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A Study of invasive species cover near roads in a Red Rock Canyon Blackbrush Community

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A Study of Invasive Species Cover near Roads in a Red Rock Canyon Blackbrush Community

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ABSTRACT

The monitoring of Mojave Desert plant communities during and following disturbance is an important process that could provide invaluable information about disturbance/recovery regimes in similar arid environments across the globe. Blackbrush communities are of particular interest because of their low replacement rate, which makes them highly susceptible to disturbance. Roads in the Mojave Desert have been associated with soil compaction resulting in a lack of vegetation as well as an increase in invasive species cover in the immediate proximity. To investigate these statements, eight fifty-foot line transects were established in each of three plot types (perpendicular to dirt roads, perpendicular to single-track roads, and controls) in Red Rock Canyon, NV. Two questions were posed of this study: 1) Is percent invasive species cover greater on transects in proximity to roads or on transects situated in undisturbed areas? 2) Does distance from a road influence invasive species cover? SPSS for Windows was used to conduct cross-tabulation tests in order to establish points of statistical significance ($p<0.05$). Results reveal that both invasive and endemic species cover is greater in undisturbed plots. Furthermore, three cross-tabulation tests reveal that a statistical relationship indeed exists between endemic/invasive species and proximity to a road. Examination of the cross-tabulation output reveals that 37.6% of all invasive species encountered in road transects occurred within ten feet of the road. Future investigations of the ecological impacts of roads should include fully developed roads and also account for bare ground as a disturbance impact equal to that of invasive species.

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Introduction

The monitoring of Mojave Desert plant communities during and following disturbance is an important process that could provide invaluable information about similar arid environments across the globe. As desert climax communities may take centuries to develop any kind of discernable change in ecological structure and/or function (Bolling and Walker) following disturbance, long-term research on various aspects of succession in the Mojave Desert is absolutely necessary. One of the foremost reasons for this is that deserts are considered to be among the most fragile of Earth's ecosystems since they are extremely prone to degradation of soil and vegetation (Webb and Wilshire 1983) (Hinckley, Iverson, and Hallet, 1983), and thus, prone to destruction by disturbance. Observation of Mojave Desert vegetation communities, their spatial structure, and potential sources of ecological and human-induced disturbance over a span of several decades can provide important clues about disturbance-recovery regimes, as well as the effects of climate change, human activity, non-native plant invasions, and plant/animal interactions (Webb et al 2001).

To date, most knowledge about ecological succession in low latitude deserts like the Mojave comes from studies on the effects of natural and anthropocentric disturbance upon vegetation. A strong foundation in past research has been established in this area, and serves as an invaluable resource from which to derive questions about disturbance and its effect upon Mojave Desert plant ecology.

Dr. Janice Beatley's establishment and continued observation of sixty-eight permanent ecological plots at the Nevada Test Site (NTS) has contributed enormously to this end (Webb et al 2001). The NTS served as an ideal site for Dr. Beatley's research, as the facility was able to exert a great deal of control over the type and extent of disturbance affecting plant communities contained within its boundaries (Webb et al 2001). As Dr. Beatley was provided unrestricted, long-term

access to these plots, she was able to observe the recovery of typical Mojave Desert plant communities following disturbances (Beatley 1966). During the course of her research, Beatley (Webb et al 2001) observed that the often-ancient Blackbrush communities scattered throughout the NTS were among the most susceptible of Mojave vegetation types to disturbance, particularly fire. She also observed that the eradication of Blackbrush communities by fire often resulted in establishment of invasive brome grasses (1966).

A study by Mathew L. Brooks (1999) makes similar observations of invasive plant establishment in the Mojave Desert. Brooks'study of habitat ivasibility by alien annual plants concluded that disturbance in *Larea tridentata/Ambrosia dumosa* communities often led to the establishment of invasive species, mainly grasses (Brooks 1999). In a 2003 study, Brooks and J.R. Matchett attested to the same susceptibility within Blackbrush communities, essentially echoing Beatley's earlier conclusions regarding the species' susceptibility to fire and subsequent invasion by non-native species (Brooks and Matchett 2003).

In addition to her observations on succession following disturbance, Beatley (1975) also explored the idea that the locations of different plant communities throughout the Mojave Desert ecosystem were due, in large part, to climate and geography. Through this research, Beatley was able to define the locations of several typical Mojave Desert plant community types, including Blackbrush, primarily as ecological functions of climatic factors such as wind, temperature, elevation, and precipitation (Beatley 1975).

Unfortunately, natural disturbances and climatic processes are not the only factors affecting the continued ability of native plant communities to prosper in the Mojave Desert. Human activities can drastically alter the composition of plant communities in deserts. The presence of roads and trails intended for off-road vehicle use has become an area of growing concern in desert

conservation strategies, as compaction of the desert soil greatly reduces the ability of many shrub species to become established (Gelbard and Belnap 2001)(Webb and Wilshire 1980)(Bolling and Walker 1998). Soil compaction inhibits N cycling among soil microbes, which further detracts from the soil's ability to support endemic shrubs (Webb and Wilshire 1980). Bolling and Walker (1998) studied the establishment of shrubs along eight abandoned desert roads, and found that research sites containing roads supported fewer *Larrea tridentata* and *Ambrosia dumosa* individuals than did control plots that contained no roads. This study concluded that the decline in plant density with proximity to roads was due to compaction of the desert soil that occurs as a result of road construction and continued use by motorized vehicles (Bolling and Walker 1980). In another study dealing with the recovery of desert vegetation along abandoned roads, Webb and Wilshire (1991) discovered that soil on some desert roads still suffered from the ecological consequences of compaction fifty-one years after the last recorded use of the road.

If a study is to properly address the effects of disturbance in the Mojave Desert, an increased potential for invasive species establishment must certainly be considered. In areas that have been subject to severe disturbance, invasives are often able to quickly establish large populations and inhibit the ability of endemic plants to successfully regain their foothold. Identification of invasive plants and the determination of their effect on Mojave Desert ecology could be vital in determining whether or not endemic vegetation will be able to successfully recover following a particular disturbance type, and, if not, how to best mitigate the invasion. In their study on roads as conduits for invasive species establishment, Gelbard and Belnap (2001) found that the percent invasive species cover in roadside verges increased in corellation to the development level of the road. For example, Cheatgrass (*Bromus tectorum*) cover along off road vehicle tracks (9%) was three times less than that in proximity to developed dirt roads used by passenger vehicles (27%) (Gelbard and Belnap 2001).

The establishment of invasives in a particular area can present important ecological concerns. In deserts, water and soil nutrients are in shorter supply than many other ecosystems. If a particular invasive establishes itself within a native plant community, the water and nutrient availability on that particular site could be drastically altered (Brooks 1999). Increased fire risk is also an important issue with some invasives (Beatley 1966). The presence of certain invasive species, such as Russian thistle (*Salsola kali),* which, upon death, accumulates in large, dry masses which often serve as excellent, fast burning fuel for desert wildfires (Yoder and Nowak 2000)(U.S. Forest Service 2004).

Blackbrush communities are of particular concern when contemplating disturbance in the Mojave Desert ecosystem. Given the species' extremely low replacement rate (USFS 2004), Blackbrush can often assist scientists in ascertaining whether or not a particular area has been subject to disturbance. Because Blackbrush populations take a very long time to re-establish themselves following disturbance, it can often be concluded that a healthy, dense Blackbrush community is indicative of an area that has experienced little to no disturbance for quite some time (USFS 2004). Blackbrush is considered to be of further importance because of the fact that the species occurs almost monotypically in the transition zones between the Mojave Desert and Great Basin, as well as the western border of the the Sonoran Desert (USFS 2004)(NRCS 2003). Thus, Blackbrush communities often serve to delineate the borders between these three distinct deserts. Because of the species' importance and fragility, the preservation of Blackbrush communities in public recreation areas should be an important land management consideration.

As the construction of roads and the often simultaneous spread of invasive species within desert shrub communities may produce long lasting, if not irreversible, consequences to the Mojave Desert ecosystem (sited above), a solid understanding of how the these consequences develop and how they may be halted and eventually reversed is surely an important aspect of "multiple-use"

land management. In an effort to add to this understanding, the intention of this study was to determine whether or not the percent cover of invasive species is affected by proximity to two road types in a Red Rock Canyon NCA (Clark County, NV) Blackbrush community:

1. Is percent invasive species cover greater on transects in proximity to roads or on transects situated in undisturbed areas?
2. Does distance from a road influence invasive species cover?

Methods

<u>Study Site</u>

The site chosen for this study was located in the Red Rock Canyon National Conservation Area, in Clark County, Nevada ("Red Rock Canyon" henceforth), approximately 20 miles west of Las Vegas (U.S. BLM 2004). Because of the area's unique scenery and natural aesthetic value, Red Rock Canyon is well known among Las Vegas residents and tourists for its excellent opportunities to engage in many different types of outdoor recreation, ranging from hiking, to horseback riding, to mountain biking, to rock climbing.

At its lower and intermediate elevations, Red Rock Canyon experiences conditions typical of the Mojave Desert climate (Herriman 2004). The area has an average annual temperature of 66 degrees F, with the highest temperatures often occurring in August (104 degrees F), and the lowest temperatures typically occurring in January (32 degrees F). Red Rock Canyon receives an average annual rainfall of 4.23", which accumulates over approximately 71 days out of each year (RRCIA 2004).

Red Rock Canyon is home to several different Mojave Desert vegetation assemblages, which vary primarily according to elevation. At higher elevations (5000'-7000'), pinyon/juniper forests

dominate, while areas of low elevation are commonly home to desert shrub and Joshua Tree (*Yucca brevifolia)* communities (3500'-5000'). Blackbrush (*Coleogyne ramosissima)* is commonly found in the intermediate elevations (4000'-6000') (RRCIA 2004).

At the lower end of its elevational range in Red Rock Canyon, Blackbrush communities may often be located in close proximity to roads and trails used primarily for recreational purposes. The particular area within Red Rock Canyon utilized in this study, commonly referred to as Cottonwood Valley, expresses both of these characteristics. Cottonwood Valley, which occurs at the Southern end of the Red Rock Canyon National Conservation Area, is home to visually distinct populations of characteristic low-elevation desert plant communities, including Larea tridentata, Ambrosia dumosa, and Joshua Tree. As intermediate elevations are achieved in this area, Blackbrush appears to become the dominant vegetation very rapidly.

Cottonwood Valley is subject to considerable use by the public. The developed dirt road utilized for access to the study site passed directly through all of the area's dominant vegetation types and was used steadily throughout the morning and early afternoon by motorized vehicles on the day of the study, mainly passenger cars and trucks. A portion of a smaller road, referred to in this study as a "single-track" road, occurred in proximity to the main road for a short distance, and actually intersected it once within the study site, in an area dominated by Blackbrush. People were observed riding mountain bikes along the single-track road throughout the day.

Figure (1)- Developed dirt road

Figure (2)- Single-track trail

Procedures

The developed dirt road and the single-track road were identified as suitable subjects for this study due to the fact that both roads are presently being utilized, and both occupied space within Blackbrush-dominant plant communities. An area that was located a significant distance from the roads, while still belonging to the same vegetative association was established as a control area for the study to assist in minimizing the opportunity for error presented by sampling only near roads.

In order to evaluate whether or not invasive species density varied with proximity to these roads, line transects were used as the primary sampling method. The line transect method has been established by the US Fish and Wildlife Service (2004) as an effective measurement of species composition by cover. The method is designed for maximum effectiveness in grass, forb, or shrub communities where most individuals are less than 2m in height (USFWS 2004).

Once the appropriate transect distance is determined, a measuring tape is laid out in a straight line across this distance (either on a specific bearing or random in direction), so that horizontal, linear measurements may be taken. Beginning at distance=0 along this transect, each plant type and the corresponding distance it occupies along the measuring tape is recorded for each individual. If two or more species are encountered in the same distance interval, all species present are recorded as occupying that particular interval.

This study employed a relatively large number of short transects in order to ensure that a sufficient length of each road type (as well as the control area) was sampled. Eight transects each were established along the single-track road and the developed dirt road. Four one hundred foot transects were established in the control area, and were subsequently re-divided into eight, fifty

foot long transects for the purposes of consistency with the number of plots established along each road type.

Transect locations in the control area were determined by walking in a random direction for at least 100m using the pace length of Dr. Patrick Drohan as the method of measurement. Transect bearing was also determined at random for all transects in the control area. Transects along the single track road were located at intervals of no less than 100m. Four transects were established on each side of the road, alternating sides between each, with each transect lying approximately perpendicular to the road. Sampling for the developed, dirt road remained consistent with sampling along the single-track road. However, because a deep wash ran along one side of the road for some distance, alternating sides of the road was not a viable option. Thus, although four transects were sampled on each side of the developed dirt road, they did not alternate consistently. Starting points of each line transect along both road types as well as in the control area, were recorded using a handheld GPS unit.

The actual sampling for this study took place on February 29, 2004. For the sake of efficiency, two people were utilized to collect the line transect data. Dr. Patrick Drohan identified the plants and the intervals along the line transect, while I wrote down the interval and species type called out by Dr. Drohan. Unknown plant species were photographed for later identification with a digital camera. Photograph reference numbers were recorded along with plant data at the corresponding intervals. A one hundred foot tape, subdivided into 0.1" increments was used to delineate the each transect, and thus, transect intervals were recorded to the nearest tenth of an inch.

Upon completion of field data collection, a limited amount of statistical analysis was performed to aid in answering the two principal questions posed by this study. All species encountered in

the study were identified and recorded. Subsequently, species were identified as invasive, endemic and unknown.

Graphical representations of percent cover of bare ground, invasive species, and endemic species will be created for each transect studied. Graphical representations will also be created for comparison of total percent cover by transect type (control, single-track, dirt road). Comparisons of raw data and graphical data should help in answering the first question, regarding the difference in invasive species cover between control transects and road transects.

A computerized statistics program, SPSS for Windows, was used to determine whether or not statistically significant relationships exist between 1) invasive vs endemics species cover and proximity to roads. Five cross-tabulation tests were developed based on the fact that the data collected in the study was mainly categorical and/or nominal (indemic or invasive, distance interval ID, etc), they are as follows:

1. All road transects: distance from road * endemic or invasive species
2. Dirt road transects: distance from road * endemic or invasive species
3. Single-track transects: distance from road * endemic or invasive species
4. Single-track transect or dirt road transect * endemic or invasive species
5. Road transect or control transect * Endemic or invasive species

In order to obtain the largest sample size for cross-tabulation, each transect was broken into "occurences", whereby 0.01"=1 occurrence. A "distance interval ID", ranging from 1-10 with each number representing a five foot interval on each road transect, was also assigned to each occurrence based on its distance from the road (10 being closest to the road, 1 being furthest away). Bare ground was not considered in any cross-tabulation tests.

Each cross-tabulation test was reported with both a chi-square significance score and a Kramer's-V score. The chi-square score (p) simply reports whether or not statistical significance exists, not the degree or direction of significance (statistical significance/reject null= $p<0.05$). The Kramer's-V score does not show exactly where the data are significant either, but it should help "dial in" the chi-square score by providing somewhat of a scale of significance, where the closer the score is to one, the more significant the relationship. Since crosstabulation compares percentages within categories to determine significance, the results of the crosstabulation tests will also be used to compare percent covers of invasive species at different distance intervals from the road, which should enable a better idea of where relationships in this area exist, if at all.

Results

I. Species Identified

Figure (3)- Species Identified

Blackbrush (*Coleogyne ramosissima*)	
Nevada Ephedra (*Ephedra nevadensis*)	
White Bursage (*Ambrosia Dumosa*)	
Buckwheat (*Genus Erigonium*)	
Desert Marigold (*Baileya multiradiata*)	
Indigo Bush (*Dalea fremontii)*	
Yucca (Genus *Yucca*)	
Brittlebush (*Encelia Adans*.)	
Black Sage (*Salvia mellifera*)	
Burro Brush (*Hymenoclea monogyra*)	
Desert Pepperweed (*Lepidium fremontii*)	
Cholla (Genus *Opuntia*)	
Cheatgrass (*Bromus tectorum L*.)	
Red Brome (*Bromus madritensis*)	
Mediteranean Grass (*Schismus barbatus*)	
Mustard (*Brassicaceae* Family)	

II. Percent cover of major vegetation types by transect and transect type

Figure (4)- Control Transects: Percent Cover of Bare Ground, Invasive Species and Endemic Species

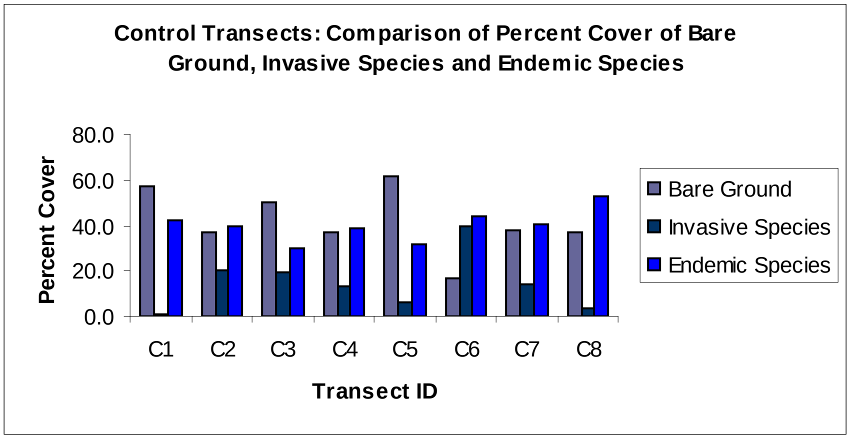


Figure (5)- Single-track Transects: Percent Cover of Bare Ground, Invasive Species and Endemic Species

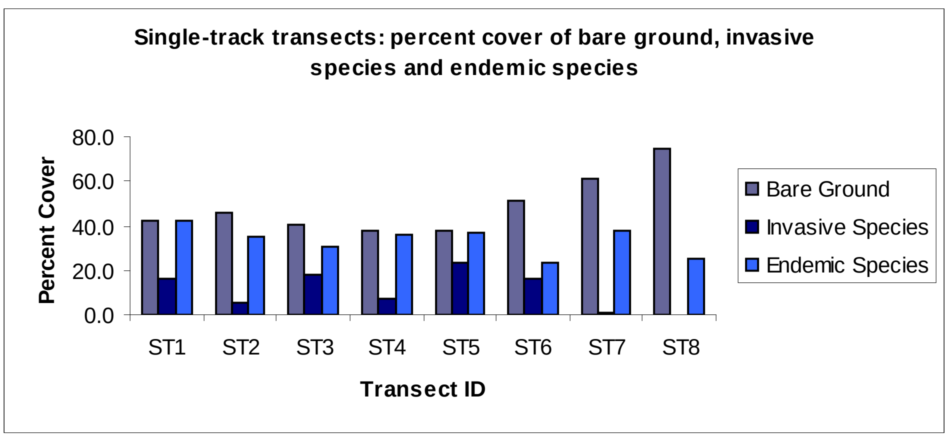


Figure (6)-Dirt Road Transects: Percent Cover of Bare Ground, Invasive Species and Endemic Species

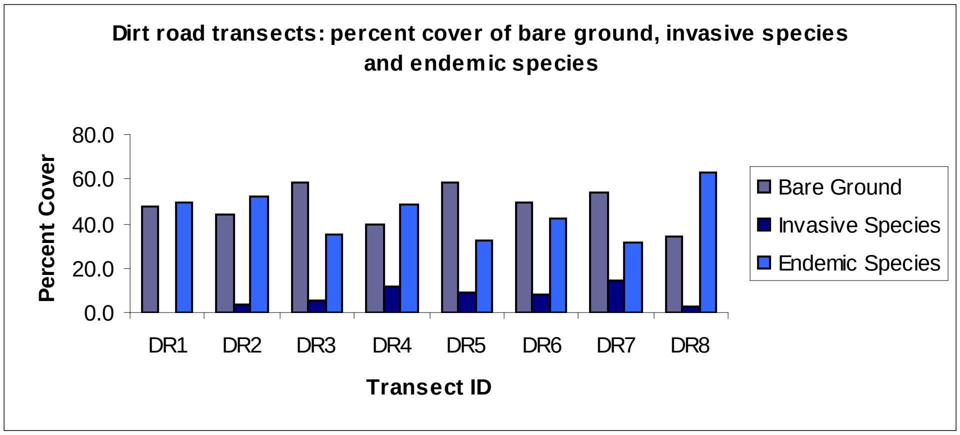
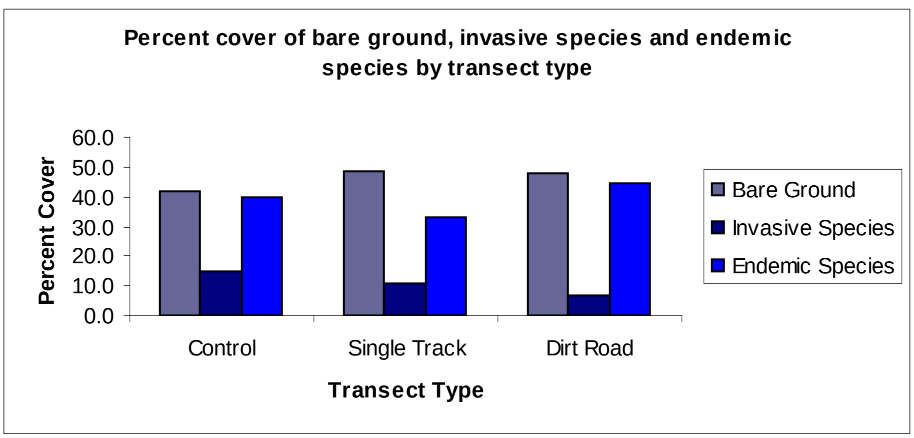


Figure (7)-Percent Cover of Bare Ground, Invasive Species and Endemic Species by Transect Type



III. Percent total invasive species cover with relation to distance from roads

Figure (8)- Percent total invasive species cover as a function of distance from the road: dirt road and single-track transects

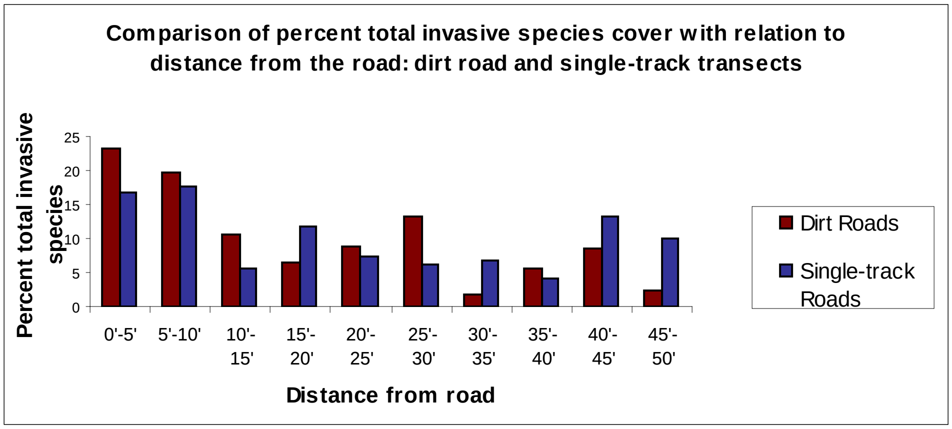
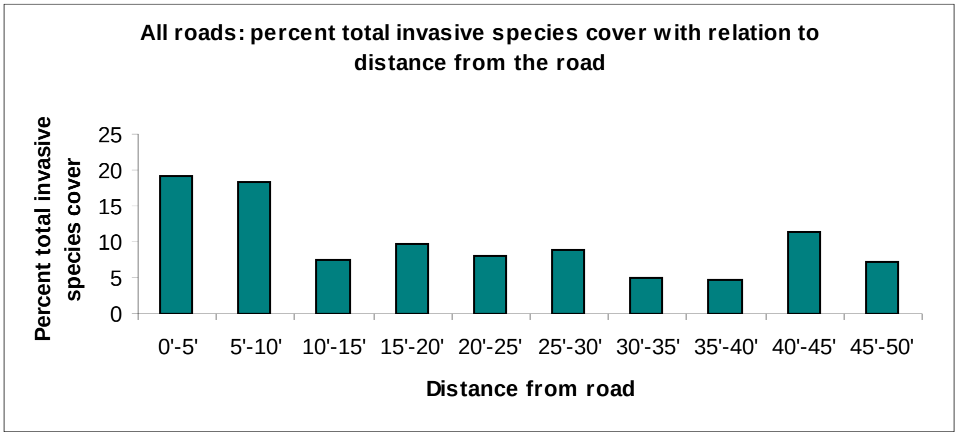


Figure (9)- Percent total invasive species cover as a function of distance from the road: all road transects



IV. Determination of Statistical Significance

Table (1)- Summary of results for measures of statistical significance (See Appendix B for actual SPSS output)

Crosstabulation test description (variable 1 * variable 2):	Chi-square significance	Kramer's V score	*p*<0.05?
All road transects: distance from road * endemic or invasive species	0.000	0.278	y
Dirt road transects: distance from road * endemic or invasive species	0.000	0.337	y
Single-track transects: distance from road * endemic or invasive species	0.000	0.281	y
Single-track transect or dirt road transect * endemic or invasive species	0.000	0.225	y
Road transect or control transect * endemic or invasive species	0.000	0.087	y

Discussion

This study poses two principal questions regarding invasive species cover near roads in Red Rock Canyon Blackbrush communities:

1. Is percent invasive species cover greater on transects in proximity to roads or on transects situated in undisturbed areas?
2. Does distance from a road influence invasive species cover?

This section will discuss how the answers to these questions might be derived from the data recorded over the course of this study. Following this analysis of the results are some ideas regarding how this study could be improved in terms of sample size, sample characteristics, and procedural error.

With regard to the first question posed by this study, whether or not invasive species cover is greater in undisturbed control transects as opposed to transects in proximity to roads, the results reveal that both invasive and endemic species cover is greater in the udisturbed control plots. A

cross-tabulation of invasive or endemic species by road or control transects, via a *p*-value of 0.000, reveals that a statistical significance exists between these two variables. The fact that both invasive species cover and endemic species cover are greater in undisturbed areas than areas near either road type could indicate that the presence of roads may somehow inhibit the growth of either plant type, possibly through soil compaction. This idea is further reinforced by examining the amount of bare ground in each transect. Control transects contain less bare ground altogether than either type of road transect. Unfortunately, the presence of a potential outlier (transect C6 shows 39.2% invasive species cover) arouses suspicion as to the accuracy of these results since the transect with the next-highest percent invasive species cover displays just over half of this value (transect ST5 at 23.0%). Due to the relatively small number of transects sampled, the extreme value in transect C6 could certainly result in a poor representation of actual invasive species cover in undisturbed areas.

The second question addressed in this study, as to whether or not distance from roads drives invasive species cover, proves more difficult to answer conclusively given the current study design and time alotted for completion of research and analysis. However, strong results were obtained in this category, and certainly warrant further research at the very least.

Statistical significance ($p < 0.05$) was established for this relationship through three cross-tabulation tests:

1. All road transects: distance from road * endemic or invasive species
2. Dirt road transects: distance from road * endemic or invasive species
3. Single-track transects: distance from road * endemic or invasive species

All three tests reported significant Kramer's-V scores, as well, with single tracks scoring about 0.06 points higher than dirt roads. These indicators of statistical significance could certainly be interpretted as invasive species cover occurring as a function of proximity to a road. However,

these same scores could also indicate that *endemic* species cover may occur as a function of proximity to roads. This could also mean that either invasive or endemic species cover occurs as a function of location at the far end of a transect.

As the Chi-square and Kramer's-V outputs fail to reveal the location and degree of significance in the data, a closer examination of the actual percent cover (not including bare ground) of invasives is necessary (this data is produced as a part of SPSS cross-tabulation output and is included in appendix()).   Perhaps the most integral data to this study, the cross-tabulation output, revealed that approximately 42.9% of all invasive species encountered on dirt road transects occurred within ten feet of the road. In addition, 34.7% of all invasive species encountered on single-track transects were also located within ten feet of the road.

When considered in conjunction with the statistical significance established by the cross-tabulation tests, it certainly appears that invasive species cover is related to proximity to roads. The percent covers of invasive species within ten feet of roads certainly seem large enough to infer that the greatest percentage of invasives is likely to occur in this interval. On the other hand, it may not be inferred that invasive species cover declines with distance from a road, as percent cover data seem to fluctuate throughout the rest of most transects. Since average invasive species cover varies by a margin of 6.2% in the ten feet nearest the road for both dirt roads and single-tracks, it also seems logical to state that the effect of the larger dirt road upon invasive species cover slightly exceeds that of the smaller, single-track trail.

Due to the simple, quantitative nature of the questions posed by this study, I am confident in the accuracy of both the study results and the above discussion of those results. However, over the course of study design and research, several potentially important weaknesses became apparent.

Had more time been allotted, a larger sample of Red Rock Canyon could have been studied. It would be interesting to investigate whether or not a study containing fifteen, 100 foot transects per transect type (dirt road, single-track or control) would have yeilded similar percent cover results. A fully developed, paved road could also have made a worthy addition to the study. Research upon a fully developed road could further support or refute the hypothesis established above, whereby different road types seem to produce similar percent covers of invasive species in the closest ten feet.

Several unknown plant species were encountered over the course of research. Given my limited experience in Mojave Desert plant identification, on-site identification of all species present would have been extremely difficult. Although good-quality digital photographs were taken of all unknown species for later identification by an expert (Doug Merkler, USNRCS Soil Scientist), several species remained unidentified, and therefore, left out of the final invasive or endemic species count.

Another potential source of error was the time of year in which the study was conducted. At the time, it appeared as though almost all of the grass species encountered, particularly the Red Brome, were just beginning to emerge. If this is the case, individuals of these species could occupy significantly more linear space later in the season or in early summer.

To effectively evaluate the full ecological impact of a particular road disturbance upon vegetation, future studies should examine the presence of bare ground as a disturbance impact at least equal in magnitude to that of the presence of invasive species. This should be particularly true in low-replacement vegetatitive communities such as those dominated by Blackbrush. The greater amount of bare ground observed in proximity to roads as opposed to undisturbed areas could represent areas of extreme compaction resulting from construction or use. Furthermore,

soils that have experienced a high degree of compaction may not be able to successfully support any kind of vegetation for centuries. Thus, identifying the relationship between bare space and proximity to roads is vital.

I believe this study to be a very effective starting point for research of the ecological impacts of roads upon low-replacement vegetative communities. Simple, yet effective data collection and statistical analysis methods were used to identify some very basic quantitative characteristics of different vegetation types along roads in Red Rock Canyon. From this study, two interesting conclusions were reached that may serve as effective hypotheses for further research:

1) Invasive species cover in Blackbrush communities is different near roads than in undisturbed areas.
2) Invasive species cover changes with proximity to roads. This effect seems to be similar across two different road types.

By examining all potential impacts of road disturbance, ranging from invasive species cover, to soil compaction to water and nutrient availability, a much more detailed picture of the impacts of road construction and use will eventually be constructed. It is imperative that these impacts be investigated thoroughly if effective measures of mitigation are to be developed or if irreversible consequences are to be identified.

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Appendix A- Percent cover by transect and species

Transect ID	Blackbrush	Nevada Ephedra	White Bursage	Erigonium	Baileya multiradiata	Indigo Bush
C1	39.2	2.6	0.0	0.0	0.0	0.0
C2	31.2	6.0	2.2	0.0	0.0	0.0
C3	13.4	5.6	0.0	0.0	0.0	0.0
C4	36.8	0.0	0.0	0.0	0.0	0.0
C5	24.8	0.4	0.0	4.2	0.0	0.0
C6	34.6	7.2	0.0	0.0	0.0	0.0
C7	30.8	2.8	0.0	0.0	0.0	0.0
C8	32.2	10.0	0.0	0.0	0.0	0.0
ST1	35.2	0.0	0.0	0.0	0.0	0.0
ST2	19.8	8.6	0.0	0.0	0.0	0.0
ST3	11.2	10.8	0.0	0.0	2.8	0.0
ST4	32.6	3.0	0.0	0.0	0.0	0.0
ST5	27.0	1.4	7.4	0.0	0.0	0.0
ST6	13.0	1.2	1.4	8.0	0.0	0.0
ST7	11.6	10.8	0.6	2.6	0.0	0.0
ST8	20.8	2.4	2.2	0.0	0.0	0.0
DR1	32.4	2.0	0.0	15.0	0.0	0.0
DR2	38.8	11.0	2.4	0.0	0.0	0.0
DR3	17.4	4.6	4.4	0.0	0.0	4.4
DR4	35.0	11.6	1.4	0.0	0.0	0.0
DR5	29.0	0.0	3.8	0.0	0.0	0.0
DR6	25.6	10.6	4.6	0.0	0.0	1.8
DR7	23.8	1.6	4.6	1.4	0.0	0.0
DR8	39.4	10.2	13.6	0.0	0.0	0.0
Totals						
Control	30.4	4.3	0.3	0.5	0.0	0.0
Single Track	21.4	4.8	1.5	1.3	0.4	0.0
Dirt Road	30.2	6.5	4.4	2.1	0.0	0.8

Appendix A (cont.)

Transect ID	Yucca Brevifolia	Encelia	Eph/Bai mix	Black Sage	Burro Brush	Cholla
C1	0.0	0.0	2.6	0.0	0.0	0.0
C2	0.0	0.0	6.0	2.2	0.0	0.0
C3	11.0	0.0	5.6	0.0	0.0	0.0
C4	0.0	1.6	0.0	0.0	0.0	0.0
C5	0.0	0.0	0.4	0.0	4.2	0.0
C6	0.0	0.0	7.2	0.0	0.0	0.0
C7	0.0	1.4	2.8	0.0	0.0	0.0
C8	0.0	4.0	10.0	0.0	0.0	0.0
ST1	0.0	0.0	0.0	0.0	0.0	0.0
ST2	0.0	0.0	8.6	0.0	0.0	0.0
ST3	0.0	0.0	10.8	0.0	0.0	2.8
ST4	0.0	0.0	3.0	0.0	0.0	0.0
ST5	0.0	0.0	1.4	7.4	0.0	0.0
ST6	0.0	0.0	1.2	1.4	8.0	0.0
ST7	0.0	0.0	10.8	0.6	2.6	0.0
ST8	0.0	0.0	2.4	2.2	0.0	0.0
DR1	0.0	0.0	2.0	0.0	15.0	0.0
DR2	0.0	0.0	11.0	2.4	0.0	0.0
DR3	0.0	0.0	4.6	4.4	0.0	0.0
DR4	0.0	0.0	11.6	1.4	0.0	0.0
DR5	0.0	0.0	0.0	3.8	0.0	0.0
DR6	0.0	0.0	10.6	4.6	0.0	0.0
DR7	0.0	0.0	1.6	4.6	1.4	0.0
DR8	0.0	0.0	10.2	13.6	0.0	0.0
Totals						
Control	1.4	0.9	4.3	0.3	0.5	0.0
Single Track	0.0	0.0	4.8	1.5	1.3	0.4
Dirt Road	0.0	0.0	6.5	4.4	2.1	0.0

Appendix A (cont.)

Transect ID	Litter	Cheatgrass	Red Brome	Mediteranean Grass	Med gr/ RB mix	Pepper Weed
C1	0.0	39.2	0.8	0.0	0.0	0.0
C2	0.0	31.2	13.8	2.2	0.0	0.0
C3	0.0	13.4	19.4	0.0	0.0	0.0
C4	3.8	36.8	13.2	0.0	0.0	0.0
C5	0.0	24.8	4.4	0.0	4.2	0.0
C6	0.0	34.6	8.2	0.0	0.0	0.0
C7	0.0	30.8	6.6	0.0	0.0	0.0
C8	0.0	32.2	0.0	0.0	0.0	0.0
ST1	0.0	35.2	9.4	0.0	0.0	0.0
ST2	3.8	19.8	11.6	0.0	0.0	0.0
ST3	0.0	11.2	19.6	0.0	0.0	2.8
ST4	0.0	32.6	2.8	0.0	0.0	0.0
ST5	0.0	27.0	20.0	7.4	0.0	0.0
ST6	0.0	13.0	16.4	1.4	8.0	0.0
ST7	0.0	11.6	1.2	0.6	2.6	0.0
ST8	0.0	20.8	0.0	2.2	0.0	0.0
DR1	3.2	32.4	0.0	0.0	15.0	0.0
DR2	0.0	38.8	3.8	2.4	0.0	0.0
DR3	0.0	17.4	4.4	4.4	0.0	0.0
DR4	0.0	35.0	10.0	1.4	0.0	0.0
DR5	0.0	29.0	5.2	3.8	0.0	0.0
DR6	0.0	25.6	2.8	4.6	0.0	0.0
DR7	0.0	23.8	9.0	4.6	1.4	0.0
DR8	0.0	39.4	2.6	13.6	0.0	0.0
Totals						
Control	0.5	30.4	8.3	0.3	0.5	0.0
Single Track	0.5	21.4	10.1	1.5	1.3	0.4
Dirt Road	0.4	30.2	4.7	4.4	2.1	0.0

Appendix A (cont.)

Transect ID	Mustard genus	Unknown	Wash	Bare Ground	Total Invasives	Total Endemics
C1	0.0	0.0	0.0	57.4	0.8	41.8
C2	0.0	2.8	0.0	37.2	20.6	39.4
C3	0.0	0.0	0.0	50.4	19.6	30.0
C4	0.0	0.0	7.4	37.2	13.2	38.4
C5	0.4	0.6	0.0	61.4	5.8	31.8
C6	0.0	0.2	0.0	17.0	39.2	43.6
C7	0.0	8.0	0.0	37.8	14.0	40.2
C8	0.0	6.6	0.0	36.8	3.8	52.8
ST1	3.4	0.0	0.0	41.8	16.2	42.0
ST2	0.0	4.0	0.0	45.8	5.2	34.8
ST3	0.0	0.2	7.4	40.2	18.2	30.4
ST4	0.0	10.6	8.4	37.8	7.6	35.6
ST5	0.0	2.2	0.0	37.8	23.0	37.0
ST6	0.0	8.4	0.0	51.6	16.4	23.6
ST7	0.0	0.0	0.0	61.0	1.2	37.8
ST8	0.0	0.0	0.0	74.6	0.0	25.4
DR1	0.0	0.0	0.0	47.4	0.0	49.4
DR2	0.0	0.0	0.0	44.0	3.8	52.2
DR3	0.0	0.8	0.0	58.2	5.6	35.4
DR4	0.0	0.0	0.0	39.4	11.8	48.8
DR5	0.0	0.0	0.0	58.0	9.2	32.8
DR6	4.4	0.0	0.0	49.4	8.0	42.6
DR7	0.0	0.0	0.0	54.0	14.6	31.4
DR8	0.0	0.0	0.0	34.2	2.6	63.2
Totals						
Control	0.1	2.3	0.9	41.9	14.6	39.8
Single Track	0.4	3.2	2.0	48.8	11.0	33.3
Dirt Road	0.6	0.1	0.0	48.1	7.0	44.5

Appendix B- SPSS output

<u>Test 1- Endemic or Invasive species * Road transect or Control transect</u>

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
end/inv * rd/control	6296	100.0%	0	.0%	6296	100.0%

end/inv * rd/control Crosstabulation

			rd/control		
			c	r	Total
end/inv		Count	112	180	292
		Expected Count	106.3	185.7	292.0
		% of Total	1.8%	2.9%	4.6%
	e	Count	1562	3036	4598
		Expected Count	1674.6	2923.4	4598.0
		% of Total	24.8%	48.2%	73.0%
	i	Count	619	787	1406
		Expected Count	512.1	893.9	1406.0
		% of Total	9.8%	12.5%	22.3%
Total		Count	2293	4003	6296
		Expected Count	2293.0	4003.0	6296.0
		% of Total	36.4%	63.6%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	47.502[a]	2	.000
Likelihood Ratio	46.753	2	.000
N of Valid Cases	6296		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 106.35.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.087	.000
	Cramer's V	.087	.000
N of Valid Cases		6296	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Test 2- Endemic or Invasive species * Single-track transect or Dirt road transect

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
end/inv * STDR	4003	100.0%	0	.0%	4003	100.0%

end/inv * STDR Crosstabulation

			STDR		Total
			DR	ST	
end/inv		Count	21	159	180
		Expected Count	91.3	88.7	180.0
		% of Total	.5%	4.0%	4.5%
	e	Count	1713	1323	3036
		Expected Count	1539.6	1496.4	3036.0
		% of Total	42.8%	33.1%	75.8%
	I	Count	296	491	787
		Expected Count	399.1	387.9	787.0
		% of Total	7.4%	12.3%	19.7%
Total		Count	2030	1973	4003
		Expected Count	2030.0	1973.0	4003.0
		% of Total	50.7%	49.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	203.445[a]	2	.000
Likelihood Ratio	218.099	2	.000
N of Valid Cases	4003		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 88.72.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.225	.000
	Cramer's V	.225	.000
N of Valid Cases		4003	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Test 3- All roads: Distance from road (Distance Interval ID) * Endemic or Invasive species

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
dist interval ID * end/inv	3823	47.8%	4169	52.2%	7992	100.0%

dist interval ID * end/inv Crosstabulation

			end/inv		
			e	I	Total
dist interval ID	1	Count	270	56	326
		Expected Count	258.9	67.1	326.0
		% of Total	7.1%	1.5%	8.5%
	2	Count	249	90	339
		Expected Count	269.2	69.8	339.0
		% of Total	6.5%	2.4%	8.9%
	3	Count	372	37	409
		Expected Count	324.8	84.2	409.0
		% of Total	9.7%	1.0%	10.7%
	4	Count	447	39	486
		Expected Count	386.0	100.0	486.0
		% of Total	11.7%	1.0%	12.7%
	5	Count	275	70	345
		Expected Count	274.0	71.0	345.0
		% of Total	7.2%	1.8%	9.0%
	6	Count	232	63	295
		Expected Count	234.3	60.7	295.0
		% of Total	6.1%	1.6%	7.7%
	7	Count	419	77	496
		Expected Count	393.9	102.1	496.0
		% of Total	11.0%	2.0%	13.0%
	8	Count	346	58	404
		Expected Count	320.8	83.2	404.0
		% of Total	9.1%	1.5%	10.6%
	9	Count	193	145	338
		Expected Count	268.4	69.6	338.0
		% of Total	5.0%	3.8%	8.8%
	10	Count	233	152	385
		Expected Count	305.7	79.3	385.0
		% of Total	6.1%	4.0%	10.1%
Total		Count	3036	787	3823
		Expected Count	3036.0	787.0	3823.0
		% of Total	79.4%	20.6%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	294.413[a]	9	.000
Likelihood Ratio	283.078	9	.000
N of Valid Cases	3823		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 60.73.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.278	.000
	Cramer's V	.278	.000
N of Valid Cases		3823	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Test 4- Dirt Roads: Distance from road (Distance Interval ID) * Endemic or Invasive species

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
dist interval ID * end/inv	2009	50.8%	1945	49.2%	3954	100.0%

dist interval ID * end/inv Crosstabulation

			end/inv		Total
			e	I	
dist interval ID	1	Count	162	7	169
		Expected Count	144.1	24.9	169.0
		% of Total	8.1%	.3%	8.4%
	2	Count	130	25	155
		Expected Count	132.2	22.8	155.0
		% of Total	6.5%	1.2%	7.7%
	3	Count	184	17	201
		Expected Count	171.4	29.6	201.0
		% of Total	9.2%	.8%	10.0%
	4	Count	319	5	324
		Expected Count	276.3	47.7	324.0
		% of Total	15.9%	.2%	16.1%
	5	Count	157	39	196
		Expected Count	167.1	28.9	196.0
		% of Total	7.8%	1.9%	9.8%
	6	Count	122	26	148
		Expected Count	126.2	21.8	148.0
		% of Total	6.1%	1.3%	7.4%
	7	Count	285	19	304
		Expected Count	259.2	44.8	304.0
		% of Total	14.2%	.9%	15.1%
	8	Count	132	31	163
		Expected Count	139.0	24.0	163.0
		% of Total	6.6%	1.5%	8.1%
	9	Count	78	58	136
		Expected Count	116.0	20.0	136.0
		% of Total	3.9%	2.9%	6.8%
	10	Count	144	69	213
		Expected Count	181.6	31.4	213.0
		% of Total	7.2%	3.4%	10.6%
Total		Count	1713	296	2009
		Expected Count	1713.0	296.0	2009.0
		% of Total	85.3%	14.7%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	228.640[a]	9	.000
Likelihood Ratio	228.596	9	.000
N of Valid Cases	2009		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.04.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.337	.000
	Cramer's V	.337	.000
N of Valid Cases		2009	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Test 5- Single-track Roads: Distance from road (Distance Interval ID) * Endemic or Invasive species

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
dist int * end/inv	1814	44.9%	2224	55.1%	4038	100.0%

dist int * end/inv Crosstabulation

			end/inv		
			e	I	Total
dist int	1	Count	108	49	157
		Expected Count	114.5	42.5	157.0
		% of Total	6.0%	2.7%	8.7%
	2	Count	119	65	184
		Expected Count	134.2	49.8	184.0
		% of Total	6.6%	3.6%	10.1%
	3	Count	188	20	208
		Expected Count	151.7	56.3	208.0
		% of Total	10.4%	1.1%	11.5%
	4	Count	128	34	162
		Expected Count	118.2	43.8	162.0
		% of Total	7.1%	1.9%	8.9%
	5	Count	118	31	149
		Expected Count	108.7	40.3	149.0
		% of Total	6.5%	1.7%	8.2%
	6	Count	110	37	147
		Expected Count	107.2	39.8	147.0
		% of Total	6.1%	2.0%	8.1%
	7	Count	134	58	192
		Expected Count	140.0	52.0	192.0
		% of Total	7.4%	3.2%	10.6%
	8	Count	214	27	241
		Expected Count	175.8	65.2	241.0
		% of Total	11.8%	1.5%	13.3%
	9	Count	115	87	202
		Expected Count	147.3	54.7	202.0
		% of Total	6.3%	4.8%	11.1%
	10	Count	89	83	172
		Expected Count	125.4	46.6	172.0
		% of Total	4.9%	4.6%	9.5%
Total		Count	1323	491	1814
		Expected Count	1323.0	491.0	1814.0
		% of Total	72.9%	27.1%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	143.076[a]	9	.000
Likelihood Ratio	149.479	9	.000
N of Valid Cases	1814		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 39.79.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.281	.000
	Cramer's V	.281	.000
N of Valid Cases		1814	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.