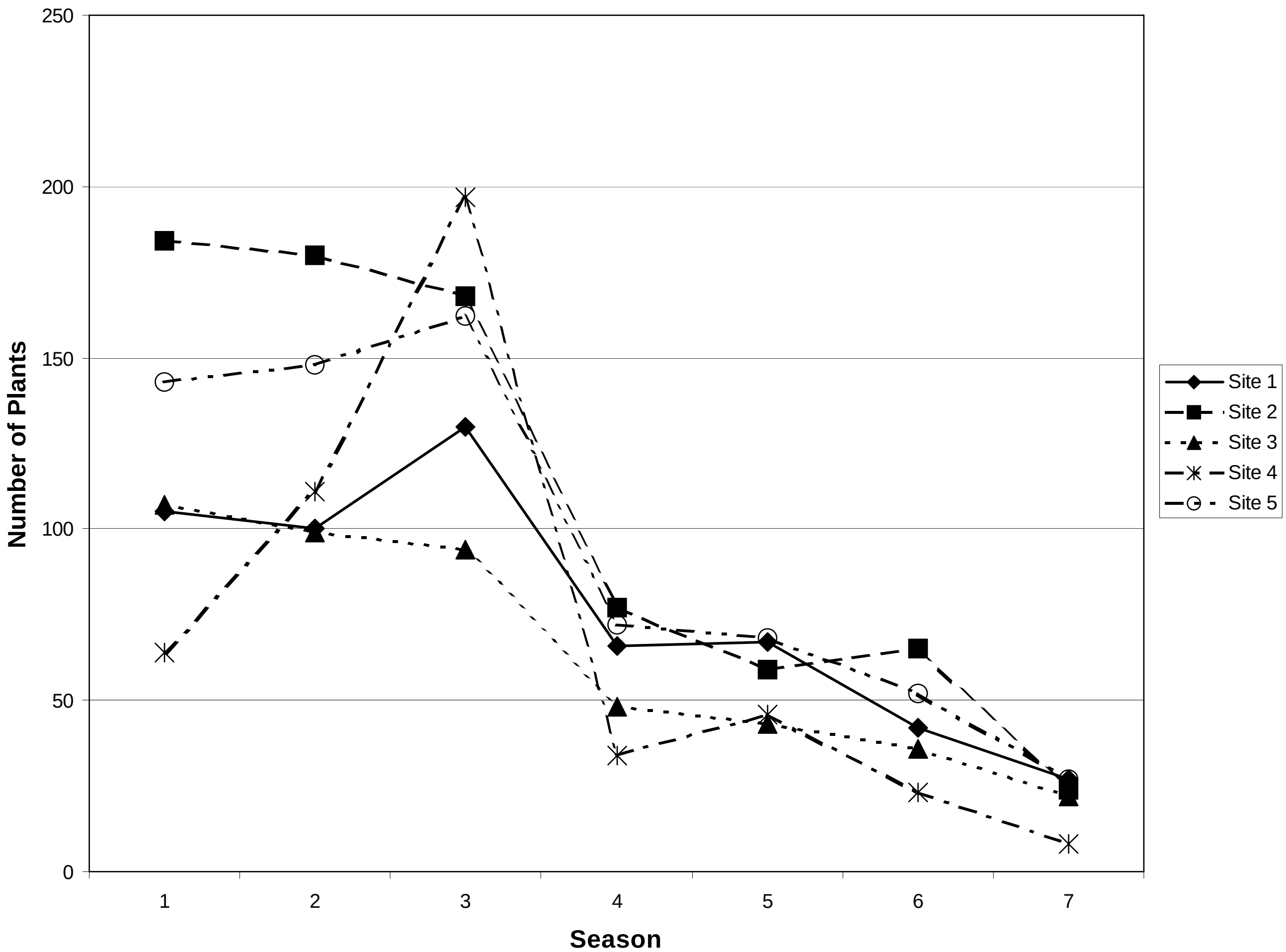

Figure 4 - Total Plants Per Site. Total plants per site (per 10 plots) per season of the study. For each site, there was a decline in numbers of plants over the seven years. All sites declined sharply between the third and fourth seasons. Site 4 had a sharp increase between the second and third seasons as a result of the El Nino rainfall.

Plant Mortality

Table 9 provides the mortality rates (adults and seedlings) for each site and for each of the five transition periods, as well as the overall mean mortality rates for the seven-year study. Over the seven-year study period, the mean mortality rate was greater than 30 percent for each site. For all sites, mortality was the lowest for the first two transition periods, and then increased sharply in the third transition period following a period of below-normal rainfall. Mortality has continued to be higher (relative to the first few seasons) for all sites through the end of the seventh season. Statistical analyses revealed no significant differences between the sites with respect to mortality, although there were significant differences between transition periods with respect to mortality. Figure 5 graphically depicts the mortality rates for the five sites. Figure 6 depicts the average mortality rates for the five sites over the course of the seven years.

Table 9 - Mortality rates (adults and seedlings) per site and for each transition period.

Site	Transition #1	Transition #2	Transition #3	Transition #4	Transition #5	Transition #6	Mean
1	10.5%	28.0%	53.1%	25.8%	56.7%	40.5%	35.8%
2	9.2%	22.8%	56.0%	29.9%	33.9%	63.1%	35.8%
3	10.3%	11.1%	60.6%	41.7%	27.9%	36.1%	31.3%
4	3.1%	18.0%	82.7%	32.4%	54.3%	69.6%	43.4%
5	4.2%	23.6%	57.4%	52.8%	30.9%	48.1%	36.2%

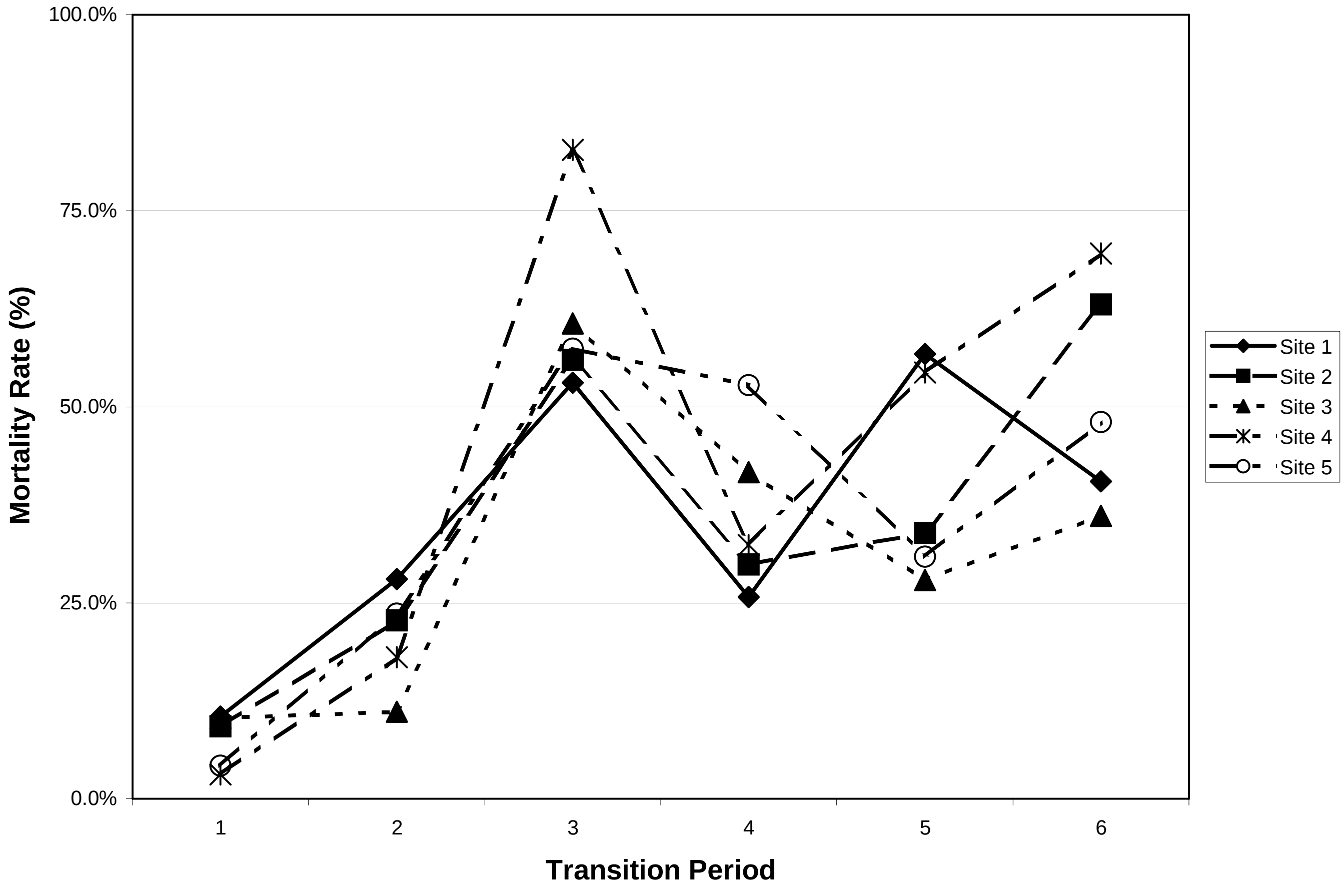

Figure 5 -Mortality Rates for the Five Study Sites. Mortality rates for each site (per 10 plots) and for each transition period. For all five sites, mortality was lowest for the first two transition periods, and then increased sharply in the third transition period, following a period of below-normal rainfall.

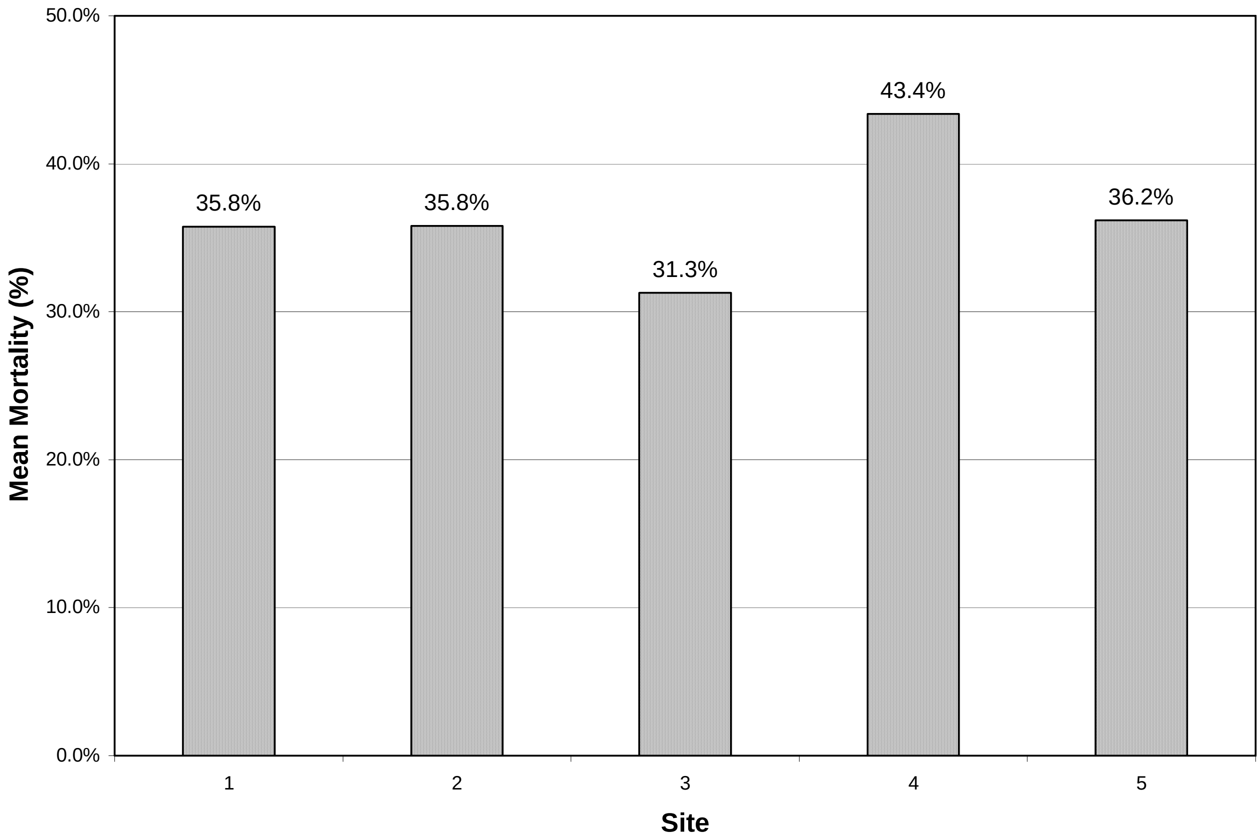

Figure 6 -**Mean Mortality Rate Over Seven Years**. Mean mortality rate for each of the five sites (per 10 plots) over the course of the seven-year study.

Branching Stage Distributions

Table 10 provides the average stage distribution for each site for the seven-year study period. With the exception of Site 4, the most abundant branching stages identified at each site were Stages 2 and 3. Site 4 contained more plants at the seedling stage (Stage 0) overall, which was the result of increased recruitment following above-normal rainfall for the first two seasons. However, Site 4 had the highest average mortality of all the sites, which was reflected mainly in the loss of a large number of seedlings in the third transition period. The mortality occurred during a season of below-normal rainfall, which followed two seasons of above-normal rainfall.

Table 10 - Average branching stage distributions per site.

Site	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
1	15.0	10.3	**21.3**	20.9	7.9	1.4	0
2	13.4	13.9	27.7	**34.0**	16.3	2.9	0
3	5.6	10.4	16.0	**18.6**	10.3	2.9	0.7
4	**25.7**	14.9	11.4	11.7	4.9	2.9	0
5	17.4	15.7	24.0	**25.9**	12.3	2.9	0

Habitat Monitoring/Aerial Photography Analysis

A total of 765 acres was mapped within the Woolly Star Mitigation Area. Acreages and percent of total area for each feature type within the Woolly Star Mitigation Area are presented in Table 11. Figures 7 through 12 depict feature types of mapped acreages for conservation zones, denoted here as Sections A through F (Figure 2). Preferred by the woolly star, early alluvial fan sage scrub successional habitats associated with active and inactive stream channels total 301 acres (39.3%). This number excludes intermediate habitat, late disturbed habitat, and unknown disturbed habitat, all potentially suitable habitat, which total an additional 321 acres (42.6%). Of the 291 acres classified as disturbed, 66 acres were classified as unknown due to pervasive human activity making stage determination from aerial photography difficult. However, these 66 acres are likely potentially suitable habitat because the woolly star prefers the open habitat created by disturbance.

Table 11 - 2003 Mapped Acreages and Percent Cover of Stream Channel and Terraces: Riversidian Alluvial Fan Sage Scrub Habitat

Feature Stage	Feature Type	Map Code	Feature Acreage	Percent Cover
Early	Active channel	Ac	41	5
Early	Disturbed	Ed	49	6
Early	Inactive Channel	Ic	85	11
Early	Non-disturbed	End	126	16
	Total Early Age Terraces		**301**	**39.3**
Intermediate	Disturbed	Id	94	12
Intermediate	Non-disturbed	Ind	79	10
	Total: Intermediate Age Terraces		**173**	**22.6**
Late	Disturbed	Ld	82	11
Late	Non-disturbed	Lnd	143	19
	Total Late Age Terraces		**225**	**29.4**
Unknown	Disturbed	D	66	9
	Total: Unknown Disturbed Habitat		**66**	**8.6**
	Total		**765**	**100**

SECTION 3.2 Habitat Renewal and Population Expansion

This section provides the most recent information on the habitat renewal and population expansion studies, updating the 2002 report.

Environmental Variables

Precipitation data indicated that the annual rainfall, for both years of the study, was below average and occurred later in the season with 86% of the total precipitation falling between January and April. In 2001, rainfall increased by 63 mm, and the number of rainfall events required to stimulate germination doubled compared with rainfall to data collected in 2000. The number of months in which the mean monthly temperature remained in the range (11.2 - 20.3 ^{o} C, Wheeler, 1991) for Woolly Star decreased in 2001 (Table 12).

Table 12 - Daily precipitation and mean monthly temperature, Habitat Renewal Study Site, San Bernardino County, California, 2000-2001

	2000			2001		
Month	Date	Rainfall (mm)	Temp. (^{o}C)	Date	Rainfall (mm)	Temp. (^{o}C)
Jan.	1	9.7	12.5 **	12	54.8 *	9.6
	27	15.9		18	4.1	
	30	3.1		22	2.9	
Feb.	14	20.7	11.9 **	1	14.4	10.1
	19	8.8		11	6.6	
	25	54.7 *		17	35.9 *	
	19	8.8		21	3.1	
				28	44.9 *	
Mar.	3	7.3	13.6 **	7	23.4	14.3 **
	13	45.9 *		13	22.0	
Apr.	15	8.5	17.4 **	3	3.9	14.5 **
	24	25.0		30	32.3 *	
May	25	3.0	20.5 **	30	1.5	20.5 **
	30	8.0				
Jun.	-----	0.0	23.2	-----	0.0	22.9
Jul.	-----	0.0	24.4	5	0.6	23.9
Aug.	-----	0.0	26.0	-----	0.0	25.6
Sep.	1	1.8	22.8	-----	0.0	23.7
	8	0.3				
Oct.	4	0.8	17.1 **	1	1.0	19.8 **
	30	14.0		15	8.1	
				29	21.8	
Nov.	-----	0.0	12.2 **	-----	0.0	14.7 **
Dec.	-----	0.0	12.9 **	7	3.8	10.0
				18	6.9	
Total		230.2			293.50	

* = Adequate rainfall events to stimulate germination.
** = Monthly mean air temperature within optimal range for germination.

Germination

There was no significant difference in the average percent germination with respect to each soil condition (Table 13) (2-way ANOVA, df = 6, F = 0.73, P = 0.626). Across all soil conditions, a significantly greater percentage of seeds germinated in February (21.0 ± 0.9 %) than in April (7.6 ± 0.8 %) (1-way ANOVA, df = 1, F = 14.34, P = 0.001) (Table 10). A significant year- effect was detected with an annual decrease in germination from 2000 to 2001 (3-way ANOVA, df = 1, F = 33.80, P = 0.004). Interaction variables were not significant. The block variable was included as a random factor.

Table 13 - A list of the measured biological factors. No significant soil condition effect was detected in the mean percent germination and the mean percent survivorship. Germination and survivorship are reported as raw percentages, but the ANOVA was conducted on arcsine-transformed proportions. For each soil condition n = 10.

Soil condition	% Germination mean ± SE	% Survivorship mean ± SE
Control	25.6 ± 2.9	0
Cleared	16.7 ± 1.4	2.8 ± 0.8
Cut	32.6 ± 3.5	9.9 ± 1.1
Diked	16.9 ± 1.6	3.3 ± 0.7
Sand-fill 10 cm	26.1 ± 2.5	5.2 ± 1.0
Sand-fill 20 cm	25.5 ± 2.5	2.2 ± 0.7
Sand-fill 30 cm	29.7 ± 2.4	4.9 ± 0.9

Survivorship

Percent Survivorship. Although there was no significant soil condition effect on the proportion of seedlings that survived, seedling survivorship was highest on the cut and sand-fill (10 cm and 30 cm) plots (Table 13, Figure 13) (2-way ANOVA, df = 6, F = 1.82, P = 0.111). Over the two-year study, seedlings failed to survive on the control plots, which are characterized as late succession habitat. As a result, the data associated with the treatment factor did not meet the equal variance assumptions of ANOVA. There were no significant year-to-year differences detected in seedling survivorship (2-way ANOVA, df = 1, F = 0.22, P = 0.642). There was, however, a significant year by soil condition interaction indicating that the effect of each soil condition on survivorship was dependent upon the year in which survivorship was recorded (2-way ANOVA, df = 6, F = 2.53, P = 0.031). For the soil condition variable, the power of the ANOVA was estimated to be 0.35; that is, there was a 65% chance of having committed a Type II error in this analysis.

Across all soil conditions, no significant difference was detected in the percent survival between seedlings that had germinated earlier as opposed to seedlings that had germinated later in the season (1-way ANOVA, df = 1, F = 0.37, P = 0.548).

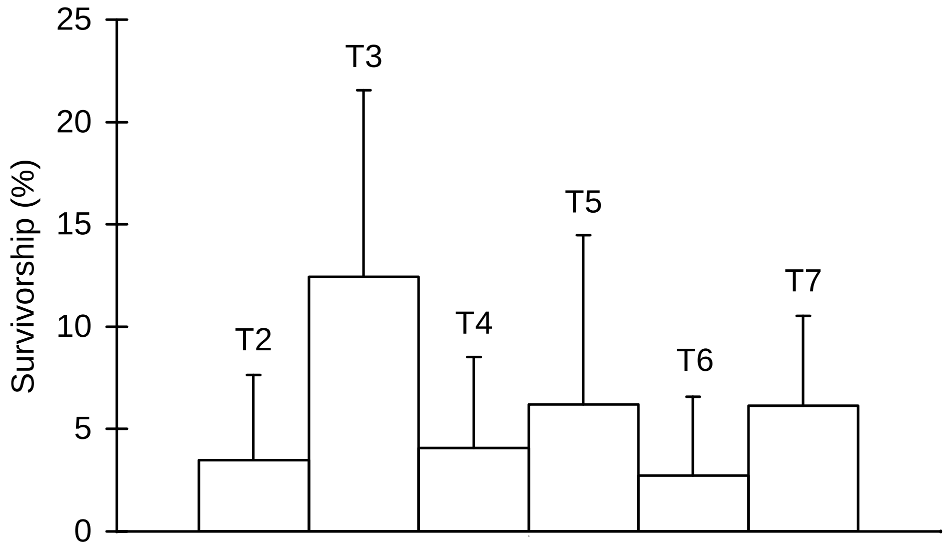

Figure 13 - The average percent survivorship of *E. densifolium* ssp. *sanctorum* seedlings for two years. N = 4 for each soil manipulation treatment. A Friedman test detected no significant treatment effect with respect to seedling survivorship ($p > 0.05$). Treatments include: T2 = cleared, T3 = cut, T4 = dike, T5 = sand fill-10 cm, T6 = sand fill-20 cm, and T7 = sand fill-30 cm. Seedlings failed to survive in the control plots (T1).

<u>Seedling Establishment.</u> Seedlings failed to establish on the cleared plots and rarely established on the control plots. With the exception of vegetation removal from the cleared plots, both treatments (control and cleared) represent late succession habitat. On average the greatest number of seedlings established on the cut plots (Figure 14). A two-way ANOVA (GLM) indicated no significant difference between the numbers of seedlings that established in relation to each soil manipulation treatment. The cleared treatment was omitted from the final analysis since seedlings did not establish. The block variable was included as a random factor and there was no significant block effect. Data were log transformed for measures of equal variance.

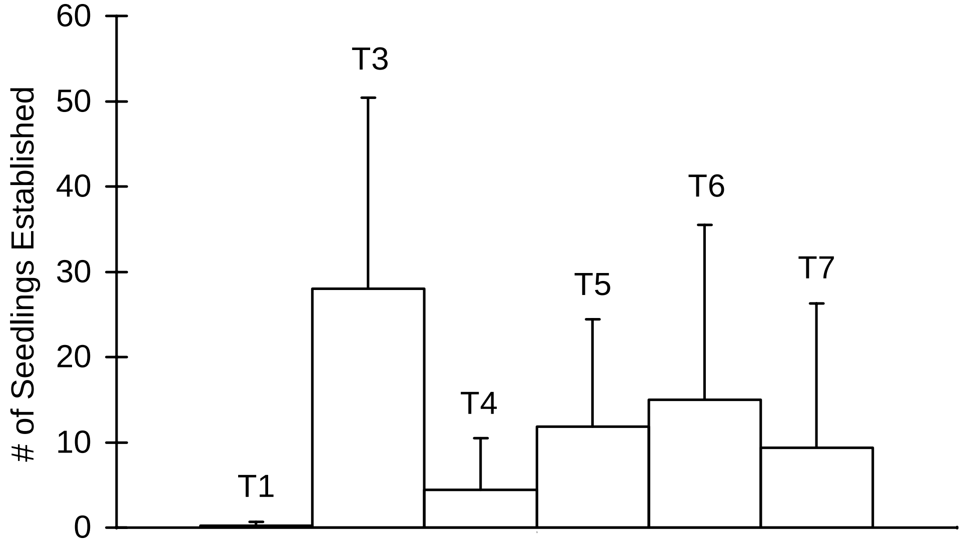

Figure 14 - Seedling Establishment. Bars represent the mean and n = 5 for each soil manipulation treatment. There was no significant difference between the established means with regard to each soil manipulation treatment and block (two-way ANOVA, $p > 0.05$). Establishment data are graphed as raw counts, but analysis of variance was conducted on the log transformed counts. Treatments include: T1 = control, T3 = cut, T4 = dike, T5 = sand fill-10 cm, T6 = sand fill-20 cm, and T7 = sand fill-30 cm.

Soil Analysis

Soil texture - percent clay. A significant difference in the proportion of clay was detected between the soil conditions (1-way ANOVA, df = 8, $F = 9.71$, $P < 0.001$). When compared to the control, soils sampled from the cut, sand-fill (10 cm, 20 cm, and 30 cm), early succession site (ES), and late succession site (LS) contained a significantly lower proportion of clay (Table 14).

Soil texture - percent silt. A significant difference in the proportion of silt was detected between the soil conditions (1-way ANOVA, df = 8, $F = 8.32$, $P < 0.001$). When compared to the control, soils collected from the sand-fill (10 cm, 20 cm, and 30 cm) plots and the ES site contained a significantly lower proportion of silt (Table 14).

Soil texture - percent sand. Among all the soils sampled, the soil texture was composed mostly of sand. Results indicate a significant difference in the proportion of sand between the soil conditions (1-way ANOVA, df = 8, $F = 10.58$, $P < 0.001$). When compared to the control, soils sampled from the ES and LS sites had a significantly higher proportion of sand (Table 14).

Soil texture - percent gravel. A significant difference in the proportion of gravel was detected between the soil conditions (1-way ANOVA, df = 8, $F = 30.83$, $P < 0.001$).

When compared to the control, the sand-fill (10 cm, 20 cm, and 30 cm) plots contained a significantly higher percentage of soil particles > 2 mm in diameter (Table 14).

Table 14 - Soil particle size distribution in the control and experimental plots. A significant difference in soil texture was detected among the soil conditions. Means were compared using a Dunnett's multiple comparison test with a control. Silt and clay data are reported as raw percentages, but the ANOVA was conducted on arcsine-transformed proportions. For soil collected from the early succession (ES) and late succession (LS) sites, n = 3 (Burk et al. 1988), and n = 5 for each remaining soil condition.

Substratum condition	% Clay mean ± SE	% Silt mean ± SE	% Sand mean ± SE	% Gravel mean ± SE
Control	3.5 ± 0.4 [a]	10.3 ± 1.1 [a]	82.4 ± 1.2 [a]	3.7 ± 0.4 [a]
Cleared	4.8 ± 0.6 [a]	12.8 ± 1.1 [a]	76.5 ± 1.4 [a]	5.8 ± 0.8 [a]
Cut	1.9 ± 0.4 [b*]	5.2 ± 0.8 [a]	86.7 ± 0.9 [a]	6.2 ± 0.9 [a]
Diked	2.7 ± 0.4 [a]	7.1 ± 0.8 [a]	85.9 ± 0.9 [a]	4.3 ± 0.5 [a]
Sand-fill 10 cm	1.8 ± 0.4 [b*]	3.0 ± 0.4 [b*]	74.7 ± 0.8 [a]	20.5 ± 0.7 [b*]
Sand-fill 20 cm	1.7 ± 0.3 [b*]	2.9 ± 0.4 [b*]	76.7 ± 0.8 [a]	19.4 ± 0.9 [b*]
Sand-fill 30 cm	1.5 ± 0.3 [b*]	2.9 ± 0.5 [b*]	76.4 ± 0.8 [a]	19.1 ± 0.7 [b*]
(ES) $_{\text{post-hoc}}$	0.4 ± 0.2 [b*]	1.2 ± 0.4 [b*]	98.4 ± 0.4 [b*]	5.2 ± 1.2 [a]
(LS) $_{\text{post-hoc}}$	1.1 ± 0.4 [b*]	4.8 ± 0.7 [a]	94.1 ± 0.6 [b*]	5.5 ± 1.0 [a]

* Reported means with different letters are significantly different from the control (P < 0.05).

<u>Macronutrients.</u> No significant difference was detected in the average level magnesium (1-way ANOVA, df = 6, F = 1.89, P = 0.118), calcium (1-way ANOVA, df = 6, F = 0.53, P = 0.782), potassium (1-way ANOVA, df = 6, F = 0.94, P = 0.483), and phosphorous (1-way ANOVA, df = 6, F = 1.57, P = 0.194) in the soils sampled from each soil condition (Table 15). A significant difference was detected in the level of nitrogen between the soil conditions (1-way ANOVA, df = 6, F = 4.81, P < 0.002). When compared to the control, the sand-fill (10 cm, 20 cm, and 30 cm) treatments contained a significantly lower level of nitrogen (Table 15).

Table 15 - Average level of extractable macronutrients expressed as parts per million (ppm) dry soil in the control and experimental plots. A significant difference was found in the level of nitrogen between the soil conditions. No significant difference was detected in the average level of magnesium, calcium, potassium, and phosphorous among the soil conditions. Means were compared using Dunnett's multiple comparison tests with a control. For each soil condition n = 5.

Soil condition	NO_3^-/NH_4^+ mean ± SE	Mg^{2+} mean ± SE	Ca^{2+} mean ± SE	K^+ mean ± SE	PO_4^- mean ± SE
Control	62.0 ± 2.6 [a]	44.0 ± 1.3 [a]	142.0 ± 2.3 [a]	12.0 ± 1.6 [a]	62.0 ± 2.6 [a]
Cleared	70.0 ± 2.4 [a]	48.0 ± 1.3 [a]	122.0 ± 1.9 [a]	20.0 ± 1.7 [a]	70.0 ± 2.4 [a]
Cut	34.0 ± 1.0 [a]	46.0 ± 1.3 [a]	126.0 ± 2.0 [a]	10.0 ± 1.2 [a]	34.0 ± 1.0 [a]
Diked	56.0 ± 1.3 [a]	46.0 ± 1.5 [a]	136.0 ± 2.6 [a]	14.0 ± 1.5 [a]	56.0 ± 1.3 [a]
Sand-fill 10 cm	32.0 ± 1.6 [b*]	54.0 ± 1.0 [a]	152.0 ± 2.9 [a]	12.0 ± 1.6 [a]	32.0 ± 1.6 [a]
Sand-fill 20 cm	32.0 ± 1.5 [b*]	56.0 ± 1.0 [a]	164.0 ± 3.0 [a]	14.0 ± 1.5 [a]	32.0 ± 1.5 [a]
Sand-fill 30 cm	28.0 ± 1.5 [b*]	56.0 ± 1.3 [a]	166.0 ± 3.6 [a]	10.0 ± 1.4 [a]	28.0 ± 1.5 [a]

* Reported means with different letters are significantly different from the control ($P < 0.05$).

MDS Ordination. The MDS ordination of soil particle size distribution showed that the early succession (ES) soil ranked the least similar to soil sampled from the control (T1) and the cleared (T2) plots (Figure 14). Among all of the experimental soil conditions (T2-T7), soil sampled from the cut (T3) plots was the most similar to early succession (ES) soil (Figure 14). When compared to the control, cleared, and diked conditions, soil collected from the sand-fill (T5-T7) plots were more similar to early succession (ES) substratum, but the high proportion of gravel separated these soils from all of the other soil conditions. Soil collected at the late succession (LS) site (Burk et al 1988) was more similar to early succession (ES) soil rather than to soil sampled from the control (T1) plots, which represent late succession soil to date (Figure 15).

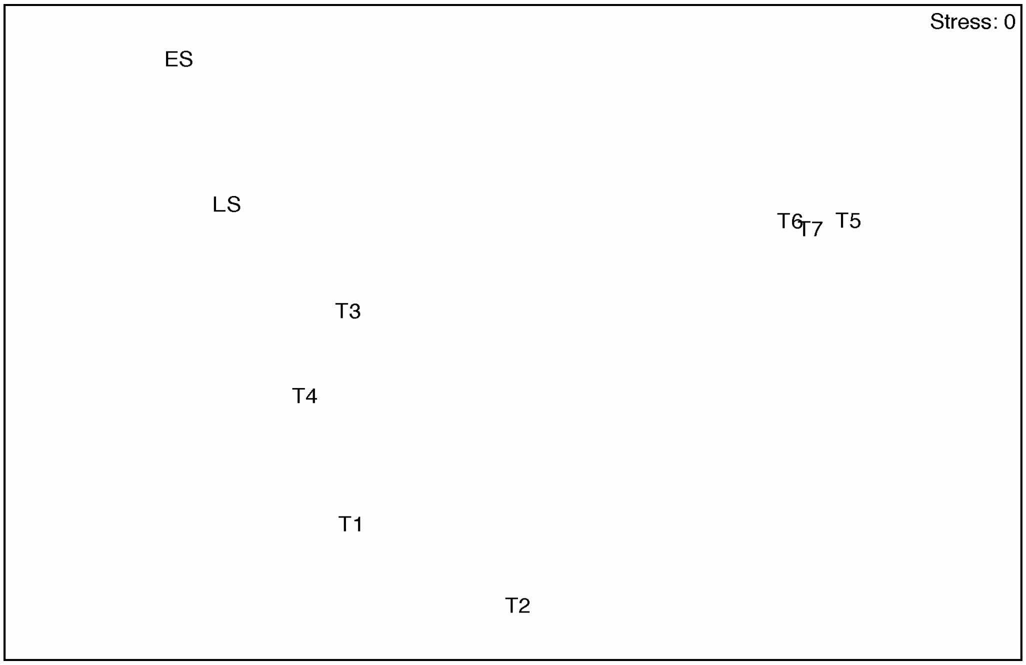

Figure 15 - An MDS ordination of the soil conditions based on soil texture and Bray- Curtis similarities. Soil conditions include: T1 = control, T2 = cleared, T3 = cut, T4 = diked, T5 = sand-fill 10cm, T6 = sand-fill 20cm, T7 = sand-fill 30cm, ES = early succession substratum, and LS = late succession substratum.

Seed Viability Trials

There was a significant difference in germination of seeds held in different storage conditions for 3 years 8 months (P-value = 0.024, ANOVA df = 7). Germination was highest for the deep freezer treatment (-35°C) with no added silica gel at 90%, while the lowest value was obtained in the refrigerator treatment (+3°C) with gel at 58% (Figure 16). Variation between replicates was greatest in the refrigerator treatment with silica gel. Both the room temperature (+24°C) and the freezer (-18°C) treatments exhibited greater germination in the presence of silica gel, than without. For the refrigerator (+3°C) and the deep freezer (-35°C) treatments, germination was higher for seeds stored without silica gel (see Table 16).

Despite efforts to maintain optimal storage conditions for this experiment, the deep freezer malfunctioned. The key that controls the power switch on the machine was accidentally bumped into the off position at least 5 days prior to removal of the woolly star seeds. This indicates that the treatment of -35°C does not represent a full year of storage at that temperature. Fungus was found growing on the outside of the seed vials and moisture was lining the doors of the freezer. The seeds remain viable, but the storage treatment experiment has been compromised.

Upon removal of the deep freezer treatment from the data set, the other three treatments become not significantly different from each other (P-value = 0.479). These data provide statistical evidence that the deep freezer treatment may allow for increased germination of seeds.

Table 16 - Mean germination values for each treatment after a period of 11 days for seeds placed in the growth chamber on 6 December 2002.

Storage Treatment	Mean ± Standard Deviation	Percent Germination
Refrigerator, no gel (3°C)	7.0 ± 1.2	70 %
Refrigerator, with gel (3°C)	5.8 ± 2.2	58 %
Room Temp, no gel (24°C)	6.8 ± 1.6	68 %
Room Temp, with gel (24°C)	7.2 ± 0.8	72 %
Deep Freezer, no gel (-35°C)	9.0 ± 1.0	90 %
Deep Freezer, with gel (-35°C)	8.0 ± 0.7	80 %
Freezer, no gel (-18°C)	7.0 ± 0.7	70 %
Freezer, with gel (-18°C)	7.6 ± 1.1	76 %

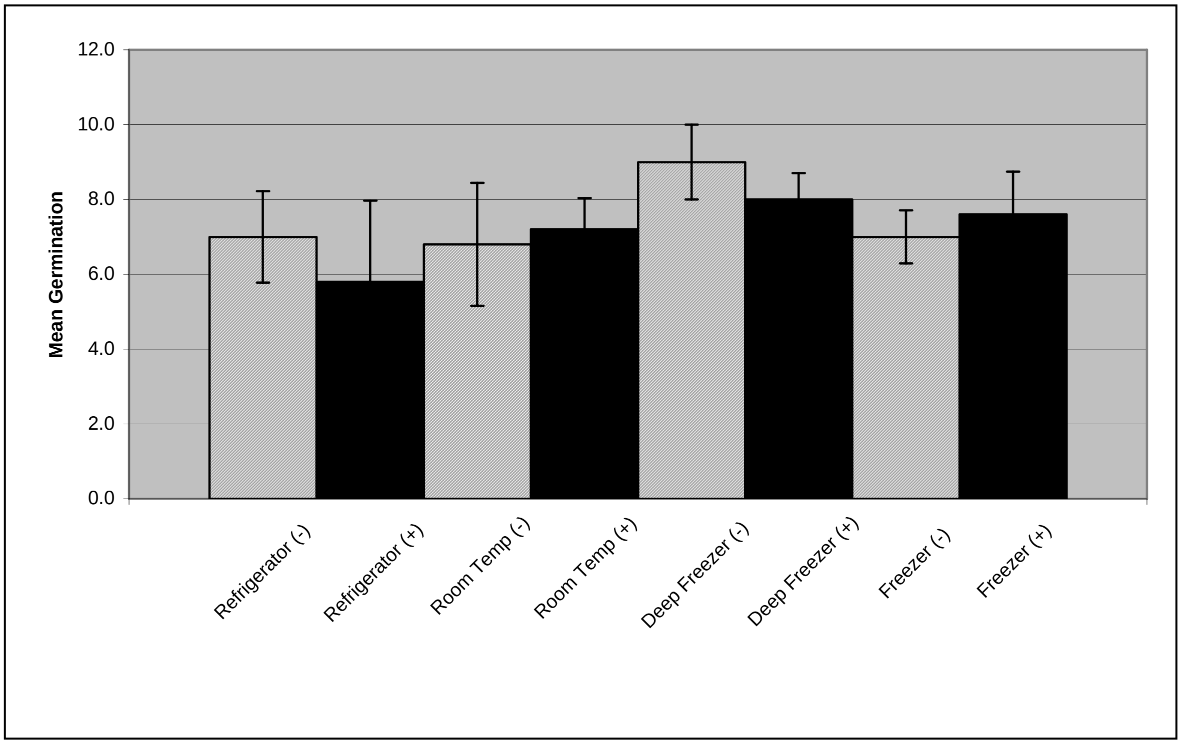

Figure 16 Number of seeds germinated per module for seeds placed in the growth chamber on 6 December 2000. Treatments with no silica gel are indicated by hatched bars (-), while treatments stored in the presence of silica gel are shown by solid bars(+). Error bars represent 1 standard error. Results show a significant difference between treatments (P<0.05, ANOVA df=7).

SECTION 4.0 DISCUSSION

The Santa Ana River woolly star is a short lived subshrub that occupies mixed age alluvial terrace habitats associated with the Santa Ana River flood plain. The deposition of sand and silts, and the formation of the terraces, results from these materials carried down river by periodic flood events. Variation in the age of the terraces results from the length of time since that terrace was formed or scoured by flooding. Terraces of different ages support different habitats. The vegetation community associated with these alluvial terraces along this section of the Santa Ana River is Riversidean alluvial fan sage scrub. Riversidean alluvial fan sage scrub exists in different successional stages depending on the age of the terraces and condition of the soils. Three successional ages are typically recognized: early (young), intermediate, and late, and each successional stage supports its own association of plant species. Although three types of plant associations are recognized, they tend to display transition areas and often blend into one another.

Early (young) terraces are characterized by the presence of scale broom (*Lepidospartum squamatum*), California buckwheat (*Eriogonium fasiculatum*), fastigate golden aster (*Heterotheca fastigata*), California croton (*Croton californicus*), and Santa Ana River woolly star. Intermediate stage terraces are characterized by the presence of scale broom, California buckwheat, California juniper (*Juniperus california*), yerba santa (*Eriodyction trichocalyx*), valley cholla (*Opuntia parryi*), and prickly pear (*O. littoralis*), and Santa Ana River woolly star, but in fewer numbers. Late stage terraces are characterized by the presence of sugar bush (*Rhus ovata*), holly-leafed cherry (*Prunus ilicifolia*), and chamise (*Adenostoma fasiculatum*).

The Santa Ana River woolly star is a species that prefers the early stage terrace environment. This species persists on these early stage terraces in sand deposits until the soils accumulate enough resources and nutrients to support other less stress tolerant plant species. As these less stress tolerant plant species move into the terrace, they out compete the woolly star for space. In the absence of these other species, woolly star populations will persist through recruitment of young plants (seedlings) from the soil seed bank. woolly star plants reproduce by outcrossing with other woolly star plants, and require pollinators to perform the outcrossing. Known pollinators include the giant flower loving fly (*Raphiomidas acton acton*), the long-tongued digger bee (*Micranthophora flavocincta*), and various humming birds. The maintenance of populations of pollinators is also an important factor in maintaining healthy populations of woolly stars.

SECTION 4.1 Population and Habitat Monitoring

Based the results of the past seven years of population monitoring and modeling, each of the sites studied has a population growth rate of less than 1.0, indicating that the population at each site is declining. Based on these data the study populations of woolly stars within the mitigation area will be come extinct from between six to eleven years. Over the course of the seven seasons of this study the total number of individual woolly star plants declined dramatically. No site experienced an increase the number of individual plants. All sites declined sharply between the third and fourth seasons, and maintained low numbers through the seventh season. Interestingly, there did not appear to be a correlation between site age and number of individual plants.

Aerial Photography Analysis

The Management Plan for the Santa Ana River Woolly Star (Chambers 1993), mapped a total of 760 acres within the boundaries of the mitigation lands as defined under the Plan. Subsequent to the finalization of the Management Plan the configuration of the mitigation lands was changed, with some areas deleted and others added, but the total acres remained essentially the same. Of the 760 acres located within the mitigation lands, young surfaces accounted for 314 acres, and intermediate surfaces accounted for 208 acres. Late age surfaces were not specifically called out, but presumably they would total 238 acres. The terraces were determined and mapped using a combination of field observations and aerial photograph interpretation.

The present study utilized high quality digital ortho-rectified color aerial photographs taken in the year 2002. The photos were then georeferenced prior to mapping. Geomorphic surfaces within the mitigation area were then mapped using GIS/ArcInfo software. 765 acres were mapped within the boundaries of the mitigation land, of those 301 acres were early stage terraces, 173 were intermediate stage terraces, 225 were late stage terraces, and 66 acres were mapped as unknown age and disturbed.

This represents an apparent loss of 48 acres of potentially suitable habitat within the mitigation lands. Since the original aerial photographs were used to map habitat for the plan, at least one major storm event occurred and the current aerial photographs were taken after that event. The apparent loss could also have occurred by the conversion of intermediate stage habitat to late stage habitat, and by an increase of human disturbance within the mitigation land area. However, the apparent loss of 48 acres of potentially suitable habitat may not represent a true difference or loss of habitat, but may be a reflection of the different technologies utilized to determine the acres of each habitat type. The present study was able to very accurately determine the boundaries of each habitat type based on a predetermined set of criteria.

The Management Plan determined, based on population genetics and the known ecology of the woolly star, that a minimum of 385 acres of prime (early stage) habitat would be required in the mitigation area to sustain a healthy viable population of woolly star. At the time the plan was prepared the amount of prime habitat within the mitigation area totaled only 314 acres, leaving the mitigation area 71 acres short of the recommended acres of prime woolly star habitat. This study has determined that only 301 acres of prime early stage habitat is present within the mitigation area, leaving the mitigation area short 84 acres. However, woolly star also is known to utilize intermediate stage habitats as well as disturbed habitats. This study has determined that mitigation area supports 173 acres of intermediate stage habitat and an additional 148 acres of late disturbed and unknown disturbed habitat.

The apparent or real loss of prime habitat combined with the continuing decline in the woolly star populations within the monitoring plots presents a serious situation with regard to the continued management of the woolly star.

4.2 Habitat Renewal and Population Expansion

Due to the short duration of the study during a drought period, results of experimental woolly star habitat renewal plots were statistically inconclusive with respect to effects of treatments on seed germination and survivorship. However, because population modeling predicts a local extinction of the Santa Ana River woolly star from the mitigation site, immediate habitat renewal and population expansion efforts are likely necessary for the preservation of this rare taxon. Regardless of a lack of statistical significance among treatments, study findings can still provide valuable information to serve as the basis for initiating a management program for Santa Ana River woolly star habitat renewal and population expansion. Study results suggest the following: that the “cut” treatment was most effective in supporting germination and survivorship; that seeds kept in deep freeze maintain the highest germination rate; and that seedling survivorship is greater when seeding is conducted in early winter rather than in the spring.

SECTION 5.0 RECOMMENDATIONS

- Large-scale restoration of woolly star habitat: Implementation of the "cut" treatment to large areas of potentially suitable habitat, applying seed, stored in deep freeze, during early winter.
- Determine and map the acreage of early, intermediate, and late stage habitats within the mitigation area by ground-truthing the aerial photography analysis with GPS/GIS.
- Determine and map the quality of each stage of habitat in the mitigation area, including percent non-native cover, soil quality (percent sand), and level of disturbance.
- Determine and map which areas of intermediate and late stage habitat would be best suited for conversion to early stage habitat for a total of 385 acres, minimum.
- Continue to monitor the naturally occurring population demographics using current methods.
- Seed collection in support of habitat renewal and population expansion and adaptive management in general.
- Continue habitat renewal experimental plots and seed viability trials in support of adaptive management.
- Assess the genetic diversity of the woolly star at year 10 as suggested by the Management Plan in support of adaptive management.

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APPENDIX A
Literature Generated by Santa Ana River Woolly Star Studies

APPENDIX B
2003 Branching Site Data

APPENDIX C
2003 Number of Plants per Plot per Site

APPENDIX D
2003 Mortality Rates

APPENDIX E
2003 Branching Stage Distributions

APPENDIX A: Literature Generated by Santa Ana River Woolly Star Studies

EDS Master's Degree Theses and Ph.D. Dissertations

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APPENDIX B – 2003 BRANCHING STAGE DATA

SITE 1

Plot 1

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
03-96	0.7	1.82	2	2	D	D	D	D	D
06-96	1.19	1.06	1	2	2	3	3	D	D
09-96	0.44	1.02	0	1	D	D	D	D	D
11-96	0.63	0.17	0	1	D	D	D	D	D
13-96	0.89	0.43	0	1	D	D	D	D	D
14-96	0.96	0.91	2	2	D	D	D	D	D
15-96	1.28	0.82	1	2	2	3	3	D	D
21-96	1.46	0.19	3	3	D	D	D	D	D
23-96	3.85	1.00	4	4	4	D	D	D	D
01-97	2.34	1.97		0	D	D	D	D	D
02-97	2.63	1.26		0	D	D	D	D	D
01-98	0.53	0.13			0	D	D	D	D
01-00	4.48	1.37					0	0	1
02-00	3.22	1.10					0	D	D
01-01	3.29	1.88						0	1
02-01	4.17	1.34						0	D
03-01	2.58	0.18						0	D

Plot 2

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
14-96	0.35	0.16	3	4	4	D	D	D	D
27-96	1.33	0.27	1	2	D	D	D	D	D
10-96	1.65	1.39	3	3	D	D	D	D	D
05-96	1.55	0.76	2	2	2	3	3	D	D
09-96	2.74	0.15	2	2	3	D	D	D	D
03-96	3.69	1.96	3	3	4	D	D	D	D
01-98	3.01	1.18			0	D	D	D	D
01-01	2.48	0.07						0	D
02-01	1.42	0.1						1	2

Plot 3

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
04-96	0.56	1.58	3	3	D	D	D	D	D
12-96	0.24	0.22	2	2	3	4	4	D	D
17-96	3.38	1.29	3	3	3	3	4	D	D
33-96	3.39	1.31	2	3	D	D	D	D	D
36-96	3.28	0.46	3	D	D	D	D	D	D
38-96	4.42	0.06	3	D	D	D	D	D	D
01-98	0.14	1.72			0	D	D	D	D
02-98	1.08	1.93			0	D	D	D	D
03-98	1.14	1.78			0	D	D	D	D
04-98	1.34	1.75			0	D	D	D	D
05-98	1.35	1.25			0	D	D	D	D
06-98	2.91	0.52			0	D	D	D	D
07-98	3.49	1.63			0	D	D	D	D
08-98	3.93	1.59			0	1	2	2	D
09-98	3.10	0.54			0	1	2	D	D
10-98	3.28	0.46			0	D	D	D	D
01-00	3.02	1.03					0	1	D
02-00	3.03	1.28					0	D	D
03-00	3.05	1.35					0	D	D
04-00	2.57	1.15					0	D	D
05-00	3.08	0.62					0	0	D
06-00	2.5	0.53					0	1	D

Plot 4

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
02-96	0.40	1.51	1	2	2	D	D	D	D
07-96	0.60	0.64	2	2	D	D	D	D	D
12-96	1.47	0.12	1	D	D	D	D	D	D
22-96	4.24	0.74	3	D	D	D	D	D	D
01-97	4.06	0.33		0	D	D	D	D	D
01-98	0.32	1.31			0	1	D	D	D
02-98	0.45	0.97			0	D	D	D	D
03-98	1.78	1.27			0	D	D	D	D
04-98	1.60	0.57			0	D	D	D	D
05-98	2.52	0.80			0	D	D	D	D
06-98	3.23	0.88			0	D	D	D	D
07-98	4.05	0.50			0	D	D	D	D
08-98	4.19	0.61			0	D	D	D	D
09-98	4.48	0.47			0	D	D	D	D

01-00	0.31	1.72					1	2	D
02-00	1.10	1.27					0	D	D
01-01	1.01	1.64						0	D

Plot 5

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
03-96	0.86	1.26	3	3	D	D	D	D	D
05-96	1.12	1.83	3	3	D	D	D	D	D
22-96	2.16	0.81	2	2	D	D	D	D	D
23-96	2.32	0.43	0	1	2	3	3	D	D
25-96	3.06	1.05	1	2	2	3	D	D	D
30-96	3.74	1.08	1	2	D	D	D	D	D
01-97	0.94	1.99		0	1	2	2	D	D
02-97	1.84	1.56		0	1	D	D	D	D
01-98	1.13	1.20			0	1	2	D	D
02-98	0.87	0.94			0	D	D	D	D
03-98	0.98	0.95			0	D	D	D	D
04-98	1.59	1.56			0	D	D	D	D
05-98	1.92	1.55			0	1	2	D	D
06-98	2.20	1.67			0	1	2	D	D
07-98	2.40	1.32			0	1	2	2	D
08-98	2.71	1.70			0	1	2	D	D
01-00	0.01	0.23					0	1	D
02-00	1.85	0.77					0	1	D

Plot 6

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
02-96	0.38	1.91	2	2	3	D	D	D	D
08-96	1.31	1.28	3	3	4	D	D	D	D
09-96	0.25	0.87	3	3	3	D	D	D	D
11-96	0.60	0.72	2	2	2	D	D	D	D
14-96	1.76	1.67	2	D	D	D	D	D	D
15-96	1.90	1.40	1	2	2	D	D	D	D
32-96	2.60	0.26	1	2	2	D	D	D	D
38-96	3.39	1.05	2	2	D	D	D	D	D
50-96	3.60	0.40	D	D	D	D	D	D	D
01-97	3.51	1.60		0	1	D	D	D	D
01-98	0.19	1.52			0	D	D	D	D
02-98	0.27	1.71			0	D	D	D	D
03-98	0.30	1.17			0	1	2	D	D

04-98	0.30	1.84			0	D	D	D	D
05-98	0.53	1.39			0	D	D	D	D
06-98	0.86	1.09			0	D	D	D	D
07-98	1.03	1.94			0	D	D	D	D
08-98	1.12	0.75			0	D	D	D	D
09-98	2.16	1.89			0	D	D	D	D
10-98	2.25	1.06			0	1	2	D	D
11-98	2.36	1.90			0	1	2	3	4
12-98	2.52	1.03			0	D	D	D	D
13-98	2.15	0.42			0	D	D	D	D
14-98	2.38	0.67			0	D	D	D	D
15-98	3.17	1.86			0	D	D	D	D
16-98	3.93	2.00			0	D	D	D	D
17-98	3.14	0.34			0	1	1	D	D
01-00	0.04	1.95					1	2	3
02-00	4.49	1.17					1	1	D
01-01	1.57	1.75						0	D
02-01	2.46	0.30						0	D
03-01	2.57	0.34						0	D

Plot 7

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
02-96	0.94	1.81	2	3	3	4	D	D	D
03-96	0.91	1.72	3	3	D	D	D	D	D
05-96	1.31	1.30	1	2	D	D	D	D	D
09-96	1.29	0.16	2	2	2	D	D	D	D
21-96	1.48	0.27	1	2	2	3	4	4	5
10-96	1.66	1.74	2	2	2	D	D	D	D
11-96	1.78	1.56	3	3	3	D	D	D	D
13-96	1.78	1.24	2	2	2	3	3	4	5
14-96	1.88	1.08	2	2	3	4	4	D	D
18-96	2.64	1.70	3	3	3	D	D	D	D
23-96	1.79	0.04	0	1	2	3	3	4	4
25-96	1.88	0.38	3	3	4	4	D	D	D
29-96	2.73	0.32	3	3	3	D	D	D	D
35-96	3.48	1.12	3	3	D	D	D	D	D
39-96	4.09	1.49	3	D	D	D	D	D	D
38-96	3.86	0.97	2	2	2	3	4	4	4
01-99	0.29	2.71				0	D	D	D
02-99	0.28	2.72				0	D	D	D
01-00	0.30	1.40					1	1	2
02-00	0.31	1.18					0	1	2
03-00	0.6	1.39					0	1	2

Plot 8

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
02-96	0.6	1.86	1	2	2	D	D	D	D
04-96	0.8	1.71	0	1	2	2	3	D	D
07-96	1.11	1.98	0	1	D	D	D	D	D
14-96	0.84	0.41	3	3	3	D	D	D	D
17-96	1.89	1.30	3	3	4	D	D	D	D
20-96	2.70	1.05	2	3	D	D	D	D	D
24-96	2.29	0.42	2	2	2	3	3	4	5
25-96	2.58	0.1	3	3	4	D	D	D	D
27-96	3.24	1.23	3	3	4	5	5	D	D
29-96	3.47	1.28	2	2	D	D	D	D	D
28-96	3.51	1.46	1	2	D	D	D	D	D
33-96	3.58	0.50	0	1	2	3	3	D	D
01-98	0.26	0.75			0	D	D	D	D
02-98	0.38	0.49			0	D	D	D	D
03-98	4.35	0			0	D	D	D	D

Plot 9

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
02-96	1.06	1.67	4	4	4	5	D	D	D
08-96	0.05	1.01	3	3	3	D	D	D	D
09-96	0.17	0.56	3	3	3	D	D	D	D
11-96	0.57	0.96	2	2	3	4	4	D	D
13-96	1.15	0.4	3	3	3	3	D	D	D
14-96	1.17	0.23	0	1	2	3	3	D	D
18-96	1.53	1.80	1	2	2	3	3	D	D
19-96	1.50	1.73	1	2	2	3	D	D	D
23-96	2.24	1.18	2	2	2	3	3	D	D
24-96	2.39	1.10	3	3	4	D	D	D	D
25-96	2.08	0.62	2	2	3	3	4	D	D
27-96	2.61	0.57	2	3	3	4	4	5	5
28-96	2.68	0.38	2	3	D	D	D	D	D
32-96	4.38	1.18	2	3	3	D	D	D	D
01-98	0.41	0.15			0	1	2	2	2
02-98	1.28	0.26			0	1	2	2	3
03-98	3.67	0.30			0	1	1	D	D
01-99	3.81	0.35				0	0	D	D
01-00	0.23	1.66					1	D	D

Plot 10

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
61-96	0	1.28	2	2	3	D	D	D	D
02-96	0.29	1.94	2	2	2	2	D	D	D
09-96	0.57	1.06	3	3	3	4	D	D	D
10-96	0.56	1.56	2	2	3	4	D	D	D
14-96	1.05	1.46	2	2	3	D	D	D	D
18-96	0.42	0.49	2	2	3	4	D	D	D
20-96	0.93	0.60	2	2	2	3	D	D	D
24-96	1.27	0.58	3	D	D	D	D	D	D
32-96	2.53	2.00	1	2	3	4	4	D	D
34-96	1.77	0.11	2	D	D	D	D	D	D
35-96	1.82	0.01	2	D	D	D	D	D	D
36-96	2.00	0.47	2	2	2	D	D	D	D
37-96	2.56	0.60	3	3	3	D	D	D	D
39-96	2.94	0.06	2	D	D	D	D	D	D
40-96	3.18	1.13	4	4	4	4	D	D	D
43-96	3.44	1.60	2	3	3	4	4	4	5
47-96	4.18	1.58	2	2	3	D	D	D	D
50-96	4.35	1.44	3	3	D	D	D	D	D
49-96	4.34	1.58	2	D	D	D	D	D	D
52-96	4.41	1.16	2	2	3	3	D	D	D
54-96	3.28	0.65	2	2	3	D	D	D	D
55-96	3.41	0.19	3	3	3	3	4	D	D
59-96	4.49	0.74	3	3	3	4	4	D	D
60-96	4.49	0.85	3	3	3	4	4	4	5
01-98	0.36	0.07			0	1	2	D	D
02-98	2.43	1.69			0	1	1	2	3
03-98	3.05	1.88			0	1	D	D	D
04-98	4.16	0.05			0	1	2	2	3
05-98	4.35	0.65			0	1	2	3	3
06-98	4.49	0.23			0	1	2	2	3
01-99	1.69	1.04				0	1	2	3
02-99	1.97	0.98				0	1	2	3
01-01	0.65	1.12						0	D
02-01	0.48	0.72						0	1
01-02	2.41	1.93							0
02-02	0.74	1.37							1

SITE 2

Plot 1

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.29	0.52	2	3	3	3	3	3	D
03-96	0.90	0.88	1	2	2	D	D	D	D
08-96	2.33	1.78	4	D	D	D	D	D	D
07-96	2.16	1.14	4	D	D	D	D	D	D
11-96	2.00	0.84	D	D	D	D	D	D	D
12-96	2.29	0.36	3	4	D	D	D	D	D
15-96	3.22	1.58	2	3	3	4	4	4	D
16-96	3.29	1.46	D	D	D	D	D	D	D
17-96	3.50	1.44	3	4	4	D	D	D	D
18-96	3.95	1.82	3	4	4	5	D	D	D
19-96	4.17	1.55	3	4	4	5	D	D	D
20-96	4.40	1.44	2	2	D	D	D	D	D
21-96	3.08	0.24	D	D	D	D	D	D	D
22-96	3.49	0.67	D	D	D	D	D	D	D
23-96	3.58	0.46	D	D	D	D	D	D	D
24-96	4.03	0.65	2	3	3	3	3	D	D
25-96	4.18	0.53	2	3	3	4	4	5	D
01-97	2.26	1.14		0	D	D	D	D	D
01-99	1.84	0.76				0	D	D	D
01-00	2.33	0.35				1	2	D	D

Plot 2

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
03-96	1.26	1.61	2	D	D	D	D	D	D
04-96	1.3	1.41	D	D	D	D	D	D	D
01-96	0.06	1.10	2	3	4	5	5	5	D
05-96	0.33	0.33	3	D	D	D	D	D	D
06-96	0.56	0.05	1	2	2	D	D	D	D
07-96	0.82	0.58	3	4	4	5	5	5	D
08-96	2.41	1.38	3	3	3	D	D	D	D
12-96	1.97	0.62	3	4	4	D	D	D	D
13-96	2.25	0.42	2	3	3	D	D	D	D
14-96	2.45	0.67	3	4	D	D	D	D	D
16-96	2.83	0.58	1	2	2	3	3	D	D
18-96	2.86	0.51	1	D	D	D	D	D	D
23-96	3.07	1.93	3	4	D	D	D	D	D
19-96	3.24	1.86	4	5	D	D	D	D	D

21-96	4.24	1.46	3	4	4	D	D	D	D
22-96	3.22	0.13	3	4	D	D	D	D	D
01-97	0.37	1.14		0	D	D	D	D	D

Plot 3

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.05	1.55	3	3	3	D	D	D	D
02-96	0.03	1.36	2	2	3	4	D	D	D
03-96	0.09	1.36	2	3	4	4	4	4	D
04-96	0.10	1.27	2	D	D	D	D	D	D
05-96	0.09	1.15	3	4	4	D	D	D	D
06-96	0.24	1.33	2	3	3	4	D	D	D
07-96	0.32	1.30	2	3	4	4	4	4	D
08-96	0.88	1.49	3	4	4	D	D	D	D
09-96	1.02	1.49	3	D	D	D	D	D	D
32-96	0.06	0.13	1	2	D	D	D	D	D
12-96	1.24	0.52	3	4	4	D	D	D	D
13-96	1.52	1.49	3	4	D	D	D	D	D
14-96	2.07	1.03	3	4	4	D	D	D	D
15-96	1.72	0.92	3	3	3	4	4	4	D
16-96	1.78	0.49	4	D	D	D	D	D	D
17-96	2.60	0.76	3	4	4	D	D	D	D
20-96	3.43	1.37	3	4	4	4	D	D	D
21-96	4.01	1.11	4	4	4	D	D	D	D
22-96	4.42	1.36	1	2	3	3	3	3	4
23-96	3.09	0.41	2	D	D	D	D	D	D
25-96	3.24	0.43	2	3	D	D	D	D	D
29-96	3.68	0.92	3	D	D	D	D	D	D
30-96	3.80	0.75	2	3	3	4	D	D	D
31-96	3.93	0.52	D	D	D	D	D	D	D
01-01	3.10	1.27						1	D

Plot 4

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
03-96	1.02	1.9	3	3	4	D	D	D	D
05-96	0.20	0.84	2	3	3	D	D	D	D
06-96	0.62	0.11	1	2	2	2	2	3	D
07-96	0.72	0.73	4	D	D	D	D	D	D
08-96	1.62	1.84	1	2	3	4	D	D	D
09-96	1.70	1.46	2	3	3	D	D	D	D

10-96	1.60	1.32	2	3	4	D	D	D	D
12-96	1.91	1.76	2	3	4	D	D	D	D
16-96	1.88	0.11	1	2	3	D	D	D	D
17-96	2.16	0.28	D	D	D	D	D	D	D
18-96	2.26	0.12	1	1	2	D	D	D	D
19-96	2.62	0.23	3	3	4	D	D	D	D
20-96	3.90	1.12	D	D	D	D	D	D	D
21-96	4.08	1.33	3	D	D	D	D	D	D
24-96	3.82	0.54	D	D	D	D	D	D	D
23-96	3.81	0.06	3	D	D	D	D	D	D
25-96	4.14	0.49	4	D	D	D	D	D	D
26-96	0.28	1.28	2	2	2	2	2	D	D
01-97				0	D	D	D	D	D
02-97				0	D	D	D	D	D
01-98	3.95	1.95			0	1	2	D	D
02-98	4.37	1.59			0	D	D	D	D
03-98	4.46	1.44			0	D	D	D	D
01-00	3.53	0.49					1	1	2
01-01	0.24	1.70						1	D
02-01	2.45	0.86						0	1
03-01	2.63	0.16						0	1

Plot 5

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	1.19	1.33	D	D	D	D	D	D	D
02-96	0.08	0.29	2	3	4	D	D	D	D
03-96	0.23	0.97	3	D	D	D	D	D	D
04-96	0.44	1.03	2	3	3	D	D	D	D
05-96	0.53	1.00	D	D	D	D	D	D	D
06-96	1.51	1.56	3	3	D	D	D	D	D
09-96	2.01	1.46	2	3	3	D	D	D	D
07-96	1.78	1.06	D	D	D	D	D	D	D
08-96	1.93	1.12	D	D	D	D	D	D	D
10-96	2.03	1.15	3	3	3	D	D	D	D
11-96	2.70	1.67	D	D	D	D	D	D	D
14-96	1.71	0.68	3	3	3	D	D	D	D
15-96	1.82	0.27	3	D	D	D	D	D	D
16-96	2.25	0.08	3	D	D	D	D	D	D
18-96	3.48	1.70	3	4	4	D	D	D	D
19-96	3.79	1.25	2	2	D	D	D	D	D
20-96	3.22	0.26	3	4	4	D	D	D	D
21-96	4.09	0.77	D	D	D	D	D	D	D

Plot 6

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
02-96	0.47	0.61	3	4	4	D	D	D	D
04-96	1.04	0.95	3	4	D	D	D	D	D
05-96	1.35	0.76	2	2	2	3	3	D	D
07-96	1.86	1.75	2	3	3	D	D	D	D
13-96	2.61	1.63	4	5	5	D	D	D	D
24-96	2.13	0.32	3	3	3	D	D	D	D
27-96	2.76	0.73	1	2	2	3	3	4	D
28-96	3.83	1.21	3	4	4	D	D	D	D
32-96	4.00	1.13	3	4	D	D	D	D	D
30-96	3.12	0.22	3	3	3	D	D	D	D
31-96	3.68	0.36	0	1	2	2	3	3	D
29-96	4.19	0.95	0	1	2	D	D	D	D
33-96	3.71	0.10	3	3	3	D	D	D	D
34-96	3.85	1.23	3	3	3	D	D	D	D
01-98	2.31	1.62			0	D	D	D	D

Plot 7

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.11	1.33	3	4	4	D	D	D	D
02-96	0.25	1.97	3	4	4	D	D	D	D
06-96	1.00	1.68	1	2	2	3	3	D	D
07-96	1.05	1.27	3	4	4	D	D	D	D
10-96	1.76	1.97	2	3	3	D	D	D	D
13-96	2.04	1.70	2	3	3	4	5	5	D
14-96	2.09	1.01	2	3	3	D	D	D	D
24-96	2.01	0.68	1	2	2	D	D	D	D
27-96	2.50	0.69	3	3	3	D	D	D	D
29-96	2.80	0.23	3	3	3	D	D	D	D
32-96	3.60	1.46	3	4	D	D	D	D	D
33-96	4.08	1.16	2	3	3	D	D	D	D
34-96	4.14	1.10	3	4	D	D	D	D	D
37-96	3.55	1.01	2	3	D	D	D	D	D
38-96	3.90	0.82	3	4	D	D	D	D	D
42-96	4.11	0.61	3	3	3	3	3	3	D
45-96	4.48	0.61	3	4	D	D	D	D	D
46-96	2.90	0.60	4	4	4	4	D	D	D
01-97	0.79	0.47		0	1	2	3	3	D
01-98	0.28	0.10			0	1	D	D	D
02-98	0.72	0.89			0	1	2	2	D
03-98	1.96	1.49			0	1	1	D	D
04-98	2.86	1.12			0	1	1	2	2
05-98	1.53	0.11			0	1	2	2	D
06-98	2.86	0.64			0	D	D	D	D
07-98	3.10	1.31			0	D	D	D	D
08-98	3.03	0.10			0	D	D	D	D
09-98	4.12	0.58			0	D	D	D	D
10-98	4.37	0.28			0	D	D	D	D
01-00	2.53	0.09					1	D	D
02-00	2.70	0.82					1	D	D
01-01	2.13	0.57						0	D
02-01	2.94	0.88						0	1
03-01	4.21	1.15						0	1
04-01	3.08	0.80						0	0
05-01	4.22	0.84						1	2
06-01	4.48	0.38						0	D
07-01	2.86	0.66						2	3

Plot 8

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0	1.86	2	3	3	D	D	D	D
03-96	0.41	1.90	2	3	3	4	D	D	D
04-96	0.59	1.87	2	3	3	3	D	D	D
05-96	0.77	1.14	2	3	3	4	D	D	D
15-96	0.23	0.20	1	2	2	D	D	D	D
17-96	0.45	0.71	1	2	2	3	3	D	D
25-96	0.89	0.49	1	1	2	3	4	4	D
28-96	1.03	0.85	2	3	4	5	5	5	D
30-96	1.15	0.88	2	3	D	D	D	D	D
31-96	1.38	0.76	2	3	D	D	D	D	D
32-96	1.49	0.41	2	3	3	3	D	D	D
37-96	2.73	1.91	1	2	3	3	3	D	D
36-96	2.64	1.56	0	1	2	2	D	D	D
38-96	2.88	1.59	2	3	3	D	D	D	D
40-96	1.76	0.86	3	3	D	D	D	D	D
43-96	1.89	0.38	2	2	D	D	D	D	D
44-96	1.94	0.11	3	3	D	D	D	D	D
51-96	2.78	0.61	3	4	4	5	D	D	D
54-96	3.66	1.33	3	4	D	D	D	D	D
56-96	4.15	1.19	1	2	D	D	D	D	D
58-96	3.05	0.76	2	2	2	3	3	3	D
60-96	3.24	0.53	1	2	2	3	3	3	D
61-96	3.43	0.84	2	2	2	3	D	D	D
63-96	3.59	0.82	2	3	4	4	D	D	D
64-96	3.76	0.35	2	2	3	4	4	D	D
65-96	3.91	0.92	3	4	4	5	D	D	D
73-96	4.35	0.29	2	3	4	5	D	D	D
01-97	0.07	0.36		0	D	D	D	D	D
02-97	0.62	0.22		0	1	1	1	2	2
03-97	2.64	1.22		0	D	D	D	D	D
04-97	2.71	1.17		0	D	D	D	D	D
05-97	1.73	0.27		0	D	D	D	D	D
06-97	4.24	1.17		0	D	D	D	D	D
01-98	0.87	1.94			0	D	D	D	D
02-98	1.34	1.52			0	D	D	D	D
03-98	0.68	0.28			0	D	D	D	D
04-98	1.79	1.16			0	1	1	2	D
05-98	2.11	1.91			0	1	1	2	D
06-98	2.28	1.90			0	1	1	2	D
07-98	2.47	0.03			0	1	1	2	3
01-99	4.51	1.58				0	1	2	D

Plot 9

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.45	1.26	3	3	3	D	D	D	D
02-96	0.52	1.51	2	2	2	D	D	D	D
07-96	1.21	1.82	2	2	2	D	D	D	D
10-96	0.19	0.54	3	3	3	D	D	D	D
11-96	0.59	0.95	3	3	3	4	D	D	D
14-96	1.08	0.95	3	3	3	D	D	D	D
16-96	1.68	1.96	2	3	3	D	D	D	D
17-96	1.79	1.46	2	2	3	4	4	4	D
18-96	2.44	1.82	2	2	2	D	D	D	D
21-96	2.49	1.06	2	2	2	D	D	D	D
26-96	2.38	0.03	3	3	3	D	D	D	D
25-96	2.49	0.63	2	3	4	D	D	D	D
23-96	2.56	0.78	2	2	2	D	D	D	D
29-96	3.18	1.25	1	2	2	2	3	3	D
35-96	4.20	1.71	3	3	3	D	D	D	D
37-96	4.47	1.73	2	2	2	D	D	D	D
39-96	4.50	1.37	2	2	2	D	D	D	D
40-96	3.13	0.57	2	2	3	D	D	D	D
43-96	3.66	0	0	1	D	D	D	D	D
44-96	3.87	0.84	1	2	2	D	D	D	D
46-96	4.32	0.28	3	3	3	D	D	D	D
01-97	1.57	0.16		0	1	2	3	D	D
01-98	0.96	0.89			0	D	D	D	D
02-98	1.52	0.73			0	1	2	2	D
03-98	1.64	0.82			0	1	2	2	2
04-98	3.64	1.68			0	1	2	2	3
01-01	0.17	1.04						0	0
02-01	0.83	1.42						0	0
03-01	1.16	1.51						0	D
04-01	1.33	1.81						0	D
05-01	2.47	1.04						0	0
06-01	2.14	0.80						0	0
07-01	2.30	0.08						0	0
08-01	3.34	1.45						0	1
09-01	4.14	1.10						0	D
10-01	4.33	1.25						0	1
11-01	3.80	0.46						0	0
12-01	3.89	0.59						0	0

Plot 10

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
06-96	0.08	1.01	1	1	1	2	3	3	D
09-96	0.44	1.19	2	2	2	D	D	D	D
14-96	0.04	0.31	0	1	1	2	3	3	D
17-96	0.41	0.30	0	1	2	D	D	D	D
18-96	0.45	0.16	1	2	2	D	D	D	D
19-96	0.50	0.31	1	2	2	D	D	D	D
20-96	0.59	0.31	1	2	2	D	D	D	D
21-96	0.75	0.27	0	1	1	D	D	D	D
22-96	0.92	0.26	0	1	1	D	D	D	D
73-96	1.10	0.39	0	1	2	3	D	D	D
29-96	1.58	1.37	0	1	1	D	D	D	D
36-96	2.16	1.05	2	3	3	3	3	D	D
40-96	2.47	1.39	0	1	2	2	3	D	D
41-96	2.54	1.46	0	1	D	D	D	D	D
42-96	2.55	1.39	1	2	D	D	D	D	D
45-96	2.16	0.02	1	2	3	D	D	D	D
50-96	2.73	0.29	0	1	2	2	3	D	D
51-96	2.98	0.85	0	1	2	3	4	D	D
54-96	3.25	1.25	0	1	1	2	D	D	D
56-96	3.48	1.56	2	3	3	D	D	D	D
57-96	3.51	1.33	3	3	D	D	D	D	D
59-96	3.98	1.15	0	1	D	D	D	D	D
61-96	4.08	1.07	0	1	D	D	D	D	D
64-96	4.25	1.39	2	2	2	D	D	D	D
66-96	4.29	1.09	0	1	1	2	3	D	D
71-96	3.91	0.88	2	2	2	D	D	D	D
72-96	4.13	0.12	2	2	2	D	D	D	D
01-97	2.10	1.04		0	D	D	D	D	D
01-98	0.19	1.35			0	D	D	D	D
02-98	1.79	1.65			0	1	2	2	D
03-98	2.14	0.96			0	D	D	D	D
04-98	3.18	0.45			0	1	2	2	D
01-00	0.39	1.34					0	D	D
02-00	2.23	1.12					0	1	2
01-01	0.40	1.27						0	D
02-01	0.92	0.76						0	D
03-01	2.83	0.69						0	D

SITE 3

Plot 1

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.08	1.31	3	3	4	5	D	D	D
04-96	0.49	0.25	3	D	D	D	D	D	D
07-96	2.74	1.71	1	2	3	4	4	D	D
10-96	1.68	0.76	2	3	4	4	4	4	D
11-96	1.96	0.03	1	2	3	3	D	D	D
12-96	2.37	0.71	3	D	D	D	D	D	D
13-96	2.74	0.82	3	D	D	D	D	D	D
14-96	4.40	0.67	4	D	D	D	D	D	D
01-97				0	D	D	D	D	D
01-98	2.69	1.40			1	2	D	D	D
01-99	0.29	1.30				1	D	D	D
02-99	2.73	0.52				1	D	D	D
03-99	2.76	0.31				1	D	D	D
04-99	3.45	0.42				0	D	D	D
05-99	4.00	1.73				1	D	D	D
01-00	1.72	1.48					1	2	D
02-00	4.28	0.49					0	1	2
03-00	1.71	1.69					0	D	D
01-01	1.58	1.31						D	D

Plot 2

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	1.24	1.86	1	D	D	D	D	D	D
02-96	2.50	1.59	4	4	D	D	D	D	D
03-96	1.83	0.25	2	3	4	D	D	D	D
04-96	2.01	0.74	2	3	4	4	D	D	D
05-96	2.34	0.72	0	1	2	3	D	D	D
08-96	3.42	1.86	4	4	5	D	D	D	D
01-97	2.54	1.72		0	1	1	2	2	2
01-98	2.28	1.84			0	1	2	2	3
02-98	3.26	1.20			0	0	1	2	D
03-98	3.75	1.31			0	0	1	D	D
01-99	1.76	1.11				1	1	2	D
02-99	3.13	0.52				1	2	3	3
01-01	0.18	1.44						0	1
02-01	0.06	0.59						1	2

Plot 3

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.68	1.19	D	D	D	D	D	D	D
05-96	2.42	1.46	3	D	D	D	D	D	D
06-96	1.99	0.25	D	D	D	D	D	D	D
07-96	3.29	1.09	2	2	3	4	D	D	D
08-96	4.03	1.46	1	2	3	D	D	D	D
09-96	3.92	0.33	D	D	D	D	D	D	D
10-96	4.05	0.64	1	2	D	D	D	D	D
01-99	1.40	0.23				0	D	D	D
01-01	0.42	0.57						0	D

Plot 4

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.41	0.51	3	D	D	D	D	D	D
02-96	1.37	0.35	1	2	D	D	D	D	D
03-96	1.43	0.27	1	2	D	D	D	D	D
04-96	2.06	0.96	1	2	3	4	D	D	D
05-96	2.41	1.88	1	2	3	D	D	D	D
06-96	2.70	1.07	1	2	3	D	D	D	D
07-96	2.23	0.11	3	3	4	D	D	D	D
08-96	2.69	0.58	1	2	3	D	D	D	D
09-96	2.94	0.91	0	1	2	D	D	D	D
12-96	3.85	1.90	0	1	2	D	D	D	D
16-96	3.09	0.96	1	2	2	D	D	D	D
20-96	3.06	0.79	1	2	2	D	D	D	D
22-96	3.31	0.62	1	2	2	D	D	D	D
28-96	3.52	0.61	1	2	2	D	D	D	D
29-96	3.58	0.52	2	2	D	D	D	D	D
31-96	3.58	0.12	3	3	D	D	D	D	D
01-00	1.90	0.40					0	1	2
02-00	3.14	1.78					1	1	D
03-00	2.05	0.49					0	D	D
04-00	1.25	0.88	4(D)	4(D)	4(D)	4(D)	4	4	D
01-01	0.31	1.55						0	D
01-02	0.34	1.93							0

Plot 5

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.92	1.06	1	2	3	4	4	4	D
02-96	1.10	1.77	3	D	D	D	D	D	D
07-96	2.25	1.31	2	2	3	4	4	D	D
08-96	2.26	1.19	2	2	3	D	D	D	D
09-96	2.36	1.15	2	2	3	D	D	D	D
10-96	2.48	1.33	1	2	3	D	D	D	D
11-96	2.52	1.45	1	2	3	D	D	D	D
13-96	2.5	1.14	1	2	3	D	D	D	D
14-96	2.75	1.92	3	3	3	D	D	D	D
15-96	2.64	1.73	0	1	2	D	D	D	D
16-96	2.70	1.61	1	2	2	D	D	D	D
20-96	3.08	1.08	3	D	D	D	D	D	D
22-96	3.22	1.61	1	2	3	D	D	D	D
24-96	3.19	0.84	1	D	D	D	D	D	D
25-96	3.17	0.53	3	D	D	D	D	D	D
01-99	1.26	1.50				1	1	2	2
01-00	2.80	1.75					0	D	D
02-00	2.79	1.78					0	1	2

Plot 6

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.21	1.23	3	3	4	D	D	D	D
03-96	0.73	1.84	2	2	3	D	D	D	D
04-96	0.91	1.63	2	2	3	D	D	D	D
05-96	1.15	1.83	3	3	4	5	D	D	D
06-96	1.38	1.85	0	1	2	3	D	D	D
09-96	2.72	1.09	2	3	4	D	D	D	D
11-96	3.35	0.9	3	4	5	5	5	5	D
12-96	3.73	0.64	3	3	4	D	D	D	D
01-99	3.17	1.25				1	1	2	2

Plot 7

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
04-96	0.97	1.98	2	2	3	D	D	D	D
09-96	1.22	1.23	4	4	4	4	D	D	D
14-96	0.17	0.78	0	1	1	2	2	2	3
15-96	0.72	0.11	3	3	3	3	4	5	5

19-96	1.92	1.32	2	2	3	D	D	D	D
20-96	1.52	0.47	2	2	2	D	D	D	D
21-96	1.71	0.34	4	4	D	D	D	D	D
22-96	2.24	0.27	0	1	2	3	3	3	4
24-96	3.54	1.57	3	3	3	D	D	D	D
25-96	3.77	1.66	2	2	3	D	D	D	D
26-96	4.04	1.58	4	4	D	D	D	D	D
29-96	3.79	0.74	2	2	3	D	D	D	D
30-96	3.95	0.73	2	2	2	D	D	D	D
01-97	1.11	1.33		0	1	2	3	D	D
01-00	1.09	0.06	3(D)	3(D)	3(D)	3	3	3	D

Plot 8

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
01-96	0.19	1.26	3	3	4	D	D	D	D
17-96	0.25	1.26	3	3	4	D	D	D	D
02-96	0.94	1.8	2	3	4	D	D	D	D
03-96	0.24	0.76	3	3	4	D	D	D	D
04-96	0.52	0.63	3	3	3	D	D	D	D
05-96	0.60	0.74	3	3	3	D	D	D	D
06-96	0.74	0.67	3	3	3	D	D	D	D
07-96	0.69	0.02	3	3	3	D	D	D	D
09-96	1.68	1.69	2	2	3	D	D	D	D
10-96	2.76	1.21	0	1	2	D	D	D	D
13-96	1.73	0.91	3	3	4	D	D	D	D
14-96	3.20	1.96	2	3	4	D	D	D	D
15-96	3.35	1.43	0	1	2	D	D	D	D
16-96	3.05	0.81	1	2	3	D	D	D	D
01-98	4.40	1.53			0	D	D	D	D
01-00	4.31	1.82					0	D	D
02-00	4.35	1.28					0	1	1
01-01	4.32	0.81						1	2

Plot 9

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
01-96	0.92	1.23	3	4	5	5	5	D	D
03-96	0.34	0.64	3	3	4	D	D	D	D
05-96	0.72	0.57	0	1	2	3	3	3	4
06-96	1.78	1.83	3	3	4	5	D	D	D
13-96	1.71	1.66	1	2	3	D	D	D	D

07-96	1.77	1.56	2	2	3	4	4	4	5
08-96	1.94	1.61	2	2	3	D	D	D	D
09-96	2.41	0.87	3	4	5	6	6	6	D
10-96	3.78	1.98	3	4	5	6	6	D	D
01-99	2.84	1.95				0	D	D	D

Plot 10

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
03-96	1.21	1.95	3	3	4	4	D	D	D
02-96	1.04	1.02	1	1	2	3	4	4	D
04-96	0.91	0.09	4	4	4	D	D	D	D
07-96	1.52	1.40	0	1	2	3	3	4	5
13-96	3.00	1.65	3	3	D	D	D	D	D
05-96	1.47	0.60	2	3	4	D	D	D	D
10-96	2.22	0.40	3	3	D	D	D	D	D
11-96	2.37	0.34	2	2	3	D	D	D	D
12-96	2.58	0.59	3	3	4	5	D	D	D
14-96	3.61	1.85	2	2	3	4	4	D	D
16-96	4.44	1.51	3	3	3	D	D	D	D
17-96	3.02	0.25	3	3	4	D	D	D	D
01-98	3.05	0.61			0	1	1	2	D
01-00	4.35	0.40					1	2	2
02-00	4.11	0.96					0	1	2
03-00	4.27	1.06					0	1	2
04-00	3.75	1.16					0	D	D
05-00	3.78	1.00					0	D	D
01-01	4.09	0.84						1	2

SITE 4

Plot 1

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
02-96	0.89	1.76	2	3	3	D	D	D	D
15-96	2.75	1.42	0	1	2	D	D	D	D
17-96	2.27	0.92	0	1	D	D	D	D	D
18-96	3.03	1.28	1	2	2	D	D	D	D
20-96	3.40	1.01	3	3	4	D	D	D	D
21-96	4.39	0.63	4	4	4	D	D	D	D
01-97	0.63	1.19		0	1	2	3	3	D
02-97	1.32	1.93		0	1	D	D	D	D
03-97	1.34	1.75		0	D	D	D	D	D
04-97	0.99	0.77		0	D	D	D	D	D
05-97	1.55	1.52		0	1	D	D	D	D
06-97	1.50	1.29		0	1	2	2	3	D
07-97	1.77	0.99		0	1	D	D	D	D
08-97	1.86	1.1		0	1	D	D	D	D
09-97	2.36	1.34		0	1	D	D	D	D
10-97	2.07	0.33		0	1	D	D	D	D
01-98	1.30	1.04			0	D	D	D	D
02-98	0.84	0.62			0	D	D	D	D
03-98	2.82	0.54			0	D	D	D	D
04-98	3.37	1.18			0	D	D	D	D
05-98	4.02	1.06			0	D	D	D	D
06-98	3.21	0.35			0	D	D	D	D
07-98	3.34	0			0	D	D	D	D
08-98	4.12	0.04			0	D	D	D	D

Plot 2

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
07-96	1.04	1.06	0	1	2	D	D	D	D
11-96	0.14	0.08	0	1	D	D	D	D	D
14-96	1.16	1.05	1	2	2	3	D	D	D
15-96	1.42	0.94	0	1	2	D	D	D	D
19-96	2.08	1.68	1	2	3	3	4	4	D
23-96	2.79	0.66	1	2	3	D	D	D	D
25-96	3.54	1.31	1	2	3	D	D	D	D
29-96	3.06	0.43	3	3	3	4	D	D	D
37-96	3.68	0.16	2	2	3	D	D	D	D
01-97	1.56	0.17		0	1	2	D	D	D

01-98	1.84	1.87			0	D	D	D	D
02-98	2.79	1.61			0	0	D	D	D
03-98	2.67	0.04			0	D	D	D	D

Plot 3

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
08-96	2.97	1.58	3	4	4	D	D	D	D
12-96	2.14	0.16	0	1	2	D	D	D	D
11-96	3.46	0.02	3	4	4	D	D	D	D
01-97	1.42	0.50		0	1	D	D	D	D
02-97	2.24	1.19		0	1	D	D	D	D
01-98	2.26	1.34			0	D	D	D	D
02-98	2.37	0.70			1	2	3	3	D
03-98	2.20	1.22			0	D	D	D	D
01-00	2.95	1.68					0	1	D
02-00	3.60	1.27					0	D	D

Plot 4

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.59	1.12	3	4	4	D	D	D	D
03-96	1.46	0.35	3	3	3	D	D	D	D
04-96	2.01	1.87	3	3	3	D	D	D	D
08-96	2.13	0.42	2	2	3	4	D	D	D
13-96	3.84	0.91	3	3	4	D	D	D	D
01-97	2.59	1.24		0	D	D	D	D	D
02-97	1.73	0.67		0	1	2	3	3	4
01-98	0.67	0.8			0	D	D	D	D
02-98	2.00	1.67			0	D	D	D	D
03-98	1.62	0.01			0	D	D	D	D
04-98	3.42	1.99			0	0	1	2	D

Plot 5

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
12-96	2.11	1.08	3	3	D	D	D	D	D
14-96	2.54	1.33	2	2	3	D	D	D	D
18-96	1.92	0.69	0	1	2	D	D	D	D
27-96	3.09	1.10	2	2	3	D	D	D	D
28-96	3.18	1.20	0	1	1	D	D	D	D

29-96	3.23	1.11	2	2	D	D	D	D	D
31-96	3.45	1.10	2	2	2	D	D	D	D
32-96	3.57	1.14	3	3	3	D	D	D	D
37-96	3.27	0.56	3	4	4	D	D	D	D
01-97	1.44	0.50		0	D	D	D	D	D
02-97	1.48	0.57		0	D	D	D	D	D
03-97	2.85	1.95		0	D	D	D	D	D
04-97	1.71	0.93		0	1	D	D	D	D
05-97	1.55	0.69		0	1	D	D	D	D
06-97	1.51	0.50		0	1	D	D	D	D
07-97	1.58	0.10		0	1	D	D	D	D
08-97	1.68	0.05		0	1	D	D	D	D
09-97	2.77	1.54		0	1	D	D	D	D
10-97	1.52	0.50		0	1	D	D	D	D
11-97	1.51	0.49		0	1	D	D	D	D
01-98	0.16	1.12			0	D	D	D	D
02-98	0.85	1.01			0	D	D	D	D
03-98	1.28	0.20			0	D	D	D	D
04-98	1.32	0.04			0	D	D	D	D
05-98	2.03	1.55			0	D	D	D	D
06-98	2.59	1.47			0	D	D	D	D
07-98	2.66	1.50			0	D	D	D	D
08-98	2.79	1.73			0	D	D	D	D
09-98	1.70	0.35			0	D	D	D	D
10-98	2.45	0.72			0	D	D	D	D
11-98	2.57	0.61			0	D	D	D	D
12-98	2.58	0.30			0	D	D	D	D
13-98	2.95	0.13			0	D	D	D	D
14-98	3.36	1.69			0	D	D	D	D
15-98	3.66	1.41			0	D	D	D	D
16-98	3.66	1.31			0	D	D	D	D
17-98	3.72	1.10			0	D	D	D	D
18-98	4.11	1.26			0	D	D	D	D
19-98	4.11	1.13			0	D	D	D	D
20-98	4.20	1.39			0	D	D	D	D
21-98	3.04	0.70			0	D	D	D	D
22-98	3.11	0.47			0	D	D	D	D
23-98	3.85	0.13			0	1	1	D	D
24-98	3.87	0.51			0	D	D	D	D
25-98	3.97	0.79			0	D	D	D	D
26-98	4.18	0.80			0	D	D	D	D
27-98	4.19	0.41			0	1	1	D	D
28-98	4.19	0.05			0	1	2	D	D
29-98	4.50	0.41			0	0	D	D	D

30-98	4.50	0.13			0	1	2	2	D
31-98	2.60	0.25			0	D	D	D	D
01-00	2.63	0.70					1	D	D

Plot 6

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
18-96	3.07	0.28	1	2	2	D	D	D	D
21-96	4.49	1.21	2	3	3	D	D	D	D
01-97	0.75	1.25		0	1	D	D	D	D
02-97	0.73	1.15		0	1	D	D	D	D
03-97	2.76	0.13		0	D	D	D	D	D
04-97	3.32	0.61		0	1	D	D	D	D
05-97	3.72	0.13		0	1	D	D	D	D
06-97	3.75	0.04		0	1	D	D	D	D
07-97	0.78	1.17		0	D	D	D	D	D
33-96	3.88	0.42	2	2	2	D	D	D	D
01-98	0.71	1.03			0	D	D	D	D
02-98	0.82	1.43			0	D	D	D	D
03-98	0.96	1.63			0	D	D	D	D
04-98	1.30	1.61			0	1	2	D	D
05-98	1.48	1.79			0	D	D	D	D
06-98	1.65	1.25			0	D	D	D	D
07-98	1.68	1.99			0	D	D	D	D
08-98	1.58	0.74			1	D	D	D	D
09-98	1.59	0.84			0	D	D	D	D
10-98	1.69	0.59			0	D	D	D	D
11-98	1.76	0.83			0	D	D	D	D
12-98	2.78	0.21			0	D	D	D	D
13-98	3.34	0.44			0	1	D	D	D
14-98	3.59	0.11			0	D	D	D	D
15-98	3.66	0.39			0	D	D	D	D
16-98	3.86	0.43			0	D	D	D	D

Plot 7

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
04-96	0	0.50	2	2	2	D	D	D	D
08-96	0.84	0.25	2	3	3	D	D	D	D
09-96	0.9	0.43	2	3	D	D	D	D	D
15-96	1.57	0.74	3	3	3	D	D	D	D
16-96	1.59	0.24	2	3	3	D	D	D	D

19-96	2.84	0.65	1	2	2	D	D	D	D
27-96	4.04	0.67	2	2	3	D	D	D	D
01-97	1.45	1.26		0	1	D	D	D	D
02-97	0.37	0.92		0	1	D	D	D	D
03-97	2.94	1.41		0	1	D	D	D	D
04-97	1.99	0.94		0	1	D	D	D	D
01-98	0.88	1.05			0	D	D	D	D
02-98	0.68	0.71			0	D	D	D	D
03-98	1.34	0.14			0	D	D	D	D
04-98	1.47	0.17			0	D	D	D	D
05-98	1.71	1.21			0	D	D	D	D
06-98	2.29	1.26			0	D	D	D	D
07-98	2.31	1.80			0	D	D	D	D
08-98	1.74	0.30			0	D	D	D	D
09-98	2.77	0.81			0	D	D	D	D
10-98	3.55	1.03			0	D	D	D	D
11-98	3.66	1.29			0	D	D	D	D
01-01	1.96	1.00						0	D

Plot 8

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	1.05	1.45	2	2	3	D	D	D	D
04-96	1.53	1.91	1	2	2	D	D	D	D
08-96	2.73	0.30	3	3	4	D	D	D	D
09-96	2.61	0.87	3	4	4	D	D	D	D
11-96	3.88	1.18	3	3	D	D	D	D	D
15-96	0.23	0.46	3	3	3	3	D	D	D
01-97	0.04	1.39		0	1	D	D	D	D
02-97	0.11	1.26		0	1	D	D	D	D
03-97	0.92	1.12		0	1	D	D	D	D
04-97	0	0.86		0	D	D	D	D	D
05-97	0.25	0.98		0	1	2	2	3	D
06-97	0.35	0.20		1	2	3	3	D	D
07-97	0.57	0.42		0	1	D	D	D	D
08-97	1.21	0.44		0	1	D	D	D	D
09-97	0.27	0.88		0	1	2	3	D	D
01-98	0.26	1.25			0	D	D	D	D
02-98	0.76	1.25			0	1	2	D	D
03-98	1.07	1.19			0	D	D	D	D
04-98	1.29	1.83			0	D	D	D	D
05-98	1.36	1.70			0	D	D	D	D
06-98	0.12	0.26			1	2	D	D	D

07-98	0.12	0.88			1	2	D	D	D
08-98	0.12	0.88			0	D	D	D	D
09-98	1.66	1.19			0	D	D	D	D
10-98	1.94	1.70			0	D	D	D	D
11-98	1.90	0.31			0	1	2	D	D
12-98	1.91	0.94			0	D	D	D	D
13-98	1.99	0.74			0	D	D	D	D
14-98	2.12	0.60			0	D	D	D	D
15-98	2.38	0.98			0	D	D	D	D
16-98	2.51	0.55			0	D	D	D	D
17-98	3.00	0.90			0	1	D	D	D
18-98	3.00	0.43			0	1	1	D	D
19-98	3.42	1.37			0	D	D	D	D
20-98	3.71	0.10			0	D	D	D	D
01-00	1.20	1.70					0	D	D
02-00	1.31	1.73					1	D	D
03-00	0.30	0.20					0	0	1
04-00	0.95	0.99					0	D	D
05-00	1.89	1.01					1	D	D
06-00	2.58	1.13					0	D	D
07-00	2.30	0.94					1	D	D

Plot 9

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.01	1.89	D	D	D	D	D	D	D
03-96	0.59	1.82	1	2	3	D	D	D	D
04-96	1.03	1.26	3	3	3	D	D	D	D
06-96	1.43	1.31	3	D	D	D	D	D	D
07-96	1.05	0.49	2	2	3	D	D	D	D
08-96	1.99	1.4	3	4	4	4	4	5	D
11-96	2.51	0.6	4	4	4	D	D	D	D
15-96	3.22	0.14	3	3	3	D	D	D	D
01-98	2.10	1.40			0	D	D	D	D
02-98	2.58	1.91			0	D	D	D	D
03-98	2.66	0.76			0	1	1	D	D
04-98	2.68	0.64			0	1	1	D	D
05-98	2.8	0.83			0	1	1	D	D
06-98	3.01	1.66			0	D	D	D	D
07-98	3.10	1.59			0	D	D	D	D
08-98	3.25	1.49			0	D	D	D	D
09-98	3.50	0.24			0	D	D	D	D
10-98	3.56	0.64			0	D	D	D	D

01-00	0.68	1.83					0	0	D
02-00	0.81	1.49					0	0	1
03-00	0.80	1.70					0	1	1
04-00	0.96	1.42					1	D	D
05-00	1.63	0.12					0	1	D
06-00	2.13	0.77					0	1	D
07-00	2.67	0.19					1	1	D
08-00	2.72	0.45					1	1	2
09-00	3.01	0.58					1	2	3
10-00	4.29	0.44					1	D	D
01-01	2.55	0.79						0	1

Plot 10

	Coordinates (m)		**Season**						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.39	1.19	1	2	D	D	D	D	D
04-96	1.13	1.46	3	4	D	D	D	D	D
07-96	1.73	1.46	3	3	4	D	D	D	D
09-96	2.52	0.09	2	3	4	4	5	5	D
10-96	2.87	0.19	2	2	D	D	D	D	D
11-96	4.24	1.02	2	3	4	D	D	D	D
12-96	3.00	0.32	0	1	2	3	4	D	D
13-96	3.14	0.27	2	D	D	D	D	D	D
14-96	0.16	1.43	2	2	2	D	D	D	D
01-97	0.09	1.46		0	D	D	D	D	D
02-97	1.93	0		0	1	D	D	D	D
03-97	1.40	0.77		0	D	D	D	D	D
01-00	2.13	0.58					0	D	D
02-00	4.09	1.75					0	1	D
03-00	4.13	1.15					1	D	D
01-02	0.67	1.96							1

SITE 5

Plot 1

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
01-96	0.23	1.52	3	D	D	D	D	D	D
03-96	0.34	0.40	2	2	3	D	D	D	D
04-96	1.80	1.15	1	2	D	D	D	D	D
06-96	2.03	1.6	3	3	3	D	D	D	D
08-96	2.15	0.06	2	D	D	D	D	D	D
09-96	2.40	0.66	2	2	D	D	D	D	D
11-96	2.66	0.24	2	3	D	D	D	D	D
12-96	3.09	1.55	2	2	3	D	D	D	D
13-96	3.18	1.21	3	3	D	D	D	D	D
01-97	1.45	1.61		0	1	D	D	D	D
02-97	3.88	1.99	2(D)	2	D	D	D	D	D
03-97	3.74	1.09		0	1	2	D	D	D
01-98	1.01	1.75			0	1	D	D	D
02-98	1.37	0.62			0	D	D	D	D
03-98	2.23	0.03			0	1	2	2	D
04-98	2.53	0.96			0	1	D	D	D
05-98	4.42	1.58			0	1	D	D	D
06-98	4.39	0.82			0	D	D	D	D
01-00	2.43	0.68					0	0	1
02-00	2.39	0.51					0	1	2
03-00	2.64	1.27					0	1	1
04-00	3.67	1.39					0	1	1
05-00	3.93	1.17					0	1	2
06-00	4.29	1.45					0	2	D
07-00	4.48	1.48					1	1	2
08-00	3.31	0.99					0	1	2
09-00	3.72	0.90					0	1	2
10-00	3.45	0.49					0	1	1
11-00	3.58	0.58					0	0	1

Plot 2

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
01-96	0.20	1.56	0	1	2	D	D	D	D
02-96	0.30	1.19	2	D	D	D	D	D	D
03-96	0.42	1.29	2	2	3	D	D	D	D
08-96	1.20	1.37	3	3	3	D	D	D	D
09-96	0.49	0.56	3	3	4	D	D	D	D

10-96	0.58	0.60	2	2	2	D	D	D	D
12-96	0.72	0.15	3	3	4	D	D	D	D
11-96	0.75	0.52	2	2	3	D	D	D	D
14-96	0.96	0.87	2	2	2	D	D	D	D
17-96	1.50	1.12	4	4	4	D	D	D	D
20-96	2.64	1.10	3	3	4	D	D	D	D
21-96	2.89	1.63	2	2	3	D	D	D	D
22-96	2.98	1.28	2	2	3	D	D	D	D
23-96	1.96	0.36	3	3	3	D	D	D	D
26-96	2.49	0.42	3	3	4	D	D	D	D
29-96	2.68	0.49	2	2	3	D	D	D	D
33-96	3.48	1.18	2	2	2	D	D	D	D
36-96	3.19	0.58	0	1	2	D	D	D	D
37-96	3.30	0.67	0	1	2	D	D	D	D
38-96	3.01	0.17	4	4	4	4	D	D	D
01-97	1.84	0.78		0	D	D	D	D	D
02-97	2.99	0.21		0	D	D	D	D	D
01-98	0.04	1.56			0	D	D	D	D
02-98	0.70	1.46			0	D	D	D	D
03-98	0.18	0.76			0	D	D	D	D
04-98	0.54	0.28			0	D	D	D	D
05-98	0.62	0.47			0	D	D	D	D
06-98	2.03	1.85			0	D	D	D	D
07-98	2.50	0.98			0	D	D	D	D
01-99	1.85	0.82				1	2	3	4
01-00	0.24	1.95					0	D	D
02-00	0.98	1.70					0	1	2
03-00	1.49	1.69					0	1	2
04-00	1.85	1.99					0	D	D
05-00	2.37	1.52					1	2	3

Plot 3

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.02	1.63	2	2	3	4	D	D	D
04-96	0.09	0.07	0	1	D	D	D	D	D
07-96	0.79	0.53	0	1	2	3	4	4	D
14-96	2.71	1.02	2	2	2	D	D	D	D
11-96	2.25	1.72	2	3	4	D	D	D	D
15-96	1.50	0.75	1	2	3	4	4	4	D
18-96	2.17	0.29	3	3	3	4	4	5	D
19-96	2.61	0.80	4	4	4	D	D	D	D
22-96	3.34	0.88	D	D	D	D	D	D	D

23-96	3.32	0.68	3	3	4	4	D	D	D
24-96	3.35	0.48	3	3	3	D	D	D	D
25-96	3.54	0.88	3	3	D	D	D	D	D
26-96	3.76	0.42	4	4	5	5	D	D	D
27-96	0.06	0.04	3	3	3	3	4	4	5
08-96	0.80	0.51	0	1	1	2	3	D	D
03-97	1.87	0.19	1	2	2	D	D	D	D
01-98	3.67	1.45			0	1	1	2	3
02-98	3.74	1.51			0	1	D	D	D
03-98	4.33	1.90			0	1	D	D	D

Plot 4

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
02-96	0	1.53	3	3	4	D	D	D	D
06-96	0.33	1.47	2	2	2	D	D	D	D
05-96	0.37	1.67	2	3	D	D	D	D	D
08-96	0.66	1.52	0	1	2	D	D	D	D
11-96	0.92	1.80	2	2	3	D	D	D	D
12-96	0.91	1.66	0	1	D	D	D	D	D
14-96	1.07	1.68	0	1	2	D	D	D	D
16-96	1.14	1.46	2	3	D	D	D	D	D
17-96	1.06	1.19	0	1	D	D	D	D	D
20-96	0.76	0.89	1	2	3	4	D	D	D
30-96	1.23	0.79	2	2	3	4	D	D	D
33-96	1.36	0.95	0	1	1	2	2	D	D
32-96	1.38	0.78	2	2	3	4	4	D	D
34-96	1.48	0.92	0	1	2	3	3	D	D
22-96	0.98	0.33	0	1	2	2	3	4	4
24-96	1.02	0.27	0	1	D	D	D	D	D
26-96	1.20	0.13	4	D	D	D	D	D	D
28-96	1.18	0.38	3	3	4	4	D	D	D
35-96	1.48	0.46	3	3	D	D	D	D	D
38-96	1.52	1.38	0	1	1	D	D	D	D
39-96	1.58	1.39	3	3	D	D	D	D	D
40-96	1.65	1.69	3	3	D	D	D	D	D
41-96	2.00	1.55	0	1	2	3	3	4	D
44-96	2.03	1.08	0	1	1	D	D	D	D
43-96	2.13	1.33	3	3	D	D	D	D	D
48-96	2.27	1.19	3	3	3	D	D	D	D
47-96	2.34	1.59	2	2	3	D	D	D	D
55-96	1.88	0.52	0	1	D	D	D	D	D
65-96	2.6	0.92	3	3	3	4	4	D	D

61-96	2.54	0.34	3	3	3	4	D	D	D
72-96	3.00	1.17	2	3	3	D	D	D	D
74-96	3.24	1.53	3	3	D	D	D	D	D
75-96	3.34	1.58	3	3	3	D	D	D	D
73-96	3.37	1.95	3	3	4	D	D	D	D
94-96	3.33	0.43	2	2	2	D	D	D	D
95-96	3.32	0.01	2	2	2	D	D	D	D
96-96	3.47	0.05	3	3	3	D	D	D	D
25-96	1.06	1.32	0	1	D	D	D	D	D
01-97	3.21	1.38		0	1	D	D	D	D
02-97	3.07	0.27		0	1	2	2	D	D
100-96	1.27	0.92	2(D)	2	2	2	D	D	D
102-96	3.57	1.03	4(D)	4	4	4	D	D	D
101-97	1.07	0.27	4(D)	4	4	4	4	4	4
01-98	0.73	1.22			0	D	D	D	D
02-98	2.97	0.65			0	1	2	3	D
03-98	3.08	0.43			0	0	1	1	D
04-98	3.36	0.79			0	0	D	D	D
01-01	0.80	1.27						0	D
02-01	1.15	1.67						0	0

Plot 5

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.08	1.00	4	4	D	D	D	D	D
02-96	0.67	1.24	2	2	D	D	D	D	D
04-96	0.50	0.18	3	3	3	4	D	D	D
05-96	1.35	0.20	3	3	3	D	D	D	D
06-96	1.43	0.30	3	3	4	4	4	D	D
10-96	2.09	1.69	3	3	D	D	D	D	D
09-96	2.00	1.11	3	3	3	D	D	D	D
12-96	2.72	1.23	1	2	3	4	D	D	D
14-96	2.44	0.40	2	2	3	4	4	D	D
16-96	2.87	0.83	1	2	2	3	3	4	4
18-96	3.62	1.80	1	2	3	4	D	D	D
20-96	3.65	0.03	3	3	3	D	D	D	D
21-96	0.89	1.85	2	2	2	2	2	3	4
01-98	0.88	0.84			0	1	2	3	D
02-98	0.94	0.72			0	1	2	2	D
03-98	1.73	1.74			1	2	3	D	D
04-98	2.69	0.46			0	1	2	3	D
01-99	1.05	0.78				0	D	D	D
01-00	0.33	0.91					0	1	2

02-00	1.59	0.57					1	2	2
03-00	2.25	0.04					0	D	D
04-00	4.28	0.97					0	0	D

Plot 6

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	1.33	1.30	2	2	3	D	D	D	D
02-96	0.21	0.47	D	D	D	D	D	D	D
03-96	1.14	0.19	D	D	D	D	D	D	D
04-96	1.43	0.14	D	D	D	D	D	D	D
06-96	1.64	1.38	2	2	D	D	D	D	D
13-96	2.86	1.90	0	1	2	D	D	D	D
14-96	1.79	0.96	D	D	D	D	D	D	D
15-96	1.76	0.42	0	1	2	D	D	D	D
17-96	1.87	0.47	2	2	D	D	D	D	D
27-96	3.30	1.35	3	3	4	D	D	D	D
37-96	4.03	0.17	0	1	2	D	D	D	D
01-97	2.19	1.95		0	D	D	D	D	D
02-97	2.89	0.58		0	1	D	D	D	D
03-97	3.20	1.15		0	1	D	D	D	D
01-98	2.36	1.47			0	1	2	2	D
02-98	2.66	1.39			0	D	D	D	D
03-98	2.81	1.47			0	D	D	D	D
04-98	2.42	0.20			0	D	D	D	D
05-98	2.55	0.89			0	D	D	D	D
06-98	2.87	0.44			0	D	D	D	D
07-98	4.38	0.26			0	D	D	D	D
01-00	2.90	0.23					0	1	D
02-00	3.97	1.16					0	D	D
03-00	4.05	1.22					1	D	D
04-00	4.19	1.95					0	D	D
01-01	3.06	1.20						1	2
02-01	4.13	0.93						1	2

Plot 7

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.38	1.88	0	1	D	D	D	D	D
04-96	1.43	1.06	3	3	D	D	D	D	D
07-96	1.63	1.48	3	3	3	D	D	D	D
06-96	1.76	1.81	3	3	3	4	D	D	D

09-96	1.97	1.71	2	2	3	4	D	D	D
11-96	2.62	1.21	2	2	3	D	D	D	D
13-96	2.07	0.48	2	3	4	D	D	D	D
15-96	2.49	0.25	3	3	3	D	D	D	D
14-96	2.61	0.52	3	3	3	D	D	D	D
16-96	2.62	0.12	2	3	3	D	D	D	D
17-96	3.30	1.51	2	2	3	D	D	D	D
19-96	3.38	0.93	D	D	D	D	D	D	D
20-96	3.63	0.84	3	3	D	D	D	D	D
21-96	4.21	1.00	3	D	D	D	D	D	D
01-97	1.72	1.74		1	2	3	D	D	D
01-98	1.00	1.21			0	D	D	D	D
02-98	1.65	1.93			0	0	D	D	D
03-98	1.72	1.89			0	0	D	D	D
04-98	1.88	1.97			0	0	D	D	D
05-98	1.94	1.16			1	2	D	D	D
06-98	2.02	1.21			0	1	2	3	D
07-98	2.07	1.08			1	2	3	D	D
08-98	2.08	1.17			0	1	D	D	D
09-98	2.37	1.18			0	1	D	D	D
10-98	1.71	0.78			1	2	2	3	D
11-98	1.82	0.98			0	0	D	D	D
12-98	1.90	0.96			0	1	D	D	D
13-98	2.03	0.19			0	1	D	D	D
14-98	2.66	0.27			0	D	D	D	D
15-98	3.03	1.64			0	D	D	D	D
16-98	3.08	0.90			0	1	D	D	D
17-98	3.39	0.60			0	1	D	D	D
01-99	2.24	1.90				1	2	D	D
01-00	2.22	0.81					1	D	D
02-00	3.61	1.34					0	1	D
01-01	2.97	1.84						0	D

Plot 8

	Coordinates (m)		Season						
Plant ID#	x	y	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
01-96	0.24	0.71	0	1	2	D	D	D	D
02-96	0.28	0.52	1	2	3	D	D	D	D
03-96	1.19	0.28	2	2	2	D	D	D	D
04-96	2.30	1.67	4	4	4	D	D	D	D
06-96	1.94	0.05	3	3	4	D	D	D	D
07-96	2.43	0.63	0	1	2	3	D	D	D
08-96	2.49	0.69	2	2	3	D	D	D	D

09-96	2.78	0.38	1	2	3	D	D	D	D
12-96	3.46	1.42	1	2	2	D	D	D	D
13-96	3.91	0.64	2	2	3	D	D	D	D
14-96	3.50	0	1	2	3	D	D	D	D
01-98	2.74	1.26	*	*	0	1	1	2	D
01-00	1.80	0.70	*	*	*	*	1	2	D
02-00	2.60	0.67	*	*	*	*	0	D	D
03-00	2.82	0.58	*	*	*	*	0	D	D
04-00	2.88	0.16	*	*	*	*	1	1	D
05-00	2.88	0.82	*	*	*	*	0	1	2
06-00	2.95	0.76	*	*	*	*	0	1	D

Plot 9

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
02-96	0.78	1.17	0	1	D	D	D	D	D
06-96	0.36	0.68	3	3	D	D	D	D	D
09-96	2.45	1.37	2	2	2	3	4	4	4
13-96	2.25	0.31	2	2	2	D	D	D	D
18-96	3.30	1.96	3	3	D	D	D	D	D
17-96	3.28	1.84	3	3	3	D	D	D	D
01-97	1.26	0		0	D	D	D	D	D
01-00	0.07	0.67					0	1	D
02-00	0.18	0.43					0	1	D

Plot 10

	Coordinates (m)		Season						
Plant ID#	**x**	**y**	**F96-S97**	**F97-S98**	**F98-S99**	**F99-S00**	**F00-S01**	**F01-S02**	**F02-S03**
01-96	0.63	1.04	3	3	3	D	D	D	D
02-96	1.03	1.33	3	3	4	4	D	D	D
06-96	1.44	0.14	2	D	D	D	D	D	D
07-96	1.88	0.61	3	3	D	D	D	D	D
09-96	2.19	0.14	3	3	3	3	3	D	D
10-96	3.8	1.90	3	3	4	4	D	D	D
12-96	3.03	0.38	4	4	5	D	D	D	D

APPENDIX C – 2003 NUMBER OF PLANTS PER PLOT / PER SITE

Site 1

Plot	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
1	9	11	4	2	4	4	2
2	6	6	5	1	1	2	1
3	6	4	12	4	10	4	0
4	4	3	10	1	2	2	0
5	6	8	12	7	9	3	0
6	8	8	24	2	6	6	2
7	16	15	12	9	8	7	7
8	12	12	11	4	4	1	1
9	14	14	16	12	11	3	3
10	24	19	24	20	12	10	11
Total	**105**	**100**	**130**	**62**	**67**	**42**	**27**

Site 2

Plot	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
1	12	11	8	8	5	3	0
2	15	13	8	3	3	2	0
3	23	18	15	8	4	5	1
4	15	13	14	4	4	5	3
5	12	9	7	0	0	0	0
6	14	14	13	3	3	2	0
7	18	19	24	10	10	12	6
8	27	33	28	23	13	10	2
9	21	22	25	7	6	17	11
10	27	28	26	11	11	8	1
Total	**184**	**180**	**168**	**77**	**59**	**64**	**24**

Site 3

Plot	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
1	8	5	5	10	5	3	1
2	6	6	8	8	6	7	5
3	4	3	2	2	0	1	0
4	17	16	12	2	4	4	2
5	15	11	11	3	5	3	2
6	8	8	8	4	2	2	1
7	14	15	13	6	5	4	3
8	14	14	15	0	2	2	2
9	9	9	9	7	5	3	2
10	12	12	11	6	9	7	5
Total	**107**	**99**	**94**	**48**	**43**	**36**	**23**

Site 4

Plot	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
1	6	16	21	2	2	2	0
2	9	10	12	5	1	1	0
3	3	5	8	1	3	2	0
4	5	7	10	3	2	2	1
5	9	20	46	5	5	1	0
6	3	10	24	2	1	0	0
7	7	11	21	0	0	1	0
8	6	15	33	10	13	1	1
9	7	6	16	4	14	10	5
10	9	11	6	2	5	2	1
Total	**64**	**111**	**197**	**34**	**46**	**22**	**8**

Site 5

Plot	F96-S97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
1	10	10	11	5	12	12	10
2	20	21	26	2	6	4	4
3	15	15	16	11	6	5	2
4	41	42	34	17	10	5	3
5	13	13	14	12	12	8	4
6	7	10	14	1	5	4	2
7	13	13	27	18	6	4	0
8	11	11	12	2	7	5	1
9	6	7	3	1	3	3	1
10	7	6	5	3	1	0	0
Total	**143**	**148**	**162**	**72**	**68**	**50**	**27**

APPENDIX D – 2003 MORTALITY RATES

Site 1

Plot	year 1-2	year 2-3	year 3-4	year 4-5	year 5-6	year 6-7
1	0	8	2	0	3	2
2	0	2	4	0	1	1
3	2	2	8	0	4	4
4	2	2	9	1	1	2
5	0	4	4	1	6	3
6	1	1	20	0	3	4
7	1	3	5	4	1	0
8	0	4	7	0	3	0
9	0	1	4	3	8	0
10	5	1	6	8	4	1
Total	**11**	**28**	**65**	**17**	**36**	**17**
Rate	**10.5%**	**28.0%**	**53.1%**	**25.8%**	**50.7%**	**40.5%**

Site 2

Plot	year 1-2	year 2-3	year 3-4	year 4-5	year 5-6	year 6-7
1	2	3	2	3	2	3
2	3	5	5	0	1	2
3	5	3	7	4	0	4
4	4	2	10	1	2	2
5	3	2	7	0	0	0
6	0	2	10	0	1	2
7	0	5	14	2	4	7
8	0	12	6	10	3	8
9	0	1	18	1	1	6
10	0	6	15	2	6	7
Total	**17**	**41**	**94**	**23**	**20**	**41**
Rate	**9.2%**	**22.8%**	**56.0%**	**29.9%**	**33.9%**	**63.1%**

Site 3

Plot	year 1-2	year 2-3	year 3-4	year 4-5	year 5-6	year 6-7
1	4	1	0	8	3	2
2	1	1	2	2	1	2
3	1	1	1	2	0	1
4	1	4	10	1	1	3
5	4	0	9	0	2	1
6	0	0	5	2	0	1
7	0	2	7	1	1	1
8	0	0	15	0	1	0
9	0	0	3	2	2	1
10	0	2	5	2	3	2
Total	**11**	**11**	**57**	**20**	**14**	**14**
Rate	**10.3%**	**11.1%**	**60.6%**	**41.7%**	**32.6%**	**38.9%**

Site 4

Plot	year 1-2	year 2-3	year 3-4	year 4-5	year 5-6	year 6-7
1	0	3	19	0	0	2
2	0	1	7	4	0	1
3	0	0	7	0	1	2
4	0	1	7	1	0	1
5	0	5	41	1	4	1
6	0	2	22	1	1	0
7	0	1	21	0	0	1
8	0	2	23	4	12	1
9	1	0	12	0	6	5
10	1	5	4	0	3	2
Total	**2**	**20**	**163**	**11**	**27**	**16**
Rate	**3.1%**	**18.0%**	**82.7%**	**32.4%**	**58.7%**	**69.6%**

Site 5

Plot	year 1-2	year 2-3	year 3-4	year 4-5	year 5-6	year 6-7
1	2	5	6	4	0	2
2	1	2	25	1	2	0
3	0	2	5	5	1	3
4	1	12	17	7	5	4
5	0	3	3	4	4	4
6	0	3	13	0	3	2
7	1	3	10	14	3	4
8	0	0	10	1	2	4
9	0	4	2	0	0	2
10	1	1	2	2	1	0
Total	**6**	**35**	**93**	**38**	**21**	**25**
Rate	**4.2%**	**23.6%**	**57.4%**	**52.8%**	**30.9%**	**48.1%**

APPENDIX E – 2003 BRANCHING STAGE DISTRIBUTIONS

Site 1

Stage	Season S96-F97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
0	9	6	58	5	14	12	1
1	16	9	3	21	10	9	4
2	42	45	26	3	17	11	5
3	35	36	32	21	12	2	8
4	3	4	11	14	13	7	3
5	0	0	0	2	1	1	6
Total	**105**	**100**	**130**	**66**	**67**	**42**	**27**

Site 2

Stage	Season S96-F97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
0	18	13	29	2	2	22	8
1	27	21	10	17	11	5	6
2	64	45	40	13	11	15	6
3	66	64	53	19	22	11	3
4	9	35	35	18	9	7	1
5	0	2	1	8	4	5	0
6	0	0	0	0	0	0	0
Total	**184**	**180**	**168**	**77**	**59**	**65**	**24**

Site 3

Stage	Season S96-F97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
0	11	3	5	5	12	3	0
1	25	12	4	11	9	10	2
2	25	40	18	3	4	10	12
3	38	33	38	9	5	4	3
4	8	11	24	12	9	6	2
5	0	0	5	6	2	2	3
6	0	0	0	2	2	1	0
Total	**107**	**99**	**94**	**48**	**43**	**36**	**22**

Site 4

Stage	Season S96-F97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
0	9	48	102	3	13	5	0
1	10	10	42	13	17	7	5
2	21	23	16	9	7	3	1
3	22	21	23	5	5	5	1
4	2	9	14	4	3	1	1
5	0	0	0	0	1	2	0
Total	**64**	**111**	**197**	**34**	**46**	**23**	**8**

Site 5

Stage	Season S96-F97	F97-S98	F98-S99	F99-S00	F00-S01	F01-S02	F02-S03
0	26	10	45	7	27	6	1
1	11	27	14	22	10	21	5
2	46	47	30	11	13	9	12
3	50	55	50	9	8	7	2
4	10	9	21	22	10	8	6
5	0	0	2	1	0	1	1
Total	**143**	**148**	**162**	**72**	**68**	**52**	**27**