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Estimating Recreational OHV Trip Generation Using GIS

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Recreational OHV use has been increasing at a high rate over the last few decades. Due to the conflicts associated with recreational OHV, It is helpful for land use planners and open space managers to be able to predict the amount of OHV recreation that is likely to occur within a selected area. The resulting estimate can be used to aid in the development of management plans that limit or decrease the amount of inter-user and environmental conflicts that are associated with OHV use. Geographic Information Systems is a powerful tool that may help planners make the OHV trip generation estimate. By combining Census block group demographics data, previous OHV surveys, Aerial Imagery, and other geographic data; one can make an estimate of the number of users that will enter a study area through certain defined access points called “stub-out”. This method is relatively easy and requires few tools to make a rough estimate of OHV trip generation in a certain area.

I. Introduction

Off Highway Vehicle (OHV) travel and recreation in the United States has become increasingly popular over the last few decades. Off-highway vehicles have been defined as 4-wheel drive jeeps, automobiles, or sport utility vehicles; motorcycles designed for off-highway use; and all-terrain vehicles or ATV's. (Cordell, Betz, and Green 2005) This growth has been confirmed by confirmed by Cordell ET. Al. when they found that over 1,000,000 ATVs and off-highway motorcycles were purchased in the year 2003 compared to a little more than 350,000 purchased in 1995. Along with this growth, there has been an increase in the amount of conflicts that occur between different types of trail users such as hikers, bikers, OHV recreational users and horse riders.

User conflict has been defined as "goal interference attributed to other (types of users') behavior." (Gerald and Schreyer 1980) OHV use can have an undesirable impact on the recreation experience of non-OHV users. According to Anderek ET. Al. the three greatest concerns of non-motorized vehicle trail users are; lack of trail ethics, erosion and deterioration of trails, and lack of funding for trails. The first two sources of user conflict can be attributed to OHV use. Erosion and deterioration of trails as a result of OHV use has been confirmed by several studies including: Dregne, H.E. 1983; Stokowski and LaPointe 2000; and Payne, Foster, and Leininger 1983; which states "Damage to a previously undamaged range by a four-wheel drive truck increased with the number of passes over the same area." This erosion is undesirable to other types of users; such as hikers, bikers, and equestrians, and it is important to identify areas where this type of conflict may occur.

The behavior of recreational OHV users has been covered by many studies prior to this one. OHV users are predicted to travel off-trails, (Shore, T. 2001) and (Robertson 2003), which contributes to erosion and can have a negative effect on the experience of wilderness by other types of users. In a study conducted by the Division of Forestry, OHV users have also been observed to travel from developed areas into areas "located away from human activities" (Schuett, 1998) This information suggests that OHV users will enter into the defined study area and move away from the suburban areas located at its northern and western perimeter. Another issue that is pertinent to this study is the City of Las Cruces annexation process and the creation of a build-out scenario that will help predict recreational changes in OHV use and multi-use conflicts that may result from this predicted change in use. The ability to predict these changes

can result in management direction, which is particularly important as the Las Cruces Ad Hoc Committee On the Strategic Planning for Natural Resources has recently prepared its Natural Resource Strategic Plan. The Ad Hoc Committee submitted a draft of the plan to the City of Las Cruces on June 30, 2004. The plan includes an expressed commitment to protect the natural resources located on city owned open space land and create recreation opportunities that also enforce the protection of natural resources within Las Cruces city limits. Another Land Use Planning document titled Vision 2040: a Summary of the Regional Planning Project explains that by the year 2040, all of the land within the study area for this project will be either designated as Urban Center, General Urban, Rural Suburban, Office Park, with some small areas reserved for Parks/Open Space. This means that open space within the study area will be almost completely developed. It can be assumed that recreational OHV use of this area will be phased out as development continues throughout the next few decades. This process will be explained in detail when build-out scenarios are discussed.

II. Study Area and Purpose

The University of Colorado Land Use Futures Lab is doing a study on OHV use near Las Cruces, New Mexico. The study area is located within Dona Ana County approximately three miles west of the city of Las Cruces and one half mile south of Highway 70. The area is a 3.5 by 4 mile polygon consisting of mostly New Mexico State owned land with some BLM ownership areas. The terrain within the park is mostly shrubs and rough grass land. There are many dirt roads throughout the study area which act as OHV trails for Dona Ana County residents as well as tourists. **Figure 1** displays the location of the study area within New Mexico. Las Cruces is located in the southern portion of New Mexico, approximately 45 miles away from El Paso, TX.

Figure 1 Study Area within New Mexico

This study has two major goals. The first objective is to identify access points, where OHV users are likely to enter the study area. These access points will be located to indicate trip origins. The second major objective of this study will be to create an estimation of the number of trips generated at each origin. For the purpose of this study, stub-outs will be used to identify the location of trip origins. A stub-out will be defined as the end of a paved road that occurs at the extent of a developed area and continues into the study area as an unregulated dirt road or trail. These stub-outs seem to be primary access points for OHV users into the study area.

Second, after identifying several stub-outs as trip origins, the numbers of recreational OHV users within two miles of the study area who are predicted to enter at each stub-out are to be estimated. The Federal Transit Administration has termed this process "trip generation". Trip generation in the FTA's publication "Transportation Planning Process: *Key Issues*" publication, updated in 2007, is defined as "estimating the number of trips generated in a small geographic area, called a zone, or at a particular location, and attracted to another zone or particular location based on the assumed relationship among socioeconomic factors, land use characteristics, and the number of trips." Trip generation is the first step in a four part modeling process that has been used by the Federal Transit Administration over the past 40 years. The remaining steps in this modeling process include trip distribution, mode split, and network assignment. Trip

distribution takes into account the destination of the trips generated. Mode split separates each trip generated into the mode of transportation used for that trip; such as public transit versus ride share, or a description of the different types of vehicles used. The final step is to identify the network assigned to each trip generated. This involves estimating the exact trail or path that will be covered in the trip. This study will focus primarily on the trip generation step in this modeling process, and trip generation will be defined more specifically as the location of trip origins and the number of trips estimated to be generated at that origin.

Given that the land cover within the study area contains mostly low density vegetation with very few trees or other large obstacles, OHV users are able to travel off-trail relatively easily. Since previous studies have determined that recreational OHV users tend to travel off trail, it is safe to assume that these landscape conditions will create an environment where off-trail OHV use is common. This behavior is likely to cause inter-user conflict in the study area. Several examples of the terrain within the study area are displayed below in **Figures 2** through **5**. **Figure 2** displays a trail that exists among very sparse bushes. It would appear in this photo that the trail is not perfectly defined and that access to off-trail areas is readily available. This type of trail system obviously lends itself to off-trail use by recreational OHV users.

Figure 2: Trail Example

Figure 3 displays the type of trail that is most common within the study area. This type of trail is mostly straight without extreme changes in slope. This lack of variety in trail conditions can also be a reason for OHV users to desire more exciting off-trail recreation.

Figure 3: Trail Example

The vegetation within the Las Cruces area is mostly desert shrubs with a large amount of Creosote Bush, Soaptree, Tarbush, mixed with a great deal of desert grasses such as Tobosa and Black Grama. This type of vegetation does not include large trees or other obstacles that would significantly hinder or impede the operation of an off-highway vehicle outside of designated trails in this area. **Figure 4** displays an example of the vegetation in the Las Cruces OHV study area.

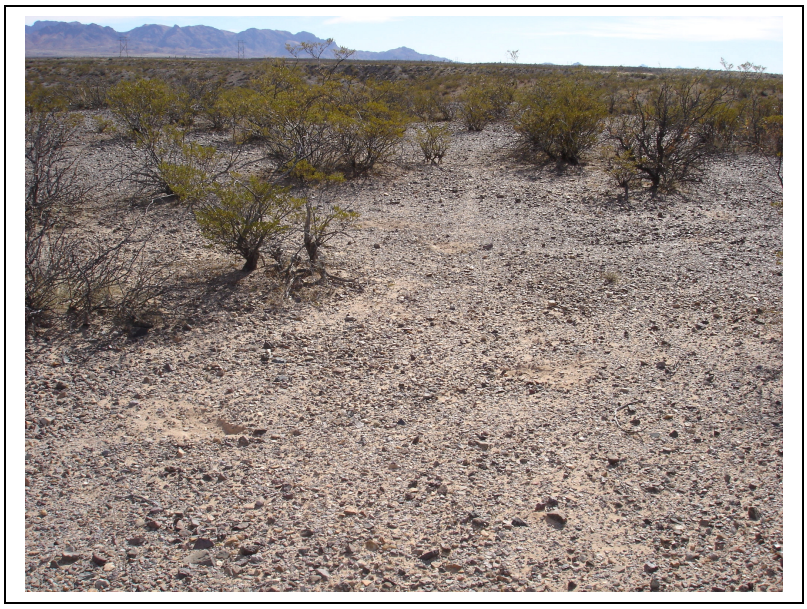


Figure 4: Trail Example

Upon viewing the type of terrain cover present in the Las Cruces area it becomes apparent that this type of open landscape makes it easier for recreational OHV users to venture off trail and engage in the type of behavior which creates conflict with other types of users. It is important to identify areas where this type of conflict is likely to occur. Several studies of OHV users indicate that OHV users are likely to venture off-trail. One of these studies is a survey taken by the Human Dimensions Research Lab at the University of Tennessee to observe and identify OHV user behavior. One result of the Tennessee OHV Survey showed that the average percentage of motorcycle, ATV, and 4-wheel drive users that prefer traveling off-trails is 56.55% while the average percentage of OHV users that prefer to ride on designated trails is 43.45%. This shows that OHV users are about 13% more likely to travel off-trail than stay on designated trails. Another study completed by the California Wilderness Coalition examined the effects of off-trail OHV use on several Californian landscapes. The major finding of their publication titled "Off Road to Ruin: How Motorized Recreation is Ruining California's Landscapes" is that reckless OHV users do tend to cause "damage to sensitive soils, degrade critical wildlife habitat, trespass onto private property and closed areas, and shatter the quiet of the great outdoors." Since this reckless type of behavior has been observed to come from recreational OHV users, it is important to observe areas where OHV recreation is popular and where conflict is likely to occur between OHV and non-OHV users.

This study has been designed to locate and identify areas where OHV users are most likely to enter the study area. Once the locations of these trip origins, known as stub-outs, have been identified, the next step is to estimate the number of users that will enter through each access point. This process is widely known as trip generation. These access points can lead to areas within the study area where there are likely to be different types of conflict. Specific preventative management plans can then be developed to deal with these conflict areas before they become a problem.

A side objective of this study is to explore a unique method for estimating trip origins, trip generation, and travel demand in general. According to a review of published literature, there has yet to be an attempt to use geographic information systems to identify areas where recreational OHV travel is likely to occur, and then use demographic characteristics, in addition to income, to estimate the number of people who will participate in OHV recreation within a certain area. Existing OHV travel demand methods have created a function of income and travel cost to estimate trip generation (Englin ET Al.). The travel cost method is primarily economic and does not take into account the variance of human demographics that are likely to participate in OHV recreation. For the purpose of this study, demographics will play a more central part in determining recreational travel demand. The combination of remote sensing images, OHV users' surveys, and U.S. Census demographics data resources should prove a reasonably accurate yet efficient way to estimate OHV travel demand and trip generations throughout a relatively large area.

The final objective of this project will be to estimate a build-out scenario for residential areas surrounding the study area. This step is important because it will aid in the prediction of future OHV travel demand in the area. The results of the build-out scenario can be analyzed using this method to estimate the number of recreational OHV users to enter the study area when all of the currently vacant parcels have been occupied. This part of the analysis will be completed using the parcels layer obtained from the Las Cruces Management Planning office. This layer contains attribute information describing whether each parcel is Residential (RS) or Vacant (VA). It will be assumed that parcels currently labeled as vacant will become occupied in the near future. The results of this analysis will be displayed as a map output in the results section of this study.

III. Methodology

Previously, methods for estimating travel demand have been defined by Englin ET Al. in a paper titled "Alternative Models of Recreational Off-Highway Vehicle Site Demand" This study identifies OHV demand as an incomplete demand system which is a "function of income and the prices of concerned goods". For the purpose of their study, Englin ET Al. define the price of concerned goods as travel cost and compare this information with count data to estimate the number of recreational OHV users. This method does not take into account other demographic patterns that are present in recreational OHV use. A United States Forest Service report completed by H.K. Cordell ET Al. titled, "Off-Highway Vehicle Recreation in the United States, Regions and States: A National Report from the National Survey on Recreation and the Environment." identifies other demographic characteristics that effect recreational OHV use. One significant characteristic that was determined is gender. In the western region, which contains New Mexico, the likelihood of a male participating in OHV recreation is 9% higher than for females. This information suggests that other demographic categories such as gender and age should be considered when estimating travel demand. This study will include age, gender, and income to identify travel demand

The methodology behind this study involves viewing a remotely sensed image of the area to identify stub-outs and trails. Then, assigning parcels from the four surrounding census tracts to each stub-out. This is done using the "Near" function in ESRI's ArcMap version 9.3. The top three most likely demographic groups to participate in OHV recreation in New Mexico were identified using the U.S. Forest Service publication titled "Off-Highway Recreation in the United States, Regions and States". The ratio of each of these three demographics to participate in OHV recreation can also be derived from the report. These three most likely demographic categories are then compared to U.S. Census demographics data from the year 2000 for the block groups 1201, 1202, 1301, and 1302. The demographic information includes age, income and gender. The ratio of each demographic group from the OHV Report is compared to the population of each demographic group within each census tract. This number, related to the total population of each census tract gives another ratio. This ratio describes the percentage of each tract from each of the three demographic groups that are likely to participate in OHV recreation This method of determining cumulative user likelihood ratios is called the Weighted Mean method. The weighted mean is mathematically described as:

Formally, the weighted mean of a non-empty set of data

$$[x_1, x_2, \ldots, x_n],$$

With non-negative weights

$$[w_1, w_2, \ldots, w_n],$$

Is the quantity

$$\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i},$$

Which means:

$$\bar{x} = \frac{w_1 x_1 + w_2 x_2 + \cdots + w_n x_n}{w_1 + w_2 + \cdots + w_n}.$$

. The final step of this analysis is to identify the average number of people per household, the number of households within a two mile radius of the study area and assign each to a stub-out, and then multiply those two numbers to find the number of people in households within two miles of the study area per stub-out. The households within this radius must be identified by census tract as well as stub-out. The ratio of users per census tract must be multiplied by the number of parcels within each census tract and then separated into their assigned stub-outs. The result is an estimated number of people to enter each stub-out for OHV recreational purposes. These OHV users must live within two miles of the study area.

III. Data

The data for this study uses the NAD 1983 coordinate system and is projected into UTM Zone13N. The spatial data sets required for analysis and display include block groups, parcels, a remotely sensed image of the study area, stub-outs, BLM Roads, and a polygon which defines perimeter of the study area. The Land Use Futures lab is responsible for creating the study area polygon, stub-outs, and trails layers. The roads and parcels data come from the Bureau of Land Management Las Cruces District Office. The census tract layer is derived from the Census Tiger

files of census tracts. The stub-out layer is created from the remote sensing image. The remotely sensed image of the study area was acquired from the New Mexico Resource Geographic Information System Program. The image was collect in the year 2005 and shows some development along the western border of the study area. This does coincide with parcel boundaries in the same area. However, the parcel layer from 2008 indicates a further level of development than is displayed in the 2005 remotely sensed image. The NMRGIS program is a cooperative program between the University of New Mexico and the New Mexico Information Technology Commission. It is a Color Infrared Imagery (CIR) image taken originally from a Digital Orthophoto Quadrangle collected by the USGS. I believe that it is safe to say that this data is accurate enough for the purpose of this study. This is due to the reliability of government sources and the creation of new data based on data from these sources. Other data sources include Vision 2040, a collaboration effort between Dona Ana County, the City of Las Cruces, and the University of New Mexico. Vision 2040 is a planning project used to determine the future land uses of areas within Las Cruces city limits. Build-out scenario data was digitized from maps created by the Vision 2040 project. Other build-out data was digitized from maps collected from the Las Cruces Metropolitan Planning Organization.

IV. **Analysis and Results**

The first step in this analysis is to identify stub-out locations based on the aerial image of the study area. A stub-out is an access point for OHV users into the study area. In many cases a stub-out will occur at the end of a paved road, where it turns into dirt, and continues into open land without regulation. Finding the stub-outs was accomplished by zooming into the aerial image and locating large areas of dirt road on the edge of the study area. These dirt roads must also provide access to the trail system within the study area. A new layer named Stub-Out was created to represent these areas. A map of stub-out locations is displayed in **Figure 5** below.

Seven stub-outs along the north and west borders of the study area were identified using this method.

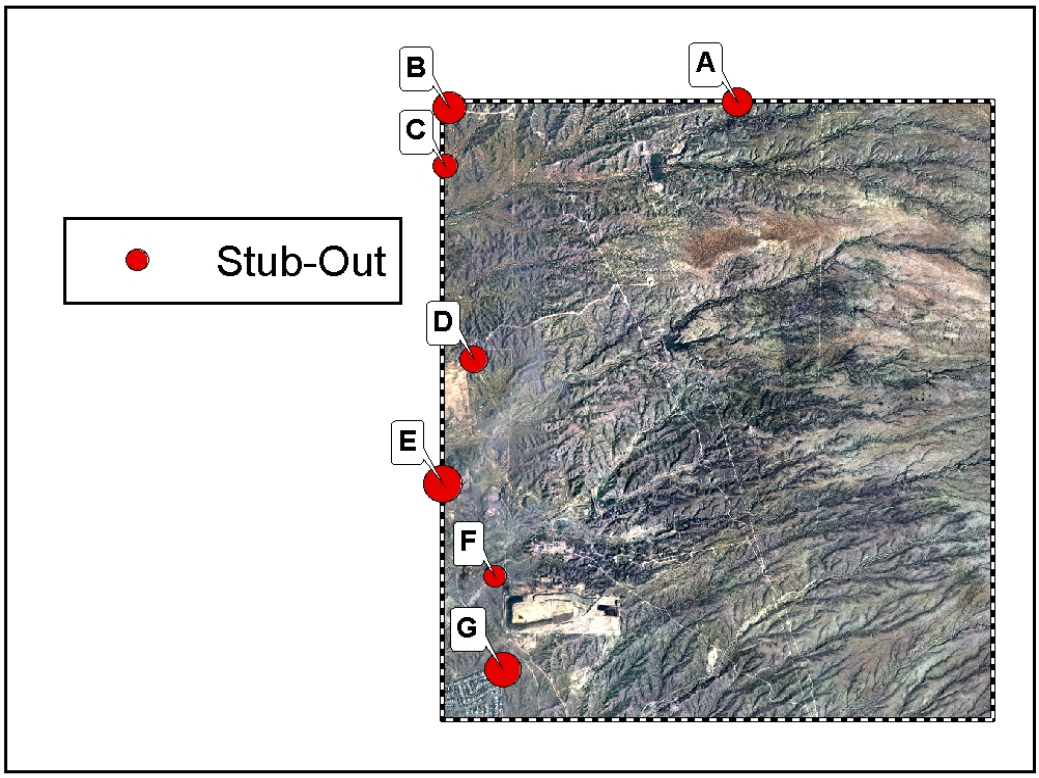


Figure 5: Stub-Out Locations

The concept of a stub-out is loosely defined. In transportation literature, it is assumed to take on the meaning provided earlier that will be used for this study. Again, the definition of a stub-out will be the end of a paved road that occurs at the extent of a developed area and continues into the study area as an unregulated dirt road or trail. It is hard to find an absolute definition of a stub-out, so it may be hard to identify exactly what a stub-out is. To provide

further specification regarding the definition of a stub-out, three stub-outs identified by this study are displayed below.

Figure 6: Close Up of Stub-Out G

Figure 7: Close Up of Stub-Out F

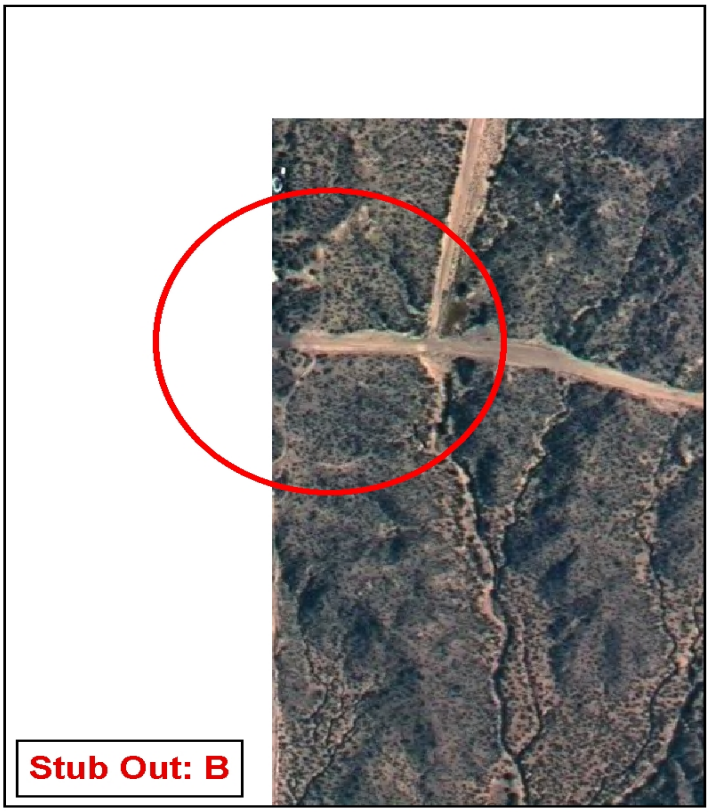
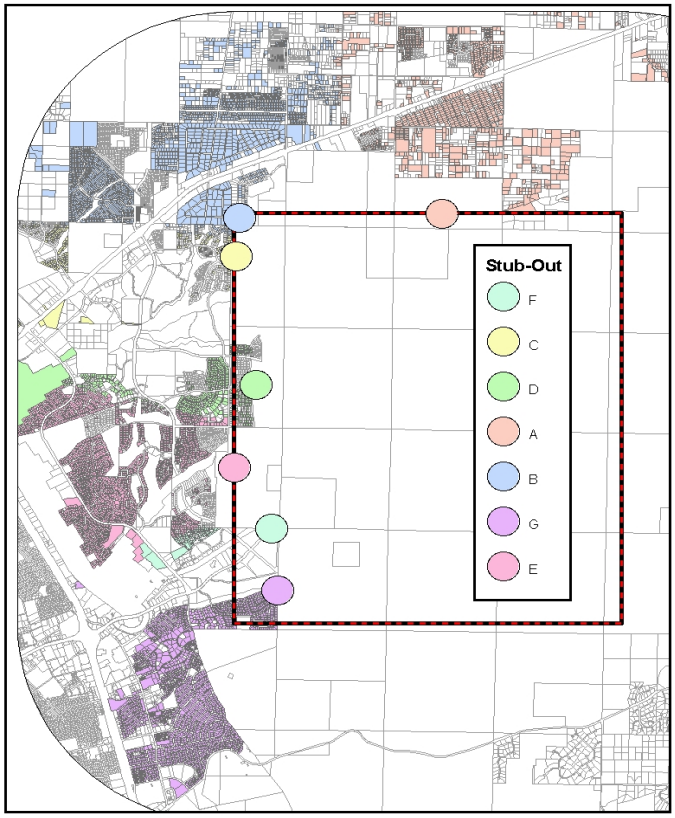


Figure 8: Close-Up of Stub-Out B

The second step in this analysis is to assign parcels from surrounding subdivisions to each stub-out. The parcel data acquired from the BLM Las Cruces office contains attribute data that identifies parcels as either occupied or vacant. Only occupied residential parcels were selected from the parcel data. Occupied residential parcels were assigned to each stub-out using the "Near" function in ArcGIS version 9.3. This function selects the parcels which are closest to each stub-out. The breakdown of parcels per stub-out and their location around the study area is shown in **Figure 9**. It is important to note at this time that the majority of parcels exist to the southwest of the study area. Also, there are no stub-outs and very few occupied parcels to the east. The parcel data allows for an estimate of build-out for each subdivision. It can be assumed that vacant residential parcels will be developed and occupied in the relatively near future. By locating the area and number of parcels which have been planned for residential purposes, it is possible to get an idea of a build-out scenario for the area. Build out scenarios can be analyzed using the same method defined by this study to project the number of trips generated at each origin into the future.



Stub-Out	Number of Parcels
A	774
B	1817
C	255
D	544
E	2400
F	101
G	1643

Figure 9: Occupied Residential Parcels per Stub-Out

Once the parcels per stub-out are identified, the next step is to use the USFS OHV Report to identify the top three demographic groups of OHV users and their likelihood to participate in OHV recreation. The report separates OHV use into regions of the United States. These regions include North, South, Midwest, West, and Pacific. New Mexico belongs to the West region of states. The report includes a table of demographic groups and the percentage of the population of each group that is likely to participate in OHV recreation. The demographic types included in the report are gender, age, income, education, ethnicity, and place of residence. For the purpose of this Las Cruces study; only gender, age, and income were selected for analysis. By averaging percentages, it was found that the three demographic groups most likely to participate in OHV use in the West region of states are as follows:

Dem1: Gender: Male
Age: 16-29
Income: 50k-100k

Dem2: Gender: Male
Age: 30-49
Income: >100k

Dem3: Gender: Female
Age: 16-29
Income: 50k-100k

In order to know the amount of people who fit these demographic groups, census tract data was used. Gender, age, and income statistics were gathered for the population of census tracts 12.01, 12.02, 13.01, and 13.02. located in Dona Ana County. These tracts cover all of the area within two miles of the study area. The break down of census tracts around the study area is displayed in **Figure 10** below.

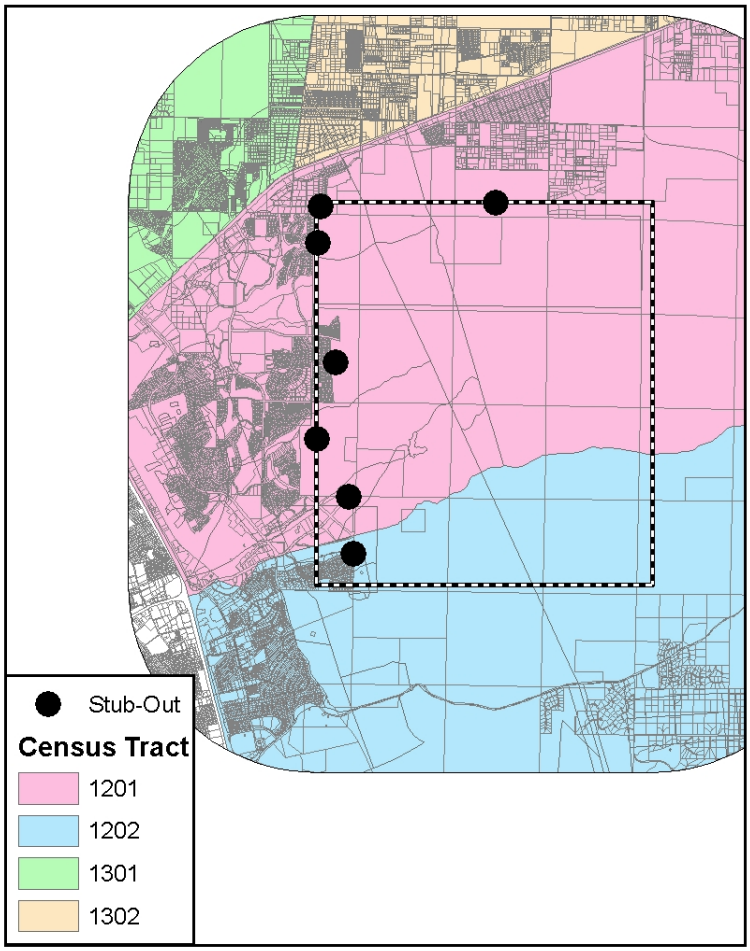


Figure 10: Census Tracts within Two Miles of the Study Area

The census tract population statistics were compared to the OHV report demographics ratios by; first, finding the number of each demographic group present in each census tract. Then, the ratios describing likelihood of participation from the report were applied to the population of each demographic. The result is the estimated number of people in each demographic group, per census tract, that are likely to participate in OHV recreation. That estimated number of people is then averaged with the combined ratio of all three demographic groups to produce a likelihood of each demographic group within each census tract to participate in OHV recreation this is done using the weighted mean method described above. The cumulative likelihood ratios for each demographic group and their census tract location are displayed in **Table 1**. It appears as though the population of the third demographic group is more prevalent than the second group. This would explain why Dem3 has an overall higher likelihood to participate in OHV recreation in the study area.

Census Tract	Demographic Group	OHV User Likelihood per Population
12.01	Dem1	0.006041595
	Dem2	0.002168003
	Dem3	0.00544042
12.02	Dem1	0.007579907
	Dem2	0.003115598
	Dem3	0.006972002
13.01	Dem1	0.005278214
	Dem2	0.000843963
	Dem3	0.004765061
13.02	Dem1	0.003917737
	Dem2	0.000411843
	Dem3	0.003424358

Table 1: Ratios of OHV Participation per Population of Demographic Group and Census Tract

The final step in this analysis requires obtaining the average population per household in Dona Ana County. This was found to be 2.85 people per household and was obtained from the year 2000 census data. Multiplying the number of people per household by the user likelihood ratio will result in the estimated likelihood of people per household per demographic group and census tract to participate in OHV recreation. The parcels must then be separated into their assigned stub-out from previous steps. The number of occupied parcels, now identified by census tract and stub-out must be multiplied by the ratio of household size and user likelihood. The result of this will be an estimate of number of users per stub-out. The table describing this process is displayed in **Table 2**.

			User Likelihood Ratio per Average Household Size				Number of Users		
	Tract	Parcels	Dem1	Dem2	Dem3		Dem1	Dem2	Dem3
StubOut A	*1201*	401	0.017218547	0.006178808	0.015505		7	2	6
	1302	373	0.01116555	0.001173752	0.009759		4	0	4
						Total	**11**	**3**	**10**
StubOut B	*1201*	104	0.017218547	0.006178808	0.015505		2	1	2
	1301	1132	0.015042909	0.002405294	0.01358		17	3	15
	1302	581	0.01116555	0.001173752	0.009759		6	1	6

						Total	**25**	**4**	**17**
StubOut C	*1201*	113	0.017218547	0.006178808	0.015505		2	1	2
	1301	142	0.015042909	0.002405294	0.01358		2	0	2
						Total	**4**	**1**	**4**
StubOut D	*1201*	544	0.017218547	0.006178808	0.015505		**9**	**3**	**8**
StubOut E	*1201*	2400	0.017218547	0.006178808	0.015505		**41**	**15**	**37**
StubOut F	*1201*	101	0.017218547	0.006178808	0.015505		**2**	**1**	**2**
StubOut G	*1201*	2	0.017218547	0.006178808	0.015505		0	0	0
	1202	1641	0.021602735	0.008879454	0.01987		35	15	33
						Total	**35**	**15**	**33**

Table 2: User Ratio per Household Size and Total Number of Users per Stub-Out

The results of this study show that a total of 281 OHV trips are predicted to enter the study area through seven stub-outs. People belonging to the first demographic group; Male, Age 16-29, Income 50k-100k are predicted to generate 46% of the trips into the study area. Stub-out E will be the source of the majority of trips into the area with a predicted ratio 33% of the total trips. Even though **Dem2** had a higher likelihood of generating an OHV trip, based on the OHV Report, there are a significantly greater number of people belonging to **Dem3** than **Dem2** living within 2 miles of the study area. A map displaying stub-outs and the amount of trips generated from each demographic group is displayed in **Figure 11**. The majority of trips generated are predicted to enter the study area from the stub-outs in the southwest region of the study area border. This can reasonably be assumed to be due to the concentration of subdivisions in that area and its proximity to the city of Las Cruces. To make the distribution of trips per stub-out more clearly visible, **Figure 12** displays the trips per stub-out generated by the total of all three demographic groups.

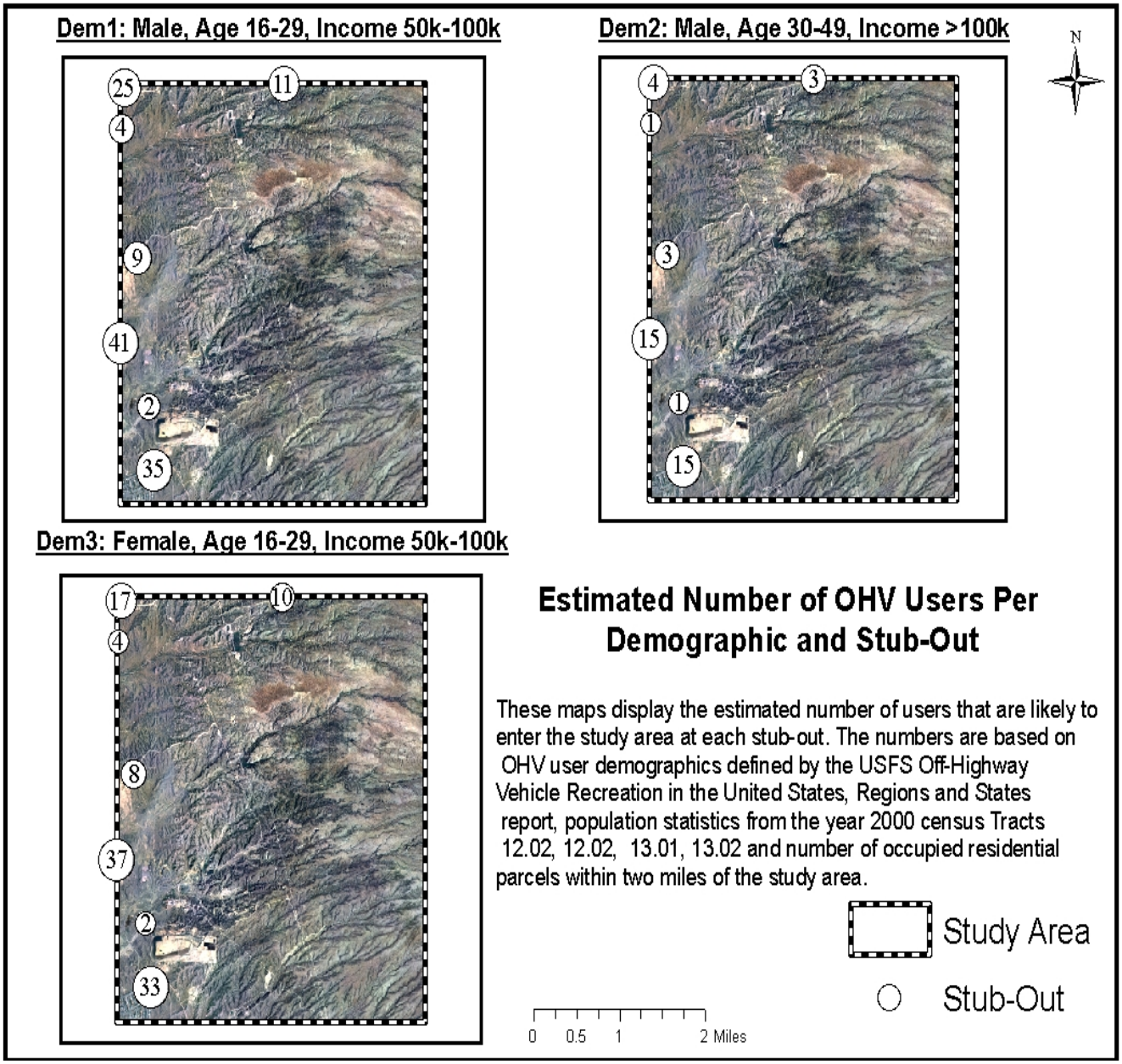


Figure 11: Number of Trips per Stub-Out by Demographic

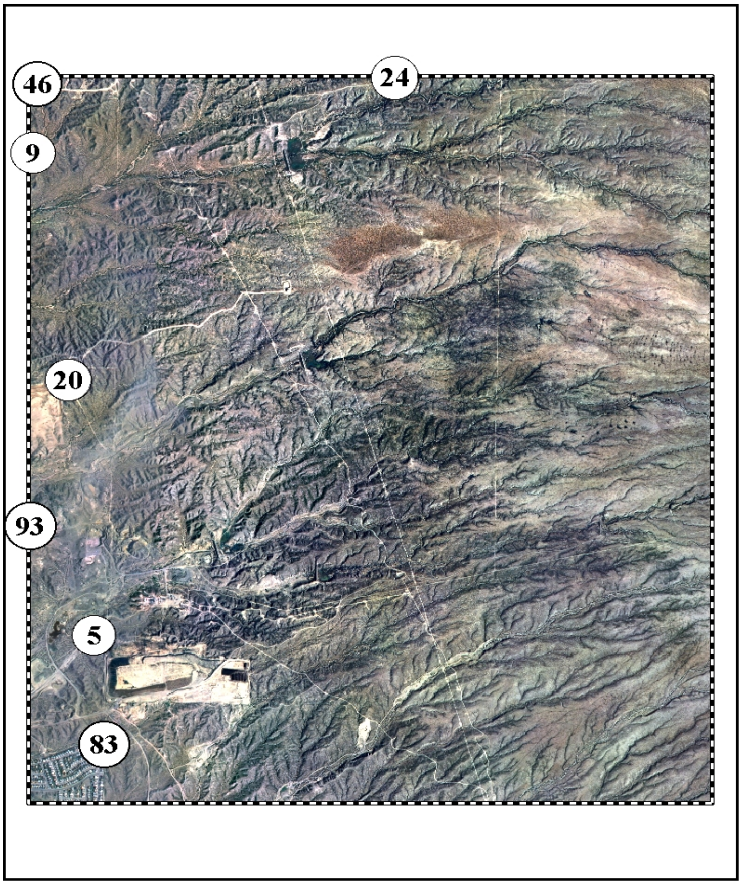


Figure 12: Total Number of Trips Generated

The final results of this analysis include a prediction of a build-out scenario for the subdivisions that surround the study area. This involves separating the existing parcels data into occupied and vacant parcels using the attribute table for the dataset. Vacant parcels are displayed along with occupied parcels in different shades of gray. For the purpose of this study, it will be assumed that all vacant parcels will be occupied and that future occupancy will depend on the level of developed parcels in the area. The parcels data was gathered in the year 2008. This is three years after the CIR image that has been used for this study. The image obtained from RNMGIS was collected in the year 2005 and shows signs of some development in areas where parcels are present in the year 2008. However, the level of development displayed by the image is less mature than the parcels layer indicates. It can be assumed that a fair amount of development occurred around the area in the year 2005 and beyond. The build-out scenario predicted for this area is displayed by **Figure 13** below.

Figure 13: Build-out Scenario

The results of the build-out analysis indicate that there has been a large amount of development in the Las Cruces area over the passed decade. This growth is still taking place and the Las Cruces city limits are predicted to grow because of this development. According to the

Las Cruces Metropolitan Planning Organization, the city has been growing steadily by decade to account for the rapid development of the urban area east of the city of Las Cruces. The areas of land that have been annexed by decade area displayed below in **Figure 14**.

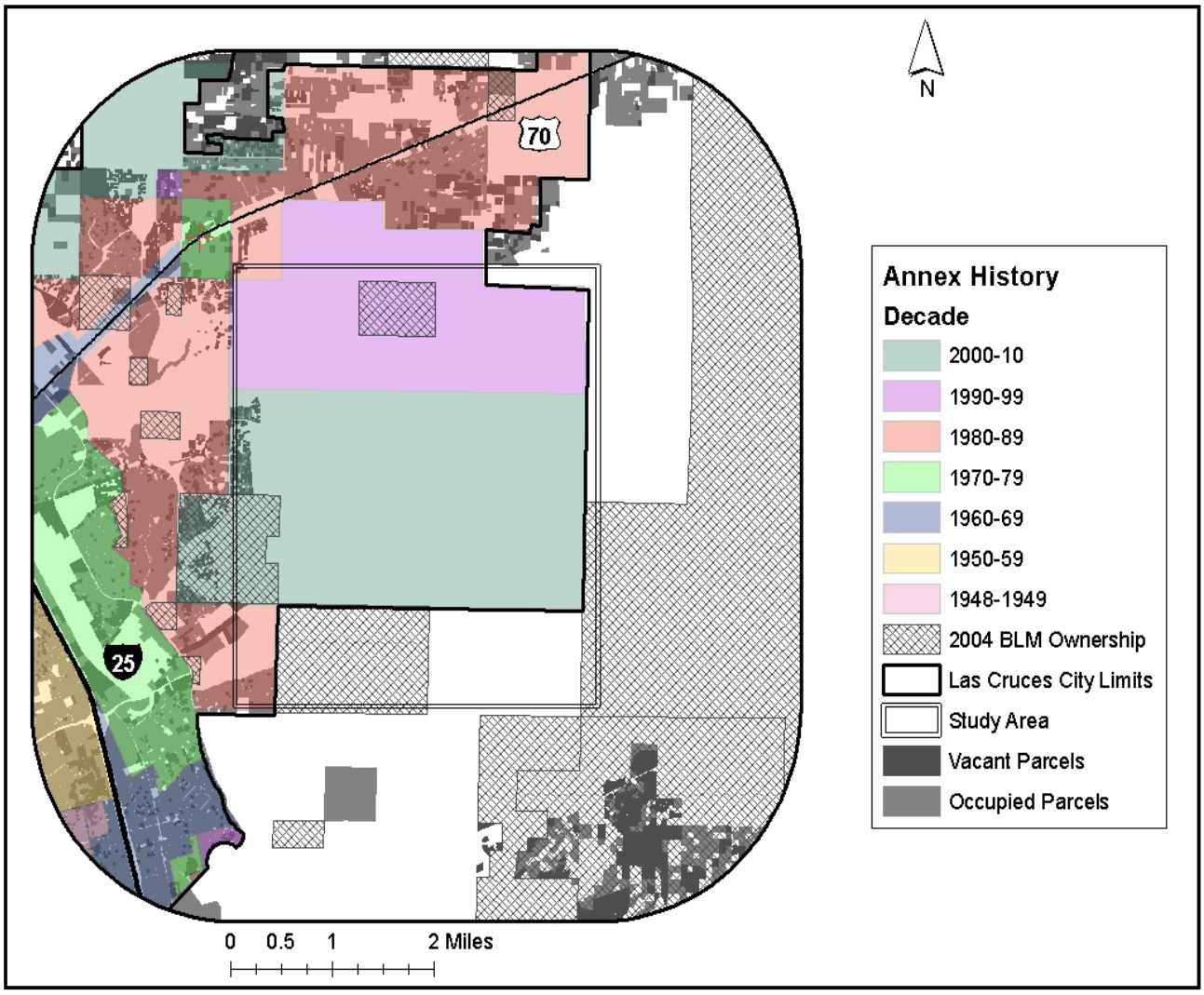


Figure 14: Las Cruces Annexation Process by Decade

It is apparent that Las Cruces city limits have been expanding along with the build-out of subdivisions. In most areas, it appears that city limits are expanding to provide a buffer between the urban edge and the boundary of city limits. This expansion has recently included the majority of the study area into Las Cruces city limits. This raises several management issues and creates the opportunity for the city of Las Cruces to regulate OHV use in the area and gives the city the authority to enforce these regulations utilizing Las Cruces law enforcement agencies. The

Natural Resources Management Plan was prepared by the Las Cruces Ad Hoc Committee on the Strategic Planning for Natural Resources This document was submitted to the City of Las Cruces and describes some goals and strategies for the management of open spaces and natural resources within Las Cruces city limits. The one goal in this document is to establish a regional open space authority. This organization will be structured similarly to the Las Cruces Management Planning Organization and will be responsible for creating a "regional open space master plan with an emphasis on the preservation of critical environmental areas, especially those that provide linkage to create and/or further a network of open space" (Las Cruces Ad Hoc Committee on the Strategic Planning for Natural Resources, 2004) This organization will be responsible for making management decisions over all areas located within Las Cruces city limits. The second goal of the Natural Resources Management Plan is to encourage the preservation of major arroyos and open space areas within city limits. To accomplish this goal, the city of Las Cruces will likely be encouraged to manage OHV trail systems in order to prevent the destruction of natural resources cause by recreational OHV users who tend to travel off of the established trail system. Increased trail regulation and enforcement can help solve some of the conflict described by (Shore, 2001) and (Robinson, 2003) another management issue that is raised by this annexation is that of trail maintenance. Additional sources of funds may be available to be used for trail maintenance. This could help lead to he creation of a trail system that caters to the preferences of recreational OHV users. If the types of terrain that are sought after by users off of the existing trail can be found on a well managed and clearly marked trail system, perhaps OHV users will tend to travel off trail less often. The final issue that arises from the build-out scenario relates to recreational OHV user's desire to avoid populated areas. If subdivisions encroach on the open space study area passed a certain extent, it can be predicted that OHV users will tend to avoid this area due to over-popularity.

On a longer time scale, it can be assumed that the vast majority of open space land within the study area will be developed and its use will become suburban, urban, office pack, or other. Dona Ana County and the City of Las Cruces have prepared Vision 2040. This Vision is the concept of development within Dona Ana County over the next thirty years. This concept will provide the basis for land use decisions made by the Comprehensive Plans of the City of Las Cruces and Dona Ana County. A map of future land use was prepared as part of Vision 2040 and it displays some results that are pertinent to this study. It appears that the vast majority of land

within the study area will be designated for development by the year 2040. **Figure 15** below displays the land use designations for areas within the study area as defined by Vision 2040. The Land use data has been digitized from the Vision 2040 catalog and may have some accuracy issues, however for the purpose of this study the digitized version of the Vision 2040 map should be accurate enough. You may see from the figure below that there are two small areas within the study area that will be designated for Parks and Open Space.

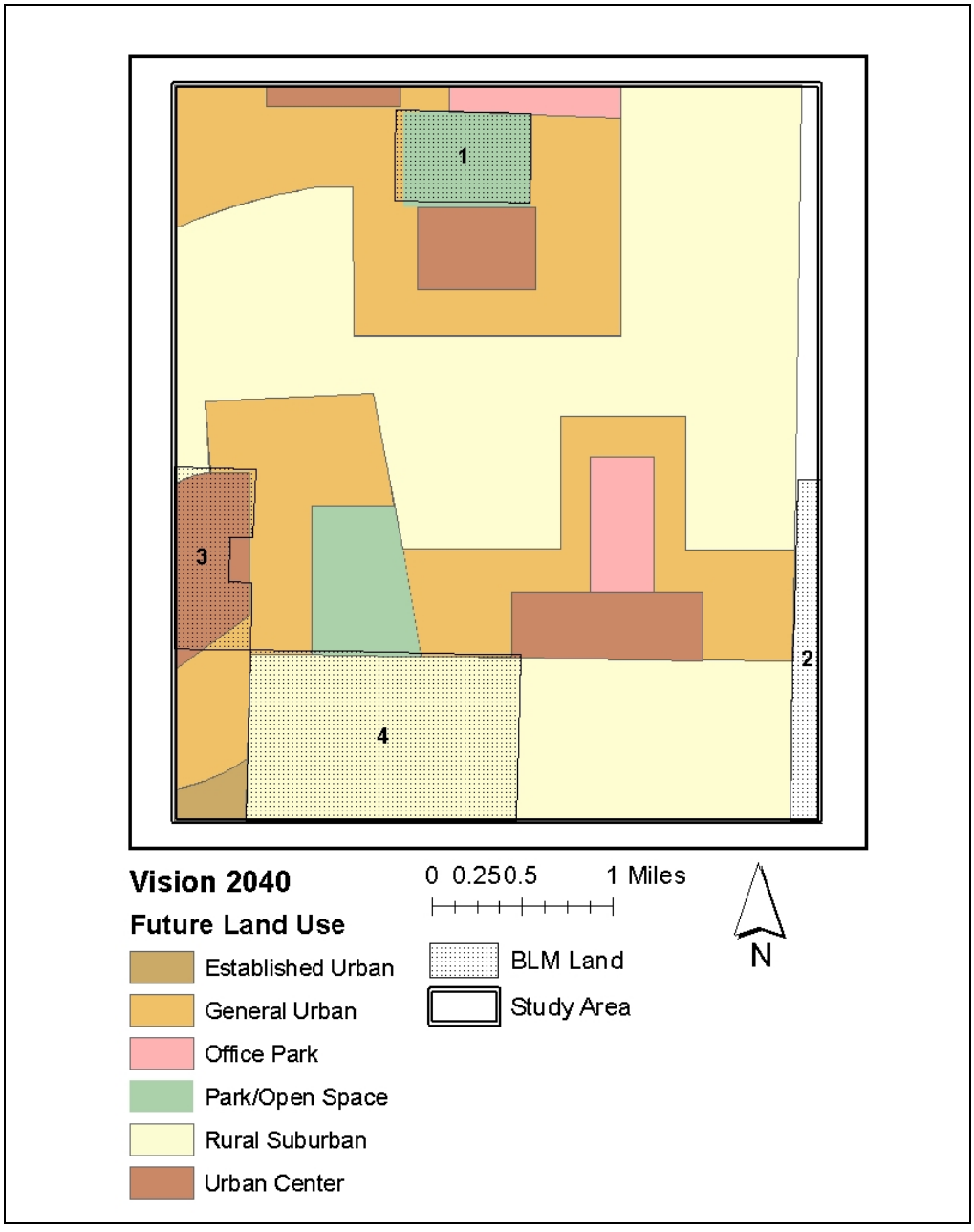


Figure 15: Vision 2040 Land Use Designation within Study Area

Upon examining the Vision 2040 land use designations it becomes apparent that most BLM land within the study area will be sold and converted from public land to residential or business uses. One BLM parcel that is likely to remain under BLM ownership is the parcel labeled **1**. This parcel is designated as Park/Open Space and will likely remain suitable for recreation in the future. However, the question remains as to whether this parcel of land is large enough to support OHV recreation. For the purpose of this study, land use designation in the year 2040 is irrelevant, though it is important to note that open space management decisions concerning the area within the study area will be temporary according to the planning process which the City of Las Cruces has already begun to initiate.

V. **Conclusion**

After performing this study, it became apparent that most OHV trips are going to be generated through two stub-outs in the southwest corner of the study area. Another stub-out in the northwest corner of the study area will also be responsible for generating a significant proportion of the total trips. It can be assumed that this is because of the proximity of the west side of the study area to a dense concentration of residential subdivisions as well as the city of Las Cruces.

The top three demographic groups to participate in OHV recreation in New Mexico are similar and belong to middle and upper middle class income brackets. The only difference between the first and third demographic groups is gender; income bracket and age group are the same. There are many more people who belong to the first and third demographic groups than the second, and this explains why there are more trips generated by the third demographic group than the second. This supports the hypothesis that demographic characteristics other than income play significant role in determining OHV recreational trip generation. The results of this study suggest that males do in fact tend to participate in OHV recreation more often than females and thus the ratio of gender should be considered when estimating OHV trip generation for an area. Age was also found to be a determining factor in estimating trip generation. The OHV Final Report by Cordell ET Al. suggests that younger people do tend to participate in OHV recreation at a higher rate than elderly people. This also suggests that demographic characteristics, additional to income, should be considered when estimating OHV trip generation. However, income is still a very important demographic factor.

There will be an estimated 281 trips generated by people living within two miles of the study area. This is enough traffic to cause changes and conflicts within the study area. In the southwest, where many people will enter through a few stub-outs, it can be assumed that there will be several types of user conflict and perhaps an increased amount of environment degradation due to off-trail riding. This portion of the study area could be investigated further for the need and use of increased trail regulation. Additional research could consist of detailed focus groups consisting of OHV participants in Las Cruces County, surveys of OHV recreation participants as they enter the study area, and collection of more detailed imagery to identify high traffic areas where new trails may be forming. This project has the potential to help estimate the location of high traffic areas where more research could be completed regarding recreational OHV use and its effects on the eastern Las Cruces, NM landscape.

A broader outcome of this research is the development of a model that can be used to identify trip origin and generation at a large scale using the Decennial Census, Aerial Imagery, local parcel data, and Geographic Information Systems. These tools are relatively easy to come by for planners and researchers who may be interested in modeling travel demand. This method does not require personal visits to the study area, focus groups, or other footwork that adds to the cost of developing similar models. One requirement for this model, however, is that accurate demographic descriptions of recreational OHV users must be found for the area of concern. For this study, a survey done by H.K. Cordell titled "Off-Highway Vehicle Recreation in the United States, Regions and States: A National Report from the National Survey on Recreation and the Environment" was used to identify the demographics most likely to participate in OHV recreation and the probability that someone belonging to each demographic will participate. This report contains this type of information for each sub-region of the United States, and was completed in 2005, recently enough to be considered accurate. The report by H.K. Cordell can be used along with this travel demand model to make an estimate of trip origins and trip generation on a large scale without engaging in some of the lengthy travel demand modeling processes that exist currently.

Future recreation planning research concerning the open space located east of I-25 should be focused on the parcel of BLM land labeled **1** in **Figure 15**. This is an area that is mostly likely going to remain open space through the extended future. Management decisions now should be made to reflect the long term land use decisions that are beginning to develop in Dona Ana

County. Sustainable recreation should be developed for the BLM parcel **1** since it will continue to be reserved as Park/Open Space land. A major question that arises from the implication of future development within the City of Las Cruces is that of what types of recreation will be provided within the small areas of open space that remain. The parcel within the study area that will continue to be designated Park/Open Space land is approximately .45 square miles. This is enough space for a single OHV play area; however, recreational OHV is not likely to be the most appropriate use of open space land which is surrounded by land that is designated for General Urban land use. The types of conflict created by OHV users as well as their expressed desire to avoid developed areas suggest that long term recreational OHV use of the land within the study area is not likely. This information can guide planners to the time frame for which they should focus on making decisions regarding recreational OHV use in this study area. It seems that recreational OHV management decisions should be made sooner than later and should accommodate the encroaching urban edge. Conflicts are likely to occur most frequently in the areas previously estimated to produce a lot of OHV traffic. These areas will also be subject to the greatest amount of environmental degradation. However since this entire area has been designated for development over the next 30 years, perhaps long term environmental degradation will not be a pertinent issue for city planners in this area.

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