Vegetation Response to Natural and Anthropogenic Disturbances in the *Larrea-Ambrosia* and *Coleogyne* Shrublands

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Abstract—Vegetation response to various types of disturbances was quantitatively investigated in the *Larrea tridentata-Ambrosia dumosa* (creosote bush-white bursage) and *Coleogyne ramosissima* (blackbrush) shrublands of southern Nevada. Between the two control (undisturbed) habitats, the *Larrea-Ambrosia* vegetation zone had a greater plant species richness, but had a lower percent vegetation cover than the *Coleogyne* zone. Mean plant species richness and percent vegetation cover were significantly reduced in edge (disturbed) habitats compared to adjacent undisturbed habitats in both vegetation zones. A major shift in species composition to favor weedy (pioneer) species was observed in all disturbed habitats. Mean ratios of weedy to nonweedy species were significantly higher in disturbed relative to undisturbed habitats. Among the heavily disturbed habitats, roadside corridors exhibited the greatest, while human trail corridors exhibited the least invasion of weedy species. Woody and succulent (climax) species are highly vulnerable to habitat destruction and fragmentation as a result of natural and anthropogenic disturbances in the *Larrea-Ambrosia* and *Coleogyne* vegetation zones of southern Nevada.

Introduction

Habitat alteration and destruction are direct habitat removal when an ecosystem is converted to residential, recreational, commercial, agricultural, and industrial areas. Habitat destruction and fragmentation typically begin with gap formation or perforation of the vegetation matrix as humans colonize a Mojave Desert landscape or begin extracting resources there (Lord and Norton 1991; Meffe and Carroll 1997). As the gaps get bigger and more numerous, the original Mojave Desert woody vegetation is broken. Roads and powerline corridors as narrow as 8 m may produce significant edge effects by attracting weedy and exotic plant species (Meffe and Carroll 1997). Habitat destruction, fragmentation, and degradation can alter species richness initially, but often favors weedy and exotic species. Metapopulation dynamics suggest that even once common native desert plant species are not completely immune to the adverse effects of widespread habitat fragmentation and degradation (Brown and Lomolino 1998; Meffe and Carroll 1997; Noss 1983). Weedy plants are initially found along the edges, and these plants can become well established in desert interiors and outcompete natives at certain areas through time (Lei, personal observation 1998).

The internal fragmentation of once pristine natural areas by roads, trails, powerlines, fences, and other anthropogenic activities has not been well studied, but it has potentially dramatic effects on native biodiversity (Meffe and Carroll 1997).

The Las Vegas Valley and vicinity have experienced a rapid urbanization, economic growth, and recreational activities in recent years. Yet, a comparative vegetation response to various natural (fire and soil erosion) and anthropogenic (human/jeep trail, roadside, powerline, fence, and construction site) disturbances remain poorly understood. The objectives of this article were to compare changes in plant species richness, percent vegetation cover, and weedy/nonweedy species ratio among edge (disturbed) habitats of the *Larrea-Ambrosia* and *Coleogyne* vegetation zones in Las Vegas and the adjacent Spring Mountains of southern Nevada.

Methods

Study Site

Field studies were conducted in the Las Vegas Valley and the adjacent Spring Mountains (roughly 36°30' N, 115°30' W; fig. 1) in southern Nevada during Fall 1998.

Figure 1—A sketch map showing location of study sites in southern Nevada. The Spring Mountains lie just to the west of the Las Vegas Valley.

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The *Larrea-Ambrosia* vegetation zones occur at low elevations of the Las Vegas Valley, while the *Coleogyne* zones occur directly above the *Larrea-Ambrosia* zones at mid-elevations of the Spring Mountains.

The natural Mojave Desert woody vegetation occurred throughout the Las Vegas Valley and the Spring Mountains several centuries ago (fig. 2A). Gaps were gradually formed several decades ago, but became highly intensified in recent years as humans rapidly colonize this desert landscape (figs. 2B-C). At the present time, a substantial portion of the natural desert vegetation is broken (fig. 2D). Considerably more habitat destruction through fragmentation is expected in the near future due to rapid urbanization through residential, recreational, commercial, and industrial (economic) development. Eventually, the Las Vegas Valley and vicinity will become an immense anthropogenic habitat, with relatively little remaining of the native Mojave Desert woody vegetation.

The four seasons are well defined. Summers display desert conditions, with a maximum air temperature usually in the 40 °C range. Winters are generally mild and pleasant, with a minimum temperature just below the freezing range (Local Climatological Data, Las Vegas). The spring and fall seasons are considered most ideal, although sharp temperature changes can occur during these months. The precipitation patterns include summer storms and winter rains. Summer rainfalls generally occur in July through early September, and come from the Gulf of California, drawn into the Mojave Desert by strong convectional currents (Rowlands and others 1977). Conversely, winter rains are mild and widespread, and come from the Pacific Ocean. Winter rainfalls may last several days. Winter and summer precipitation contribute significantly to the annual precipitation (table 1), which varies considerably from year to year.

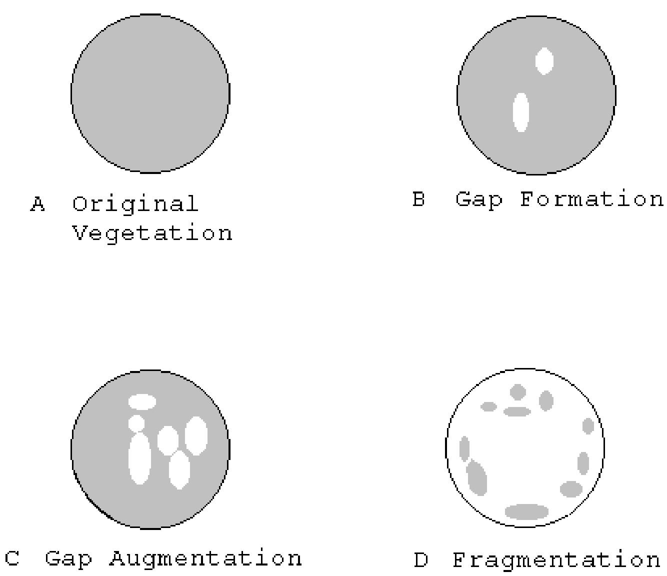

Figure 2—A schematic diagram showing a temporal sequence of habitat destruction through fragmentation starting from an original Mojave Desert woody vegetation (A) to a massive anthropogenic habitat (D).

Table 1—Mean monthly precipitation and mean monthly maximum and minimum air temperature based on the 1936-1997 data in the Las Vegas Valley. The climatological data (National Weather Service) were obtained collectively from multiple long-term weather stations in Las Vegas of southern Nevada.

Month	Air temperature (°C) High	Air temperature (°C) Low	Precipitation (mm)
January	14.4	1.1	12.7
February	17.2	3.9	11.4
March	20.6	6.7	10.2
April	25.6	10.6	5.1
May	31.1	15.6	5.1
June	37.7	20.6	5.1
July	41.1	23.3	11.4
August	39.4	23.3	14.0
September	35.0	18.9	7.6
October	27.8	12.2	6.4
November	19.4	6.1	11.4
December	14.4	1.1	7.6

In general, precipitation is positively correlated with elevation (Rowlands and others 1977). Relative humidity of 20 percent or less is common in the summer months, resulting in exceedingly high evaporation (Lei and Walker 1997a,b).

Field Surveys and Statistical Analyses

Three transects were established along each of the eight types of natural and anthropogenic disturbances (a total of 24 transects) in the *Larrea-Ambrosia* and *Coleogyne* vegetation zones. Three transects were also established in the adjacent undisturbed (control) habitats in each of the two vegetation zones. Each transect was 400 m in length. Within each transect, 10 (20 x 20 m) plots were randomly placed to avoid biased vegetation sampling. Within each plot, species richness was quantified, and vegetation cover was visually quantified in 10 percent increments. Ratios of weedy to nonweedy species were also computed.

Within each type of disturbance, vegetation data from three transects were pooled. One-way Analysis of Variance (ANOVA; Analytical Software 1994) was conducted to detect differences in vegetation attributes among the eight types of disturbed habitats in the *Larrea-Ambrosia* and *Coleogyne* shrublands. Tukey's Multiple Comparison Test (Analytical Software 1994) was performed to compare mean species richness, percent vegetation cover, and ratio of weedy to nonweedy species when a significant habitat effect was detected. Mean values are expressed with standard errors, and statistical significance is determined at $p \leq 0.05$.

Results

The *Larrea-Ambrosia* vegetation zone was considerably more disturbed and fragmented by anthropogenic activities than the *Coleogyne* zone in recent years in southern Nevada. Mean species richness declined significantly ($p \leq 0.001$; fig. 3) across the six types of disturbed habitats

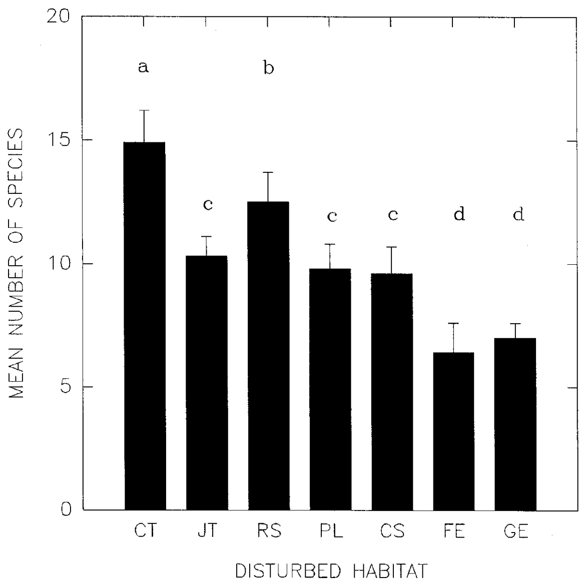

Figure 3—Species richness (mean ± S.E., n = 30 plots in each type of disturbance) in disturbed and undisturbed (control) habitats in the *Larrea-Ambrosia* shrublands. Symbols of disturbed habitats: Control (CT); jeep trail (JT); roadside (RS); Powerline (PL); construction site (CS); fence (FE); and gully erosion (GE).

compared to adjacent undisturbed habitats in the *Larrea-Ambrosia* vegetation zone. Among the edge habitats, roadside corridors had the greatest, while fence corridors had the lowest mean species richness (fig. 3). Mean percent vegetation cover also decreased significantly ($p \leq 0.001$; fig. 4) in these disturbed habitats relative to undisturbed habitats. Roadside corridors revealed the greatest, whereas gully erosion corridors revealed the lowest mean percent vegetation cover (fig. 4). However, mean ratio of weedy to nonweedy species increased significantly ($p \leq 0.001$; fig. 5) in disturbed habitats compared to undisturbed habitats in the *Larrea-Ambrosia* shrubland. Roadside corridors exhibited the highest mean ratio with a variety of weedy, herbaceous species (fig. 5).

Furthermore, mean species richness was significantly lower ($p \leq 0.001$; fig. 6) across the five types of disturbed habitats compared to adjacent undisturbed habitats in the *Coleogyne* shrubland. Conversely, mean species richness between the roadside and undisturbed habitats did not differ significantly (fig. 6). Mean percent vegetation cover was significantly lower ($p \leq 0.001$; fig. 7) in disturbed than undisturbed habitats. Roadside corridors exhibited the greatest, while fence corridors exhibited the lowest mean percent vegetation cover (fig. 7). In contrast, mean ratio of weedy to nonweedy species was significantly higher ($p \leq 0.001$; fig. 8) in disturbed relative to undisturbed habitats in the *Coleogyne* vegetation zone. Among the highly disturbed habitats, roadside corridors showed the highest mean ratio with abundant weedy, herbaceous individuals (fig. 8).

Discussion

The Las Vegas Valley and the Spring Mountains of southern Nevada have recently experienced a severe habitat destruction through fragmentation largely due to rapid urbanization, economic growth, and recreational activities. Ecological impacts of disturbance on vegetation of the *Larrea-Ambrosia* and *Coleogyne* vegetation zones have been conspicuous. The Mojave Desert habitats disturbed by natural and anthropogenic forces contributed to significant shifts in plant species richness, percent vegetation cover, and ratio of

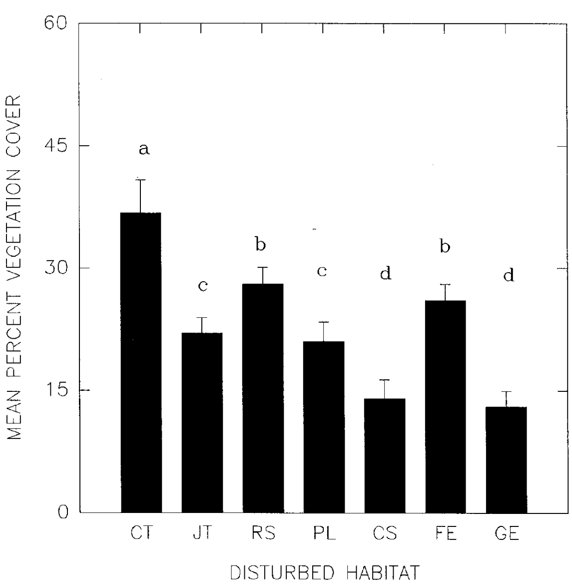

Figure 4—Percent vegetation cover (mean ± S.E., n = 30 plots) in disturbed and undisturbed (control) habitats in the *Larrea-Ambrosia* shrublands. Symbols of disturbed habitats are explained in figure 3.

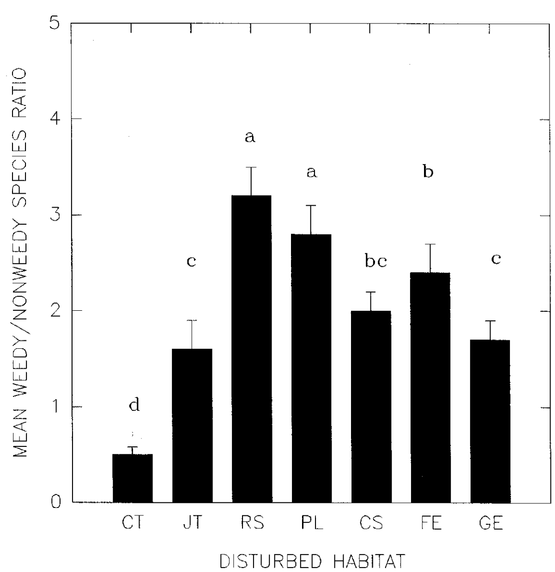

Figure 5—Ratio of weedy to nonweedy species (mean ± S.E., n = 30 plots) in disturbed and undisturbed (control) habitats in the *Larrea-Ambrosia* shrublands. Symbols of disturbed habitats are explained in figure 3.

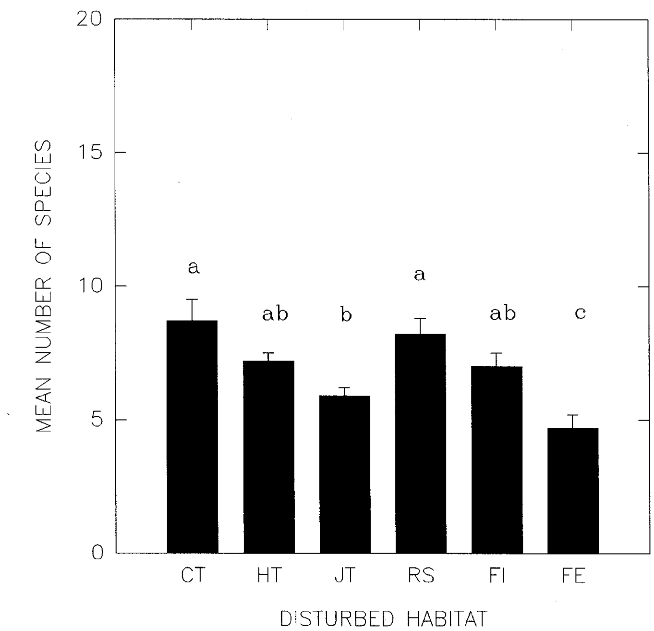

Figure 6—Species richness (mean ± S.E., n = 30 plots in each type of disturbance) in disturbed and undisturbed (control) habitats in the *Coleogyne* shrublands. Symbols of disturbed habitats: Control (CT); human trail (HT); jeep trail (JT); roadside (RS); fire (FI); and fence (FE).

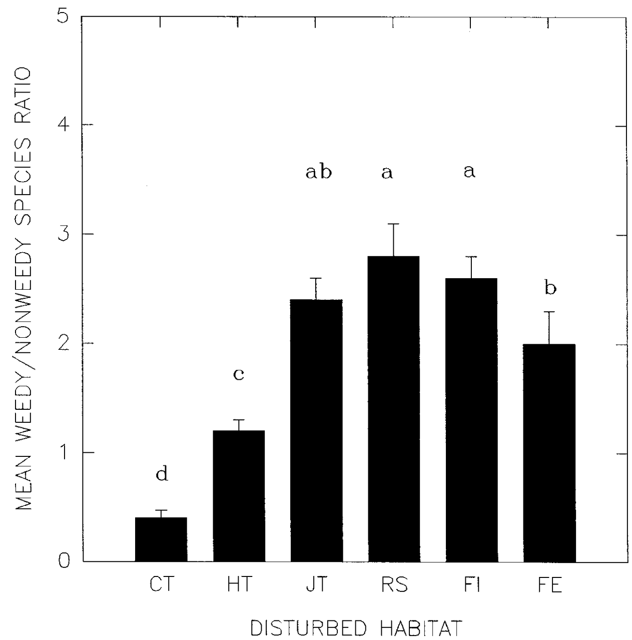

Figure 8—Ratio of weedy to nonweedy species (mean ± S.E., n = 30 plots) in disturbed and undisturbed (control) habitats in the *Coleogyne* shrublands. Symbols of disturbed habitats are explained in figure 6.

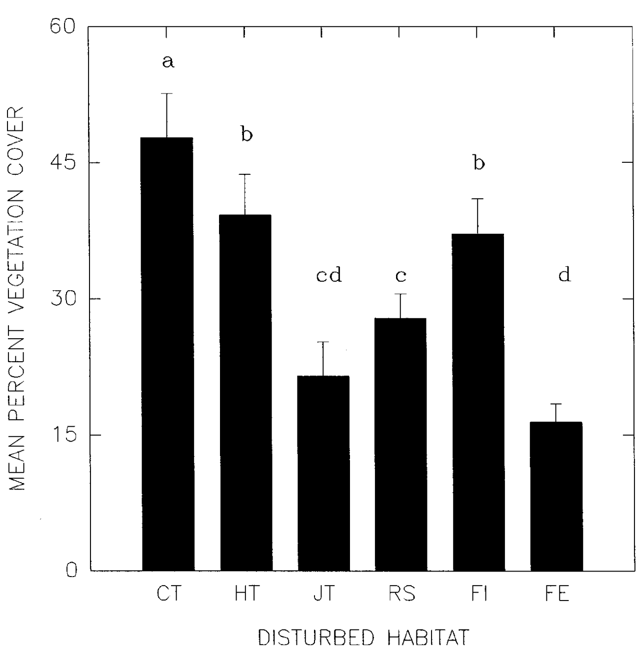

Figure 7—Percent vegetation cover (mean ± S.E., n = 30 plots) in disturbed and undisturbed (control) habitats in the *Coleogyne* shrublands. Symbols of disturbed habitats are explained in figure 6.

weedy to nonweedy species to favor weedy and opportunistic species.

From casual observations, weedy species, such as Russian thistle (*Salsola kali*), *Pectis papposa*, red brome grass (*Bromus rubens*), and *Eriogonum* spp., colonize within two months after initial disturbances. In this study, species richness and percent vegetation cover decreased significantly at highly disturbed sites, primarily due to the complete or nearly complete removal of native woody vegetation in the *Larrea-Ambrosia* and *Coleogyne* zones. Conversely, native woody, subwoody, and succulent plants contribute substantially to species richness and percent vegetation cover at undisturbed sites. Disturbance and fragmentation are not isolated events; rather, they are ongoing processes and may lead to a complete replacement of the native vegetation by many weedy and exotic plants along the edge habitats (Soule and others 1992). The ratio of weedy to nonweedy species was significantly higher at disturbed than undisturbed sites in this study, and such ratio is often more useful than species abundance and richness (Meffe and Carroll 1997). In both *Larrea-Ambrosia* and *Coleogyne* vegetation zones, roadside disturbance exhibited the highest ratio of weedy to nonweedy species, presumably due to an excess moisture supply (surface water run-off) along the gutter after major storm events. Nevertheless, human trail disturbance exhibited the lowest ratio of weedy to nonweedy species since the trails were typically less than 1.5 m wide and the extent of disturbance beyond the trails was minimal in this study.

Natural and anthropogenic disturbances through fragmentation in the *Larrea-Ambrosia* and, to a lesser extent, *Coleogyne* shrublands have led to a substantial habitat loss, and have created edge habitats and spatial heterogeneity. Edge zones subject to more disturbance than interior core zones, favoring weedy and opportunistic (edge) species (Murica 1995; Soule and others 1992). In general, the greater the structural contrast between adjacent undisturbed habitats, the more intense the edge effects (Meffe and Carroll 1997). The Mojave Desert landscape in Las Vegas has abundant edge zones and may gradually become dominated by edge-adapted species. The edge effect studies suggest that species composition and abundance patterns change in disturbed landscapes because some species are more vulnerable than others to increased isolation (metapopulation), edge effects, reduced interior core areas that contain critical resources, and other factors that accompany the disturbance process (Meffe and Carroll 1997; Murica 1995). As cosmopolitan plant species invade more and more disturbed areas, local vegetation types are likely to become homogenized by losing their floristic and ecological distinctness through time.

Implications and Future Directions

Habitat destruction and fragmentation are a major threat to biodiversity without significant changes in climatic, edaphic, and geomorphic conditions. Significant alterations in species diversity and vegetation cover at a local scale due to invasions by weedy and exotic species were evident in the Las Vegas Valley and vicinity. Although not quantitatively investigated in this study, biotic interactions, along with ecological processes and attributes, may change substantially as a result of edge effects and other accompaniments of habitat destruction and fragmentation. As urbanization, economic growth, and recreational activities intensify through time, considerably more conversion of a native Mojave Desert woody vegetation to an immense anthropogenic habitat is fully expected. Landscape restoration and large-scale revegetation to the original, pristine level are virtually impossible. In recognition of the alarming yet largely unmeasured destruction and conversion of native desert habitats, future research is required to properly address the biological underpinnings of ecological and conservation issues. Such issues may include ecological processes and attributes, biotic interactions, biodiversity, invasive and endangered species, metapopulation dynamics, as well as reserve size and design in a fragmented landscape caused by natural and anthropogenic disturbances in the southern Nevada region of the Mojave Desert.

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