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FINAL REPORT

AN ANALYSIS OF CONSTRUCTION EFFECTS ON VEGETATION AND SOILS OF THE COLORADO DESERT

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ABSTRACT

The construction and maintenance of pipelines, power transmission lines, and highways are major sources of environmental disturbance in the Colorado Desert. Changes in vegetation and soils are frequently associated with these disturbance types. The magnitude and direction of such changes are quantified for creosote bush scrub, cactus scrub, and wash woodland communities. Vegetation disturbance was assessed by analyzing differences between disturbed and control areas using productivity, stability, and diversity indices; soil disturbance was assessed in the same manner using soil bulk density and soil porosity.

Field observations and analysis of vegetational dynamics along each disturbance type showed the following:

1. Pipeline construction produced long-term changes in vegetation composition and structure, soil bulk density, and porosity. Along the right-of-way (area of greatest disturbance), vegetation productivity, stability, and diversity were substantially lower than controls. Soil bulk density and porosity indicated severe compaction. These changes were evident after 25 years, and it is estimated that recovery will require at least several millenia.

2. Power transmission line construction produced comparatively minor impacts on vegetation and soils. Under power lines, there were slight decreases in cover and density, but stability remained unchanged. The greatest source of disturbance was pylon construction with slight reduction

in cover, density, stability, and diversity; but recovery is expected within decades.

3. Paved roads showed enhanced road edge productivity, stability, and diversity. This edge effect is due to the accumulation of runoff stimulating growth and recovery. However, the edge effect may be modified by certain topographic and vegetational conditions. Sandy fans exhibited minor road edge effects; on alluvial fans, the road edge reached its greatest development.

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Section 1

CONCLUSIONS

The results of on-site inspection and analysis of vegetational change along pipelines, power transmission lines, and highways have indicated that utility construction has long-term effects on vegetation and soils of arid environments.

Pipeline construction produced long-term changes in vegetation and soils. In creosote bush and cactus scrub communities, vegetation cleared from the immediate right-of-way had not recovered to predisturbance levels after 25 years. In disturbed areas vegetation productivity, stability, and diversity were lower than adjacent controls. Changes in soil bulk density and soil porosity indicated compaction of the soil subsurfaces. River wash areas did not exhibit substantial changes in vegetation and soils. Vegetation in these areas are preadopted to periodic disturbances, and quickly recover from pipeline impacts.

Power transmission construction had minor impacts on vegetation and soils. Areas under power lines were not substantially different from control areas. There were slight decreases in cover and density due to trampling, but stability remained unchanged. Soils under the lines were not compacted.

The areas under pylons exhibited variable effects depending upon the construction techniques employed. Under steel lattice pylons, vegetation cover and density were slightly reduced, and soils showed some compaction. Apparently, steel pylons were assembled elsewhere, trucked to the site, and lifted by cranes; or they were flown to the site fully assembled.

In either case, the damage to vegetation and soils was minimal. In contrast, the older "H" type pylons resulted in substantial losses of vegetation cover and density. These pylons were constructed and assembled at the site necessitating the use of drilling rigs, cranes, and trucks. Soil compaction was severe to moderate by these pylons.

Paved roads traversing creosote bush scrub showed substantial increases in vegetation productivity, stability and diversity. This indicates that the road effect is a real phonomena manifested by:

- shrubs of comparatively larger size and extent
- higher density
- greater percentage of long-lived shrubs

On sandy alluvial fans the road effect plays a minor role in vegetation dynamics along paved roads. Vegetation along the road edge was not different from adjacent controls.

Areas subjected to severe disturbance exhibited definite successional patterns. Short-lived shrubs such as *Hymenoclea salsola* and *Euphorbia polycarpa* are usually the first to invade and establish open ground. This confirms observations from other areas suggesting a general pattern of vegetational recovery.

Section 2

INTRODUCTION

The natural vegetation of the Colorado Desert has been subjected to a variety of man-made disturbances. The more important of these disturbances includes pipelines, power transmission lines, and highways. Along the right-of-way, the primary impacts of construction result in the complete removal of vegetation and the disruption of soils. Secondary impacts of maintenance operations either slow or halt revegetation of disturbed areas. Both impacts create narrow construction corridors, devoid of vegetation, that traverse vast stretches of desert land.

There are few reports that detail the effects of disturbance on Colorado Desert vegetation. At present, available information concerning the effects of pipelines (Vasek et al. 1975a), power transmission lines (Vasek et al. 1975b), and highways (Johnson et al. 1975) has dealt exclusively with Mojave Desert vegetation. Since there are distinct climatic and floristic differences between the Mojave and Colorado Deserts (Vasek and Barbour 1977; Burk 1977) critical questions become evident: 1) What are the effects of different disturbances on native vegetation and the associated soils of the Colorado Desert? 2) What is the magnitude and change in vegetation and soils associated with each disturbance? 3) What are the rates of vegetation recovery given topographic and vegetational information? and 4) Can the effects of disturbance be modified by landforms or soil types?

The purpose of this report is to address the above questions by providing basic information gathered from on-site inspection and analysis of vegetational dynamics along pipelines, power transmission lines, and highways. The objectives are: 1) to interpret and analyze "natural experiments" that were inadvertently performed through post construction activities; 2) to describe the direction and rates of change that occur in different community types: specifically, creosote bush scrub, cactus scrub, and wash woodland communities; 3) to determine the effects of disturbance on community diversity, community stability, and community productivity; and 4) to identify and quantify soil disturbance types.

It is felt that in-depth study of vegetational dynamics after exposure to different disturbances at selected locations would provide a broad informational base. It is hoped that adequate information based on soil disturbance and vegetational change would aid the field investigator in the decision making process involved in assessing areas sensitive to disturbance.

Section 3

LITERATURE SURVEY

Utility construction activities in arid environments have primary and secondary impacts on vegetation and soils. Primary impacts are those initial disturbances that occur as a result of the installation process (e.g., trenching, grading, backfilling, etc.). These impacts result in the disruption of vegetation and soils along the right-of-way. Secondary impacts are those disturbances that occur after the construction project is completed and primary impacts have ceased. Secondary impacts may have a recurrent history either along the construction corridor, or at localized areas. Frequently, secondary impacts involve oil spills, natural gas leaks, and routine maintenance activites.

The focus of this survey will be on two components of the desert ecosystem, namely vegetation and its associated soils, and how they respond to primary and secondary impacts. Particular attention will be given to vegetational dynamics and soil disturbances associated with each impact. Additional information will include successional responses and restoration attempts following disturbance.

I. Primary Impacts

At present, there are few reports available that either document, analyze, or interpret ecologic changes that follow disturbance activities. This apparent absence of information contrasts with the considerable research available for mesic environments. However, what information there is available is discussed under two subsections: vegetation disturbances and edaphic disturbances.

Vegetation Disturbances

The natural vegetation of arid environments has long been subjected to a variety of man-made disturbances. The more important of these disturbances includes the construction of underground pipelines, power transmission lines, and paved roads. Since these utility projects vary in their methods of construction operation and maintenance, the impact on vegetation is decidely different. The following will provide background information highlighting vegetation response to each of these utility projects.

Vasek et al. (1975) have examined the effects of pipeline construction in creosote bush scrub of the Mojave Desert. They noted considerable variation in vegetative recovery along the pipeline which probably reflect differences in topography, slope, exposure, elevation, and climate. Revegetation occurs more successfully in areas with high to moderate productivity of intermediate community age (i.e., the relative proportion of long-lived to short-lived species). They found that areas with a high proportion of long-lived species might be expected to recover to predisturbance levels in 30 to 40 years. However, this estimate was regarded as too optimistic based on sigmoid growth curve relationships since returning vegetation would still be in the exponential phase of growth.

Another estimate of vegetational recovery was based on the growth behavior exhibited by Larrea tridentata (Creosote Bush). They observed that when centrally located older stems died they were replaced by younger stems to the outside. In time these younger stems became rooted, eventually producing a distinct clonol ring. Radiocarbon dating suggested that a 30 cm diameter creosote ring had an estimated age of 585 $\pm$150 years with a clonal ring increase of 39 years cm^{-1}. This suggests that complete recovery of disturbed areas will require at least several millenia.

Another study aspect included considerations of secondary succession following pipeline disturbance. They observed that Hymenoclea salsola and Euphorbia polycarpa were early successional plants, but formed major proportions of the surrounding undisturbed vegetation. They concluded that most species of the mature creosote community were adapted in varying degrees to continual but slight disturbance.

Vasek et al. (1975a) showed that powerline construction in Mojave Desert vegetation exhibits three distinct disturbance types: the localized clearing and trampling of areas beneath pylons, the temporary disturbance by trampling between pylons, and permanent destruction of vegetation along access roads. Along a 1937 transmission corridor, the vegetation associated with each disturbance type was assessed. They found that there was slight enhancement of cover beneath the wires, greater enhancement along the road edge, and a variable response under the pylons. Vegetation along a transmission corridor constructed in 1970 exhibited similar trends; however, there was a lesser effect under the wires, and a greater effect under the pylons. Explanation for the enhancement of vegetation include: rain and fog drip beneath the wires, water accumulation and removal of competitors along road sides, and the thoroughness of plant removal under pylons.

They also observed that vegetation was severly disturbed under several pylon sites, but exhibited significant recovery after 35 years. However, the variability is greater than undisturbed vegetation suggesting low predictability for the time course of recovery.

Malefyt et al. (1976) developed a semi-quantitative methodology for assessing the impact of power transmission construction on several different biotic communities. This methodology was based on estimation of habitat restoration using the maximum height of the dominant species. They reported that sonoran desert scrub (lower Colorado) vegetation had a restoration period of only 10 years. This estimate of habitat recovery following disturbance is much lower than predicted by Vasek et al. (1975a). There are several possible explanations:

1. Malefyt et al. did not consider that each species responds differently to the environment and may exhibit entirely different growth rates under similar growing conditions.

2. Growth estimates were based on available siviculture information, not on field collected data.

3. They ignored the overriding influences of climate (e.g., temperature, rainfall, etc.) on growth.

4. The maximum height of dominant plant species does not provide an accurate estimation of recovery.

This study, nonetheless, represents an important step in developing a holistic approach, rather than economic expediency, that may be used to qualitatively assess the potential impact of power transmission construction.

Johnson et al. (1975) examined changes in productivity, diversity, and stability relationships for vegetation along paved and unpaved roads of the Mojave Desert. Comparing roadside-control ratios for density, cover, and biomass, they found that values for paved roads were significantly higher than unpaved roads. Vegetation along roadsides were larger and more numerous than adjacent controls. The paved road sides when compared to controls exhibited increased productivity (i.e., standing crop) approximately 18 times on the basis of vegetative area alone and 6 times when total area was considered. The roadsides of unpaved roads exhibited similar trends, but were comparatively lower than paved roads. They further found that differences in diversity and stability between paved and unpaved roads suggested a weak link between both relationships. They concluded that road surfaces and depressions are "water harvesting systems" that serve to concentrate water deeper in the soil profile. This water then becomes available for extended seasonal periods of plant growth.

Edaphic Disturbances

The movement of heavy equipment and materials across unprotected desert soils creates a number of important edaphic disturbances. Two edaphic disturbances, in particular, may have far reaching effects on habitat recovery. These edaphic disturbances include: 1) disruption of the soil surface, and 2) soil subsurface compaction. Both disturbances, while not as apparent as vegetation removal, are nonetheless important to the complete understanding of vegetation and soil dynamics following construction.

The surface of desert soils exhibit two features that have important influences over the rates of water infiltration, erosion control, soil stabilization, and plant growth. These features are: 1) the presence of a thin colloidal armor or "soil crust" over the surface and 2) the occurrence of a algal-lichen mat. Both features are quite common in arid environments occurring on a variety of soil types, and climatic conditions. Each edaphic feature will be discussed in relation to the factors involved in their formation and their ecologic roles.

The formation of soil crusts over arid soil surfaces is a function of three factors: rain drop impact, radient solar energy, and the inherent properties of the soil itself. The former two factors supply external energy that results in soil compaction, structure breakdown, and the eventual deposition of fine particles over the soil surface. For example, Nichols and Gray (1941) calculated that 2 inches of rain impacting at 20 mph on a 1-acre field would have sufficient energy to raise a 1-inch layer of soil to a height of 3 feet. This force coupled with radient solar energy cements the finer particles that wash into the interstitial spaces between the larger soil aggregates.

The inherent properties of the soil can have important consequences for soil crust formation. Desert soils vary widely in their structural and textural characteristics (Marks 1950; Yang and Lowe 1956). These soils may also vary in the degree to which soil crusts will form. Lutz

(1952) found that soil crusts will form on soils of almost any textural condition, except coarse sand with an extremely low silt and clay content. However, several studies have shown that increasing the silt or clay content will increase crust hardness or strength (Lemos and Lutz 1957; Tackett and Pearson 1965).

Recently, it has been determined that soil crusts provide a stabilizing influence on arid soils, and once disturbed there is an increased potential for accelerated wind and water erosion (Webb 1978). Nakata et al. (1976) using high altitude aerial photography (LANDSAT-1) located the sources of desert dust plumes generated by Santa Ana winds in the Mojave Desert. They found that wind erodibility of desert soils was due to road building, agriculture, urbanization, and off road vehicle (ORV) activities which destabilized natural surfaces. These observations were further confirmed by Wilshire and Nakata (1978). They found that heavy rains impacting on ORV destabilized soils resulted in higher rates of erosional loss than adjacent undisturbed areas.

Chepil (1951, 1953 , 1955) studied several factors that influence soil structure and wind erodibility. He confirmed the general observations that wind erodibility is highest for coarse and fine textured soils than medium textured soils. Coarse textured soils lack significant amounts of silt and clay to bind soil particles; in contrast, fine textured soils have too much clay which produce clods that are easily broken down to a fine condition. He also found that the higher proportion of silt to sand reduces the erodibility of soil by forming clods and surface crusts which lend stability against the abrasive action of wind blown particles.

Another feature of soil surfaces prevalent in many desert habitats is algal and lichen crusts. These algal-lichen crusts may be important to arid and semi-arid soils in regard to soil stabilization, erosion control, and water penetration. Booth (1941) observed that soil losses from plots protected by algal crusts were greatly reduced compared with losses from unprotected plots. He suggests that algal crusts bind soil particles together forming an erosion-resistent protective layer over bare soils.

It is commonly known that algae provide important sources of organic matter to soils. For instance, Fletcher (1948) observed that crusts with extensive microbial activity exhibited increases of organic carbon content as high as 300 percent. Compared to areas without surface crusts, Cameron and Fuller (1960) found that algal crusts contain more organic matter than noncrusted soils to some depth beneath the crusts.

McIntosh and Mayland (1970) found that algal crusts from arid soils contain a variety of atmospheric nitrogen fixing blue-green algae from the genera *Nostoc*, *Scytonema*, and *Microcoleus*. Mayland and McIntosh (1966) demonstrated that nitrogen fixed by algal crusts can be utilized directly by higher plants, since 3.4 percent of total nitrogen fixed is water soluable. Moreover, MacGregor and Johnson (1971) found that algal crusts were capable of fixing 0.7 μg N cm^{-2} three hours after a rainfall. Their measurements indicate that 1 ha of desert grassland can receive 3 to 4 gms of N hr^{-1} following a rainfall.

II. Secondary Impacts

Secondary impacts on vegetation and soils that occur after ceasation of construction activity can have a recurrent episodic history. Frequent disturbances can have a detrimental effect on the eventual recovery of the habitat. However, the nature of the disturbance may have an overriding influence over rates of recovery. Three potential secondary impacts have been identified: 1) oil pipeline leaks, 2) natural gas pipeline ruptures, and 3) off-road vehicle (ORV) activities.

Oil Pipelines Spills

Much of the available research that examines the effects of accidental spills on terrestrial ecosystems deals with northern latitudes. Comparable information in arid ecosystems is nonexistent. However, the observations and conclusions from studies in other ecosystems may have some importance to arid environments.

Carr (1919) investigated the effects of crude petroleum oil on soybean growth and found that vegetative growth and root nodule development could be enhanced by small quantities of oil. However, at higher concentrations of oil, growth ceased, eventually resulted in plant death. He speculated that oil interfered with the plant's uptake of water.

Murphy (1929) studied the effects of crude petroleum on nitrate production, seed germination, and growth of wheat in pot culture. His results suggest that slight applications of petroleum interfered with nitrate production, delayed seed germination, and inhibited vegetative growth. Seed germination was entirely inhibited at higher concentrations of petroleum.

Ginsberg (1931) examined the effect of oil with varying viscosities on various plant tissues. He found that oil penetration was inversely proportional to oil viscosity, and that penetration was rapid on the under surfaces of leaves (entering tissues presumably through the stomata). He also followed oil uptake in detached stems and found that oils are transported through the xylem elements. He found that oil transport through the xylem elements was inversely proportional to oil viscosity. The effect of oil applications on desert vegetation is presently unknown. However, desert plants lacking either a thick resinuous or sclerophyllous leaves would presumably absorb oil on contact resulting in vegetative death.

Plice (1948) observed the effects of pipeline spills on the soil and vegetation. He determined that oil penetration into soils was inversely proportional to soil moisture content. He pointed out that the degree of oil saturation in soils was related to the amount of oil spilled, topography, and soil texture. He also noted that degradation of petroleum was enhanced by warm temperatures, and that areas of low productivity increased productivity after several years following an oil spill. His work suggests that increased productivity was related to a decrease in the oxidation-reduction potential of the soil and an increase in the number of nitrogen-fixing microbes. He hypothesized that nitrogen-fixers were capable of converting petroleum to soil organic matter.

Ellis and Adams (1961) studied several soil physical properties (e.g., water retention, bulk density, soil porosity, etc.) as effected by petroleum saturation. They found that petroleum oils dispersed soil particles eventually making the soil resistent to wetting. However, once petroleum soils were wetted, water retention was enhanced. Soil bulk density was generally lower and soil porosity increased under high levels of petroleum saturation.

Natural Gas Pipeline Leaks

Davis (1952) reported that soil saturated with natural gas contained high numbers of yeasts, fungi, and bacteria. These microbiol elements were converting natural gas hydrocarbon to microbiol cells giving the soils a characteristic waxy appearance ("paraffine dirt").

Ellis and Adams (1960) observed that soils exposed to saturating levels of natural gas exhibited severe physical and chemical changes. They found that contaminated soils showed increases in total carbon, manganese, and ferric iron. They also observed that soil pH increased in acidic soils and decreased in basic soils, indicating that natural gas contamination results in soil buffering. In addition to changes in soil pH, there were moderate increases in available phosphorus. Accompanying these soil chemical changes soil physical properties changed as well. Soil bulk density was generally lower, and soil porosity and water retention increased with higher levels of natural gas contamination. They postulated that increased levels of organic matter from increased microbiol activity were responsible for soil changes.

Garner (1973) found that natural gas leaking into the soil displaces soil air and provides an environment suitable for bacterial growth. Under anaerobic soil conditions, bacteria transform available sulfates to hydrogen sulfide. He postulated that hydrogen sulfide interferes with root respiration and nutrient uptake resulting in the death of woody plants.

ORV Activities

A secondary impact of a more controversial nature is the unrestricted use of off-road vehicles (ORVs) in desert areas. In recent years, the widespread use and misuse of ORVs in sensitive desert ecosystems has been cause for growing alarm among conservation and environmental groups alike. The growing concern is the apparent destruction of native plants, disruption of soils, and wildlife disturbance (Baldwin and Stoddard, 1973; Stebbins, 1974; Bury et al., 1977).

The effects of ORV's on vegetation and soils has been extensively examined and documented only within the last decade. Davidson and Fox (1974) examined the effects of motorcycle disturbances on vegetation and soils of the Mojave Desert. They found that existing trail and pit areas exhibited substantial decreases in plant density and cover when compared to adjacent controls. They also found that soils were severely compacted as evidenced by increased soil bulk density. They hypothesized that since increased bulk density infers a reduction in macropore space between soil particles, this may lead to decrease in soil water holding capacity. Reduction of soil water holding capacity coupled with increased soil hardness may be important factors inhibiting seed germination and seedling growth.

This explanation may be complicated by various edaphic factors present in the disturbed areas. Liddle and Greig-Smith (1975) found that compressed sand has a water content higher than undisturbed soil. This could have a beneficial effect on the surrounding plants. However, compaction is likely to induce anaerobic conditions and increase the buildup of nutrients. How these observations relate to desert areas needs to be examined in greater detail.

In support of Davidson and Fox (1974), Vollmer et al. (1976) using controlled truck traffic found that annual plant densities were significantly less in heavily traveled truck paths. However, annual plant densities in randomly driven and controls areas were not significantly different. This suggests that severe compaction has an adverse effect on seed germination and growth.

Another major problem caused by ORV's is the increased potential for wind and water erosion in disturbed areas. Wilshire and Nakata (1976) measured the physical changes of fire categories of surface materials along the 1974 Barstow-Las Vegas motorcycle race course in the Mojave Desert. Soil compaction and loss of vegetative cover were the major consequences of the race. They concluded that vehicle disturbance in desert areas has substantially increased the potential for wind and water erosion. Wilshire and Nakata (1977) estimated that soil loss from an ORV impacted hillside was 0.2 metric tons m^{-2} or 11 million kg per year. This compares with other estimates (Synder et al. 1976) of 0.15 to 0.30 m of soil surface materials lost from ORV trails in a 2-year period. The main factors responsible for increasing the erosion potential of natural areas by ORV use is the destruction of vegetative cover, disruption of soil crusts, compaction of subsurface soils, and loosening of sandy soils (Wilshire 1977; Webb et al. 1978; Wilshire et al. 1978).

At present, it is unknown how long the effects of ORV disturbances will last. Wilshire and Nakata (1976), citing the apparent longevity of Indian intaglios, estimate that ORV tracks will last for several hundred years. They point out that ORV tracks will likely be deepened and enlarged by water erosion. This leaves erosional scars that become permanent features of the desert landscape.

One problem that has not been addressed in the literature concerns the role of utility corridors in encouraging off-road use of previously undisturbed areas. Utility corridors and their associated maintenance roads provide easy accessibility into adjacent areas. Frequently, ORV enthusiasts will use these construction corridors as convenient entry and departure points. In time, the damage along the lateral length of the corridor is gradually enlarged by the increased numbers of ORV's. Mitigation measures are needed to deter ORV use either by increased aerial patrols or cosmetic restoration of areas adjacent paved roads.

Section 4

STUDY AREA DESCRIPTION

Location/Boundary Delineation

The Colorado Desert, the northern extension of the Sonoran Desert, lies entirely within the geographic boundaries of California (Figure 4-1). Within California, the Colorado Desert is delineated by physiognomic and provincial boundaries on three sides. The western boundary is represented by the natural barriers formed by the Transverse (Little San Bernardino, Eagle, and Pinto Mountains) and Pennisular (Santa Ana, San Jacinto, and Santa Rose Mountains) Ranges. The eastern boundary follows the contours of the Colorado River which forms the California-Arizona state border. The International Border forms the southern boundary of the Colorado Desert.

The northern demarcation between the Colorado and Mojave Deserts is less distinct. There are no natural barriers or convenient borders to clearly indicate where one desert stops and another begins. Both deserts intergrade with each other. However, the northern boundary can be roughly drawn if based on floristic and elevational criteria. For example, the boundary between both deserts might be delimited by the large number of Colorado Desert trees and shrubs whose range extend as far north as the Providence Mountains. Specific plant species (Hastings et al. 1972, Burk 1977) include:

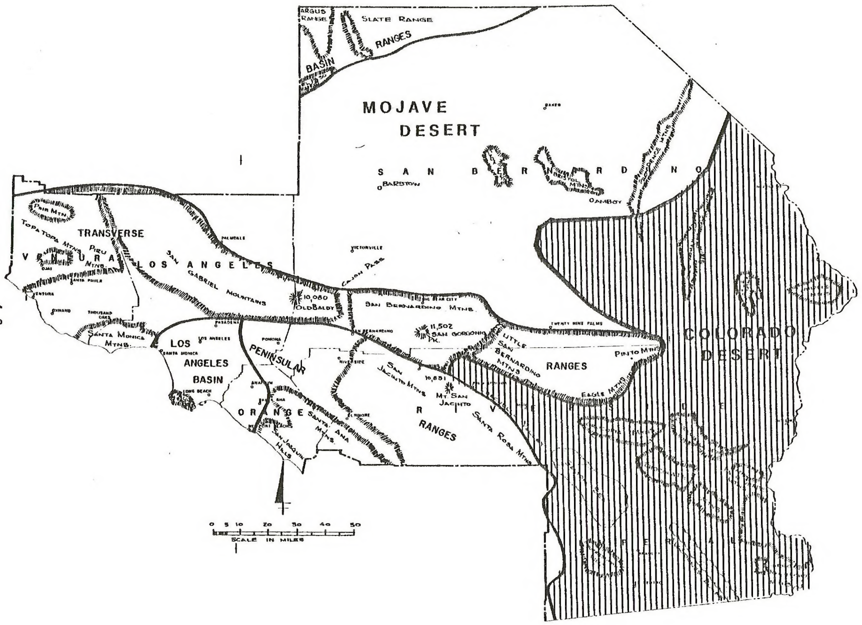

Figure 4-1. LOCATION OF THE COLORADO DESERT

Trees	Shrubs
Cercidium floridum	Beloperone californica
Olneya testota	Dalea emoryi
	Hyptis emoryi
	Simmondsia chinensis

However, further west the northern boundary of the Colorado Desert turns inward to surround the higher elevational areas of the Transverse Mountain Range.

Climate

The climate of the Colorado Desert is subtropical, but modified by the mountains on the north and west. The distribution of annual precipitation follows a bimodal pattern with precipitation peaks in the winter and summer. In the winter, the subtropical high pressure ridge moves farther south. This allows frontal rains to enter from the Pacific Ocean. These rains are regional and usually gentle allowing maximum penetration into the soil profile. In the summer, moist air from the Gulf of Mexico is heated convectionally causing localized thunder storms. These storms are usually brief and intense with most of the rainfall lost as runoff.

Within this desert the pattern of rainfall varies along a west-to-east gradient. Shreve (1925) reported that the contribution of summer percipitation to total annual rainfall increases further east. Turnage (1941) reported similar trends by noting that the northwestern Chihuahuan Desert receives more winter rain than summer rain, while the southeastern half receives more summer rain than winter rain.

Seasonal temperatures frequently exceed 38^{o}C. for several weeks of the year. Temperatures become moderate further east as summer percipitation becomes increasingly important. Winter temperatures will occasionally dip below 0^{o}C. in the southern part, but the number of 0^{o}C. days increases further north to the higher elevational Mojave Desert.

Physiography

The Colorado Desert is generally regarded as an area of low elevational relief rarely exceeding 600 m. At its sountern end, the lowest point in the Colorado Desert is the Salton Trough at 90 m below sea level. To the north, there is a gradual elevational cline which continues into the higher elevational ($>$600 m) Mojave Desert.

Within the Colorado Desert there are a number of major fault lines located in the northwest corner: the Ludlow, Pisgah, and Pinto Faults. All three transverse the desert basin from northwest to southeast eventually intersecting the Eagle Mountain Fault. The area north of Palm Springs is heavily faulted with the Banning and Mission Creek Faults joining the San Andreas Fault in the Coachella Valley. Recent historic faults are confined to the Salton Trough area. These faults include the Superstitution Hills and Imperial Faults and segments of the San Andreas Fault.

Another interesting feature is the number of dry lake beds situated in the northern Colorado Desert. Bristol, Danby, and Cadiz Lakes are usually dry for much of the year. During the winter and early spring months, moisture will accumulate in these basins as runoff from the higher elevations. In the summer months, this moisture will rapidly evaporate leaving high concentrations of salt.

The Salton Sea represents the only undrained basin of the Colorado Desert. This inland sea was formed by repeated intrusion of the Colorado River into the Coachella Valley (Proctor 1968).

Vegetation

The Transmontane Floristic Province of California has approximately 131 genera and 938 species that occur only on the desert areas of the state. As part of this floristic province, the Colorado Desert has approximately 33 percent of the total, including 100 species not found elsewhere in the state (Raven 1977).

The vegetation of the Colorado Desert contains an unusually high frequency (26-30 percent) of the state's relic species (Stebbins and Major 1965; Raven 1977). These relic species include *Washingtonia filifera*, *Fouquieria splendens*, and *Olneya testota* which are restricted to the Sonoran Desert.

In this report, there are approximately 73 perennial species (representing 22 families) commonly observed (Appendix A). This represents only 24 percent of the total number of Colorado Desert species.

Section 5

AN EVALUATION OF PIPELINE CONSTRUCTION ON VEGETATION AND SOILS OF THE COLORADO DESERT

The construction of underground pipelines involves a number of distinct operations that include clearing, grading, installation, backfill, and restoration. These activities result in the complete eradication of vegetation and disruption of soils along the immediate right-of-way. The right-of-way represents a linear strip with a minimum width of 31 meters corresponding to about 3.1 ha per kilometer of pipeline distance. This represents a substantial amount of disturbance to desert areas, especially if all pipelines are considered in the Colorado Desert.

Revegetation along the pipeline right-of-way does occur with time (Vasek et al. 1975), but its rate of recovery is probably a function of several variables: the degree of aridity, the type of vegetation disturbed, and the modifying influence of landform, exposure, and edaphic characteristics. Quantitative estimates of vegetative recovery following pipeline disturbances have never been done in the Colorado Desert. Accordingly, three vegetative and landform types along several pipelines were surveyed and analyzed.

Figure 5-1. LOCATION OF PIPELINE SAMPLE AREAS

Study Areas

Three utility corridors, representing five underground pipelines, were surveyed for construction impacts on vegetation and soils (Figure 5-1). The first utility corridor ("Fenner Valley") is located in the northern Colorado Desert. This corridor enters from the lower Mojave Desert, crosses Fenner Valley, and skirts the Old Woman and Piute Mountains as it travels east towards Needles, California. This corridor has two pipelines constructed at different times. Pipeline 1 was constructed in 1956 by the Southern California Gas and Electric Company. It has a 76 centimeter diameter pipe buried in a 1.0 meter trench. Pipeline 2 was constructed in 1951-1955 by Pacific Gas and Electric. This pipeline is somewhat larger with a 86 centimeter diameter and is buried approximately 1.0 meter below the surface.

The second utility corridor ("Sheephole") is located several miles north of Joshua Tree National Monument. It travels in a northeasterly direction through Sheephole Pass between the Sheephole and Bullion Mountains. There is only one pipeline (Pipeline 3) present that transports petroleum oil for the Four Corners Pipeline Company. It was built in 1957 by the Four Corners Pipeline Company (22-year reference frame). This pipeline has a 40 centimeter diameter and is buried in a 1.0 meter trench.

The third utility corridor ("Desert Center") has two parallel natural gas pipelines that enter the Colorado Desert from the west through San Gorgonio Pass between the San Bernardino and San Jacinto Mountains. Both pipelines extend eastward along Interstate 10 to Blythe, California. The northernmost pipeline (Pipeline 4) was constructed in 1968-1970 by the Southern California Gas Company. It has a 90 centimeter diameter pipe which is buried in a 1.4 meter trench. Pipeline 5 was constructed somewhat earlier in 1954. This pipe is smaller (76 centimeter diameter) and is buried in a shallow trench ±1.0 meters below the surface. Both pipelines have been coated with coal tar to prevent corrosion.

Methods

Landforms and Communities Studied

Along each pipeline, specific sample sites were selected for study based on landform, community type, and edaphic characteristics. The location of each sample site is shown in Figure 5-1. The characteristics of each sample area including community and landform type, exposure, slope, etc., are described in Table 5-1.

Landforms sampled along each pipeline include alluvial fans[1], river washes, and hilly areas. Alluvial fans were differentiated into dissected and sand-covered fans based on the size and frequency of major topographical irregularities, and the presence/absence of a thin veneer of sand. Riverwashes are wide, braided channels with minor topographical irregularities. Hilly areas are dominated by local relief of less than 150 meters and moderately steep slopes.

Community types common to particular landforms include: Sonoran creosote bush scrub[2], cactus scrub, and wash woodlands. These community types were selected for study because of differing topographical requirements, edaphic characteristics, and water availability.

Sonoran creosote scrub is the most widespread vegetative type in the Colorado Desert. It occurs predominately on well-drained alluvial fans (Marks 1950). The soils are usually gravelly with high content of calcium carbonate (Hallmark and Allen 1975). The dominant species are *Larrea tridentata* (Creosote bush) and *Ambrosia dumosa* (Burrobush).

Cactus scrub is found in localized situations at the base of mountains, preferring rocky south facing slopes. The soils have been described as fine textured (Marks 1950), but will vary from coarse sands to rocky suggesting undeveloped soils (Benson 1969). The dominant species include a variety of stem succulent plants: *Opuntia bigelovii* (Jumping Cholla), *Opuntia echinocarpa* (Silver Cholla), *Opuntia basilaris* (Beavertail Cactus), and *Opuntia acanthocarpa* (Cholla).

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[1]BLM California Desert Landform Classification

[2]Nomenclature follows Kuchler (1977)

Table 5-1. PIPELINE SAMPLE AREA CHARACTERISTICS

SAMPLE AREA	COMMUNITY TYPE	LAND FORM TYPE	EXPOSURE AND SLOPE	SURFACE STABILITY	SUBSTRATE ORIGIN	SUBSTRATE COMPOSITION	SURFACE HETEROGENEITY	ELEVATION (M)
1	Creosote	Fan	North facing, gradual	Stable	Colluvial	Coarse sandy to rocky	Low	460
2	Creosote	Sandy fan	Level	Moderate erosion	Alluvial	Fine sandy	Low	180
3	Washwood-land	Wash	Level	Active wash	Alluvial	Coarse sandy	Moderate	260
4	Creosote	Dissected fan	Gentle, NW facing	Old erosion	Bedrock	Coarse sandy to rocky	High	340
5	Creosote	Fan	± Flat, gentle NW facing	Stable	Alluvial	Coarse sandy	Low	680
6	Cactus scrub	Hilly	South facing	Moderate erosion	Bedrock	Coarse sandy to rocky	High	700
7	Cactus scrub	Hilly	South facing	Moderate erosion	Bedrock	Coarse sandy to rocky	High	700
8	Creosote	Fan	Gentle NW facing	Stable	Alluvial	Coarse sandy	Low	680
9	Creosote	Sandy fan	Level	Moderate erosion	Alluvial	Fine sandy	Low	70
10	Creosote	Dissected fan	Gentle S.facing	Moderate erosion	Alluvial	Coarse sandy	Moderate	150

Table 5-1. PIPELINE SAMPLE AREA CHARACTERISTICS (Continued)

SAMPLE AREA	COMMUNITY TYPE	LAND FORM TYPE	EXPOSURE AND SLOPE	SURFACE STABILITY	SUBSTRATE ORIGIN	SUBSTRATE COMPOSITION	SURFACE HETEROGENEITY	ELEVATION (M)
11	Creosote	Fan	Level	Light erosion	Alluvial	Coarse sandy to rocky	Low	420
12	Creosote	Fan	Level	Light erosion	Alluvial	Coarse sandy	Low	270
13	Creosote	Fan	Level	Light erosion	Alluvial	Coarse sandy	Low	270
14	Creosote	Fan	Level	Light erosion	Alluvial	Coarse sandy	Low	420
15	Creosote	Sandy fan	Level	Moderate erosion	Alluvial	Fine sandy	Low	70

Wash woodlands are located at the edge of river washes which support a heavy growth of trees and large shrubs. Soils are predominately silt or fine grained sand. Common species include Cercidium floridum (Palo Verde), Olneya testota (Desert Ironwood), Dalea spinosa (Smoke Tree), and Chilopsis linearsis (Desert Willow).

Vegetation Sampling

During the summer of 1978, perennial vegetation at each study site was sampled using four belt transects, each transect was 100 meters long and 2 meters wide. The transects were located parallel to the pipeline as follows: Transects 1 and 2 (controls) were located at least 50 meters above and below the corridor in undisturbed vegetation; Transect 3 was located along the service road edge (1 meter from road berm); and Transect 4 was located directly on the pipeline trench.

Perennial shurbs rooted within each transect were sampled by measuring the canopy height (at the center) and the diameter (the average of two perpendicular measurements). Cover estimates for each species were calculated using the average diameter to obtain the radius of a circle. Canopy volume was determined by assuming that canopy shape approximated a cylinder (Ludwig et al. 1975). Canopy cover and volume was used to estimate aboveground biomass (Kg/meter^3) using information supplied by the BLM (Appendix B). Aboveground biomass for each transect (Kg/100m^2) was estimated by summing the individual contribution of each species.

Vegetation Analysis

Analyses of primary transect data were directed toward describing vegetation change in terms of community productivity, community stability, and species diversity.

Community Productivity. Transect data such as density, ground cover, canopy volume, and aboveground biomass measurements from disturbed and undisturbed vegetation was used to estimate "productivity ratios" for all sampled sites (Johnson et al. 1975).

Community Stability. Species composition data were used as a basis for separating sampled shrubs into three functional categories that reflect apparent longevity and successional status (Vasek et al. 1975). These functional categories include:

1. Long-lived Perennials are characteristically found in undisturbed situations, exhibit definite clonal reproductive behavior, and are usually of large size and extent.

2. Short-lived Pioneer Shrubs are usually first to invade disturbed areas (e.g., riverwashes), noncloning, and usually of smaller size than the longer-lived perennials.

3. Pioneer Perennial Herbs are usually encountered in great numbers in disturbed areas. Their distribution is quite heterogeneous and usually form large clumps of several individuals.

The assignment of a particular species into any one functional category was based on current information (Muller 1953; Muller and Muller 1956; Vasek et al. 1975; McHargue 1975; Gulman and Mooney 1977), our judgement, and collaboration with BLM personnel (Appendix C).

Community stability ("successional status") of sample areas was estimated by using the aerial extent or ground cover of long-lived perennial plants. It was felt that the total ground covered by long-lived shrubs in disturbed situations when compared to adjacent controls provided the most direct means of assessing habitat recovery. Direct comparisons among transects were made using the Cover Ratio Index (CRI). This index is simply the ratio of ground covered by long-lived shrubs on disturbed areas to the ground covered by long-lived shrubs on undisturbed areas.

Species Diversity

The species diversity of each transect was computed using Simpson's Dominance Index as shown:

$$\lambda = \frac{\sum_{1}^{s} n_i (n_i - 1)}{N(N-1)}$$

where, n_i individuals in the ith species (s) and N is the number of individuals distributed among s species. Two components of species diversity were separately considered. The first component, species richness, is simply the number of species present per 100 m^2. The second component, evenness, is an individual's distribution among the species present. The evenness component was calculated by first considering the maximum possible diversity (d_{max}) for a collection of N individuals in a total of s species as follows:

$$d_{max} = s \ (N-1/N-s)$$

Evenness (e_s) was then calculated as the ratio of species diversity (d_s=1/) and the maximum possible diversity (d_{max}):

$$e_s = d_s/d_{max}$$

Soil Sampling

Preliminary assessment of pipeline construction impact on desert soils resulted in the identification of four soil disturbance types located: 1) along the corridor, 2) on the access road, 3) along the roadedge, and 4) undisturbed (controls) areas. Soil physical characteristics for each disturbance type involved the determination of bulk density and percent porosity.

Soil cores were collected in triplicate from each transect using a soil auger 11.1 cm deep and 5.7 cm in diameter. Soil cores were extracted by removing soil from around the auger and levelling the base. The core was lifted free, placed in a plastic bag, and securely sealed. Soil weight was determined after drying 48 hours at 105°C. Average bulk density was expressed as grams of oven dry soil per cm^{-3}.

The average pore space for each transect was determined using the equation:

$$(\%)\ \text{Pore Space} = 100(D_b/D_p \times 100)$$

where D_b is the bulk density of the soil, and D_p is the average particle density of 2.65 gms/cm^3 (Davidson and Fox 1974; Hausenbuiller 1972).

Results

Vegetation

Species composition, density, ground cover, and canopy volume are recorded for all transects and sample areas in Tables 5-2 to 5-16. This summary information is used as baseline data for estimating productivity, stability, and diversity at the community level.

Community Productivity

Table 5-17 presents plant density, cover, and canopy volume productivity ratios (P.R.) for road edge and corridor transects. As shown, there are several sample areas (Areas 4, 9, 10, 12, 13, and 15) where density P.R. for road edge vegetation exceeds 1.0. This indicates that shrubs are more numerous along the road edge than adjacent controls. Most of this increase is attributable to *Hymenoclea salsola*, *Eriogonium inflatum*, and *Euphorbia polycarpa* (Tables 5-5, 5-10, 5-11, 5-13, 5-14, and 5-16). However, in these areas cover and volume P.R. are less than 1.0 suggesting that road edge plants are smaller and more compact than plants in undisturbed areas. Exceptions to these observations include road edge vegetation on dissected fans (Areas 4 and 10) with well developed desert pavement. In these areas, road edge vegetation is larger and more numerous than controls. Areas 1 and 8 (alluvial fans) have road edge perennial vegetation that is less dense, but substantially larger than controls.

Corridor vegetation has often appeared more dense than adjacent controls. On closer inspection, much of this increase is directly attributed to the presence of *Euphorbia polycarpa*. In such cases, plant cover and volume is substantially lower than controls, except for Areas 3 and 4. Area 4 (dissected fan) has vegetation that is somewhat larger and more numerous than controls; Area 3 (riverwash) has fewer individuals, but are usually larger in size and extent (e.g., *Dalea spinosa*).

Table 5-2. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 1

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	2.5	4.0	1.5		3.86	4.20	4.47		4.71	3.50	6.86	
Ambrosia dumosa	14.5	24.5	47.5	43.5	0.98	2.14	7.68	2.06	0.39	0.96	3.40	0.49
Opuntia ramosissima	0.5				0.06				0.04			
Opuntia echinocarpa	0.5	1.0	1.0		T	0.02	0.13		T	T	T	
Ephedra californica	0.5				0.39				0.39			
Hymenoclea salsola	1.5	0.5		0.5	0.05		0.05	0.01	0.01		0.01	T
Euphorbia polycarpa	21.0	162.5		207.5	0.01		0.05	0.04	T		T	T

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-3. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 2

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	2.5	2.0	1.0		1.86	1.53	1.01		1.79	1.64	1.11	
Ambrosia dumosa	40.0	45.0	16.0	47.5	1.08	1.15	0.35	1.33	0.40	0.53	0.07	0.48
Atriplex polycarpa	2.5	2.0	2.5		0.88	0.85	0.20		0.42	0.75	0.06	
Hymenoclea salsola	1.5		4.0	4.0	0.03		0.07	0.32	0.01		0.02	0.17
Eriogonium inflatum	0.5				0.12				0.08			
Ephedra californica				0.5				T				T
Euphorbia polycarpa			0.5	0.5			T	T			T	T

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-4. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 3

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Ambrosia dumosa	1.0	1.5	0.5	0.5	0.52	0.18	0.06	2.45	0.05	0.05	0.02	0.74
Dalea spinosa	0.5	0.5		1.0	0.29	0.08		12.41	0.05	0.04		39.52
Chrysothamnus paniculatus	22.5	27.5	22.0	15.5	2.75	2.93	0.06	10.45	4.05	3.73	0.01	14.70
Hymenoclea salsola	4.0	3.0	6.0		0.49	0.73	1.04		0.57	0.46	0.61	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-5. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 4

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	2.0	0.5	3.5	2.0	2.41	0.14	0.59	1.38	2.17	0.07	0.39	2.20
Ambrosia dumosa	3.0	2.5	15.5	20.0	0.35	0.10	1.70	1.75	0.14	0.03	0.58	0.62
Euphorbia polycarpa	10.0	12.0	46.5	22.5	0.01	0.01	0.05	0.01	T	T	T	T
Hymenoclea salsola			0.5				0.06				0.03	
Eriogonium inflatum				0.5				0.35				0.32

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-6. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 5

SPECIES NAME	DENSITY (#/100M^2) Transect				GROUND COVER (M^2) Transect				CANOPY VOLUME (M^3) Transect			
	1 *	2 *	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	3.5	5.0	1.0	2.5	3.57	12.85	2.50	0.25	4.75	18.75	1.45	0.62
Ambrosia dumosa	21.0	26.5	21.5	57.5	4.08	5.54	0.95	5.49	1.45	2.02	2.30	2.07
Hymenoclea salsola	0.5	0.5	1.5	2.5	0.02	0.14	0.15	1.46	0.01	0.09	0.15	1.06
Eriogonum fasiculatum	2.5		0.5		1.00		0.05		0.65		0.11	
Euphorbia polycarpa	95.5				0.01				T			
Sarcostemma hirtellum	1.5				0.40				0.25			
Krameria grayi		0.5	0.5			0.05				0.01	0.02	
Eriogonum inflatum		0.5				0.02				0.01		

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-7. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 6

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	0.5	2.5	0.5		0.77	1.31	0.29	0.11	0.85	1.40	0.25	
Ambrosia dumosa	5.0	6.5	1.0	1.5	0.54	0.37	0.13		0.18	0.10	0.01	0.03
Krameria grayi	5.0	4.5	2.0		0.75	0.46	0.56		0.20	0.11	0.05	
Cassia armata	2.0	0.5			1.27	0.12			0.87	0.06		
Ferocactus acanthodes	2.0	1.0	0.5		0.21	0.10	T		0.13	0.06	T	
Opuntia bigelovii	48.0	11.0	1.0	3.0	5.13	1.44	T	0.08	5.89	1.18	T	0.02
Opuntia acanthocarpa	1.0	1.0	0.5		1.08	0.53	T		1.04	0.44	T	
Eriogonum fasiculatum	7.0	12.5	0.5	0.5	0.97	1.61	0.10	T	0.53	0.62	T	T
Dalea emoryi	1.5	0.5	0.5		1.37	0.25			1.14	0.13	0.15	
Encelia farinosa	6.5	9.5	12.0	85.0	0.86	1.68	1.79	8.71	0.31	0.79	0.93	2.13
Euphorbia polycarpa	3.0			7.0	0.01			T	T			T
Eriogonium inflatum	3.5	3.5	10.5	13.0	0.59	0.24	0.49	1.82	0.26	0.12	0.55	0.94
Acamptopapus sphaerocephalus	0.5				0.06				0.03			

Table 5-7. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION
FOR PIPELINE SAMPLE AREA 6
(Continued)

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Porophyllum gracile	1.5		2.0	5.0	0.02		0.01	0.35	0.01		T	0.10
Ditaxis neomexicana	1.0				0.03				T			
Lycium spp.		0.5	0.5			0.39	T			0.47	0.51	
Acacia greggii		0.5				1.57				2.51		
Mammallaria tetrancistra		0.5	0.5			T	T			T	T	
Bebbia juncea		0.5				0.06				0.02		
Stephanomeria pauciflora		2.5		9.0		0.43		0.48		0.22		0.15
Opuntia basilaris			0.5	0.5			T	T			T	T

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

T = trace less than 0.01.

Table 5-8. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 7

SPECIES NAME	DENSITY (#/100M^2) Transect				GROUND COVER (M^2) Transect				CANOPY VOLUME (M^3) Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	0.5	2.5	0.5	1.5	0.77	1.31	0.02	0.04	0.85	1.40	0.43	0.01
Ambrosia dumosa	5.0	6.5	2.0	10.0	0.54	0.37	0.28	0.97	0.18	0.10	0.09	0.28
Krameria grayi	5.0	4.5	0.5		0.75	0.46	0.06		0.20	0.11	0.04	
Cassia armata	2.0	0.5			1.27	0.12			0.87	0.06		
Ferocactus acanthodes	2.0	1.0			0.21	0.10			0.13	0.06		
Opuntia bigelovii	48.0	11.0	0.5	0.5	5.13	1.44	T	T	5.89	1.18	T	T
Opuntia acanthocarpa	1.0	1.0			1.08	0.53			1.04	0.44		
Eriogonum fasiculatum	7.0	12.5	3.5	0.5	0.97	1.61	0.85	T	0.53	0.62	0.07	T
Dalea emoryi	1.5	0.5			1.37	0.25			1.14	0.13		
Encelia farinosa	6.5	9.5	15.5	98.0	0.86	1.68	0.46	7.51	0.31	0.79	0.42	1.84
Euphorbia polycarpa	3.0		4.0	7.0	0.01		T	T	T		T	T
Eriogonium inflatum	3.5	3.5	1.5	3.0	0.59	0.24	0.12	0.39	0.26	0.12	0.15	0.19
Acamptopappus sphaerocephalus	0.5				0.06				0.03			

Table 5-8. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 7 (Continued)

SPECIES NAME	DENSITY (#/100M²) Transect				GROUND COVER (M^2) Transect				CANOPY VOLUME (M^3) Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Porophyllum gracile	1.5				0.02				0.01			
Ditaxis neomexicana	1.0				0.03				T			
Lycium spp.		0.5				0.39				0.47		
Acacia greggii		0.5				1.57				2.51		
Mammallaria tetrancistra		0.5				T				T		
Bebbia juncea		0.5				0.06				0.02		
Stephanomeria pauciflora		2.5		0.5		0.43	0.48	T		0.22		T
Opuntia basilaris			0.5				Y				T	

*Transects: 1, Control; 2, Control; 3, Road Edge,; 4, Corridor.

Transects 1 and 2 are the same for Sample Area 6.

Table 5-9. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 8

SPECIES NAME	DENSITY (#/100M²)				GROUND COVER (M²)				CANOPY VOLUME (M³)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	3.5	5.0	4.5		3.57	12.85	11.42		4.75	18.75	1.54	
Ambrosia dumosa	21.0	26.5	23.0	13.5	4.08	5.54	4.47	1.78	1.45	2.02	0.98	0.38
Hymenoclea salsola	0.5	0.5	0.5	27.0	0.02	0.14	0.28	6.76	0.01	0.09	0.05	4.04
Eriogonum fasiculatum	2.5				1.00				0.65			
Euphorbia polycarpa	95.5				0.01				T			
Sarcostemma hirtellum	1.5				0.40				0.25			
Krameria grayi		0.5				0.05				0.01		
Eriogonium inflatum		0.5	1.0			0.02	0.05			0.01	0.02	
Bebbia juncea				1.5				0.28				0.12

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-10. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 9

SPECIES NAME	DENSITY (#/100M^2) Transect				GROUND COVER (M^2) Transect				CANOPY VOLUME (M^3) Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	1.5	0.5			7.10	4.15			11.86	9.14		
Ambrosia dumosa	0.5	1.5	0.5	0.5	1.14	4.20	0.22	T	0.34	2.90	0.13	T
Atriplex spp.	1.0	5.0	2.0	1.5	0.06	0.36	2.69	0.03	0.03	0.12	2.97	0.01
Hymenoclea salsola		2.0	2.5	6.0		5.22	1.57	4.51		5.92	1.20	2.86
Petalonyx thurberi	1.5	1.0	1.0		0.25	0.02	0.51		0.13	T	0.35	
Palafoxia linearis	0.5			1.0	0.01			0.01	T			0.00
Croton californicus	2.0				0.83				0.57			
Coldenia plicata	5.0		20.0	1.0	T		3.93	0.49	T		1.12	0.09
Dalea emoryi				0.5				0.08				0.03
Euphorbia polycarpa			45.0	0.5			0.06	0.01			T	T
Erigonium inflatum			2.0				1.56				1.17	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-11. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 10

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	1.0	1.5	0.5	0.5	2.75	2.34	2.53	0.62	3.30	3.05	2.25	0.16
Ambrosia dumosa	2.5	2.0	2.5	1.5	1.35	1.10	3.23	0.81	0.27	0.38	0.43	0.07
Hymenoclea salsola	2.0	3.5	12.5	7.5	1.65	1.75	2.75	1.25	0.05	0.07	0.91	0.25
Palafoxia linearis	2.5	3.0	0.5	0.5		1.51	0.65	0.25	0.07	0.10	0.01	T
Hilaria rigidia	0.5	1.0			0.05	0.09			0.12	0.09		
Eriogonium fasiculatum	0.5	0.5	1.0	0.5	0.11	0.98	1.33	0.05	0.17	0.20	0.12	0.09
Encelia farinosa	2.0	1.0	1.0	1.5	0.35	0.54	2.15	0.98	0.26	0.16	0.45	0.12
Krameria grayii	1.0	0.5			0.95	0.03			0.95	0.15		
Krameria parviflora		0.5	0.5			0.02	1.09			0.02	0.52	
Euphorbia polycarpa		2.5				T				T		
Dalea spinosa			0.5				1.00				1.00	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-12. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 11

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3**	4*	1	2	3	4	1	2	3	4
Larrea tridentata	4.0	2.5			5.15	4.55			4.53	2.35		
Ambrosia dumosa	25.5	25.0		11.0	3.80	1.81		2.05	2.05	1.75		0.97
Hymenoclea salsola		1.5		2.5		0.08		1.13		0.05		0.10
Euphorbia polycarpa	0.5	2.0			T	0.01			T	T		
Eriogonium fasiculatum												
Encelia farinosa				0.5				0.08				0.04
Hilaria rigidia	2.0	4.0			0.17	0.16			0.01	0.01		
Palafoxia linearis	11.5	23.0		24.5	0.79	1.33		1.55	0.40	0.53		
Allionia incarnata	0.5	1.0		2.5	T	T		0.02	T	T		T

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.
**No road edge effect observed.

Table 5-13. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 12

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	1.0		2.5	1.5	3.47		3.90	0.77	3.47		4.56	0.77
Ambrosia dumosa	3.0	6.50	4.5	1.0	0.58	1.34	2.50	0.08	0.24	0.57	0.47	0.02
Krameria grayi	0.5	0.50			0.08	0.66			0.03	0.33		
Krameria parvifolia	0.5		0.5		0.25		0.34		0.13		0.23	
Olneya testota	1.0		0.5		15.50		0.03		69.07		0.75	
Bebbia juncea	1.5	0.38			0.15	0.48			0.06	0.38		
Croton californicus	1.0				0.05				0.01			
Eriogonium inflatum	5.5	1.00	8.5	5.5	2.35	0.01	3.72	1.77	1.85	T	2.03	1.29
Fagonia laevis	9.5	8.00		3.0	1.03	0.77		0.31	0.32	0.25		0.08
Hilaria rigidia		1.5	0.5			0.10	0.01			0.07	0.13	
Euphorbia polycarpa		5.5	9.5			0.02	0.01			T	0.01	
Cercidium floridum			0.5	0.5			0.02	0.08			0.05	0.03

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-14. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 13

SPECIES NAME	DENSITY (#/100M²)				GROUND COVER (M²)				CANOPY VOLUME (M³)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	1.0		1.5	20.5	3.47		4.15	6.75	3.47		4.53	5.46
Ambrosia dumosa	3.0	6.5	8.5	1.0	0.58	1.34	1.65	0.15	0.24	0.57	0.86	0.04
Krameria grayi	0.5	0.5			0.08	0.66			0.03	0.33		
Krameria parvifolia	0.5				0.25				0.13			
Olneya testota	1.0				15.50				69.07			
Bebbia juncea	1.5	0.5	3.5		0.15	0.48	0.58		0.06	0.38	0.12	
Croton californicus	1.0				0.05				0.01			
Eriogonium inflatum	5.5	1.0	10.5	5.0	2.35	0.01	2.05	0.82	1.85	T	2.76	0.44
Fagonia laevis	9.5	8.0	6.5	3.0	1.03	0.77	0.33	0.23	0.32	0.25	0.33	0.02
Hilaria rigidia		1.5				0.10				0.07		
Euphorbia polycarpa		5.5		2.5		0.02		0.01		T		T
Allonia incarnata			1.5	0.5			T	T			0.01	T
Eriogonium deflexum				0.5				0.32				0.22

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Control transects 1 and 2 are the same for Sample Area 12.

Table 5-15. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 14

SPECIES NAME	DENSITY (#/100M²)				GROUND COVER (M²)				CANOPY VOLUME (M³)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	2.5	4.5	1.0		4.59	4.87	0.05		4.25	5.02	1.01	
Ambrosia dumosa	25.0	25.0	1.0	12.0	1.78	3.61	0.02	1.95	0.56	1.54	0.06	0.70
Hilaria rigidia	4.0	2.0	0.5		0.14	1.73	0.06		0.06	0.11	0.01	
Hymenoclea salsola	1.5		2.5	2.5	0.08		3.26	1.13	0.03		0.86	0.77
Palafoxia linearis	24.0	11.5	12.0	24.5	1.41	0.75	1.26	1.44	0.61	0.37	0.35	0.69
Euphorbia polycarpa	6.5	0.5			0.01	T			T	T		
Allonia incarnata	1.0	0.5	0.5	2.5	0.01	T	0.02	0.02	T	T	T	T
Encelia farinosa				0.5				0.08				0.03

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-16. COMPOSITION, DENSITY, COVER, AND VOLUME OF VEGETATION FOR PIPELINE SAMPLE AREA 15

SPECIES NAME	DENSITY (#/100M^2)				GROUND COVER (M^2)				CANOPY VOLUME (M^3)			
	Transect				Transect				Transect			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4
Larrea tridentata	1.5	0.5			7.10	4.15			11.86	9.54		
Ambrosia dumosa	0.5	1.5	2.5	1.5	1.14	4.20	0.79	0.30	0.34	2.90	0.41	0.11
Atriplex spp.	1.0	5.0	0.5	1.5	0.06	0.36	0.25	0.87	0.03	0.12	0.20	0.72
Palafoxia linearis	0.5				T				T			
Petalonyx thurberi	1.5	1.0	1.0	1.5	0.25	0.02	0.49	0.40	0.13	T	0.31	0.21
Coldenia plicata	5.0			35.5	T			6.47	T			1.60
Hymenoclea salsola		2.0	1.0	2.5		5.22	0.78	0.81		5.92	0.67	0.49
Encelia farinosa				1.0				0.16				0.06
Croton californicus				0.5				0.04				0.03
Euphorbia polycarpa			54.0	113.0			0.72	0.22			T	0.01
Eriogonium inflatum			0.5	7.5			T	3.33			T	2.80
Stephanomeria pauciflora				1.0				0.06				0.02
Machaeranthera tortifolia				1.5				0.16				0.05
Dalea schottii			3.5				8.03				11.25	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

Table 5-17. DENSITY, COVER, AND CANOPY VOLUME PRODUCTIVITY RATIOS FOR ROAD EDGE AND CORRIDOR TRANSECTS ALONG PIPELINE SAMPLE AREAS

SAMPLE AREA	DENSITY		COVER		CANOPY VOLUME	
	Road Edge	Corridor	Road Edge	Corridor	Road Edge	Corridor
1	0.43	2.15	2.11	0.36	1.32	0.06
2	0.50	1.09	0.44	0.44	0.45	0.23
3	0.94	0.56	0.29	6.35	0.15	12.21
4	4.40	3.00	1.59	2.31	0.83	2.62
5	0.32	0.79	0.26	0.52	0.29	0.27
6	0.45	1.71	0.28	0.95	0.25	0.34
7	0.39	1.66	0.19	0.74	0.12	0.24
8	0.37	0.53	1.17	0.59	0.19	0.32
9	6.64	1.00	0.90	0.44	0.44	0.19
10	1.36	0.86	1.89	0.51	1.20	0.14
11	0.00	0.79	0.00	0.54	0.00	0.18
12	1.15	0.49	0.78	0.22	0.21	0.06
13	1.37	0.53	0.65	0.62	0.22	0.16
14	0.32	0.77	0.49	0.49	0.36	0.35
15	5.73	15.18	0.95	1.10	0.82	0.39

Community Stability

The perennial vegetation observed along pipeline corridors are grouped into categories based on longevity and successional criteria (Appendix D). Most of the long-lived perennial shrubs sampled on alluvial fans belong to the following species: Larrea tridentata, Ambrosia dumosa, and Hilaria rigidia. On rocky south-facing terraces, there were several species of stem succulent perennials most notably Opuntia basilaris, Opuntia acanthocarpa, Opuntia bigelovii, and Ferrocactus acanthodes. Along the margins of riverwashes Cercidium floridum, Dalea spinosa, Chrysothamnus paniculatus, and Acacia greggii formed dense thickets of large trees and shrubs. These species characterize their respective community and landform types and are representative of most of the standing vegetation.

Short-lived perennials are usually found in great numbers in severely disturbed areas of all landforms studied. Hymenoclea salsola and Encelia farinosa were the most abundant of these species. The latter occurred on all soil types except highly saline soils, while the former preferred rocky but well-drained soils.

In several areas, pioneer herbaceous plants contributed substantially to the total numbers of plants observed, but little to the total standing crop. This category includes only Euphorbia polycarpa which germinates after seasonal rains. Euphorbia tends to thrive in great numbers on sandy soils, particularly where water has accummulated. The presence of Euphorbia is not restricted to undisturbed areas, but will also occur frequently in mature vegetation.

The absolute density and ground cover for long- and short-lived perennials and pioneer perennial herbs are shown for each transect/sample area in Tables 5-18 to 5-20. The contribution of each functional plant group to total density and cover is presented in Tables 5-21 to 5-24.

Table 5-18. DENSITY AND COVER MEASUREMENTS FOR LONG-LIVED PERENNIALS ENCOUNTERED IN PIPELINE SAMPLE AREA TRANSECTS

SAMPLE AREA	LONG-LIVED PERENNIALS							
	DENSITY (#/100M²)				GROUND COVER (M²)			
	TRANSECT NO.				TRANSECT NO.			
	1*	2*	3*	4*	1	2	3	4
1	19	30	50	44	5.29	6.36	12.16	2.05
2	46	33	20	48	4.21	3.54	1.56	1.33
3	24	30	23	17	3.56	3.19	0.12	25.32
4	5	3	19	22	2.76	0.24	2.29	3.13
5	25	32	23	60	7.65	18.43	3.45	6.10
6	64	29	8	5	9.75	6.48	0.42	0.19
7	64	29	10	12	9.75	6.48	2.65	1.01
8	25	32	29	14	7.65	18.43	3.78	1.18
9	3	7	3	2	8.30	8.71	0.13	0.03
10	5	8	4	2	4.15	3.58	7.85	1.43
11	32	32	0	12	6.50	8.65	0.00	1.95
12	6	9	12	3	19.88	2.10	6.80	0.92
13	6	9	10	22	19.88	2.10	5.80	6.89
14	32	32	3	2	6.50	8.65	2.91	1.73
15	3	7	3	3	8.30	8.71	1.17	1.04

*Treatments: Transects 1 and 2, controls; Transect 3, road edge, Transect 4, corridor.

Table 5-19. DENSITY AND COVER MEASUREMENTS FOR SHORT-LIVED PERENNIALS ENCOUNTERED IN PIPELINE SAMPLE AREA TRANSECTS

SAMPLE AREA	SHORT-LIVED PERENNIALS							
	DENSITY (#/100M^2)				GROUND COVER (M^2)			
	TRANSECT NO.				TRANSECT NO.			
	1*	2*	3*	4*	1	2	3	4
1	2	0	1	1	0.005	0.00	0.05	0.01
2	2		4	4	0.15		0.07	0.32
3	4	3	6	4		0.73	1.04	1.48
4	0	0	1	1	0.00	0.00	0.06	0.35
5	5	1	2	3	1.41	0.16	0.20	1.46
6	22	29	24	18	3.88	4.27	15.75	11.35
7	22	29	25		3.88	4.27	13.64	7.91
8	5	1	1	29	1.41	0.16	2.05	7.04
9	9	3	15	9	1.09	5.24	5.69	5.09
10	7	8	15	10	3.06	4.78	7.56	3.08
11	27	12	0	30	1.49	0.75	4.36	2.66
12	18	10	18	12	3.58	1.25	3.73	2.18
13	18	10	22	9	3.58	1.25	2.96	1.36
14	27	12	26	6	1.49	0.75	7.56	2.28
15	9	3	6	51	1.09	5.24	9.30	11.42

*Treatments: Transects 1 and 2, controls; Transect 3, road edge; Transect 4, corridor.

Table 5-20. DENSITY AND COVER MEASUREMENTS FOR PIONEER PERENNIALS ENCOUNTERED IN PIPELINE SAMPLE AREA TRANSECTS

SAMPLE AREA	PIONEER PERENNIALS							
	DENSITY (#/100M²)				GROUND COVER (M²)			
	TRANSECT NO.				TRANSECT NO.			
	1*	2*	3*	4*	1	2	3	4
1	21	0	163	208	0.01	0.00	0.05	0.04
2	0	0	0	1	0.00	0.00	0.00	T
3	0	0	0	0	0.00	0.00	0.00	0.00
4	10	12	47	23	0.01	0.01	0.05	0.01
5	96	0	0	0	0.01	0.00	0.00	0.00
6	3	0	0	0	0.01	0.00	0.00	0.00
7	3	0	0	7	0.01	0.00	0.00	T
8	96	0	7	0	0.01	0.00	T	0.00
9	0	0	0	1	0.00	0.00	0.00	0.01
10	0	0	0	0	0.00	0.00	0.00	0.00
11	7	1	0	0	0.01	T	0.00	0.00
12	0	6	0	0	0.01	0.02	0.00	0.00
13	0	6	0	3	0.00	0.02	0.00	0.01
14	0	0	45	0	0.00	0.00	0.06	0.00
15	0	0	54	113	0.00	0.00	0.07	0.21

*Treatments: Transects 1 and 2, controls; Transect 3, road edge; Transect 4, corridor.

Table 5-21. RELATIVE DENSITY AND COVER VALUES FOR THREE FUNCTIONAL PLANT GROUPS FOR ALL AREAS SAMPLED ALONG PIPELINES

Transect No. 1 (Control)

SAMPLE AREA	DENSITY (#/100 M^2)	RELATIVE DENSITY (% OF TOTAL)			TOTAL COVER (M^2)	RELATIVE COVER (% OF TOTAL)		
		Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.		Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
1	41.0	45.12	3.66	51.22	5.35	98.88	0.93	0.19
2	48.0	95.83	4.17	0.00	4.35	96.78	3.45	0.00
3	28.0	87.23	12.77	0.00	4.05	87.83	12.17	0.00
4	15.0	33.33	0.00	66.67	2.77	99.64	0.00	0.36
5	124.5	19.68	3.61	76.71	9.07	84.34	15.55	0.11
6	88.5	72.32	24.29	3.39	13.64	71.48	28.45	0.07
7	88.5	72.32	24.29	3.39	13.64	71.48	28.45	0.07
8	124.5	19.68	3.61	76.71	9.07	84.34	15.55	0.11
9	12.0	25.00	75.00	0.00	9.39	88.39	11.61	0.00
10	12.0	41.67	58.33	0.00	7.21	57.56	42.44	0.00
11	64.0	71.59	27.27	1.14	9.91	92.02	7.98	0.00
12	23.5	25.53	74.47	0.00	23.45	84.78	15.27	0.00
13	23.5	25.53	74.47	0.00	23.45	84.78	15.27	0.00
14	64.5	48.84	41.09	10.08	8.00	81.25	18.63	0.13
15	12.0	25.00	75.00	0.00	9.39	88.39	11.61	0.00

Table 5-22. RELATIVE DENSITY AND COVER VALUES FOR THREE FUNCTIONAL PLANT GROUPS FOR ALL AREAS SAMPLED ALONG PIPELINES

Transect No. 2 (Control)

SAMPLE AREA	DENSITY (#/100 M^2)	RELATIVE DENSITY (% OF TOTAL)			TOTAL COVER (M^2)	RELATIVE COVER (% OF TOTAL)		
		Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.		Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
1	29.5	100.00	0.00	0.00	6.36	100.00	0.00	0.00
2	36.0	92.00	8.00	0.00	3.95	89.50	10.50	0.00
3	32.5	90.77	9.23	0.00	3.92	81.38	18.62	0.00
4	15.0	20.00	0.00	80.00	0.25	96.00	0.00	4.00
5	33.0	96.97	3.03	0.00	18.59	99.14	0.86	0.00
6	58.0	50.00	50.00	0.00	10.75	60.28	39.72	0.00
7	58.0	50.00	50.00	0.00	10.75	60.28	39.72	0.00
8	33.0	96.97	3.03	0.00	18.59	99.14	0.86	0.00
9	10.0	70.00	30.00	0.00	13.95	62.44	37.56	0.00
10	16.0	34.37	50.00	15.63	8.36	42.82	57.18	0.00
11	58.5	52.99	43.59	3.42	7.94	82.12	17.76	0.13
12	23.5	36.17	40.43	23.40	3.37	62.31	37.09	0.59
13	23.5	36.17	40.43	23.40	3.37	62.31	7.98	0.59
14	44.0	71.59	27.27	1.14	9.40	92.02	7.98	0.00
15	10.0	70.00	30.00	0.00	13.95	62.44	37.56	0.00

Table 5-23. RELATIVE DENSITY AND COVER VALUES FOR THREE FUNCTIONAL PLANT GROUPS FOR ALL AREAS SAMPLED ALONG PIPELINES

Transect No. 3 (Roadedge)

SAMPLE AREA	DENSITY (#/100 M^2)	RELATIVE DENSITY (% OF TOTAL)			TOTAL COVER (M^2)	RELATIVE COVER (% OF TOTAL)		
		Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.		Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
1	213.0	23.47	0.23	76.29	12.26	99.18	0.41	0.41
2	24.0	81.25	16.67	2.08	1.63	95.71	4.29	0.00
3	28.5	78.95	21.05	0.00	1.16	10.34	89.66	0.00
4	66.0	28.79	0.76	70.45	2.40	95.42	2.50	2.08
5	25.0	93.75	6.25	0.00	3.65	94.52	5.48	0.00
6	32.0	23.62	76.38	0.00	2.80	15.00	85.00	0.00
7	28.5	13.75	86.25	0.00	1.63	22.00	88.00	0.00
8	30.0	95.63	4.39	0.00	16.22	96.30	3.70	0.00
9	17.5	14.29	85.71	0.00	4.67	2.23	97.77	0.00
10	19.0	21.05	78.95	0.00	14.73	45.89	35.89	0.00
11	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	30.0	30.00	28.33	31.67	10.53	64.58	35.42	0.00
13	32.0	31.25	68.75	0.00	8.76	66.21	33.79	0.00
14	73.0	3.42	34.93	61.64	10.53	27.64	71.79	0.57
15	63.0	4.76	9.52	85.71	10.41	9.99	89.34	0.67

Table 5-24. RELATIVE DENSITY AND COVER VALUES FOR THREE FUNCTIONAL PLANT GROUPS FOR ALL AREAS SAMPLED ALONG PIPELINES

Transect No. 4 (Corridor)

SAMPLE AREA	DENSITY (#/100 M²)	RELATIVE DENSITY (% OF TOTAL) Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.	TOTAL COVER (M²)	RELATIVE COVER (% OF TOTAL) Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
1	252.0	17.30	0.02	82.50	2.10	97.62	0.48	1.90
2	53.0	91.43	7.62	0.95	1.65	80.61	19.39	T
3	21.0	80.95	19.05	0.00	26.80	94.48	5.52	0.00
4	45.0	48.89	1.11	50.00	3.50	89.43	10.00	0.29
5	62.5	96.00	4.00	0.00	7.57	80.69	19.31	0.00
6	124.5	4.02	90.36	5.62	11.54	1.65	98.35	T
7	121.0	9.92	84.30	5.79	8.93	11.31	88.58	T
8	42.0	32.14	67.86	0.00	8.22	14.36	85.64	0.00
9	11.0	18.18	77.27	4.55	5.12	0.59	99.41	0.20
10	12.0	16.67	83.33	0.00	3.96	36.11	63.89	0.00
11	41.0	26.83	73.17	0.00	4.83	42.44	57.56	0.00
12	14.5	20.63	79.31	0.00	3.11	29.90	70.10	0.00
13	33.0	65.15	27.27	7.58	8.26	83.41	16.46	0.12
14	8.0	75.00	25.00	0.00	4.01	43.14	56.86	0.00
15	167.0	1.80	30.54	67.66	12.80	9.14	89.22	1.64

Relative density and cover data indicates that there is great variability between sample areas. This data variability is the result of environmental (e.g., topography, slope, elevation, climate, etc.) and biotic (i.e., community type) differences between sample areas (Table 5-1). Because of these differences, it is very difficult to recognize discernable vegetative patterns between sample areas.

Comparisons of relative density and cover between transects indicate several general patterns. When controls (Transects 1 and 2) are compared, the absolute density and cover may vary considerably and probably reflects changes in slope from one side to the other. As expected, the relative density of long-lived shrubs is higher than the other functional plant groups except for Areas 1, 5, and 8. In these areas the relative density of pioneer herbaceous plants is quite high, but contributes little to the total cover.

When roadedge vegetation (Transect 3) is compared to adjacent controls, in most cases, the absolute density increases while total cover decreases. However, Areas 1 exhibits a dramatic increase in density and cover by long-lived shrubs. This suggests a well-developed greenbelt area along the maintenance road. Other exceptions include Areas 2, 6-8, and 11 where the greenbelt is not developed, or is entirely absent.

Areas on the pipeline corridor (Transect 4) exhibit increased absolute density and reduced total cover. Most of the increased density is contributed by short-lived shrubs and herbaceous plants. Areas 1, 2, 5, and 13 have a higher density of long-lived shrubs than short-lived shrubs or herbaceous plants. This may indicate that these areas are mostproductive and may recover faster than other areas. Area 3 is a washwoodland community characterized by scattered individuals of large size. Any increases in total cover along the corridor is questionable and probably results in complete vegetative removal during construction.

The total ground covered by long-lived perennials within each transect is presented for all sample areas in Table 5-25. As indicated, the

Table 5-25. ANALYSIS OF LONG-LIVED TOTAL COVER
FOR EACH TRANSECT AND SAMPLE AREA ALONG SELECTED PIPELINES

SAMPLE AREA	LONG-LIVED SHRUB COVER (M^2)				COVER RATIOS INDEX			
	Transect							
	1*	2*	3*	4*	1÷2	3/1÷2	4/1÷2	3÷4/1÷2
1	5.29	6.36	12.16	2.05	5.83	2.09	0.35	1.22
2	4.21	3.53	1.56	1.33	3.87	0.40	0.34	0.37
3	3.56	3.19	0.12	25.32	3.38	0.04	7.49	3.77
4	2.76	0.24	2.29	2.13	1.50	1.53	2.09	1.81
5	7.65	18.43	3.45	6.10	13.04	0.26	0.47	0.37
6	9.75	6.48	0.42	0.03	8.12	0.05	0.00	0.03
7	9.75	6.48	0.36	1.01	8.12	0.04	0.13	0.08
8	7.65	18.43	2.84	1.18	13.04	0.22	0.09	0.15
9	8.30	8.71	0.13	0.03	8.51	0.02	0.00	0.01
10	4.15	3.58	7.85	1.43	3.86	2.03	0.37	1.20
11	6.50	8.65	0.00	1.95	7.58	0.00	0.26	0.13
12	19.88	2.10	7.43	0.93	10.99	0.68	0.09	0.34
13	19.88	2.10	5.98	6.89	10.99	0.54	0.63	0.59
14	6.50	8.65	2.91	1.04	7.58	0.38	0.14	0.26
15	8.30	8.71	1.04	1.17	8.51	0.12	0.14	0.13

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

differences between paired controls (Transects 1 and 2) may vary from 0.37 to 17.78 m^2. This suggests that minor differences in topography or soils are sufficient to cause some variability in the total ground covered by long-lived perennials. A better representation of undisturbed vegetation is provided by averaging the total ground cover of perennials in Transects 1 and 2. Since the corridor is located midway between paired controls, the average control ground cover might be representative of vegetation prior to disturbance. As shown, the average control values vary markedly from one area to another; therefore, all comparisons are made among transects rather than sample areas.

Direct comparisons between transects is accomplished by using the Cover Ratio Index. The ratio between disturbance transects and the averaged control transects provides a simple means of determining differences between transect vegetation. As shown, most CRI's calculated for road edge-control comparisons were below 1.0. This immediately suggests that road edge vegetation had not fully recovered to predisturbance levels.

Areas 1, 4, and 10 did exhibit road edge CRI's that were substantially above 1.0. This suggests that there was positive enhancement of long-lived perennial vegetation along the road edge. These areas were alluvial fans, particularly dissected alluvial fans, where soil conditions, water availability, etc., provided optimum growing conditions. These conditions resulted in the formation and development of an extensive greenbelt area along the road edge (Figure 5-2).

The CRI's for pipeline corridor vegetation (Transect 4) were much lower than 1.0. This suggests that vegetation once severely disturbed had not recovered to any substantial degree. In contrast, Areas 3 and 4 had CRI values considerably higher than controls. Sample Area 3 located on a river wash is subject to frequent and periodic disturbances. Vegetation in this area may quickly re-establish where seeds have likely accumulated in numbers around small mounds, rocks, etc. The road edge with its higher sides may provide pockets for seeds. Area 4 (Figure 5-3) is a dissected fan with well developed desert pavements. Presumably, runoff from pavement areas accumulate at the base of the road edge providing adequate water availability for seed germination and seedling growth.

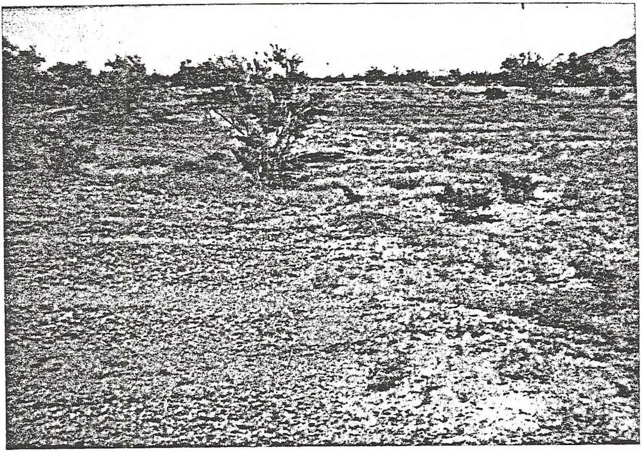

Figure 5-2 . View of the Southern California Gas Co. pipeline (Pipeline 4) near Area 11. The pipeline corridor is visible on the right by last seasons annuals. Desert pavement area (left) is free of vegetation except for scattered Olneya testota and Larrea tridentata confined to small wash areas.

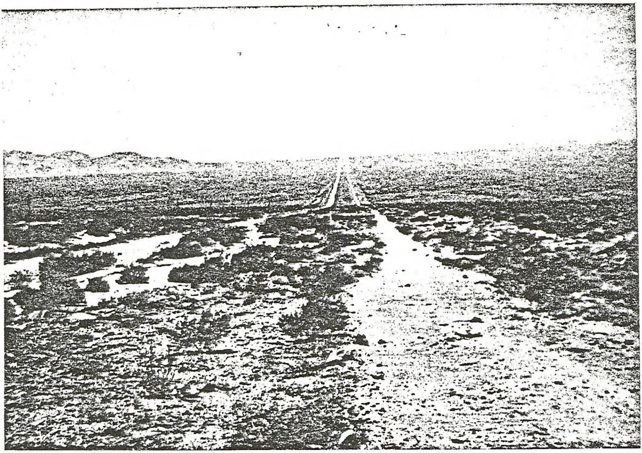

Figure 5-3 . Westward view of the Southern California Gas Co. pipeline right-of-way (Pipeline 1). Old Woman Mountains and Four Corners Pipeline (Pipeline 3) visible in the background.

One method of estimating the total impact of pipeline construction activities on vegetation involves the calculation of an overall CRI for each sample area. This index is simply the ratio of the averaged ground covered by long-lived perennials between disturbance (Transects 3 and 4) and control (Transects 1 and 2). A survey of tabulated overall CRI's indicates that most of the sample sites have values below 1.0. This suggests that vegetation in these areas was adversely impacted by construction and has not recovered to control levels after several years. In contrast, Areas 1, 3, 4, and 10 have overall CRI values that range from 1.22 to $3.73M^2$. Possible explanations for enhancement of vegetation along the pipeline corridor is different for each sample area. In the case of Areas 4 and 10, (dissected fans) vegetation was enhanced by the disruption of desert pavement allowing shrub establishment. Area 1 (alluvial fan) exhibited the highest CRI value for roadside vegetation. This increase in the total cover of long-lived shrubs may have offset the adverse impact on vegetation on the corridor resulting in higher predisturbance levels. Area 3 (river wash) is characterized by scattered wash woodland species of considerable size and extent. In this instance, it was felt that construction crews bypassed a particularly large specimen of Dalea spinosa. Hence, an overall CRI of 3.77 should not be construed as enhancement by construction activities.

As shown in Figure 5-1, there are several sample areas that can be directly compared. These sample pairs include Areas 5/8, 6/7, 11/14, 12/13, and 9/15. Because of the proximity of each pipeline, paired sample areas share the same community and land form types and exposure to similar environmental conditions. Direct comparisons of overall CRI's between paired sample areas allow estimations of vegetative recovery between disturbances.

The overall CRI's calculated for paired Sample Areas 5/8 and 6/7 are not very different. This is not unexpected since the installation completion dates between Pipelines 1 and 2 differ only by 1-5 years. In contrast, Sample Areas 11/14, 12/13, and 9/15 exhibit the largest differences in the overall CRI's. The overall CRI values vary from 13 percent to

38 percent. These differences may reflect the 14-year installation interval between Pipelines 4 and 5. Shrubs disturbed by earlier construction activities (Pipeline 4) had a longer period of recovery than companion sample areas (Pipeline 5). This additional period of regrowth and establishment contributed to the increased ground cover of long-lived perennial shrubs.

Species Diversity

Table 5-26 presents an analysis of dominance, species richness, and evenness measures for transects and sample areas. Transects within each sample area are compared directly by calculating the proportional difference between disturbance transects (e.g., road edge) and adjacent controls.*

Direct comparison between disturbance transects and controls suggest an increasing trend in dominance. This implies that road edge and corridor vegetation are in general less diverse than respective controls. Possible exception to this general observation includes Sample Areas 2-4, 8, 12 and 13. In these areas, the proportional differences are negative indicating that dominance is lower for disturbance transects than controls. This suggests that diversity is higher for road edge and corridor vegetation. This increased diversity is the result of an increase in the number of short-lived species such as *Hymenoclea salsola*, *Euphorbia polycarpa*, and *Eriogonium inflatum*, rather than long-lived perennial shurbs.

Species richness for road edge and corridor vegetation shows a general decreasing trend in the number of species present. Road edge vegetation shows a species reduction from 9.1 percent to 45.5 percent; corridor vegetation shows a species reduction from 11.1 percent to 45.5 percent.

The computed evenness components for control transects show a broad range of values that varies from 26.7 percent to 55.6 percent of the maximum possible diversity. When controls are compared to road edge and corridor vegetation there is a general decrease in the evenness component.

*For convenience, control diversity values were averaged.

Table 5-26. ANALYSIS OF DIVERSITY FOR ALL TRANSECTS WITHIN EACH PIPELINE SAMPLE AREA

SAMPLE AREA	DIVERSITY MEASURE	TRANSECT				CONTROL AVERAGE	PROPORTIONAL CHANGE	
		1*	2*	3*	4*	1+2	3	4
1	Dominance	.385	.704	.631	.710	.545	.159	.304
	Richness	7	3	5	3	5	.000	-.400
	Evenness	.343	.457	.314	.468	.400	-.215	.170
2	Dominance	.698	.844	.474	.823	.771	-.385	.067
	Richness	6	3	5	4	4.5	.111	-.111
	Evenness	.226	.307	.306	.295	.267	.448	.107
3	Dominance	.655	.723	.634	.574	.689	-.080	-.167
	Richness	4	4	3	4	4	-.250	.000
	Evenness	.339	.330	.507	.404	.335	.516	.208
4	Dominance	.485	.657	.551	.443	.571	-.035	-.224
	Richness	3	3	4	4	3	.333	.333
	Evenness	.640	.472	.443	.545	.556	-.203	-.020
5	Dominance	.617	.663	.735	.848	.640	.148	.325
	Richness	6	5	5	3	5.5	-.091	-.455
	Evenness	.265	.283	.350	.387	.274	.273	.407
6	Dominance	.313	.129	.228	.484	.221	.032	1.190
	Richness	15	17	14	9	16	-.125	-.438
	Evenness	.196	.393	.182	.215	.295	-.382	.270
7	Dominance	.313	.129	.486	.666	.221	1.200	2.014
	Richness	15	17	9	8	16	-.438	-.500
	Evenness	.196	.393	.222	.182	.295	-.246	-.283

Table 5-26. ANALYSIS OF DIVERSITY FOR ALL TRANSECTS WITHIN EACH PIPELINE SAMPLE AREA (Continued)

SAMPLE AREA	DIVERSITY MEASURE	TRANSECT				CONTROL AVERAGE	PROPORTIONAL CHANGE	
		1*	2*	3*	4*	1+2	3	4
8	Dominance	.617	.663	.642	.512	.640	.003	-.200
	Richness	6	5	4	3	5.5	-.273	-.455
	Evenness	.265	.283	.349	.635	.275	.274	1.318
9	Dominance	.289	.210	.454	.307	.250	.820	.230
	Richness	5	7	7	7	6	.167	.167
	Evenness	.545	.502	.302	.332	.524	-.423	-.366
10	Dominance	.083	.098	.447	.414	.091	3.939	3.575
	Richness	8	9	5	5	7	-.412	-.412
	Evenness	.548	.529	.348	.307	.539	-.354	-.430
11	Dominance	.401	.329	----	.423	.365	---	.159
	Richness	6	7	----	5	6.5	---	-.231
	Evenness	.367	.389	----	.426	.378	---	.127
12	Dominance	.228	.238	.232	.219	.233	.233	-.060
	Richness	9	7	8	6	8	.000	-.250
	Evenness	.402	.523	.409	.625	.463	-.116	.351
13	Dominance	.228	.238	.211	.415	.233	.094	.781
	Richness	9	7	6	7	8	-.250	-.125
	Evenness	.402	.523	.663	.312	.463	.434	.325
14	Dominance	.300	.397	.468	.422	.349	.343	.211
	Richness	7	6	6	5	6.5	-.077	-.231
	Evenness	.455	.396	.331	.451	.426	-.222	.060

Table 5-27. ANALYSES OF BULK DENSITY AND POROSITY ALONG TRANSECTS OF PIPELINE SAMPLE AREAS (n=3)

SAMPLE AREA	BULK DENSITY				PERCENT PORE SPACE			
	Disturbance Type				Disturbance Type			
	Control	Road Edge	Road	Corridor	Control	Road Edge	Road	Corridor
1	1.59	1.50	1.90	1.63	39.96	43.40	28.38	38.33
2	1.66	1.63	1.90	1.86	37.31	38.49	29.35	29.60
3	1.73	1.73	1.78	1.81	34.70	34.72	32.70	31.60
4	1.58	1.50	1.94	1.65	40.34	43.40	26.88	37.60
5	1.73	1.62	1.85	1.75	34.54	38.87	30.35	34.12
6	1.63	1.73	1.85	1.73	38.46	34.72	30.35	34.79
7	1.65	1.54	1.87	1.75	37.74	41.89	29.43	33.96
8	1.64	1.56	1.94	1.60	37.94	41.13	26.50	39.74
9	1.70	1.75	1.87	1.80	35.85	33.96	29.43	32.08
10	1.65	1.73	1.95	1.86	37.74	34.72	26.42	29.81
11	1.67	1.53	1.87	1.89	36.98	42.26	29.43	28.68
12	1.58	1.45	1.75	1.70	40.38	45.28	33.96	35.85
13	1.70	1.68	1.90	1.85	35.85	36.60	28.30	30.19
14	1.62	1.72	1.96	1.78	38.87	35.09	26.04	32.83
15	1.73	1.68	1.78	1.80	34.72	36.60	32.83	32.08

The second study consideration concerns the pattern of successional recovery following disturbance. Until recently, there has been little research on biotic changes that follow disturbance. Shreve (1925) contended that successional change does not happen in desert environments. This contrasts with later work by Wells (1961), Beatley (1965, 1966), and Davidson and Fox (1974) documenting biotic change to disturbance. Vasek et al. (1975a) observed that short-lived perennials (e.g., Hymenoclea salsola and Euphorbia polycarpa) increase in numbers when long-lived perennials (e.g., Larrea tridentata and Ambrosia dumosa) are removed by disturbance. Our observations confirm these findings in the Colorado Desert and may be generalized to other arid environments.

Wells (1961) observed that pioneering plants are characteristic of naturally disturbed areas (e.g., washes). These pioneers are preadapted to situations of periodic disturbance by possessing adaptations of "efficient seed dispersal, celerity of growth, and early maturation." Vasek et al. (1975a) extended this notion by suggesting that long-lived species have some capability as pioneers, and concluded that members of the creosote bush community are adapted in varying degrees to disturbance.

These studies are impartant in establishing that desert vegetation is dynamic, but they fail to speculate on the mechanism of succession. Barbour (1968, 1969) established that seed germination and seedling survival rates for Larrea are rare occurrences in nature. However, we have observed numerous Larrea seedlings at the base of shorter-lived plant species. If germination is enhanced even slightly by the presence of short-lived shrubs, then conceivably there might be a cyclic relationship between long- and short-lived shrubs. This cyclic relationship would be similar to the cycle described by Yeaton (1978) for Larrea and Opuntia leptocaulis. For instance, as short-lived species become established in disturbed areas, seeds of long-lived species might accumulate at their base. Eventually, these seeds germinate and grow. After several years, the shorter-lived species exhaust the subsoil water reserves (Gulman and Mooney 1977) and die, leaving the drought adapted perennials. When longer-lived perennials are removed, or die, leaving an available open space, pioneers are reintroduced; and the cycle is repeated. Admittedly, this mechanism is highly speculative, but the important point to consider is that more work is needed before successional development in arid environments is understood.

The third study consideration concerns the effects of construction on desert soils and habitat recovery. The data indicate that the movement of heavy equipment across desert soils has substantially increased soil bulk density. This implies a reduction of soil porosity or available macropore space (Davidson and Fox 1975). In turn, this decreases the amount of available water the soil can hold at field capacity, and increases the amount of runoff by reduction in soil permeability (Kubota and Williams 1967). These factors may contribute to the long-term effects of construction by impeding seed germination and seedling growth (Lowry, Taylor, and Huck 1970).

These physical soil changes may directly affect the rate of habitat recovery, the types of plants that colonize these areas, and the eventual "character" of the community. At this time, little research has been done to determine the effects of soil compaction on native plants. Until more information is available, an accurate appraisal of habitat recovery becomes uncertain.

Table 5-26. ANALYSIS OF DIVERSITY FOR ALL TRANSECTS WITHIN EACH PIPELINE SAMPLE AREA (Continued)

SAMPLE AREA	DIVERSITY MEASURE	TRANSECT				CONTROL AVERAGE	PROPORTIONAL CHANGE	
		1*	2*	3*	4*	1+2	3	4
15	Dominance	.210	.289	.738	.505	.250	1.958	1.024
	Richness	7	5	7	11	6	.167	.833
	Evenness	.502	.546	.185	.175	.524	-.647	-.666

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Corridor.

This implies that many species are not equally represented in the sample; that is, there are many species with only a few individuals. In Areas 2, 3, 5, 8, and 13 computed evenness components for either road edge or corridor vegetation exceed controls. This implies that disturbance transects in these areas have species that are equally represented.

Soil Analysis

Soil bulk density and percent porosity of samples taken from control, roadedge, road, and corridor soil disturbance types for each sample area is presented in Table 5-27. In general, access roads exhibit the highest bulk density values which range from 1.78 to 1.94 gms cm^{-3}. In terms of percent porosity, access roads have 26 to 32 percent soil pore space. This represents a dramatic decrease in available pore space when compared to controls which have 34 to 40 percent porosity. The second highest observed bulk density was exhibited by the corridor disturbance type which ranged from 1.60 to 1.89 gms cm^{-3} (28 to 38 percent porosity). Both road and corridor bulk density observations contrast with those along the road edge where bulk density is comparatively less than controls. This indicates that the soil is extremely loose without compaction.

Section 6

AN EVALUATION OF POWER TRANSMISSION CONSTRUCTION ON THE VEGETATION AND SOILS OF THE COLORADO DESERT

The principal causes of environmental impact of power transmission lines are the physical events involved in the construction, operation, and maintenance of the lines. These physical events involve: 1) the clearing of access roads along the right-of-way, 2) the assembly of towers, 3) the construction of tower footings, and 4) the stringing of cables between towers. After these activities have ceased, vegetation is permanently destroyed along the access roads, and is temporarily disturbed under the towers and conducting cables.

The assessment of these activities upon the vegetation and soils of arid regions has largely been ignored. At present, available information has dealt exclusively with Mojave Desert vegetation (Vasek et al. 1975b). Accordingly, several power transmission lines located in the Colorado Desert were surveyed to gather needed baseline information on construction and maintenance impacts.

Study Areas

In this study, three power transmission lines were surveyed for potential construction impacts on vegetation and soils. The location of each transmission line and specific study site is shown in Figure 6-1. These power transmission lines were constructed at different times and utilize different construction techniques in their installation. This provides an opportunity to study the combined effects of time and construction impact on recovery.

The first transmission line (Areas 1-10) has its origin at the Devers Generating Station. It travels south entering the northern Colorado Desert through Ward Valley. It turns east at the base of the Eagle Mountains and parallels Interstate 10 reaching an electrical substation south of Desert Hot Springs. This 220 kv line was constructed in 1945-46 (33-34 year time frame) by Southern California Edison Company. It has a right-of-way corridor of 110 feet on either side of the power lines. The steel lattice towers are approximately 110 feet high and rest on concrete pillars. The base dimensions of each tower cover 60 square meters.

The second transmission line (Areas 11 and 12) located in the lower Colorado Desert originates in Blythe and travels southwest over the Chocolate Mountains terminating at the Niland Substation. This 161 kv line was built in 1932, (a 47-year time frame) by the Imperial Municipal Irrigation District. Tower design was of the "H" type with supporting pillars anchored directly into the soil.

The third transmission line (Areas 13 and 14) is located in the lower Colorado Desert near the Arizona-California state line. It originates from Blythe and travels south along Interstate 78 to Knob, California. This 161 kv line was built somewhat earlier in 1950 (29-year time frame) by the U.S. Bureau of Reclamation. The electrical towers are of the "H" design with the supporting pillars firmly anchored directly into the soil.

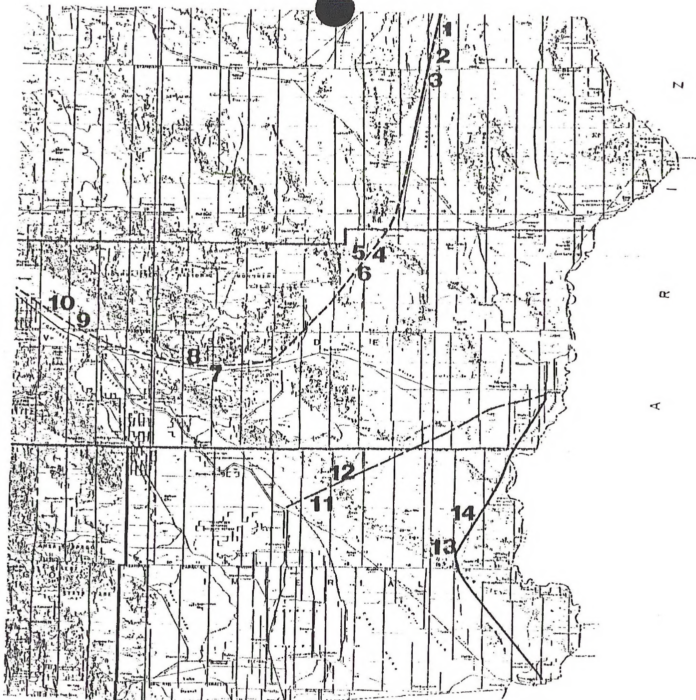

Figure 6-1. LOCATION OF POWER TRANSMISSION SAMPLE AREAS

Methods

Sample sites along each power transmission line were specifically chosen to represent creosote bush scrub and washwoodland community types. The physical characteristics of each sample site is presented in Table 6-1.

Sample site vegetation along each power transmission corridor was assessed using four belt transects, each 100 m long and 2 m wide. Transects 1 and 2 (controls) were located at least 50 m on both sides of the corridor in undisturbed vegetation. Transect 3 was located along the road edge at least 1 m from the berm. Transect 4 was located directly under the conducting wires midway between consecutive towers.

Disturbance under the steel lattice towers was assessed using 10 m x 10 m quadrants under consecutive towers. Under the "H" type towers quadrants were adjusted to a 5 m x 5 m area. Since the areas under each tower do not constitute a linear belt area, the data from all towers was pooled to approximate the 200 square meter area of each belt transect.

Shrubs rooted in each belt transect and quadrant area were sampled by measuring their height (at the center) and width (average of two perpendicular measurements). Ground cover for each species was calculated using the average width to obtain the radius of a circle. Canopy volume was obtained by assuming canopy shape approximated a cylinder.

All transects were compared using community stability and species diversity indices as described in Section 5. Because of site differences (Table 6-1), comparisons were made among transects at each site, rather than between sites.

Soil cores from each transect were obtained using a soil auger (11.1 cm deep and 5.7 cm wide). Soil cores were extracted free, placed into

Table 6-1. POWER TRANSMISSION LINE SAMPLE AREA CHARACTERISTICS

SAMPLE AREA	COMMUNITY TYPE	LANDFORM TYPE	EXPOSURE AND SLOPE	SURFACE STABILITY	SUBSTRATE[a] ORIGIN	SUBSTRATE COMPOSITION	SURFACE[b] HETEROGENEITY	ELEVATION (M)
1	Creosote	Fan	E. facing, level	Stable	Alluvium	Coarse sandy	Low	670
2	Creosote	Dissected fan	E. facing, gradual	Moderate erosion	Alluvium	Coarse sandy to rocky	High	660
3	Undeveloped[c] washwoodland	Wash	E. facing, gradual	High erosion	Alluvium	Coarse sandy	Low	660
4	Creosote	Dissected fan	SW facing	Old erosion	Bedrock	Rocky	Moderate	460
5	Washwoodland	Wash	Level	Active wash	Alluvium	Coarse sandy	Low	170
6	Creosote	Sandy fan	Level	Moderate erosion	Alluvium	Fine sandy	Low	150
7	Creosote	Fan	Level	Low erosion	Alluvium	Coarse sandy to rocky	Low	460
8	Creosote	Fan	SE facing gradual	Low erosion	Alluvium	Coarse sandy	Low	520
9	Creosote	Sandy fan	Level	Moderate erosion	Alluvium	Fine sandy	Low	70
10	Creosote	Fan	SW facing gradual	Low erosion	Alluvium	Coarse sandy to rocky	Moderate	260

Table 6-1. POWER TRANSMISSION LINE SAMPLE AREA CHARACTERISTICS (Continued)

SAMPLE AREA	COMMUNITY TYPE	LANDFORM TYPE	EXPOSURE AND SLOPE	SURFACE STABILITY	SUBSTRATE[a] ORIGIN	SUBSTRATE COMPOSITION	SURFACE[b] HETEROGENEITY	ELEVATION (M)
11	Undeveloped[c] washwoodland	Sandy fan	South facing, gradual	Moderate erosion	Alluvium	Coarse sandy to gradual	Moderate	300
12	Cactus scrub	Hill	SE facing, gradual	Stable	Colluvium	Rocky	Low	390
13	Sparse creosote	Dissected fan	S. facing, gradual	Stable	Alluvium	Rocky	High	300
14	Washwoodland	Wash	Level	Active wash	Alluvium	Coarse to fine sandy	Low	300

[a]Surface stability refers to the presence/absence of lichen-algal crust, pavement, etc.

[b]Surface heterogeneity refers to the frequency of surface irregularities per mile.

[c]Noticeable lack or scarcity of dominant washwoodland species.

plastic bags, and securely sealed. Soil weight was obtained after drying 48 hours at 105°C. Average bulk density was expressed as grams of oven dry soil cm^{-3}. Soil porosity was determined using the equation:

$$\% \text{ pore space} = 100 - (D_b/D_p \times 100)$$

where D_b is bulk density and D_p is the average particle density (2.65 gms cm^{-3}).

Results

Species composition, density, and ground cover for all transect treatments within each sample area are presented in Tables 6-2 through 6-15. Table 6-16 presents an analysis of this data including total ground cover, density, species number, and relative cover of the three functional plant groups.

When total ground cover of disturbance transects are compared to adjacent controls (Transects 1 and 2) certain general patterns are evident. In creosote bush scrub vegetation found on alluvial fans (Areas 1, 2, 4, 6, 7, 9-11, and 13), total ground cover along the road edge is comparatively higher than controls. Active and dissected fans exhibit differences in total cover between the road edge and controls that range from 7.02 to 18.55 square meters. Much of this increase in total cover is provided by long-lived shrubs, particularly Larrea tridentata and Ambrosia dumosa. Short-lived shrubs such as Hymenoclea salsola and Encelia farinosa are minor contributors to total cover. On sandy fans, the increase in total cover along the road edge is comparatively smaller than active or dissected fans, but it is still higher than controls. On this landform type, short-lived shrubs such as Hymenoclea solsola, Palafoxia lineoris, and Encelia farinosa become increasingly important. However, Larrea tridentata and Ambrosia dumosa remain as major contributors to total cover.

Wash woodland vegetation (Areas 3, 5, and 14) exhibit decreases in total cover along the road edge. Since river washes are subject to recurrent disturbances, vegetation established previously may be swept away during seasonal rains. As expected, most of the road edge vegetation consists of short-lived shrubs such as Hymenoclea solsola.

Cactus scrub vegetation (Area 12) exhibits an increase in total cover along the road edge. This increase in vegetative cover is contributed by Larria tridentata, Ambrosia dumosa, Hymenoclea solsola, and Dalea schottii. Stem succulent plants characteristic of this community type are conspicuously absent.

Table 6-2. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 1

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	8.5	2.5	3.5	2.5	5.5	8.52	1.00	10.43	2.03	5.06
Ambrosia dumosa	22.0	14.0	18.0	21.5	23.5	5.09	3.58	8.09	5.47	5.07
Cassia armata	1.0	1.5	0.5	0.5	0.5	0.98	0.62	0.83	0.14	0.28
Thamnosma montana	0.5			0.5	1.0	0.04			0.19	0.17
Lycium spp.	0.5	2.5	0.5			0.57	0.98	0.10		
Hymenoclea salsola	2.5	3.0	1.0	1.0		1.45	1.89	0.26	0.10	
Eriogonum fasiculatum	0.5	1.0		0.5		0.19	0.36		0.14	
Euphorbia polycarpa	62.0	82.0	36.0	46.0	150.0	0.01	0.01	0.01	0.11	T
Dyssodia cooperi	0.5	1.0		1.5		0.02	0.03		0.24	
Ephedra spp.		0.5		0.5	2.0		0.12		0.25	0.93
Opuntia basilaris		0.5					0.01			
Opuntia ramosissima			0.5					0.04		
Acamptopappus sphaerocephalus				0.5	14.5				0.14	3.19
Porphyllum gracile					0.5					0.22
Stipea speciosa					1.0					0.39

T = Trace (less than $0.01 m^2$)
*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-3. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 2

SPECIES NAME	DENSITY					GROUND COVER				
	Transect Number					Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	3.5	1.0	4.5	3.0	3.0	5.38	1.70	6.58	4.25	5.10
Ambrosia dumosa	16.0	17.0	20.5	15.5	15.0	3.61	3.45	4.75	3.68	1.80
Krameria grayi	2.0	1.5	1.5		1.0	0.43	0.52	1.25		0.29
Lycium spp.	0.5					0.25				
Ephedra viridis	1.5	1.5		1.5	2.5	0.24	0.41		0.35	0.70
Ferocactus acanthodes	0.5				0.5	0.08				T
Eriogonum fasiculatum	1.0				1.0	0.40				0.10
Viquiera deltoidea	0.5				2.5	0.14				0.62
Dalea spp.	1.0	2.5		1.5	3.0	0.16	1.73		0.25	0.38
Euphorbia polycarpa	90.0	17.0	22.5			0.01	T	T		
Porophyllum gracile	0.5	0.5		0.5	1.0	0.14	0.08		0.16	0.20
Cassia armata		0.5			0.5		0.06			0.03
Thamnosma montana		0.5			1.5		0.10			T
Opuntia ramosissima		1.0					0.08			
Eriogonium inflatum		0.5			6.5		0.19			2.57
Encelia farinosa		1.0			0.5			0.85		0.10

*Transects: 1, Control; 2, Control; 3, Roa[illegible]ge; 4, Line; 5, Pylon.

Table 6-4. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 3

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5***	1	2	3	4	5
Ambrosia dumosa	1.5	1.5	2.0	0.5		0.08	0.17	0.09	0.04	
Hymenoclea salsola	5.0	5.5	6.5	4.5		12.77	5.98	3.46	2.22	
Encelia farinosa	0.5					0.32				
Euphorbia polycarpa	113.0	258.0	195.0	227.5		0.41	0.43	0.01	0.03	
Lycium spp.		0.5					0.10			
Ditaxis neomexicana		0.5					T			
Ditaxis serrata			0.5					0.01		
Cassia armata				0.5					0.17	
Acacia greggii				0.5					2.86	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

**Pylons outside of river wash area.

Table 6-5. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 4

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	2.0	2.0	6.0	2.0	1.0	2.17	0.87	14.64	0.84	1.08
Ambrosia dumosa	1.0	4.0	12.5	1.0	0.5	0.29	0.67	1.94	0.12	0.13
Euphorbia polycarpa	26.0	3.5	57.5	5.0	9.0	0.09	0.02	0.09	T	0.04
Eriogonium inflatum	2.5		0.5			1.72		0.32		
Fagonia laevis	2.0	0.5	11.0	2.5		0.24	0.01	1.38	0.41	
Krameria parvifolia			3.5					2.92		
Bebbia juncea			0.5					0.08		
Viquiera deltoidea			0.5					0.04		
Ditaxis serrata			8.5	0.5				0.17	T	
Allonia incarnata				1.0					0.01	
Stephanomeria pauciflora				0.5					0.14	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-6. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 5

SPECIES NAME	DENSITY					GROUND COVER				
	Transect Number					Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Dalea spinosa	0.5					0.25				
Olneya testota	1.0	0.5				30.55	16.59			
Peucephyllum schottii	0.5	0.5				0.12	0.19			
Euphorbia polycarpa	1.5	28.5				0.08	0.01			
Larrea tridentata		0.5	0.5	0.5	6.0		2.26	2.26	1.14	5.44
Cercidium floridum		0.5		1.0			2.28		26.96	
Brandegia bigelovii		0.5					0.39			
Hymenoclea salsola		0.5	0.5	0.5	5.0		0.77	1.57	0.06	0.44
Ambrosia dumosa				0.5	2.5				0.19	0.68
Acacia greggii				1.5					7.20	
Hyptis emoryi				1.0					6.93	
Olneya testota				0.5					20.36	
Bebbia juncea				0.5					0.05	
Opuntia acanthocarpa					0.5					0.01
Krameria parvifolia					0.5					0.22
Palafoxia linearis					0.5					0.03
Allionia incarnata					0.5					0.05

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-7. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 6

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	2.0	3.5	1.5	0.5	1.0	4.52	3.64	2.44	0.05	1.65
Ambrosia dumosa	26.0	10.5	12.5	5.5	27.0	3.40	1.10	2.12	0.83	2.60
Hilaria rigidia	2.5	5.5	5.0	3.5	4.5	0.08	1.91	0.18	0.55	0.70
Hymenoclea salsola	1.0	1.0			1.0	0.31	0.15			0.15
Euphorbia polycarpa	5.5		0.5			0.01		0.02		
Ditaxis serrata		8.0		0.5	1.5		0.02		T	0.02
Palafoxia linearis			1.5		2.0			0.36		0.32
Croton californicus			2.0		0.5			1.05		0.04
Dalea emoryi			1.5	10.0	1.5			2.44	1.83	0.47

*Transect: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-8. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 7

SPECIES NAME	DENSITY					GROUND COVER				
	Transect Number					Transect Number				
	1*	2*	3*	4 *	5**	1	2	3	4	5*
Larrea tridentata	1.0	3.5	1.5	1.0		1.05	5.65	2.89	1.20	
Ambrosia dumosa	14.5	18.5	23.0	12.5		1.43	1.65	5.40	1.65	
Palafoxia linearis	3.5	2.5	39.0	2.5		0.76	0.38	1.68	1.60	
Ditaxis californica	2.0	2.0	2.5	3.5		0.02	0.03	0.16	0.07	
Hymenoclea salsola	60.0	32.5	11.5	65.0		3.42	1.89	2.52	2.79	
Encelia farinosa	2.5			1.5		2.25			1.75	
Eriogonium inflatum	4.5	6.5	6.5	6.5		2.49	2.90	3.44	2.56	
Euphorbia polycarpa	283.0	785.0	740.0	296.0		0.02	0.68	0.69	0.03	
Krameria grayi	0.5	0.5				0.05	0.19			
Opuntia bigelovii	1.0	2.5	2.0	0.5		0.07	0.13	0.03	0.08	
Fouquieria splendens	0.5		0.5	1.0		2.26		0.83	2.01	
Bebbia juncea	0.5	1.0		0.5		0.80	0.27		0.65	
Sarcostemma hirtellum	1.0	0.5	1.5	1.0		0.20	0.10	1.83	0.18	
Dalea schottii	1.0	1.0	1.5	0.5		0.92	2.36	8.07	0.48	
Olneya testota			0.5					0.83		
Opuntia ramossima			1.5					0.73		
Fagonia laevis			2.5					0.46		

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

**Not sampled.

Table 6-9. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 8

SPECIES NAME	DENSITY					GROUND COVER				
	Transect Number					Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	1.0	3.5	1.5	2.0	2.5	0.99	5.11	2.89	1.11	2.40
Ambrosia dumosa	15.0	18.5	25.0	10.5	3.0	1.32	1.59	6.33	1.52	0.69
Krameria grayi	0.5	0.5				0.25	0.19			
Opuntia ramosissima	1.5		2.5	1.5		0.25		0.64	0.11	
Opuntia bigelovii	1.0	3.0	2.0	0.5		0.04	0.05	0.03	0.05	
Fouquieria splendens	0.5		0.5			1.57		0.88		
Krameria spp.	0.5					0.03				
Opuntia echinocarpa	0.5	0.5		0.5		0.06	0.14		0.06	
Hymenoclea salsola	37.5	33.0	11.5	20.0	6.0	4.88	1.74	2.01	4.31	2.76
Encelia farinosa	2.5			0.5	7.0	1.87			0.39	3.96
Palafoxia linearis	3.5	3.0	14.0	7.5	4.0	0.68	0.39	1.88	1.56	0.55
Dalea schottii	1.0	1.0	1.5	1.5		0.92	2.30	6.52	1.29	
Euphorbia polycarpa	285.0	711.5	739.5	867.5	25.0	0.03	0.06	0.01	0.26	T
Eriogonium inflatum	4.5	32.0	8.5	0.5	31.5	4.88	2.31	4.30	0.61	5.79
Sarcostemma hirtellum	1.0	0.5	1.5	1.0		0.25	0.10	1.83	0.30	
Ditaxis serrata	1.5				17.0	0.01				0.11
Fagonia laevis	1.0	4.5	2.5	2.5		0.11	0.49	0.46	0.87	
Ditaxis californica	0.5	2.0	1.5			T	0.02	0.15		

Table 6-9. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 8 (Continued)

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Echinocereus engelmannii		0.5					0.06			
Bebbia juncea		1.0		0.5	2.5		0.27		0.10	0.77
Stephanomeria pauciflora		0.5					T			
Ditaxis neomexicana		0.5	1.0	0.5			T	0.01	0.04	
Hyptis emoryi			1.0					2.87		
Olneya testota			0.5		2.0			0.88		1.92
Simmondsia chinensis				1.0					0.50	
Allionia incarnata				0.5					T	
Ditaxis lanceolata				1.0					0.02	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-10. TRANSECT SPECIES COMPOSITION, DENSITY AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 9

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	1.5	0.5		0.5		7.10	4.15		2.17	
Ambrosia dumosa	0.5	1.5		2.0	0.5	1.14	4.20		1.49	0.77
Palefoxia linearis	0.5		0.5		2.0	T		T		7.76
Croton californicus	2.0			3.0	0.5	0.83			1.34	0.25
Petalonyx thurberi	1.5	1.0	8.5	1.0	0.5	0.25	0.02	2.07	1.65	2.76
Coldenia plicata	5.0		1.0	2.0		T		0.52	0.80	
Hymenoclea salsola		2.0	2.0	1.5	0.5		5.22	4.82	0.94	0.32
Atriplex canescens	1.0	5.0	5.5		1.0	0.06	0.36	0.29		0.01
Dalea spinosa			0.5					3.53		
Dalea emoryi			0.5					1.20		
Encelia farinosa				0.5					1.42	
Euphorbia polycarpa				5.5					0.02	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-11. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 10

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	3.5	2.5	3.0	2.5	2.5	2.24	5.13	7.21	1.76	3.51
Ambrosia dumosa	9.5	18.5	20.5	21.0	25.0	1.37	2.93	4.13	1.93	2.83
Krameria parvifolia	1.0	1.0	1.0	0.5	0.5	0.69	1.37	0.95	1.01	0.75
Encelia farinosa	2.5	2.5	3.5	1.0		0.42	1.22	1.67	1.67	
Eriogonium inflatum	1.0	7.0	17.0	6.5	2.0	0.36	3.81	6.31	2.31	2.51
Dalea schottii		0.5					0.04			
Euphorbia polycarpa		92.5			103.0		0.40			T
Ferocactus acanthodes			0.5					0.01		

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-12. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 11

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Hymenoclea salsola	2.0	0.5	4.0	2.5	0.5	2.07	0.03	2.02	2.99	0.15
Encelia farinosa	1.0	1.0	0.5	1.0	1.0	1.39	1.23	0.32	0.13	1.03
Euphorbia polycarpa	8.0	8.0	15.5	68.0	7.5	0.07	0.04	0.12	0.03	0.02
Sarcostemma hirtellum	0.5					0.10				
Nicotiana trigonophylla	0.5					0.14				
Stephanomeria pauciflora	0.5					0.02				
Opuntia bigelovii		1.0					0.06			
Atriplex hymenolytra		4.0	2.0	3.0	2.0		1.73	1.46	1.25	1.84
Hyptis emoryi		1.0	0.5				1.01	2.08		
Bebbia juncea		0.5	1.0				0.77	1.32		
Lycium spp.			1.0	1.5				0.25	0.92	
Ambrosia dumosa				0.5					0.04	
Ditaxis lanceolata				0.5					0.05	

*Transect: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-13. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 12

SPECIES NAME	DENSITY					GROUND COVER				
	Transect Number					Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	1.5	2.5	1.5	1.5		1.04	3.54	3.43	0.61	
Ambrosia dumosa	1.0	1.0	4.0	1.0	0.5	0.38	0.38	1.17	0.44	0.28
Opuntia bigelovii	18.5	24.5	0.5	0.5	0.5	1.17	1.12	0.01	0.01	0.01
Fouquieria splendens	0.5					2.26				
Echinocereus engelmannii	1.5	0.5		0.5	0.5	0.22	0.06		0.06	0.05
Trixis californica	1.0	2.0				1.01	0.07			
Bebbia juncea	1.0	0.5		0.5		0.67	0.02		0.08	
Encelia farinosa	1.0	1.0	3.0	3.5		0.13	0.73	2.13	0.98	
Euphorbia polycarpa	49.0	12.5	28.0	47.5	52.0	0.01	0.40	T	0.01	T
Hyptis emoryi		1.5	1.0				2.10	6.89		
Opuntia munzii		0.5	0.5				0.25	T		
Hymenoclea salsola		1.5	9.0	5.5	1.0		0.98	12.76	0.02	0.75

Table 6-13. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 12 (Continued)

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Dalea schottii		0.5	0.5	0.5			2.08	1.57	0.57	
Physalis crassifolius		0.5					0.03			
Cercidium floridum			0.5					4.02		
Eriogonium inflatum			1.0					0.33		
Stephanomeria pauciflora			1.5					0.33		
Hybiscus denudatus			0.5					0.19		

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-14. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 13

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Larrea tridentata	2.0	1.5	2.0	0.5	0.5	3.82	1.91	3.58	1.14	0.85
Ambrosia dumosa	4.5	5.0	11.0	6.5		2.44	1.84	4.80	1.76	
Hilaria rigidia	2.0	3.5	0.5	1.0	0.5	2.28	2.77	0.14	0.26	0.25
Krameria parvifolia	0.5					0.02				
Euphorbia polycarpa	9.5	16.5	102.5	51.0	65.0	0.01	T	0.41	0.01	0.02
Calliandra eriophylla	2.0	5.5	3.0	3.0	0.5	1.58	5.09	1.20	2.72	0.53
Ditaxis serrata			2.0					0.01		
Erioneron pulchellum				0.5					T	
Coldenia canescens				0.5					0.04	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-15. TRANSECT SPECIES COMPOSITION, DENSITY, AND GROUND COVER FOR POWER TRANSMISSION SAMPLE AREA 14

SPECIES NAME	DENSITY Transect Number					GROUND COVER Transect Number				
	1*	2*	3*	4*	5*	1	2	3	4	5
Dalea spinosa	22.5			4.0	2.0	2.91			0.11	0.25
Larrea tridentata		0.5		0.5	0.5		4.81		1.90	1.83
Lycium spp.		1.0					5.99			
Acacia greggii		1.0		2.5	1.0		0.49		0.02	0.53
Hymenoclea salsola		3.0		7.0	6.5		7.29		10.91	9.83
Ambrosia dumosa				0.5					0.19	
Cercidium floridum				0.5					1.42	
Bebbia juncea				0.5					0.25	
Euphorbia polycarpa				0.5					T	
Stephanomeria pauciflora				2.5					0.49	
Nicotiana trigonophylla				0.5					0.03	

*Transects: 1, Control; 2, Control; 3, Road Edge; 4, Line; 5, Pylon.

Table 6-16. ANALYSIS OF TRANSECT INFORMATION FOR ALL SAMPLE AREAS ALONG POWER TRANSMISSION LINES

SAMPLE AREA	TRAN. NO.	TOTAL GROUND COVER	DENSITY PER 100 M^2	NO. SPECIES	PERCENT GROUND COVER		
					Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
1	1	16.85	98.0	9	90.15	9.79	0.06
	2	8.58	108.5	10	73.31	26.46	0.12
	3	19.74	60.5	7	98.63	1.32	0.00
	4	8.81	75.0	10	91.71	7.04	1.25
	5	15.30	198.5	9	75.16	24.84	0.00
2	1	10.84	117.0	11	92.16	7.75	0.09
	2	8.32	43.5	11	75.84	24.16	0.00
	3	13.43	50.0	4	93.68	6.32	0.00
	4	8.69	22.0	5	95.28	4.72	0.00
	5	11.90	38.5	13	66.64	33.36	0.00
3	1	13.58	120.0	4	0.59	96.39	3.02
	2	6.68	266.0	5	4.04	89.52	6.44
	3	3.57	204.0	4	2.52	97.20	0.28
	4	5.32	233.5	5	57.52	41.73	0.56
	5	-----	-----	--	-----	-----	----

Table 6-16. ANALYSIS OF TRANSECT INFORMATION FOR ALL SAMPLE AREAS ALONG POWER TRANSMISSION LINES (Continued)

SAMPLE AREA	TRAN. NO.	TOTAL GROUND COVER	DENSITY PER $100\ M^2$	NO. SPECIES	PERCENT GROUND COVER		
					Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
4	1	4.50	33.5	5	54.67	43.56	1.70
	2	1.56	10.0	4	98.72	0.64	1.28
	3	21.58	100.5	9	90.36	9.22	0.42
	4	1.52	12.5	7	63.16	36.84	0.00
	5	1.25	10.5	3	96.80	0.00	3.20
5	1	31.00	3.5	4	99.74	0.00	0.23
	2	23.08	31.5	7	96.62	3.34	0.04
	3	3.57	1.0	2	2.52	97.20	0.28
	4	62.84	6.0	8	99.83	0.17	0.00
	5	6.87	15.5	7	92.58	7.42	0.00
6	1	8.30	37.0	5	96.14	3.73	0.12
	2	6.82	28.5	5	97.36	2.49	0.00
	3	8.60	24.5	7	55.12	44.77	0.23
	4	3.26	20.0	5	43.56	56.44	0.00
	5	5.95	39.0	8	83.36	16.81	0.00

Table 6-16. ANALYSIS OF TRANSECT INFORMATION FOR ALL SAMPLE AREAS ALONG POWER TRANSMISSION LINES (Continued)

SAMPLE AREA	TRAN. NO.	TOTAL GROUND COVER	DENSITY PER 100 M^2	NO. SPECIES	PERCENT GROUND COVER		
					Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
7	1	15.74	375.5	14	41.80	58.07	0.13
	2	16.23	856.0	12	63.16	32.65	4.19
	3	29.56	834.0	14	63.53	34.14	2.33
	4	15.05	392.0	13	40.33	59.47	0.20
	5	-----	-----	--	-----	-----	----
8	1	18.14	358.5	18	24.86	74.97	0.17
	2	14.84	816.5	18	48.18	51.35	0.40
	3	31.71	814.5	16	45.85	54.15	0.00
	4	13.10	919.5	18	25.57	72.44	1.98
	5	18.95	100.5	10	26.49	73.51	0.00
9	1	9.39	12.0	7	88.39	11.61	0.00
	2	13.95	10.0	5	62.44	37.56	0.00
	3	12.44	18.5	7	30.71	69.29	0.00
	4	9.83	16.0	8	37.23	62.56	0.20
	5	11.86	5.0	6	6.58	93.42	0.00

Table 6-16. ANALYSIS OF TRANSECT INFORMATION FOR ALL SAMPLE AREAS ALONG POWER TRANSMISSION LINES (Continued)

SAMPLE AREA	TRAN. NO.	TOTAL GROUND COVER	DENSITY PER 100 M^2	NO. SPECIES	PERCENT GROUND COVER Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
10	1	5.07	17.5	5	84.62	15.58	0.00
	2	14.80	124.5	8	63.39	34.05	2.69
	3	21.12	47.0	7	58.24	41.76	0.00
	4	8.66	31.5	5	54.16	45.96	0.00
	5	9.60	30.0	5	73.85	26.15	0.00
11	1	3.78	12.5	6	0.00	98.15	1.85
	2	4.87	16.0	7	57.49	41.48	0.82
	3	7.56	77.0	7	50.00	48.41	1.59
	4	5.39	24.5	7	40.82	58.63	0.56
	5	3.04	11.0	4	60.53	38.82	0.66
12	1	6.87	75.0	9	88.36	11.64	0.15
	2	11.75	49.0	13	64.00	32.60	3.40
	3	32.82	51.5	13	47.26	52.74	0.00
	4	2.77	61.0	9	40.07	59.21	0.36
	5	1.09	54.5	5	31.19	68.81	0.00

Table 6-16. ANALYSIS OF TRANSECT INFORMATION FOR ALL SAMPLE AREAS ALONG POWER TRANSMISSION LINES (Continued)

SAMPLE AREA	TRAN. NO.	TOTAL GROUND COVER	DENSITY PER 100 M^2	NO. SPECIES	PERCENT GROUND COVER Long-Lived Shrubs	Short-Lived Shrubs	Pioneer Herb.
13	1	10.15	20.5	6	84.33	15.57	0.10
	2	11.61	32.0	5	56.16	43.84	0.00
	3	10.13	121.0	6	84.11	11.85	4.05
	4	5.92	63.0	7	53.38	46.45	0.17
	5	1.65	66.5	4	66.67	32.12	1.21
14	1	2.90	22.5	1	100.00	0.00	0.00
	2	18.58	5.5	4	60.76	39.24	0.00
	3	0.00	0.0	0	0.00	0.00	0.00
	4	15.31	19.0	10	23.71	76.29	0.00
	5	12.44	9.5	3	20.98	79.02	0.00

Under the central conducting wires, total ground cover of creosote vegetation is reduced compared to controls. Area 11 is the only sample area that exhibits a slight increase in total cover. Since they are no replicate transect information available, this increase in total cover may represent sampling error rather than the direct effects of the transmission wires. Cactus scrub vegetation on Area 12 also exhibited a decrease in total ground cover. However, the area immediately below the wires was severely disturbed by heavy equipment during construction. This may have contributed to the decrease in relative cover by long-lived shrubs and an increase in short-lived shrubs.

Table 6-17 analyzes the absolute ground cover for all long-lived perennial shrubs encountered in each transect and sample area. To minimize the cover variability between paired controls, the controls were averaged. As shown, the averaged control cover estimates range from 0.18 to 26.62 m^2. This is indicative of large vegetative variation between sample areas. Since this inherent variability may be due to environmental and site specific differences (Table 6-1), comparisons are restricted to transects within sample areas rather than among sample areas.

The Cover Ratio Index (CRI) allows direct comparisons between transects within each sample area. The CIR is computed as the ratio of disturbance Transects 3, 4, and 5 to the pooled controls. All CIR's greater than 1.0 indicate positive enhancement and increased stability of long-lived vegetation; conversely, CIR's below 1.0 are indicative of negative interaction.

Road edge variation in creosote bush scrubs (Areas 1, 2, 4, 7, 8, 10-13) have CRI's above 1.0. This indicates positive enhancement of long-lived perennial growth along the road edge. In contrast, Areas 6 and 9 located on sandy fans (Figure 6-2) have CRI's 0.65 and 0.45 m^2, respectively. In these areas, road edge long-lived perennial vegetation is substantially smaller in size.

Table 6-17. ANALYSIS OF LONG-LIVED GROUND COVER FOR POWER TRANSMISSION SAMPLE AREAS

SAMPLE AREA	LONG-LIVED COVER TRANSECT					COVER INDEX RATIOS TRANSECT				
	1 Control	2 Control	3 Road Edge	4 Under Lines	5 Under Pylons	1+2	3/1+2	4/1+2	5/1+2	3+4+5/1+2
1	15.19	6.29	19.47	8.08	11.50	10.74	1.81	0.75	1.07	1.21
2	9.99	10.24	18.49	6.31	7.93	10.12	1.83	0.62	0.78	1.08
3	0.06	0.27	0.09	3.06	-----	0.18	0.50	17.00	----	5.83
4	2.46	1.54	19.50	0.96	1.21	2.00	9.75	0.48	0.61	3.61
5	30.93	22.30	2.26	62.78	6.36	26.62	0.08	2.36	0.24	0.89
6	7.89	6.64	4.74	1.42	4.96	7.31	0.65	0.19	0.68	0.51
7	6.58	10.25	18.78	6.07	-----	8.32	2.26	0.73	----	1.00
8	4.51	7.15	14.54	3.35	5.02	5.83	2.49	0.57	0.86	1.31
9	8.30	8.71	3.82	3.66	0.78	8.50	0.45	0.43	0.09	0.32
10	4.29	9.42	12.30	4.69	7.09	6.61	1.86	0.71	1.07	1.21
11	0.00	2.80	3.74	2.20	1.84	0.70	5.40	3.14	2.63	3.72
12	6.07	7.52	15.51	1.11	0.34	6.80	2.28	0.16	0.05	0.83
13	8.56	6.52	8.52	3.16	1.10	7.54	1.13	0.42	0.15	0.56
14	2.90	11.29	0.00	3.63	2.61	7.10	0.00	0.51	0.37	0.29

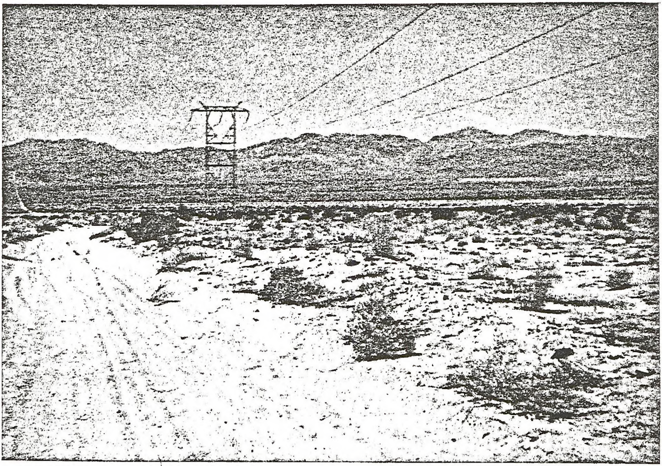

Figure 6-2. View along the Southern California Edison Co. power transmission line near Sample Area 6.

Most sample areas have CRI that are slightly below 1.0. This suggests that vegetation was only moderately affected by construction. It is expected that vegetation will eventually recover to predisturbance levels. In contrast, Areas 3, 5, and 11 have CRI ratios that are considerably above 1.0 suggesting enhancement of vegetation directly under the line. On closer inspection, these areas correspond to river wash and sandy fan areas which are subject to periodic seasonal disturbances. In these situations, plant clumping might be expected to occur. Hence, it can be safely assumed that comparatively high CRI ratios are the result of clumping, rather than enhancement of vegetation by power transmission lines.

Vegetation directly beneath electrical towers exhibit CRI ratios that indicate moderate to severe disturbance. Sites 1, 10, and 11 exhibit some vegetative enhancement due to tower construction and presence. It is hypothisized that rain drip from the steel lattice type towers encouraged faster vegetative recovery rates. Power transmission towers of the "H" type did not exhibit increased stability. Presumably, the installation process required heavy drilling rigs which damaged the immediate area, and that the towers, once installed, did not intercept rainfall to any appreciable degree.

The total impact of power transmission construction may be assessed for all sample areas by determining the overall CRI ratios calculated as average CRI for disturbance transects and then dividing by the average control CRI. The overall CRI ratio for all sample areas was quite high ranging from 0.29 to 5.83. The higher overall CRI's (above 1.0) were due primarily to road edge enhancement ("road edge effect") that counterbalanced the adverse effects of tower installation and vegetation damage under the central lines. (Figure 6-3).

Diversity

Table 6-18 presents an analysis of dominance, richness, and eveness measures for transects and sample areas. Comparisons are made among

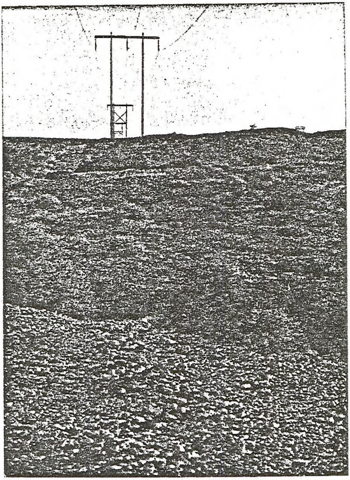

Figure 6-3 . Sample Area 13 along power transmission line built by the U.S. Bureau of Reclamation. Note the graded condition under the power lines.

Table 6-18. ANALYSES OF DIVERSITY MEASURES FOR SAMPLE AREAS ALONG POWER TRANSMISSION LINES

SAMPLE AREA	DIVERSITY MEASURE	TRANSECT NUMBER					PROPORTIONAL CHANGE		
		1	2	3	4	5	3	4	5
1	Dominance	.456	.588	.452	.457	.590	-.134	-.125	.130
	Richness	9	10	7	10	9	-.260	.050	-.050
	Evenness	.233	.163	.300	.206	.184	.515	.040	-.071
2	Dominance	.610	.305	.367	.502	.195	-.198	.097	-.573
	Richness	11	11	5	5	13	-.550	-.550	.180
	Evenness	.143	.264	.500	.322	.333	1.459	.582	.636
3	Dominance	.888	.941	.915	.950	[a]	0.000	.039	----
	Richness	4	5	4	5	---	-.111	.111	----
	Evenness	.278	.211	.271	.209	---	.108	-.145	----
4	Dominance	.610	.289	.364	.210	.719	-.190	-.533	.500
	Richness	5	4	9	7	3	1.000	.556	.333
	Evenness	.308	.727	.293	.510	.365	-.434	-.014	-.295
5	Dominance	.191	.817	---	.076	.260	---	-.849	-.484
	Richness	4	7	---	8	7	---	.455	.273
	Evenness	.656	.158	---	.600	.439	---	.474	.079

Table 6-18. ANALYSES OF DIVERSITY MEASURES FOR SAMPLE AREAS ALONG POWER TRANSMISSION LINES (Continued)

SAMPLE AREA	DIVERSITY MEASURE	TRANSECT NUMBER					PROPORTIONAL CHANGE		
		1	2	3	4	5	3	4	5
6	Dominance	.518	.255	.306	.341	.493	-.208	-.118	.276
	Richness	5	5	7	5	8	.400	.000	.600
	Evenness	.365	.728	.408	.526	.230	-.253	-.038	-.579
7	Dominance	.594	.843	.790	.598	---	.100	-.168	---
	Richness	14	12	14	13	---	.076	.000	---
	Evenness	.116	.098	.089	.125	---	-.168	.168	---
8	Dominance	.645	.763	.826	.891	.197	.173	.266	-.720
	Richness	18	18	16	18	10	-.111	.000	-.444
	Evenness	.084	.072	.075	.062	.484	-.38	-.205	5.205
9	Dominance	.210	.289	.297	.173	.156	.190	-.307	-.375
	Richness	7	5	7	8	6	.167	.333	.000
	Evenness	.502	.545	.400	.558	.476	-.236	.066	-.091
10	Dominance	.343	.576	.325	.486	.633	-.293	.058	.378
	Richness	5	8	7	5	5	.077	-.231	-.231
	Evenness	.515	.211	.411	.385	.306	.132	.061	-.157

Table 6-18. ANALYSES OF DIVERSITY MEASURES FOR SAMPLE AREAS ALONG POWER TRANSMISSION LINES (Continued)

SAMPLE AREA	DIVERSITY MEASURE	TRANSECT NUMBER					PROPORTIONAL CHANGE		
		1	2	3	4	5	3	4	5
11	Dominance	.423	.304	.426	.782	.459	.172	1.151	.263
	Richness	6	7	7	7	4	.077	.077	-.385
	Evenness	.312	.378	.293	.176	.381	-.151	-.489	.104
12	Dominance	.486	.316	.332	.616	.909	-.177	.536	1.267
	Richness	9	13	13	9	5	.182	-.182	-.545
	Evenness	.216	.214	.204	.169	.204	-.051	-.214	-.051
13	Dominance	.274	.323	.726	.666	.954	1.432	1.231	2.196
	Richness	6	5	6	7	4	.091	.273	-.273
	Evenness	.532	.579	.225	.204	.250	-.595	-.633	-.550
14	Dominance	1.000	.310	---[b]	.198	.417	---	-.698	-.363
	Richness	1	4	---	10	4	---	3.000	0.600
	Evenness	1.000	.566	---	.383	.400	---	-.511	-.489

[a]Pylons outside of landform type.

[b]Maintenance road nonexistent.

transects by calculating the proportional difference between disturbance transects (3, 4, and 5) and the average value for controls (1 and 2).

Dominance values for road edge transects present a complex picture. In relation to controls, road edge dominance in alluvial fan situations (Areas 1 and 10) is lower than controls. This implies that road edge vegetation is more diverse with greater numbers of individuals in more species (eveness component). Sample 8, on the other hand, has road edge vegetation that exhibits 27.3 percent greater dominance than controls (less diverse). For dissected fans (Areas 2 and 4) road edge vegetation and controls, the proportional difference is -19 percent suggesting roadside vegetation is more diverse. These sites were disturbed some 34 years ago, and vegetation along the roadside has recovered to predisturbance levels. However, Area 13 is considerably less diverse along the road edge with 143 percent dominance despite the 47-year recovery period following disturbance. This area is situated on well-developed desert pavement area, has very low productive potential (Table 6-2), and will require many years before road edge vegetation recovers.

The road edge dominance values for hilly areas (Area 12) are comparatively more diverse than controls. Along the road edge there is an influx of additional species, notably _Larrea tridentata_ and _Hymenoclea salsola_ (Table 6-2). Increased diversity and richness are the result of a pronounced road edge effect.

Diversity measures for areas under the power transmission lines offer a different recovery pattern than road edge vegetation. In Sample Areas 2, 7, 8, 10, 11, and 13 have dominance values that are greater than adjacent controls. This suggests that these areas are less diverse. In contrast, Areas 1, 4, and 6 are more diverse than controls. A partial explanation for the reduction in diversity beneath the conducting lines may include localized trampling that occurred during the line installation process. It has been observed that certain areas (Areas 12 and 13) have noticeable tire imprint markings directly beneath the lines. Apparently, heavy trucks have driven over the surface damaged many perennial species that still have not recovered after 29 or 47 years.

In general, the vegetation under electrical towers is less diverse than adjacent controls. The area directly beneath towers was apparently cleared of vegetation resulting in a loss of diversity, richness, and evenness (Figure 6-4).

Soil Analysis

Along power transmission lines, five soil disturbance types were recognized: 1) control, 2) the road edge, 3) beneath the central conducting wires, 4) beneath or along the towers, and 5) along the access roads. An analysis of soil samples taken from each disturbance type includes bulk density and percent porosity presented in Table 6-19.

Comparison of inter-transect bulk density and soil porosity suggests general patterns that are dependent on disturbance and landform types. In general, access roads for all landform types exhibited the highest bulk density measurements. Typical measurements ranged from 1.79 to 1.95 gm cm^{-3}. This corresponded to available pore space of 28 to 32 percent porosity. The second highest bulk density compared to controls was recorded directly under the electrical towers situated on active and dissected fans. In sandy fan landforms, bulk density was usually higher than adjacent controls. However, tower bulk density measurements for all landforms was substantially lower than those on access roads. The third highest bulk density measurements were recorded directly under the central wires for active and alluvial fans. In the case of dissected fans, bulk density measurements were higher approaching road bulk density. The lowest bulk densities were recorded along the road edge (berm) for all landform types. Compared to controls, road edge bulk densities were considerably lower indicating that road edge soil was not compacted and remained quite loose.

Hilly, or terraced landform types, exhibited essentially the same ranked pattern of bulk density as alluvial fans. The highest bulk density was observed along the access roads followed in decreasing order by tower, conducting wire, and road edge disturbance types. In contrast, riverwash

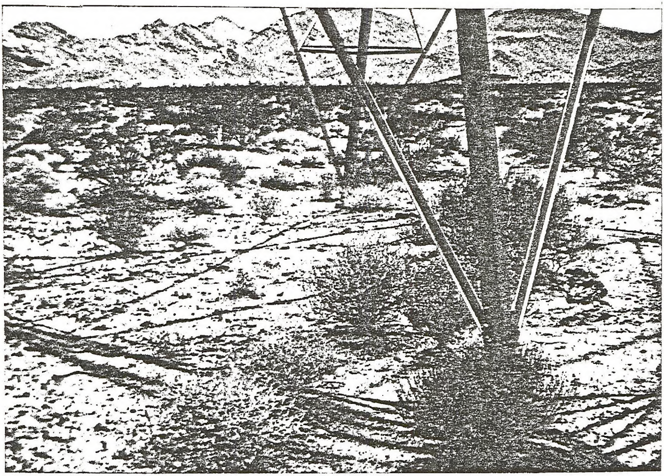

Figure 6-4 . View of vegetation beneath power transmission pylon. Note *Hymenoclea salsola* and *Ambrosia dumosa*.

Table 6-19. ANALYSES OF BULK DENSITY AND POROSITY ALONG TRANSECTS OF POWER TRANSMISSION SAMPLE AREAS

SAMPLE AREA	BULK DENSITY (gms/cm^3) Disturbance Type					PERCENT POROSITY Disturbance Type				
	Control	Road Edge	Road	Wire	Tower	Control	Road Edge	Road	Wire	Tower
1	1.80	1.86	1.95	1.79	1.70	32.20	28.38	26.42	32.56	35.90
2	1.78	1.65	1.90	1.76	1.73	32.83	37.74	28.30	33.58	34.72
3	1.66	1.84	1.93	1.67	---[a]	37.28	30.69	27.17	36.98	----[a]
4	1.78	1.63	1.85	1.78	1.69	32.83	38.49	30.19	32.83	36.23
5	1.60	1.65	1.87	.105	1.65	39.62	37.74	29.43	37.74	37.74
6	1.62	1.58	1.80	1.63	1.70	38.87	40.38	32.08	38.49	35.85
7	1.73	1.50	1.90	1.76	1.80	34.72	43.40	28.30	33.58	32.08
8	1.79	1.62	1.93	1.68	1.75	32.45	38.87	27.17	36.60	33.96
9	1.68	1.70	1.80	1.69	1.80	36.60	35.85	32.08	36.23	32.08
10	1.72	1.72	1.92	1.75	1.79	35.09	35.09	27.55	33.96	32.45
11	1.71	1.75	1.79	1.80	1.73	35.47	33.96	32.45	32.08	34.72
12	1.82	1.73	1.90	1.85	1.86	31.32	34.72	28.30	30.19	29.81
13	1.83	1.65	1.89	1.90	1.86	30.94	37.74	28.68	28.30	29.81
14	1.60	---[a]	---[a]	1.56	1.56	39.62	----[a]	----[a]	41.13	41.13

[a]Not measured

areas were less predictable. At different areas, bulk density rank values were similar for each disturbance type approaching those of controls. This suggested that compaction under the towers, conducting wires, and road edge was comparatively minor. However, along the access roads bulk density was high approaching those observed with fan and hilly landform types.

Bulk density is directly related to percent porosity; that is, higher bulk density implies greater reduction in available soil pore space. Therefore, roads exhibit the lowest porosity values for all disturbance types. This implies that compaction along roads are quite high producing a hard surface with very little potential for recovery. Under the towers, conducting wires, and along the road edge there is minor soil compaction when compared to controls.

Discussion

The effects of power transmission line construction are dependent on the severity of the disturbance, the modifying influence of landform, and the resilience of the particular community type. Along the road edge, creosote bush scrub vegetation, located on old stable alluvial fans, are comparatively larger in size and more numerous than adjacent controls. Much of this increase to total standing crop is attributed to the increased prescence of the longer-lived species of Larrea tridentata and Ambrosia dumosa. This road effect is moderate on the less stable sandy alluvial fans. In these areas, the shorter-lived Hymenoclea salsola and Euphorbia polycarpa become important contributors to total standing crop. Cactus scrub vegetation located on south facing slopes show the same trends of increased shrub size and number along the road edge. However, in these areas the road edge species are usually Larrea and Ambrosia, while stem succlent plants are almost nonexistent. Wash woodland communities generally do not feature a distinct road edge.effect; presumably,plants that become established are often washed away with the first seasonal rainstorm.

Possible explanations for the road edge effect are two.. One concerns the channelization and accumulation of runoff from the unpaved road surface to the road edge (Johnson et al. 1975). The accumulated moisture at the road edge may enhance vegetative growth and establishment of perennial shrubs. The second explanation concerns the competitive release of road edge shrubs by the removal of competitors from the road (Vasek et al. 1975b). Both runoff accumulation and competitive release may function as enhancement mechanisms that operate either inconjunction, or alone, and may ~~may~~ account for a range of road edge effects.

Under the central conducting wires, there were slight reductions in total cover and density, while diversity remained unchanged. This reduction in standing crop may be explained by the moderate to severe trampling that occurred when electrical cables were strung between supportive pylons. These observations conflict with those of Vasek et al. 1975b. They observed a slight enhancement of Mojave Desert vegetation directly beneath the central conducting wire. They hypothesized that vegetation enhancement was due to fog or rain condensing on the wire and then dripping onto the plants. In the lower elevational Colorado Desert, vegetation under the central wires did not have the advantage of increased moisture accumulation from rain drip. Hence, plants once trampled or accidently pruned by cables could not regain vegetative losses through increased growth rates.

Vegetation under the power transmission pylons exhibited variable responses to construction. Under steel lattice pylons, vegetation appeared either undisturbed or slightly enhanced. These conflicting observations may be reconciled by two explanations. First, the level of disturbance under any pylon depends on the amount of site preparation needed to provide adequate foundations. Steel lattice pylons are usually assembled elsewhere, trucked to the site, and then hoisted into place by cranes onto concrete footings. These construction techniques take into account irregular surface features resulting in minimal grading and clearing operations. Second, steel lattice pylons present large frontal areas capable of intercepting large amounts of rainfall. Moisture would condense on the pylons and eventually drip onto the vegetation or penetrate deeply into the soil.

The construction of older "H" type pylons produced drastic changes in the surrounding vegetation and soils. These pylons were constructed directly on the site using heavy drilling rigs and trucks. This necessitated elaborate site preparations involving clearing and grading operations over a large area. Vegetation was severly disturbed and oftentimes eliminated from the immediate area, while soils were compacted to several centimeters below the surface. Moreover, the comparatively smaller pylon does not adequately intercept rainfall to any appreciable degree. Mechanical disruption without the benefit of rainfall interception resulted in severe disturbance to vegetation that has not recovered after 30 to 50 years.

In general, the construction of power transmission lines in the Colorado Desert results in vegetation enhancement along the road edge; reduction in vegetative cover and density under the conducting wires due to trampling; and variable vegetation response under support pylons due to construction techniques and rainfall interception. Therefore, when compared to other utility construction projects (e.g.; underground pipelines, and highways) power transmission line construction produces minor impacts on desert vegetation and soils.

Section 7

AN EVALUATION OF THE EFFECTS OF PAVED ROADS ON VEGETATION OF THE COLORADO DESERT

It has been commonly observed that vegetation along roadsides, particularly in arid environments, appears larger and more dense than surrounding areas. The most detailed study of this road edge effect was done by Johnson et al. (1975) for creosote bush scrub vegetation of the Mojave Desert. They hypothesized that paved and, to a lesser extent, unpaved roads shed water to the sides where it accumulates, and eventually percolates deep into the soil profile. This increased reservoir of stored water prolongs vegetative growth into the summer season. They concluded that roads provide a host of "water harvesting" experiments awaiting investigation and interpretation.

When this investigation was undertaken, no similar work on road edge effects had been done in the Colorado Desert. Accordingly, a survey of paved roads traversing several community and landform types was sampled and analyzed. The objectives were: 1) to describe vegetational dynamics along roadsides in terms of diversity, stability, and productivity, 2) to compare the effects of paved roads on different community types, and 3) to provide baseline information by which to assess the effects of proposed road construction on vegetation.

Methods

Selected sample areas along the Twenty Nine Palms-Amboy Road, the Rice to Parker Dam Road, Interstate 60, and Interstate 78 are shown in Figure 7-1. The sample site characteristics such as community type, landform, exposure, slope, etc., are summarized in Table 7-1.

Vegetation along each road was assessed using four belt transects (100 meters long and 2 meters wide). Two transects served as controls, and two transects served as estimates of roadedge effects. Transects 1 and 2 (controls) were each located at least 50 meters from the road in undisturbed vegetation; Transects 3 and 4 (road edge) were each located 1 meter from the road berm. All transects provided a 200 square meter sample area.

Shrubs rooted in each belt transect area were sampled by measuring their height (at the center) and width (average of two perpendicular measurements). Ground cover for each species was calculated using the average width to obtain the radius of a circle. Canopy volume was obtained by assuming canopy shape approximated a cylinder. Estimates of aboveground biomass for dominant species was obtained using volume/biomass regression equations developed by the Bureau of Land Management (Appendix B). The total aboveground biomass for each transect area was obtained by summing the contribution of each species. Since these are only quantitative biomass measurements for few dominant shrubs, total aboveground biomass is underestimated.

Cover, density, and biomass was used to estimate area "productivity ratios" (Johnson et al. 1975) by comparing roadsides to controls. Species diversity was calculated using the Simpson's Dominance Index (Simpson 1949). Two components of diversity richness and evenness were calculated as outlined in Section 5.

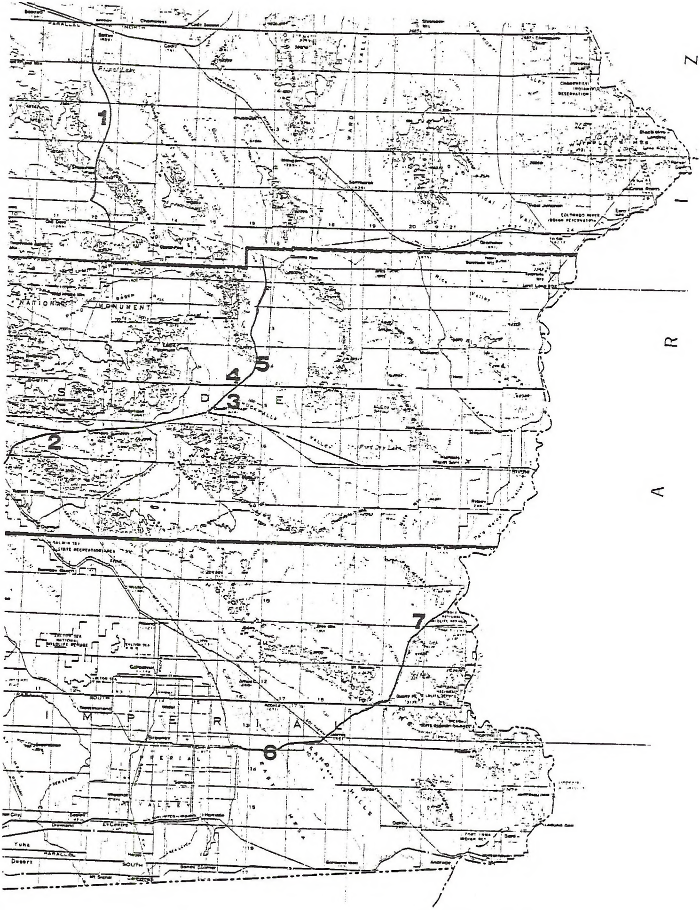

Figure 7-1. LOCATIONS OF PAVED ROADS SAMPLE AREAS

Table 7-1. SAMPLE AREA CHARACTERISTICS ALONG SELECTED PAVED ROADS

SAMPLE AREA	COMMUNITY TYPE	LANDFORM TYPE	EXPOSURE SLOPE	ELEVATION (M)	ROAD[a] WIDTH (M)	BERM[b] WIDTH (M)	DISTURBANCE[c] INTENSITY
1	Creosote	Fan	Northeast	210	10	2	High
2	Creosote	Fan	Southwest	480	10	6	Low
3	Creosote	Sandy Fan	Level	240	8	3	High
4	Washwoodland	Wash	Level	170	8	5	High
5	Creosote	Dissected Fan	Northeast	240	8	3	Low
6	Creosote	Sandy Fan	Level	0	10	6	High
7	Washwoodland	Wash	Level	300	10	9	High

[a]Road width refers to the distance from road edge to road edge of paved area.

[b]Berm width refers to the distance from road edge to berm.

[c]Disturbance intensity refers to the frequency of maintenance activity evidenced by number of road edge berms.

Results and Discussion

Productivity

Within control and road edge transects estimated ground cover, volume, density, and aboveground biomass for each species are presented in Table 7-2 to 7-8. An analysis of this data involves the calculation of productivity ratios (PR) between controls and road edge transects using totals for cover, volume, density, and biomass. Productivity ratios for each sample area are presented in Table 7-9.

The data in Table 7-9 indicate that productivity ratios for ground cover, volume, and aboveground biomass are interrelated. As PR cover values increase, there is a corresponding increase in PR values for volume and biomass. Most sample areas, except 3 and 6, exhibit PR values considerably above 1.0. This indicates that roadedge vegetation in these areas are comparatively larger in volume, cover, and biomass than vegetation in adjacent controls. Sample Areas 3 and 6, located on sandy alluvial fans, exhibit PR values that are below 1.0 indicating that shrubs along the road edge are smaller and more compact than shrubs in undisturbed areas. Sample Area 7 is an exception to this general pattern. In this area, the PR value for volume is less than 1.0, while cover, density, and aboveground biomass are above 1.0.

Direct comparisons between productivity ratios for each sample area suggest that plant density along the roadedge is inversely related to cover, volume, and biomass. Data for Sample Area 1, for instance, indicates that as vegetative cover increases there is a corresponding decrease in plant density. Conversely, as vegetative cover decreases (Areas 3 and 6) there is a concurrent increase in plant density. This suggests that interspecific competition along the roadedge may play an active role in population dynamics. Shrubs that are best able to grow at faster rates will eventually predominate over slower growing shrubs. Therefore, characteristic roadedge shrubs would include *Hymenoclea salsola*, *Eriogonium inflatum*, etc.

Table 7-2. AVERAGE COVER, VOLUME, DENSITY, AND ABOVEGROUND BIOMASS MEASUREMENTS FOR CONTROLS AND ROAD EDGE TRANSECTS FROM SAMPLE AREA 1

SPECIES NAME	CONTROL				ROADEDGE			
	Cover (M^2)	Volume (M^3)	Density (#/100 M^3)	Aboveground Biomass (Kg/100 M^2)	Cover (M^2)	Volume (M^3)	Density (#/100 M^3)	Aboveground Biomass (Kg/100 M^2)
Larrea tridentata	1.12	0.91	4.25	1.73	3.38	8.07	1.25	15.36
Ambrosia dumosa	1.17	0.34	11.50	1.77	3.54	1.53	18.50	7.95
Atriplex polycarpa	0.58	0.27	2.50	0.86	0.55	0.31	2.75	0.98
Hymenoclea salsola	1.31	0.62	6.50	1.02	0.03	0.01	0.75	0.02
Viquiera deltoidea	0.16	0.07	1.00	----	0.42	0.33	0.50	
Euphorbia polycarpa	0.12	0.01	13.75	----	0.03	0.01	4.00	
Eriogonum inflatum	0.06	0.03	0.25	----				
Stephanomeria panciflora	0.16	0.08	0.25	----				
Asclepias erosa	0.16	0.18	0.25	----				
TOTAL	4.85	2.51	40.25	5.38	7.95	10.26	27.75	24.31

Table 7-3. AVERAGE COVER, VOLUME, DENSITY, AND ABOVEGROUND BIOMASS MEASUREMENTS FOR CONTROLS AND ROAD EDGE TRANSECTS FROM SAMPLE AREA 2

SPECIES NAME	CONTROL				ROADEDGE			
	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)
Larrea tridentata	5.55	6.12	3.50	11.65	15.79	36.53	4.00	69.52
Ambrosia dumosa	4.60	2.01	46.00	10.44	2.19	1.07	16.50	5.56
Hymenoclea salsola	2.07	1.07	16.50		10.32	8.06	58.50	13.19
Palafoxia linearis	0.07	0.04	0.50					
Euphorbia polycarpa	0.20	0.01	90.00		0.43	0.23	96.50	
Stephanomaria pauciflora	0.03	0.02	0.50		0.20	0.14	0.50	
Ditaxis serrata	0.02	0.005	1.00					
Encelia farinosa					0.05	0.02	0.50	0.02
Eriogonum inflatum					0.20	0.16	0.50	
Bebbia juncea					0.06	0.03	0.50	
TOTAL	12.54	9.28	158.00	23.84	29.24	46.24	177.50	88.29

Table 7-4. AVERAGE COVER, VOLUME, DENSITY, AND ABOVEGROUND BIOMASS MEASUREMENTS FOR CONTROLS AND ROAD EDGE TRANSECTS FROM SAMPLE AREA 3

SPECIES NAME	CONTROL				ROADEDGE			
	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)
Larrea tridentata	1.73	1.91	0.5	3.64	1.45	1.36	1.00	2.59
Hymenoclea salsola	2.39	1.52	4.5	2.49	2.45	1.40	5.00	2.29
Dalea schottii	2.45	3.20	0.5					
TOTAL	6.57	6.63	5.5	6.13	3.90	2.76	6.00	4.88

Table 7-5. AVERAGE COVER, VOLUME, DENSITY, AND ABOVEGROUND BIOMASS MEASUREMENTS FOR CONTROLS AND ROAD EDGE TRANSECTS FROM SAMPLE AREA 4

SPECIES NAME	CONTROL				ROADEDGE			
	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)
Larrea tridentata	6.09	12.45	1.25	23.69	5.87	14.38	0.50	27.37
Ambrosia dumosa	0.11	0.06	0.25	0.31	0.59	0.38	0.75	1.97
Hymenoclea salsola	0.20	0.11	0.50	0.18	2.32	0.07	4.25	0.12
Cercidium floridum	1.18	2.00	0.25	2.25	23.16	135.74	1.25	152.44
Viquiera deltoidea	0.10	0.05	0.25		0.01	0.82	0.25	
Stephanomeria pauciflora	0.20	0.08	0.75		0.01	0.01	0.50	------
Atriplex polycarpa					1.06	0.82	2.00	2.60
Cucurbita palmata					0.26	0.07	0.75	
Encelia farinosa					0.54	0.481	0.25	0.41
Tidestromia oblongifolia					0.126	0.38	0.25	
TOTAL	7.88	14.75	3.25	26.43	33.95	153.15	10.75	184.91

Table 7-6. AVERAGE COVER, VOLUME, DENSITY, AND ABOVEGROUND BIOMASS MEASUREMENT FOR CONTROLS AND ROAD EDGE TRANSECTS FROM SAMPLE AREA 5

SPECIES NAME	CONTROL				ROADEDGE			
	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)
Larrea tridentata	1.19	0.83	0.50	1.58	8.95	15.85	3.50	30.16
Ambrosia dumosa	0.41	0.21	1.50	1.09	0.43	0.21	2.00	1.09
Opuntia ramosissima	0.02	0.01	0.25					
Opuntia bigilouii	1.00	0.52	0.50					
Krameria parvifolia	0.03	0.01	0.25	0.01	0.44	0.40	0.25	0.32
Atriplex hymenolytra	0.10	0.00	1.25		6.72	3.26	107.50	
Bebbia juncea	0.08	0.06	0.25		0.54	0.62	0.50	
Euphorbia polycarpa	0.06	0.00	57.00		0.14	0.02	39.00	
Eriogonum inflatum	0.31	0.21	0.75		5.05	3.73	13.50	
Hymenoclea salsola					0.03	0.02	0.25	0.03
TOTAL	3.20	1.85	62.25	2.68	22.30	24.11	166.50	31.57

Table 7-7. AVERAGE COVER, VOLUME, DENSITY, AND ABOVEGROUND BIOMASS MEASUREMENTS FOR CONTROLS AND ROAD EDGE TRANSECTS FROM SAMPLE AREA 6

SPECIES NAME	CONTROL				ROADEDGE			
	Cover (M^2)	Volume (M^3)	Density ($\#/100\ M^2$)	Aboveground Biomass ($Kg/100\ M^2$)	Cover (M^2)	Volume (M^3)	Density ($\#/100\ M^2$)	Aboveground Biomass ($Kg/100\ M^2$)
Larrea tridentata	35.64	100.58	3.75	101.40	9.10	21.52	2.25	40.95
Ambrosia dumosa	1.17	0.51	3.25	2.65	11.29	3.81	13.25	19.79
Coldenia plicata					0.08	0.01	3.50	
TOTAL	36.81	101.09	7.00	194.05	20.47	25.34	19.00	60.74

Table 7-8. AVERAGE COVER, VOLUME, DENSITY, AND ABOVEGROUND BIOMASS MEASUREMENTS FOR CONTROLS AND ROAD EDGE TRANSECTS FROM SAMPLE AREA 7

SPECIES NAME	CONTROL				ROADEDGE			
	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)	Cover (M^2)	Volume (M^3)	Density (#/100 M^2)	Aboveground Biomass (Kg/100 M^2)
Larrea tridentata	0.24	0.19	0.25	0.36	2.55	3.93	0.50	7.48
Ambrosia dumosa	0.32	0.13	0.75	0.68	0.23	0.05	2.75	0.26
Fouquieria splendens	4.16	12.46	0.25					
Encelia farinosa	1.09	0.71	1.50	0.60	3.18	1.33	11.00	1.12
Euphorbia polycarpa					0.03	0.01	11.25	
Hymenoclea salsola					0.31	0.23	0.75	0.38
Tidestromia oblongifolia					0.03	0.06	0.25	
Stephanomeria pauciflora					1.42	0.74	5.25	
Ditaxis serrata					0.01	0.01	0.75	
TOTAL	5.81	13.49	2.75	1.64	7.76	6.36	32.50	9.24

Table 7-9. CONTROL TO ROAD EDGE PRODUCTIVITY RATIOS
FOR COVER, VOLUME, DENSITY, AND ABOVEGROUND BIOMASS FOR ALL SAMPLE AREAS

SAMPLE AREA	PRODUCTIVITY RATIOS			
	COVER	VOLUME	DENSITY	ABOVEGROUND BIOMASS
1	1.64	4.09	0.69	4.52
2	2.33	4.98	1.12	3.70
3	0.59	0.42	1.09	0.80
4	4.31	10.38	3.31	7.00
5	6.96	13.03	2.68	11.78
6	0.56	0.25	2.71	0.31
7	1.34	0.47	11.82	5.63

Productivity Ratio = Road edge/Control

Sample Area 2 (Figure 7-2) represents a section of Interstate 60 that was abandoned by traffic approximately 15 years ago. Freed from disruptive highway maintenance activities and traffic, shrubs have increased in size and numbers and have begun to encroach onto the road shoulder. All productive categories have exhibited dramatic increases over controls. Area 5, on the other hand, is located on a dissected fan with well-developed desert pavement on either side of the road. Vegetation in the control areas (Table 7-2) is generally sparse and less dense than the road edge. Any increases in density, cover, biomass, etc. along the road edge would have extremely high productivity ratios.

Community Stability

The total long-lived perennial cover for control and road edge transects was averaged for all sample areas and is presented in Table 7-10. Within each sample area, cover values were compared by computing the proportional difference between the road edge and adjacent control transects.

Among sample areas, there are wide variations in the proportional differences between control/road edge cover values. Sample Areas 1, 2, 4, and 5 exhibit road edge cover values that are considerably above controls. The proportional differences between controls and road edge transects range from 0.36 to 6.23. Since cover values are based on the proportion of total ground covered by long-lived perennial shrubs, higher cover values imply greater community stability. It appears that a major influence of road edge on vegetation is to increase community stability under optimum conditions of soil type, slope, etc.

In contrast, Sample Areas 3, 6, and 7 exhibit roadedge CQI values that are much lower than controls resulting in negative proportional differences that range from -0.16 to -0.45. This seems to suggest that these areas are of such low productive potential that long-lived perennials once disturbed have difficulty in reestablishing themselves even along the road edges.

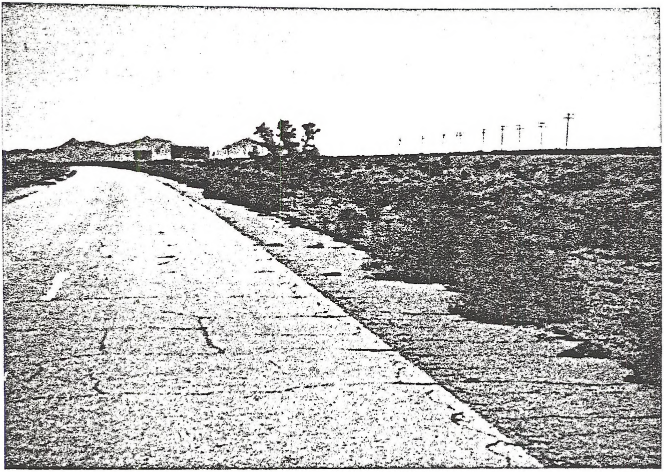

Figure 7-2. An abandoned section of highway near Area 2. Hymenoclea salsola and Euphorbia polycarpa are shown on the road edge.

Table 7-10. AN ANALYSIS OF LONG-LIVED PERENNIAL GROUND COVER FOR CONTROL AND ROAD EDGE TRANSECTS

SAMPLE AREA	TOTAL GROUND COVER (M^2)		PROPORTIONAL DIFFERENCE [a]
	Control	Road Edge	
1	4.85	7.95	0.64
2	9.13	12.40	0.36
3	1.73	1.45	-0.16
4	6.30	30.88	3.90
5	2.27	16.41	6.23
6	36.49	20.00	-0.45
7	3.11	1.90	-0.39

[a] Proportional difference = (Road edge - Control)/Control

Diversity

Additional methods of comparing control and road edge vegetation are based on the calculation of dominance and its two components - richness and evenness. These estimates of diversity for transects and sample areas are presented in Table 7-11. Diversity values were directly compared by calculating the proportional difference between control and road edge transects.

In general, dominance values for controls were higher than road edge transects. This resulted in negative proportional differences that ranged from -37.6 percent to -9 percent. These values imply that controls generally have a greater concentration of individuals in fewer species (i.e., less diverse); or conversely, roadedge vegetation had smaller concentrations of individuals in more species (i.e., more diverse) than adjacent controls.

On sandy fans (Areas 3 and 6) dominance values for controls were lower than associated road edges. The proportional difference between transects was 5.8 percent (Area 3) and 17.5 percent (Area 6). This implies that species diversity for road edge vegetation in these areas is comparatively lower than undisturbed vegetation. This pattern of lower diversity corresponds to the overall reduction in productivity (Table 7-9) and stability (Table 7-10) suggesting that road edge effects are relatively minor in sandy environments with high erosion potential.

Table 7-11. DIVERSITY MEASURES FOR PAVED ROADS

SAMPLE AREA	DIVERSITY MEASURE	CONTROL	ROADEDGE	PROPORTIONAL CHANGE
1	Dominance	.308	.236	-0.234
	Richness	6	7	0.167
	Evenness	.601	.589	-0.020
2	Dominance	.475	.418	-0.120
	Richness	6	6	0.0
	Evenness	.464	.407	-0.123
3	Dominance	.651	.689	0.058
	Richness	3	2	-0.330
	Evenness	.403	.626	0.553
4	Dominance	.245	.175	-0.286
	Richness	4	6	0.500
	Evenness	.732	.516	0.295
5	Dominance	.820	.512	-0.376
	Richness	7	7	0.000
	Evenness	.215	.307	0.428
6	Dominance	.469	.551	0.175
	Richness	2	3	0.500
	Evenness	.984	.624	-0.366
7	Dominance	.384	.384	-0.094
	Richness	3	6	1.000
	Evenness	.613	.579	-0.055

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APPENDIX A

COMMONLY OBSERVED PERENNIAL SHRUBS

APPENDIX A

COMMONLY OBSERVED PERENNIAL SHRUBS

SPECIES NAME/AUTHORITY	COMMON NAME	FAMILY NAME
Acacia greggii (Gray)	Cat's Claw	Fabaceae
Acamptopappus shockleyi (Gray)	Goldenhead	Asteraceae
Allionia incarnata L.	Windmills	Nyctaginaceae
Ambrosia dumosa (Gray) Payne	Burrobush	Asteraceae
Atriplex canescens (Pursh.) Nutt	Wingscale, Hoary Saltbush	Chenopodiaceae
Atriplex hymenolytra (Torr.) Wats.	Desert Holly	Chenopodiaceae
Atriplex polycarpa (Torr.) Wats.	Cattle Spinach, Allscale	Chenopodiaceae
Asclepias erosa Torr.	Desert Milkweed	Asclepiadaceae
Bebbeia juncea (Benth.) Greene	Sweet Bush	Amaranthaceae
Brandegia bigelovii (Wats.)Cogiv	Brandegia	Cucurbitaceae
Calliandra eriophylla (Benth.)	Fairy Duster	Fabaceae
Cassia armata (Wats.)	Desert Cassia	Fabaceae
Cercidium floridum (Benth.)	Border Palo Verde	Fabaceae
Chrysothamnus paniculatus	Black-banded Rabbit Bush	Asteraceae
Coldenia canescens DC.	Shrubby Coldenia	Boraginaceae
Coldenia plicata (Torr.) Cov.	Plicate Coldenia	Boraginaceae
Croton californicus Muell.-Arg.	Desert Croton	Euphorbiaceae
Cucurbita palmata (Wats.)	Palmate Leaved Gourd	Curcurbitaceae
Dalea emoryi (Gray)	Emory Dalea	Fabaceae
Dalea mollis (Benth.)	Silk Dalea	Fabaceae
Dalea schottii (Torr.)	Indigo Bush	Fabaceae
Dalea spinosa (Gray)	Smoke Tree	Fabaceae

SPECIES NAME/AUTHORITY	COMMON NAME	FAMILY NAME
Ditaxis californica (Bdg.) Pax & K. Hoffm.	NCN*	Euphorbiaceae
Ditaxis lanceolata (Benth.) Pax & K. Hoffm.	Lance-Leaven Ditaxis	Euphorbiaceae
Ditaxis neomexicana (Muell.-Arg.) Heller	NCN	Euphorbiaceae
Ditaxis serrata (Torr.) Heller	Saw toothed Ditaxis	Euphorbiaceae
Dyssodia cooperi (Gray)	Cooper Dyssodia	Asteraceae
Echinocereus engelmannii (Parry) Lem.	Hedgehog Cactus	Cactaceae
Encelia farinosa (Gray ex Torr.)	Brittle Bush, Incienso	Asteraceae
Ephedra californica (Wats.)	Morman Tea	Ephedraceae
Ephedra viridis (Cov.)	Mountain Joint Fir	Ephedraceae
Eriogonum deflexum (Torr.)	Skeleton Weed	Polygonaceae
Eriogonlum fasiculatum (Benth.)	California Buckwheat	Polygonaceae
Eriogonum inflatum (Torr. & Frem.)	Desert Trumpet	Polygonaceae
Erioneron pulchellum (HBK.) Tateoka	Fluffgrass	Poaceae
Euphorbia polycarpa (Benth.)	Small Seeded Sand Mat	Euphorbiaceae
Fagonia laevis (Standl.)	Smooth-Stemmed Fagonia	Zygophyllaceae
Ferocactus acanthodes (Lem.) Britton & Ruse	Barrel Cactus	Cactaceae
Fouquieria splendens (Engelm.)	Ocotillo Candlewood	Fouquieriaceae
Hibiscus denudatus (Benth.)	Rose-Mallow	Malvaceae
Hilaria rigidia (Thurb.) ex Scribn	NCN	Poaceae
Hymenoclea salsola (T.&G.)	Cheese Bush	Asteraceae
Hyptis emoryi (Torr.)	Desert Lavender	Lamiaceae
Krameria grayi (Rose & Painter.)	White Ratany	Fabaceae

SPECIES NAME/AUTHORITY	COMMON NAME	FAMILY NAME
Kameria parvilfolia (Benth.)	Little-leaved Ratany	Fabaceae
Larrea tridentata (Sesse & Moc. ex DC) Cov.	Creosote Bush, Covillea	Zygophyllaceae
Lycium sp.	--------	Solanaceae
Machaeranthera tortifolia (gray) Crogn. & Keck	NCN	Asteraceae
Mammillaria tetrancistra (Engelm.)	Corkseed Cactus	Cactaceae
Nicotiana trigonophylla (Dunal in A.DC)	Desert Tobacco	Solanaceae
Olneya testota (Gray)	Desert Ironwood	Fabaceae
Opuntia acanthocarpa (Engelm. & Bigel.)	Cholla	Cactaceae
Opuntia basilaris (Engelm. & Bigel.)	Beavertail Cactus	Cactaceae
Opuntia bigelovii (Engelm.)	Jumping Cholla	Cactaceae
Opuntia echinocarpa (Engelm. & Bigel.)	Silver Cholla	Cactaceae
Opuntia munzii (C.B. Wolf.)	NCN	Cactaceae
Opuntia ramosissima (Engelm.)	Diamond Cactus	Cactaceae
Palafoxia linearis (Cav.) Lag.	Spanish Needles	Asteraceae
Petalonyx thurberi (G.)	Thurber Sandpaper Plant	Loasaceae
Physalis crassifolius	Thick-leaved Ground Cherry	Solanaceae
Peucephyllum schottii (Gray)	Desert Fir	Asteraceae
Porophyllum gracile (Benth.)	Odora	Asteraceae
Sarcostemma hirtellum (Gray) R. Holm	NCN	Asclepiadaceae
Simmondsia chinensis	Goatnut	Buxaceae
Stephanomeria pauciflora (Torr.) Nutt	Desert Straw	Asteraceae
Stipa speciosa (Trin. & Rupr.)	NCN	Poaceae
Tidestromia oblongifolia (Wats.) Standl.	Honey Sweet	Amaranthaceae

SPECIES NAME/AUTHORITY	COMMON NAME	FAMILY NAME
Thamnosma montana (Torr. & Frem.)	Turpentine Broom	Rutaceae
Trixis californica (Kell.)	Trixis	Asteraceae
Viquiera deltoidea (Gray)	Parish Viquiera	Asteraceae

*NCN = No Common Name

APPENDIX B

CANOPY VOLUME/BIOMASS REGRESSION EQUIATIONS

Appendix B

REGRESSION EQUATIONS FOR CANOPY VOLUME VS BIOMASS MEASUREMENTS FOR SELECTED SHRUBS

SPECIES	SLOPE	INTERCEPT	r VALUE
Ambrosia dumosa	5.195	-0.0240	0.973
Atriplex polycarpa	3.167	-0.1830	0.942
Cassia armata	2.997	+0.0459	0.845
Cercidium floridum	1.123	-28.2780	0.868
Dalea spinosa	0.539	+3.2510	0.960
Encelia farinosa	0.841	+0.0450	0.841
Ephedra viridis	6.098	-0.2438	0.996
Eriogonum fasicalatum	1.373	+0.0730	0.682
Ferocactus acanthodes	93.712	+0.7840	0.993
Hilaria rigidia	4.129	-0.0335	0.938
Hymenoclea salsola	1.637	-0.2399	0.968
Krameria parviflolia	0.790	+0.0560	0.923
Larrea tridentata	1.903	+7.1250	0.913
Lycium brevipes	13.651	+7.0770	0.928
Olneya testota	1.639	+15.9080	0.903
Opuntia acanthocarpa	1.047	+0.0530	0.980
Stipa speciosa	2.703	+0.1780	-----
Thamnosma montana	3.065	-0.0127	0.956

APPENDIX C

FUNCTIONAL SPECIES LIST

APPENDIX C
FUNCTIONAL SPECIES LIST

I. Long-Lived Perennials

LARREA TRIDENTATA
AMBROSIA DUMOSA
HILARIA RIGIDIA
EPHEDRA SPP.
OPUNTIA BASILARIS
KRAMERIA GRAYI
CASSIA ARMATA
THAMNOSMA MONTANA
LYCIUM SPP.
EPHEDRA VIRIDIS
OPUNTIA RAMOSISSIMA
FEROCACTUS ACANTHODES
ACACIA GREGGII
OPUNTIA BIGELOVII
OPUNTIA ACANTHOCARPA
MAMMALLARIA TETRANCISTRA
PHORODENDRON SPP.
KRAMERIA PARVIFOLIA
DALEA SPINOSA
CERCIDIUM FLORIDUM
FOUQUIERIA SPLENDENS
ATRIPLEX HYMENOLYTRA
HYPTIS EMORYI
ECHINOCEREUS ENGELMANNII
TRIXIS CALIFORNICA
OPUNTIA MUNZII
OLNEYA TESTOTA
CUCURBITA PALMATA
PEUCEPHYLLUM SCHOTTII
BRANDEGEA BIGELOVII
ATRIPLEX CANESCENS
OPUNTIA ECHINOCARPA
ECHINOCEREUS ENGELMANNII
SIMMONDSIA CHINENSIS
EPHEDRA CALIFORNICA
ATRIPLEX POLYCARPA
CHRYSOTHAMNUS PANICULATUS

II. Short-Lived Perennials

HYMENOCLEA SALSOLA
BEBBIA JUNCEA
ERIOGONUM FASICULATUM
VIGUIERA DELTOIDEA
DALEA SPP.
ENCELIA FARINOSA
PALAFOXIA LINEARIS
AMARANTHUS SPP.

SARCOSTEMMA HIRTELLUM
ALLIONIA INCARNATA
STEPHANOMERIA PAUCIFLORA
PETALONYX THURBERI
DYSSODIA COOPERI
ACAMPTOPAPPUS SPHAEROCEPHALUS
POROPHYLLUM GRACILE
STIPA SPECIOSA
DITAXIS NEOMEXICANA
DITAXIS SERRATA
CALLIANDRA ERIOPHYLLA
ERIONERON PULCHELLUM
NICOTIANA TRIGONOPHYLLA
COLDENIA CANESCENS
TIDESTROMIA OBLONGIFOLIA *
COLDENIA PLICATA
DITAXIS LANCEOLATA
PHYSALIS CRASSIFOLIUS
HYBISCUS DENUDATUS
CROTON CALIFORNICUS *
MACHAERANTHERA TORTIFOLIA
FAGONIA LAEVIS
ERIOGONIUM DEFLEXUM
UNKOWN
DITAXIS CALIFORNICA
ASCLEPIAS EROSA
DALEA MOLLIS
TIDESTROMIA OBLONGIFOLIA
CROTON CALIFORNICUS
DALEA SCHOTTII
DALEA EMORYI
ERIOGONIUM INFLATUM

III. Pioneer Herbaceous Plants

EUPHORBIA POLYCARPA