Plant Response to Utility Right of Way Construction in the Mojave Desert

EARL W. LATHROP
EDWIN F. ARCHBOLD
Department of Biology
Loma Linda University
Loma Linda, California 92350

ABSTRACT/Disturbance of flora from utility construction tends to generate new plant growth. This growth changes productivity, diversity, and stability. Although the enhancement of vegetation may balance out the biomass destroyed by the original disturbance, it often adversely affects the quality of the vegetation. Percentage composition of the dominant long-lived perennials combined with quantitative measures are used to assess long-term effects of utility corridor construction. Differential effects of enhancement of vegetation are found along road edges, enhancement under wires of powerlines, and over trenches dug for pipelines. Areas under powerline pylons seem to receive the greatest damage and also show the most variable recovery of vegetation. Significant recovery rates are noticeable where the time span between year of construction has allowed for considerable regrowth of the older corridor. Recovery rates depend on soil type, landform, and other physical features of the disturbed sites. Drastic disturbance in one area or transect site may impede vegetation recovery, whereas slight disturbance might enhance vegetation in another, tending to offset the effect of the drastic disturbance. Disturbed areas and control areas may appear to have similar vegetation covers, biomasses, and densities, but these similarities often vanish when one examines qualitative aspects, such as proportion of long-lived species and presence of characteristic dominants.

Utility construction has caused major disturbances to soil and vegetation along the many utility pathways in the Mojave Desert. Clearing of land for powerline pylon structures; trenching, piling, and refilling to install pipelines; and the establishment of access roads for both powerlines and pipelines are the major construction activities that destroy plant cover. Also destructive are the movements of construction equipment within and around the construction sites. Pulling operations for powerlines are particularly at fault.

No qualitative or quantitative estimates of such disturbances were available prior to 1975, when studies were made by Vasek et al. (1975a) on one natural gas pipeline, by Johnson et al. (1975) on road sides, and by Vasek et al. (1975b) on two power transmission lines, all in the Mojave Desert. These studies contributed much to an understanding of the effects of utility construction on desert vegetation.

The purpose of this research, undertaken May 1978, through March 1979, was to add to our understanding of these effects through the measurement and analysis of vegetation along previously unstudied corridors (Table 1) in the Mojave Desert (Fig. 1). The corridors selected for study span a wide variety of topographic, soil, and vegetation types of the Mojave Desert (Lathrop 1979). The corridors selected were all constructed in different years, ranging from 1924 to 1977 for powerlines and from 1956 to 1973 for pipelines. It was hoped that the study of corridors of different ages would suggest a time frame for recovery or possible successional trends.

KEY WORDS: Biomass recovery; Disturbance of vegetation; Diversity index; Mojave Desert; Pipelines; Powerlines; Recovery time; Utility corridors

Methods

Information regarding history and construction dates of utility corridors was obtained from the Bureau of Land Management, from utility company managers, and from utility workers encountered in the field. An average of 6.6 200-m^2 study areas (100 × 2-m transects) were selected at intervals along each corridor (Figs. 2 and 3). Primary comparisons were made among transects at each study area. Secondary comparisons were made between corridors and study areas. Comparisons within a study area consisted of uniform evaluation of transects in control and disturbed sites for each corridor type. All control transects were placed in undisturbed vegetation 50 m to one side of the utility right-of-way and parallel to it.

Transects were placed within the utility corridor right-of-way in locations that were representative of the different types of construction disturbance. For powerlines this consisted of

1. Wire transects, midway between the pylons of the

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Table 1. Location and characteristics of utility corridors studied

Year[a]	K[b]	Location	Lines	Kilovolts per line	Function[c]	Ownership[d]
PIPELINES						
1965	8	Topback to Quigly	—	—	NG	SCG
1960	6	Needles to Pisgah	—	—	NG	SCG
1963	8	Toppack to Los Angeles	—	—	NG	PGE
1970	7	Dagget to Colton	—	—	PP	C–N
1973	6	Dagget to Roach Station, Nevada	—	—	PP	C–N
POWERLINES						
1924	7	Victorville to Vincent	1	287	—	LADWP
1933	7	Lugo to Roach Station, Nevada	1	230	—	SCE
1944	10	Lugo to Roach Station, Nevada	3	287	—	LADWP
1952	8	Brown to Los Angeles	1	230	—	LADWP
1968	5	Lugo to Vincent	2	500	—	SCE
1969	7	Pisgah to Piute Valley	1	500	—	SCE
1977	6	Dagget to Kramer Jct.	1	200	—	SCE

[a]Date of construction.
[b]Number of sites for each of the four types of transects along the corridors
[c]Pipeline function: N = Natural gas; PP = petroleum products
[d]Ownership of powerline or pipeline SCG = Southern California Gas Co.; PGE = Pacific Gas and Electric Co.; C–N = Cal–Neva Co.; SCE = Southern California Edison Co.; LADWP = Los Angeles Department of Water and Power.

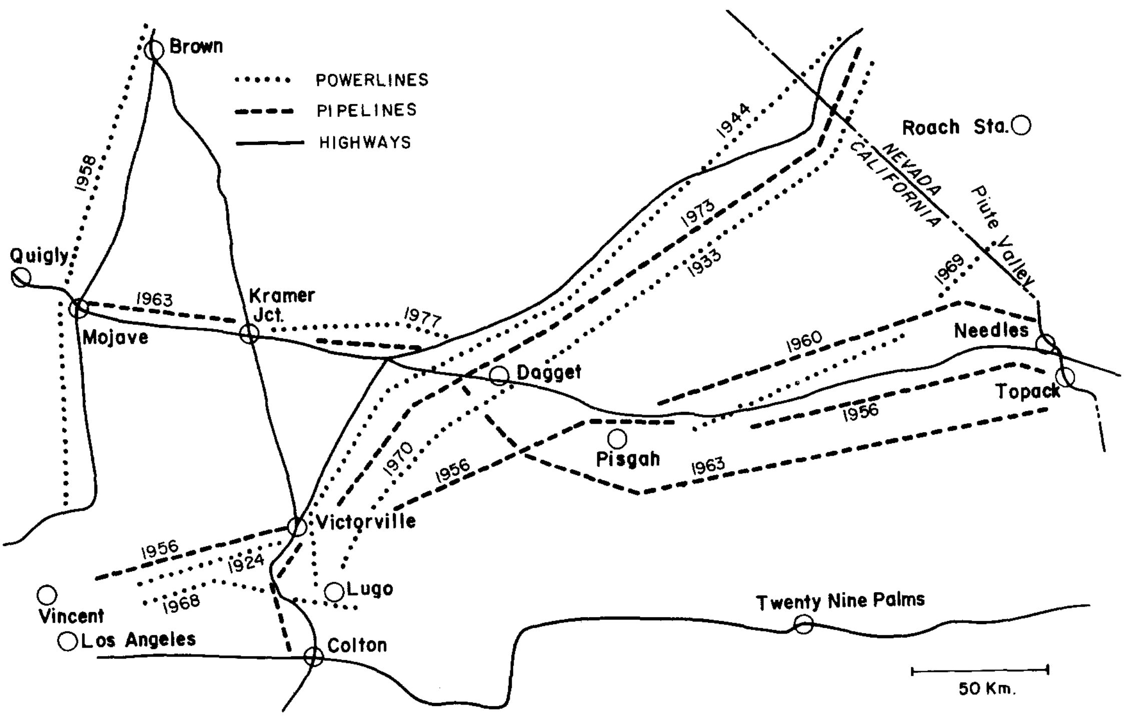


Figure 1. The Mojave Desert region showing the paths of utility corridors studied. Year of construction is indicated for each line.

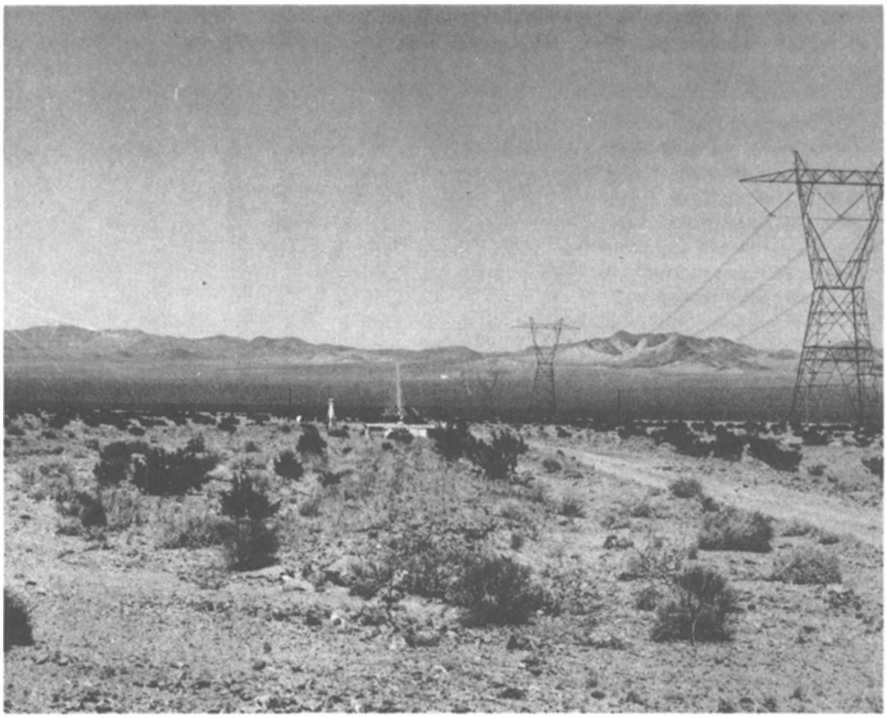


Figure 2. View facing east showing the 1960 pipeline and the 1969 powerline 2 km north of Ludlow, California. The trench transect site is the mounded area (center foreground) with the berm site immediately to the left. [Photograph taken in July 1978.]

towers and directly under the central transmission wire.
2. Pylon transects, directly under the pylons.
3. Road-edge transects, at the edge of the access road.

The area under a pylon is not sufficient to comprise a 200-m^2 transect, so data from two or more consecutive pylons were pooled until an area equal to each belt transect was sampled.

For pipelines, the study areas were

1. Berm transects, along the pipeline right-of-way where trench soil had been piled and then scraped away to refill the trench.
2. Trench transects, directly over the pipeline where trenching had produced the most severe disturbance.
3. Road-edge transects, at the edge of the access road.

The data used to determine productivity, diversity, and above-ground biomass were obtained as follows: Individual plants of each perennial species occurring in the belt transects (tr) within the designated study areas (SA) were inventoried by measuring height and crown diameters. Ground cover (GC) was calculated from the radius of each plant crown and summed for each species. Total ground cover is expressed as a percentage of the total ground surface covered by plant crowns. Density is expressed as the number of individuals per hectare (no/ha). Volume (m^3/200 m^2) was determined by assuming the plants to be a cylinder. Biomass (kg/ha) was calculated by multiplying volume times the weight density value (kg/m^3) for each species (Bureau of Land Management 1979).

Diversity values of disturbed and control transects were calculated from biomass. Richness (R) is the number of species in the sample. Evenness (V) is a measure of how equally various species are represented in the sample. For summation purposes, the two concepts of richness and evenness are combined by the diversity index (DI) proposed by McIntosh (1967). This formu-

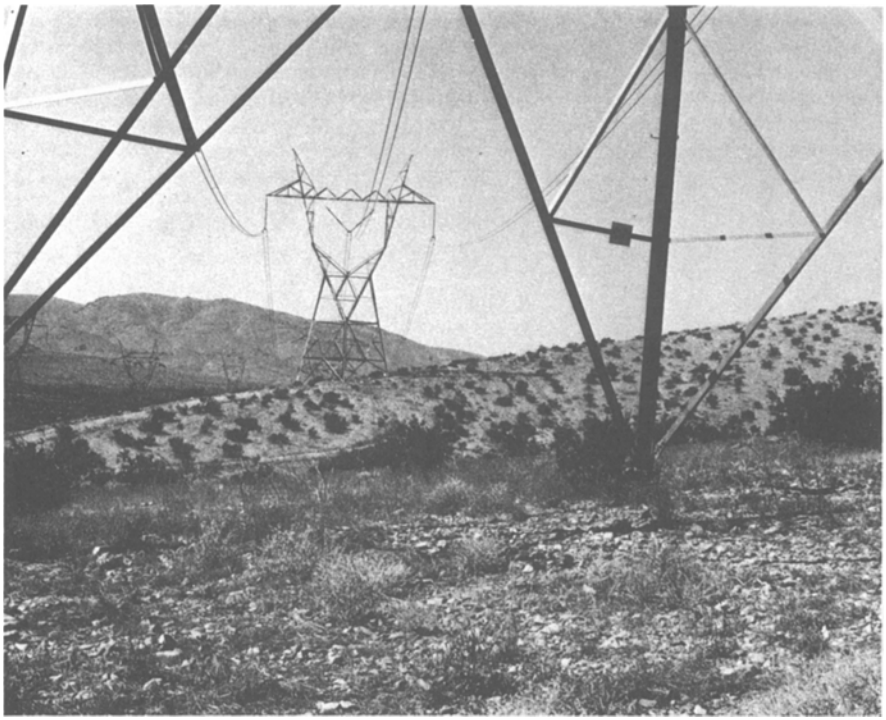


Figure 3. View facing north of the 1944 powerline showing a pylon transect site in the foreground. Road edge and under-wire transect sites are in the center background. [Photograph taken in August 1978, 3 km north of Victorville.]

lation, in which *DI* ranges from 0 to $+\infty$, provides a means for comparing the complexity of vegetation in the construction and control transects in terms of absolute numbers on a unit basis.

Stability of the plant communities along the utility corridors was estimated primarily from data provided by relative biomass and percentage of cover in relation to relative age span of species, by comparing similarity among transects and determining percentage change ($\Delta\%$) values (control $-$ test $\div$ control) of biomass for disturbed transects.

Relative age spans of long-lived (LL) and short-lived (SL) perennials are based primarily on the categories assigned to many desert species (Vasek et al. 1975a, b; Johnson et al. 1975). Similarity of plant types among transects was computed by Jaccard's coefficient of community similarity (*CCj*) as proposed by Phillips (1959; Brower and Zar 1977; and Vasek et al. 1975a).

In order to better interpret significance of the various comparisons, analysis of variance (ANOVA) (Sokal and Rohlf 1969; Vasek et al. 1975b) was applied to indices integrating total cover and percentage of long-lived species from selected corridors. Linear regression analyses were applied to selected quantitative data of the physical settings of each of the study areas (Lathrop 1969) to test for possible correlations. Visual observations were also made in an attempt to detect possible relationships between the various disturbance types and vegetation. In the interest of saving space, some transect data were summed for total corridors, and the mean ($\bar{X}$) was calculated. Likewise, the mean for data from each of the study areas along a corridor was determined. Again in the interest of saving space, plant species composition (relative biomass) derived from transect data (Lathrop 1979) is condensed to include only dominant shrubs: *Larrea tridentata* (creosote bush), *Ambrosia dumosa* (burrobush), and *Atriplex* spp. (saltbush) in the LL group and *Hymenoclea salsola* (cheesebush) in the SL group. Remaining species in transects are summed as an aggregate and are presented as Other LL and Other SL.

Table 2. Mean values for perennial vegetation of total study sites and transects along utility corridors

Transect type	K^a	R^b	DI^c	Total GC(%)[d]	GC by LL(%)[e]	Density (no/ha)	Biomass (kg/ha)
Pipelines	35						
Control		5.4	3.7	3.5	78	3990	656
Berm		4.7	1.2	1.9	60	3680	230
Trench		4.3	.4	1.8	57	3370	166
Road-edge		3.9	1.3	2.3	57	4220	244
Powerlines	50						
Control		6.1	5.6	4.5	81	4143	758
Wire		5.4	4.5	3.9	76	4871	634
Pylon		4.9	3.3	3.5	81	4571	496
Road-edge		5.2	3.7	3.8	82	4514	531

[a]Number of sites for each of the four types of transects.
[b]Number of species per transect site.
[c]Diversity index.
[d]Ground cover.
[e]Ground cover by long-lived species.

Results

Productivity

Means of three measurements of perennial plant productivity for all study sites of total utility corridors are shown in Table 2. Plant cover and biomass are almost always lower in the various disturbed transects than in the control (undisturbed) transects. Mean density for total corridors was increased (enhanced) for road-edge transects of pipelines and for all three disturbed transects of powerlines.

Productivity means for the component corridor ages were determined (Lathrop 1979). For pipeline corridors there was slight increase in density in the berm transects for the corridor constructed in 1956 and in road-edge transects for those built in 1956, 1963, 1970, and 1973. Except for the trench site for the 1973 corridor, all other disturbed transects showed a reduction of density relative to the control transects. Ground cover and biomass, however, were reduced in all disturbed transects for all pipeline corridors. Density was variably enhanced in at least one disturbed transect site for all powerline corridors except that built in 1952. Ground cover was generally reduced in all disturbed transects except for the 1944 corridor. Biomass was reduced in all disturbed transects for all powerline corridors sampled.

Diversity

Mean diversity values of richness (R) and mean diversity indices (DI) were reduced in all disturbed transects relative to controls (Table 2). Diversity results, however, are variable when one considers corridor age (Table 1 and Lathrop 1979). Richness was reduced in all disturbed transects except for two study areas each in the 1924 and 1933 powerlines. Equibility (Ec) and evenness (V) were variably enhanced in approximately half the disturbed transects of both pipeline and powerline corridors and reduced in the other half.

Stability

Relative biomass of LL and SL perennial plants (Tables 3 and 4) was used as one estimate of stability. Assuming that high composition of total LL species indicates high stability of the community, there are variable results for both sets of corridors. All corridors sampled except the 1973 pipeline and the 1933 and 1944 powerlines showed a general decrease of LL species and an increase of SL species in disturbed transects. These differences in relative biomass for control and disturbed transects are graphically compared for the 1956 and 1963 pipelines (Fig. 4) and for the 1924 and 1968 powerlines (Fig. 5).

The percentage of total ground cover contributed by LL species was slightly reduced in disturbed transects of pipelines, but there was no significant difference within powerline transects (Table 2). Significance levels (p values) from ANOVA of indices (Lathrop 1979) integrating total cover and percentage of ground contributed by LL species, from selected corridors, are shown in Table 5. Only the 1924–1977 powerline pair reached significance at the 5% probability level for variation among the above-mentioned indices. All other corridor pairs were not significant for year of con-

Table 3. Relative biomass of perennial vegetation along pipeline corridors by transect and year of construction.

Transect	Mean percentage of biomass provided by					
	Larrea	*Ambrosia*	*Atriplex*	Total LL	*Hymenoclea*	Total SL
1956 (8)[a]						
Control	43.9	14.0	0	82.8	5.0	17.1
Berm	21.8	34.1	0	66.9	19.7	33.1
Trench	11.5	31.2	0.8	49.7	26.4	50.2
Road-edge	32.4	28.4	0	67.2	25.7	32.8
1960 (6)						
Control	31.7	22.1	0	78.8	3.1	21.2
Berm	19.4	45.8	0	70.9	18.9	29.1
Trench	20.2	38.9	0	74.7	15.3	25.3
Road-edge	13.8	33.4	0	55.6	32.0	44.4
1963 (8)						
Control	26.7	3.4	34.5	67.3	10.6	32.6
Berm	2.0	15.6	30.9	54.5	12.9	45.5
Trench	16.3	8.3	38.0	71.5	6.6	28.5
Road-edge	9.8	10.5	23.9	49.6	13.9	50.4
1970 (7)						
Control	59.1	7.3	11.3	94.1	.3	5.9
Berm	31.1	16.5	13.8	61.9	9.0	38.1
Trench	22.2	10.8	14.0	48.2	13.8	51.8
Road-edge	34.8	14.4	13.2	68.6	14.7	31.4
1973 (6)						
Control	29.9	23.0	16.4	69.5	12.5	30.5
Berm	11.0	43.4	16.7	71.0	14.5	29.0
Trench	18.7	43.4	14.5	83.4	5.2	16.6
Road-edge	26.0	34.9	16.6	77.8	4.5	22.2

[a]Numbers in parentheses indicate the number of study areas for each transect type.

struction. The direct effects attributable to the different transects were significant for the 1956–1973 and 1963–1970 pipeline pairs and for the 1924–1977 powerline pair ($p<.001$, $p<.01$, and $p<.01$, respectively). The main effects due to differences in the several study areas showed significance ($p < .01$) only for the 1924–1968 powerline pair, the only two corridors with corresponding study area locations for years compared.

Percentage changes ($\Delta\%$) in biomass values were compared with percentage slope by regression analysis. There were no significant correlations among pipeline corridors. For powerlines, however, there was a positive correlation ($r = +.6132$) for pylon transects and a negative correlation ($r = -.6635$) for the same factors with road-edge transects.

Jaccard's coefficient of community similarity for pairs of transects (*CCj*) was used for another estimate of stability for pipelines and powerlines (Lathrop 1979). The *CCj* values, ranging from 0 to 1, are generally higher for powerlines than for pipelines, indicating that the control and disturbed transects are more nearly similar in the former. There are no significant differences in values among years of construction, but some differences are apparent among transect types. For pipelines, road-edge transects are most nearly similar to controls, whereas wire transects of the powerlines show the greatest similarity to controls. The berm and trench transects of pipelines were of approximately equal value and the pylon transects of powerlines had the lowest values for powerlines.

To further compare differences between control and disturbed transects, due to utility construction activities, measurements of % biomass were summed for all years of construction. Results for pipelines (Fig. 6) were particularly significant because 87% of the changes in biomass for the disturbed transects are negative. The few positive changes are highly variable, as indicated by the wide standard errors (*SE*s), but the negative changes have a relative narrow *SE*s for all disturbed transects.

Table 4. Relative biomass of perennial vegetation along powerline corridors by transect and year of construction.

	Mean percentage of biomass provided by					
Transect	*Larrea*	*Ambrosia*	*Atriplex*	Total LL	*Hymenoclea*	Total SL
1924 (7)[a]						
Control	14.5	22.0	28.2	73.8	2.0	26.2
Wire	21.3	21.1	24.9	73.6	5.2	26.4
Pylon	15.3	22.3	8.9	50.7	2.6	49.2
Road-edge	22.3	20.7	21.3	67.8	1.2	32.2
1933 (7)						
Control	33.0	14.6	18.9	85.9	10.9	14.1
Wire	31.3	25.8	34.9	94.6	2.6	5.4
Pylon	31.5	17.4	29.3	95.1	.04	4.2
Road-edge	27.0	24.5	38.2	95.3	2.4	4.7
1944 (10)						
Control	25.6	14.3	19.9	85.8	.8	14.2
Wire	24.8	35.0	23.1	87.9	.8	12.1
Pylon	20.7	21.1	34.5	91.7	1.3	8.3
Road-edge	20.1	21.9	32.2	87.5	1.9	12.5
1952 (8)						
Control	34.1	12.4	31.8	92.3	1.8	7.7
Wire	30.9	18.9	28.1	90.9	1.5	9.1
Pylon	28.8	19.1	28.5	81.7	5.1	18.3
Road-edge	28.5	19.6	30.1	86.5	4.3	13.5
1968 (5)						
Control	12.0	0.6	18.5	63.1	5.2	36.8
Wire	3.7	5.4	7.2	61.8	4.7	38.2
Pylon	8.1	5.2	16.4	51.7	4.5	48.3
Road-edge	2.5	7.1	15.3	67.3	1.0	32.7
1969 (7)						
Control	60.9	15.1	0	89.8	3.3	10.2
Wire	55.4	17.6	0	85.8	2.1	14.2
Pylon	41.0	37.7	0	75.4	10.3	24.6
Road-edge	27.4	46.5	0	77.4	14.0	22.6
1977 (6)						
Control	58.2	4.7	17.7	89.0	.8	11.0
Wire	33.7	10.4	23.4	83.0	.9	17.0
Pylon	34.1	22.2	10.4	79.9	5.2	20.1
Road-edge	37.7	20.7	27.0	88.5	1.0	11.5

[a]Numbers in parentheses indicate the number of study areas for each transect type.

Powerline Δ% biomass values (Fig. 7) average 73% negative for all disturbed transects. The *SE*s for negative transects of the powerlines are also relatively narrow, as they were for pipelines, but the *SE* ranges for positive changes in powerlines is not so great as those for pipelines.

Conclusion

Primary comparisons should be among the types of transects at each study site. Within types at each site, the soil, vegetation type, topography, and other features of the community are similar, allowing differences in disturbance to be comparable (Table 5). Study areas within corridors (secondary comparisons) included a wide variety of plant communities and landforms. Some communities, such as sparse dry playas, rocky pavement hills, and desert washes perhaps function to cut down effective comparisons. However, where the study areas were parallel corridors (Table 5) differences in study areas were significant. We interpret this to mean that corridor age affects vegetation type. Secondary com-

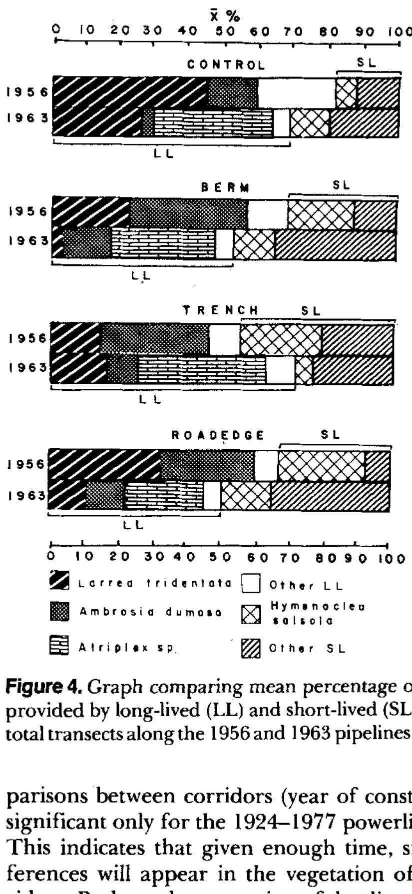


Figure 4. Graph comparing mean percentage of ($\bar{X}$%) biomass provided by long-lived (LL) and short-lived (SL) perennials for total transects along the 1956 and 1963 pipelines. (See Table 3.)

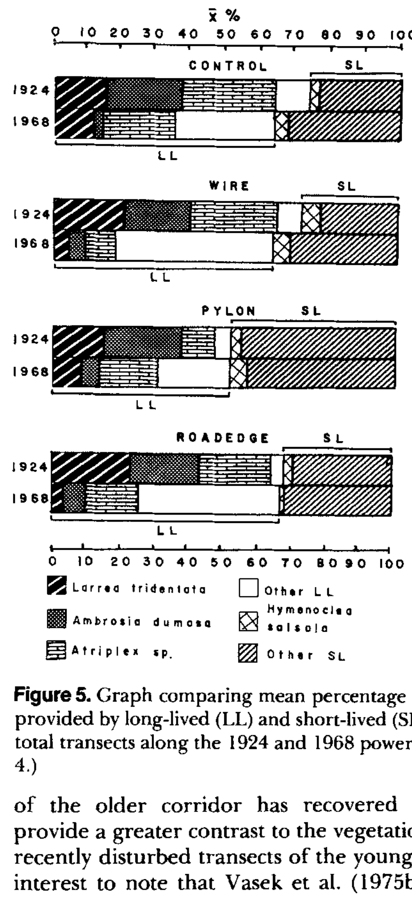


Figure 5. Graph comparing mean percentage of ($\bar{X}$%) biomass provided by long-lived (LL) and short-lived (SL) perennials for total transects along the 1924 and 1968 powerlines. (See Table 4.)

parisons between corridors (year of construction) were significant only for the 1924–1977 powerlines (Table 5). This indicates that given enough time, significant differences will appear in the vegetation of the two corridors. Perhaps the vegetation of the disturbed transects of the older corridor has recovered sufficiently to provide a greater contrast to the vegetation of the more recently disturbed transects of the younger line. It is of interest to note that Vasek et al. (1975b) reported no significance in their three-way ANOVA when they

Table 5. Significance levels from analysis of variance of indices integrating total cover and percentage of ground covered by long-lived species from selected corridors

			Source of Variation		
Corridor	Years compared	K	Construction year	Transects	Study area
Pipeline	1956–1973	6	ns[a]	p .001	—
Pipeline	1963–1970	6	ns	$p<.01$	—
Powerline	1924–1977	6	$p<.05$	$p<.01$	—
Powerline	1924–1968	3	ns	ns	$p<.01$
Powerline	1933–1969	6	ns	ns	—
Powerline	1944–1952	6	ns	ns	—

[a]Not significant at the .01 level of probability.

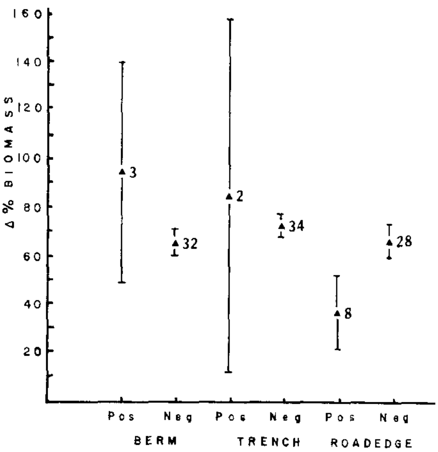


Figure 6. Total pipeline corridors summed to show percentage change (Δ %) in biomass of disturbed transects. Standard error (vertical lines) and the number of transects are shown for each mean (Δ).

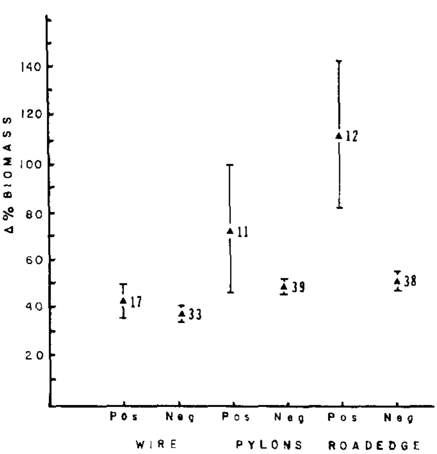


Figure 7. Total powerline corridors summed to show mean percentage change (Δ%) in biomass of disturbed transects. Standard error (vertical bars) and the number of transects are shown for each mean (Δ).

compared 1937 and 1970 powerlines. We also found no significant difference for corridor ages within the time spans reported by Vasek et al.

Disturbance brought about by construction of utilities corridors in the Mojave Desert of California generally tends to decrease productivity, diversity, and stability of the perennial vegetation. However, disturbance also enhanced vegetation in a small but significant number of disturbed transect sites. It is easy to make quantitative measurements of this enhanced cover, density, and even biomass, but when the enhancement is in the form of invader species and other less desirable species, such as *Chrysothamnus* sp., which occupy spaces once taken by dominants, then qualitative measurements must be made. These measurements are much more difficult and must be made from an ecological viewpoint.

The same qualitative–quantitative dichotomy appears when we assess productivity. Negative values of cover, density, and biomass in some transects may appear to be offset by positive values in other transects of the same study site. Likewise, differences in whole study areas may offset each other. Enhancement–loss measurements in corridors of different ages and locations sometimes offset each other. However it is worthy of note that although this offsetting does occur when we measure diversity and stability, the positive enhancement is much less pronounced in these qualitatively orientated measurements.

In short, before concluding that perennial vegetation of the Mojave Desert is holding its own against utility construction, one must examine both the quality and quantity of the vegetation changes. In doing so, one should ask the following question: Is the drastic disturbance encountered in some transects, such as under pylons and over trenches, really balanced out, ecologically speaking, by relative enhancement under wires and along road-edges? It is more important to look at what is there than how much is there. Tables 3 and 4 and Figs. 4 and 5 are valuable for this purpose because they show the mean percentage of biomass for several of the dominant LL and SL perennials. Based on the assumption that the LL perennials are the ones that are dominant in the natural undisturbed community, then it is reasonable to assume that their ranges of tolerance to the environmental factors perhaps make them best suited for the community. Invader species, often short-lived, are generally transient in the community and do not necessarily lend themselves to a high-quality community. Many of the SL species, however, are not invader species but are subdominants in the undisturbed community. The full list of species encountered in the various transects are shown by their relative age in Lathrop (1979).

The percentage change in biomass for summed total corridors (Figs. 6 and 7) indicate that most of the disturbed transects responded negatively to disturbance within a relatively narrow range. Positive changes tended to be comparatively few but highly variable. Differences in physical settings along corridor routes may contribute to some of this variability in vegetation response (Fig. 8).

In overall and long-term effects of utility corridor construction, there are variable effects of enhancement of vegetation along road edges, slight enhancement under wires of powerlines and over trenches of pipelines. Vegetation under pylons of powerlines seem to show the greatest damage and also the most variable recovery.

Depending on soil type, landform, and other physical features of disturbed sites, vegetation recovery progresses at variable rates. Drastic disturbance in one area or transect site may impede vegetation recovery, whereas slight disturbance might enhance it in another. As already stated, however, enhancements must be examined from a qualitative perspective. Percentage compositions that compare LL species to SL species allow us such a perspective.

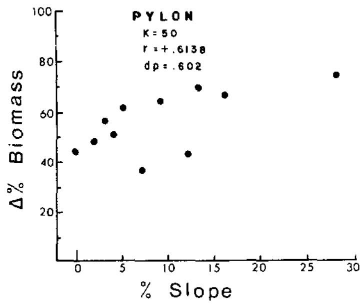
Management Considerations

Time Span for Recovery of Biomass

The biotic and physical factors affecting recovery of perennial vegetation following utility construction activities in the Mojave Desert have been discussed by Vasek et al. (1975a) for pipelines, Vasek et al. (1975b) for powerlines and by Johnson et al. (1975) for road edges.

It is very difficult to assess the time required for vegetation to return to its original condition in terms of composition, cover, and biomass, especially in a desert environment. Any attempt to estimate a time span for recovery, of biomass, for example, must take into account a number of assumptions, such as:

1. Predictability is dependent upon many variables:
   a. The degree and nature of the original disturbance, for example, pylon clearing creates greater disturbance than the laying of wires.
   b. Prevalence of invader species following cessation of disturbance.
   c. Seasonal and climatic conditions at time of initial invasion.
   d. Relative age span of a particular pioneer species.
   e. Variability of recovery within a particular disturbed site. For example, the greater the disturbance, the greater is the variability and predictability of recovery.



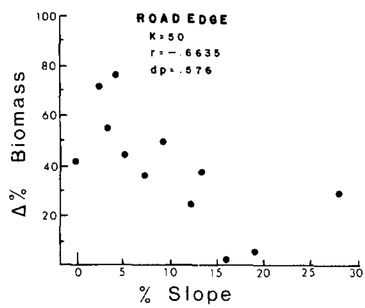


Figure 8. Linear regression analysis for pylon and road edge transects for total powerline corridors plotting percentage change ($\Delta\%$) in biomass against percentage of slope. K = number of sample sites; r = correlation coefficient; dp = decision point for r.

   f. Variability of recovery with potential site productivity, which is a function of climate, soil, etc.

2. Utility corridor construction results in virtually complete destruction to plant cover along the right of ways, with the exception of under wires of powerlines.
3. The undisturbed control sites represent vegetation as it occurred prior to disturbance.
4. The percentage of recovery for the time span from construction to observation can be estimated by plotting against the adjacent undisturbed vegetation.
5. Assuming a linear relationship, plotting percentage of recovery of the biomass of the disturbed site against the biomass of the control, we can predict a rough estimate of a time span for recovery.

Estimates of a time span for recovery are further made difficult when one considers that growth curves are not straight lines and that vegetation at disturbed sites in a desert environment may be unable to recover to full climax because the soil environment has been changed by the disturbance, that is, soil conditions on the corridor right of way are sometimes drastically different from predisturbance soil conditions (Vasek et al. 1975a).

However, on the assumption that our relatively large sample size (Table 1) will average-in the variables mentioned above we plotted biomass recovery against the year of construction for the utility corridors studied. Assuming that the successional vegetative growth (biomass) approximated a straight line relationship, biomass recovery to predisturbance conditions can be estimated as follows:

1. Pipeline berm and trench—100 years
2. Pipeline road edge—98 years
3. Powerline pylons and road edges—100 years
4. Under powerline wires—20 years

Using percentage recovery of LL species instead of biomass, our analyses indicated that the time span for recovery may be at least three times greater than that estimated for biomass recovery. Some other regeneration time estimate is necessary if percentage composition is considered for an estimate of time span for recovery.

Recovery measurements of vegetation along disturbed utility corridors appears to have higher cover and density values than similar measurements of recovery of vegetation from disturbance due to activities of off-road vehicles in the California deserts (Lathrop 1978). Wilshire and Webb (1979), in discussing recovery of vegetation on the streets of a Mojave Desert ghost town, indicated an extremely long recovery time, if the vegetation ever recovers.

Succession

According to Shreve (1942), desert plants have almost a total lack of reaction upon the environment. Muller (1940) states that, following destruction of a desert habitat, the first invaders are climax species or members of the original vegetation. Therefore, according to Shreve and Muller, the changes in species composition through to climax, are absent in the desert. While Muller and Shreve are essentially saying succession does not take place in the desert, Vasek (1979) says it does. Vasek (1979) describes long-term changes in both species composition and vegetation structure following disturbance in the desert. Vasek also indicates that such changes constitute succession as defined by Pickett (1976) and involves perennial herbs and, especially short-lived shrubs, as pioneer species. There was evidence of invasion of perennial herbs and pioneer short-lived shrubs in many of our disturbed transects, as discussed by Vasek (1979). We also found disturbed sites that had similar composition to the control area, as proposed by Muller

Mitigation Measures

The long period of time required for vegetation recovery following disturbance in deserts should be of primary concern. Mitigation measures that could be taken to minimize destruction might include the following:

1. Route corridors through less susceptible soil, vegetation, etc. Figure 8 indicates that pylon sites show better recovery on gentle slopes than on steep slopes. Road edges tend to recover to nearby control conditions better on steep slopes than on lower slopes. Also, recovery was noticed to be better where corridors passed through cheesebush (*Hymenoclea*) communities as opposed to creosote bush burrobush (*Larrea–Ambrosia*) communities.
2. Avoid known high nitrogen fixation areas, such as within cats' claw acacia (*Acacia greggii*) thickets (Garcia-Moya and McKell 1970).
3. Water harvest, particularly from construction of access roads. Part of what is destroyed is regained by the edge effect created by the road drainage.
4. Change environmental management procedures. Vegetation under power transmission lines seems to have been disturbed more in earlier construction. The recovery time spans for biomass under lines may go up to 30 years for older constructions, whereas recent constructions may show only negligible effects of disturbance.
5. Revegetate through seeding of areas that have been disturbed during construction (Brum 1979).
6. Avoid undue soil compaction; purposely loosen soil to aid natural revegetation along utility construction scars.

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