CHAPTER 4

METHODS

This chapter is intended to explain the methods used in this research project. The chapter covers the scope of project, the definition of the primary data layer (DEM) and how it is downloaded and prepared for use in a GIS, the description of other data layers required for the project, and the execution of a least-cost path analysis illustrated through a series of steps.

SCOPE OF THE PROJECT

The area of study is Lost Valley, in the north central portion of San Diego County, in southern California. The scope of study involves the use of Geographic Information Systems (GIS) in the construction of a least-cost path analysis or most effective travel route between late period occupation site-locations. Using Lost Valley as the central location, I derived layers of data in the GIS from digital elevation models (DEMs) for different blocks of United States Geological Survey (USGS) 7.5' quadrangle maps. I began with a test using one DEM (Fig. 3). This DEM is for Hot Springs Mountain, which includes Lost Valley as well as the area near Warner Springs. With the results of the pilot test, a new project was planned, which I call "San Luis Rey Watershed". This second project incorporated a larger area that covered the San Luis Rey watershed with a total of 27 DEMs (Fig. 4). Varying start and end points were used for least-cost path analysis through the watershed. For the third project, a different block of DEMs was chosen according to the results of the previous analysis. However, the results for Project 3 (the least-cost path analyses) were missing network connections through Lost Valley.

A smaller area of coverage, using a fourth block of DEMs had to be applied which had more potential to show a relationship of Lost Valley to the surrounding area. Finally, the least-cost path analyses were combined with data that included information on site locations from SCIC (the last three project locations are shown in Fig. 5).
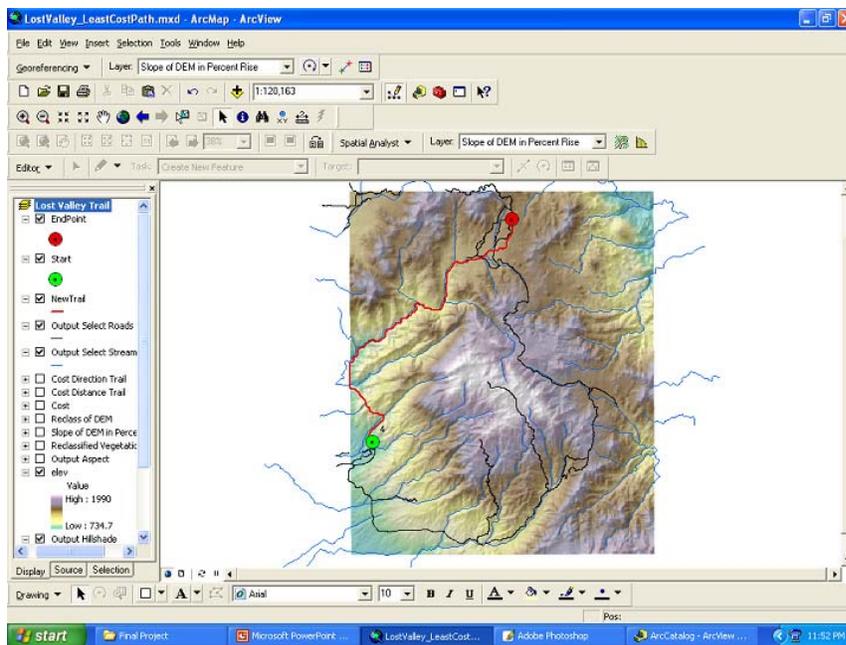
Figure 3. Test of the model using the Hot Springs Mountain DEM, start path in Warner Springs area, end path at Lost Valley (screenshot from ArcView 9.2).
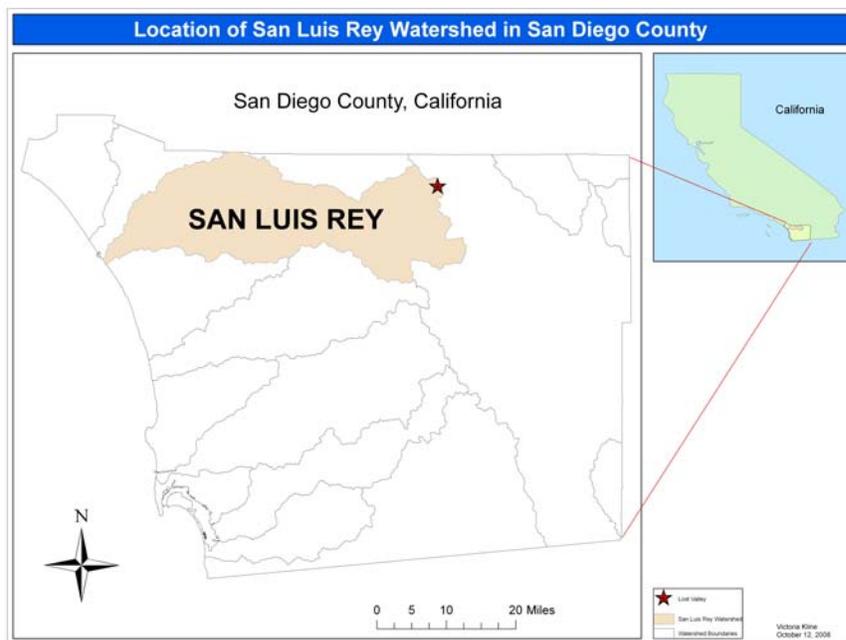

Figure 4. Location of the San Luis Rey watershed within San Diego County.

Legend

☐	Project 5 Boundary	☐	San Luis Rey Watershed
☐	Project 4 Boundary	☐	County Boundary
☐	Project 3 Boundary	☐	Watershed Boundaries

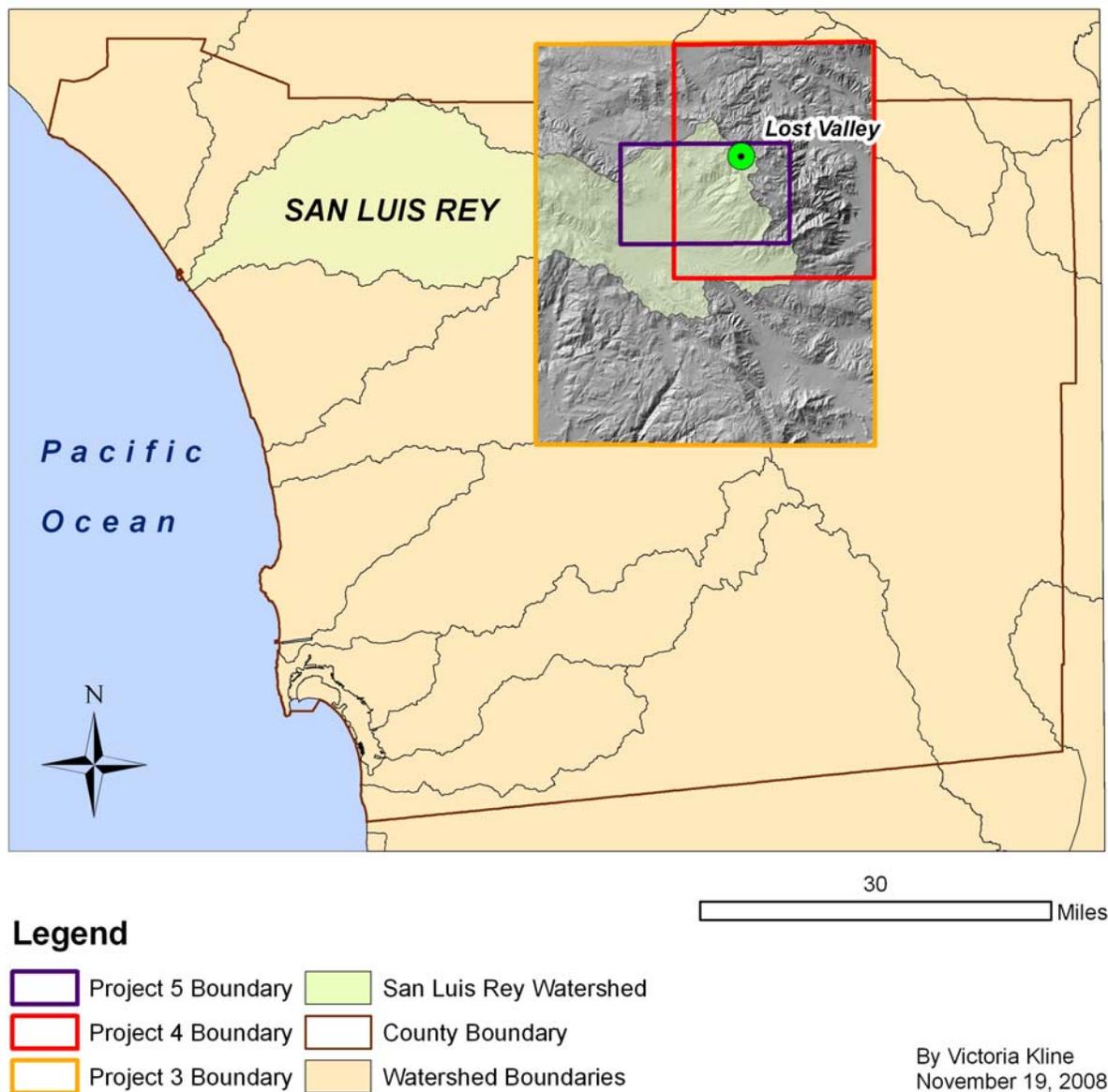By Victoria Kline
November 19, 2008

Figure 5. Changes in the boundary of the project area.

This final least-cost path analysis was conducted using two adjacent DEMs: Hot Springs Mountain and Warner Springs. Figure 6 shows the locations of all project DEMs in relationship to the County of San Diego and how the DEMs align with watershed boundaries. Additionally, one path was picked out of the tangle of intertwining generated least-cost paths for further investigation (Fig. 7). This path (shown in orange in Figure 7) was isolated and saved as a jpg file. When there was a change in direction, the coordinates of the start and end and all points in between, were recorded using the identify tool in ArcView 9.2. The

coordinates were then imported into Google Earth, where I was able to mark those coordinates, and import the jpg of the path of interest. Using Google Earth's manipulation capabilities, I was able to get the line image to line up with the coordinates of the start, end, and change in direction locations that I had marked in Google Earth. I now had a path in Google Earth that could be followed through virtual space to see how the path traversed the local geography.
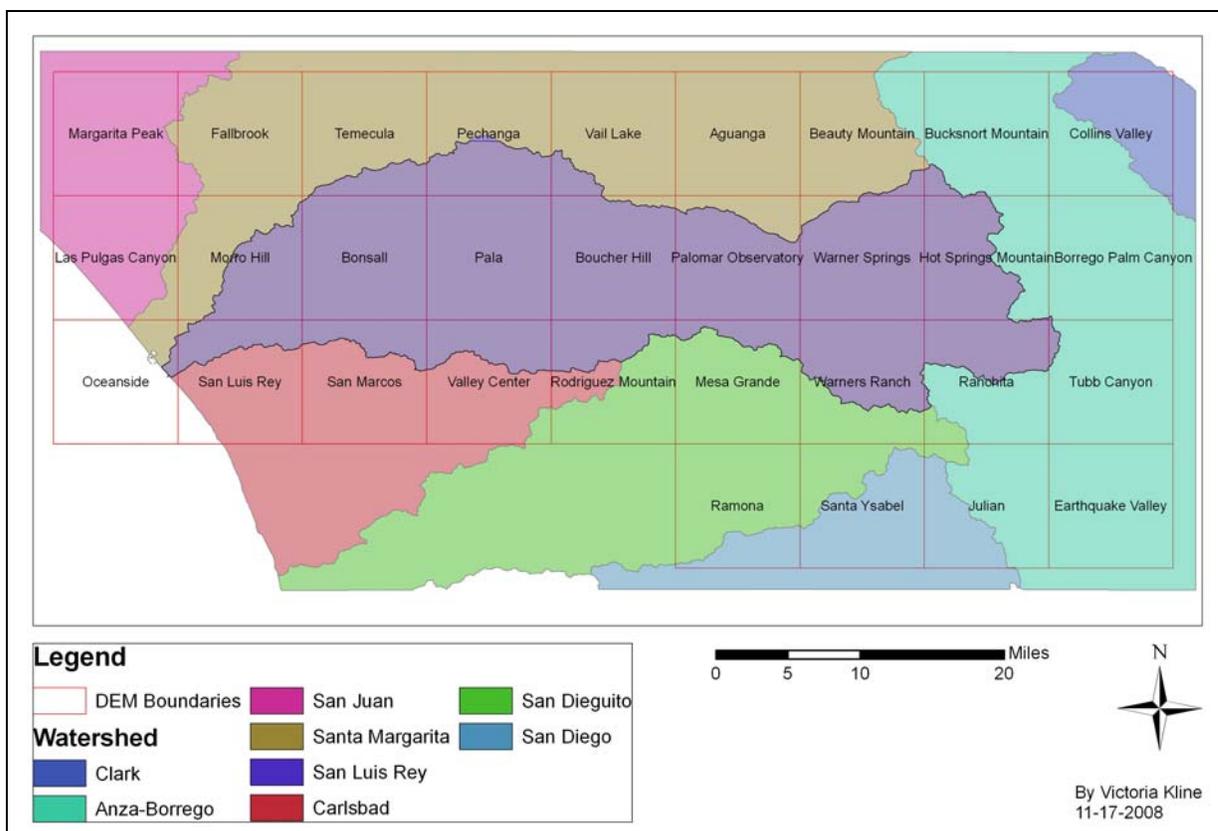

Figure 6. USGS DEM titles and placement of those used in projects.

DATA: THE DIGITAL ELEVATION MODEL

A DEM is a simulated representation of the surface of the earth created by digitization of contour lines from USGS 7.5'quadrangle maps and the interpolation of the interstices of the contour, so that the end result is a continuous representation of elevation for that area in raster format (Conolly and Lake 2006:4-5). A raster format is composed of a grid of tiny squares. Each square has a value assigned to it, which is a representation of elevation or z-value of the square.
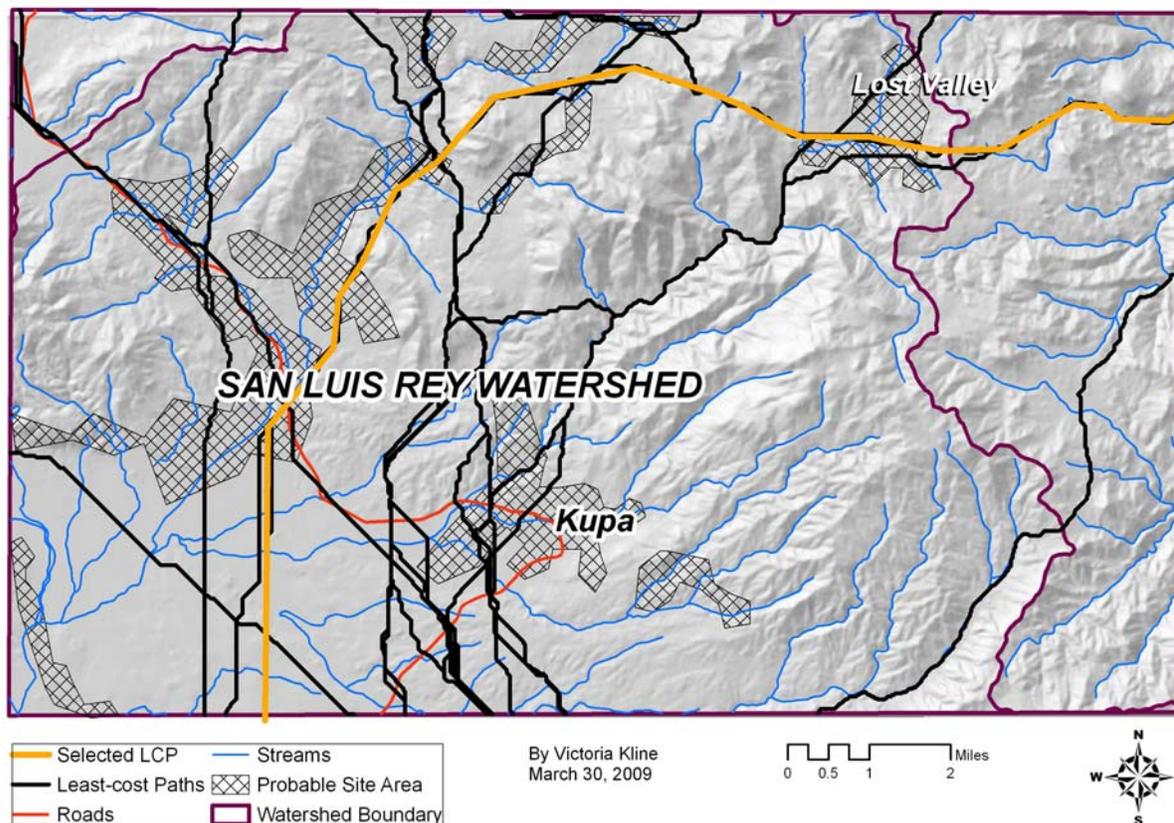
Figure 7. The selected LCP from among the many that could be chosen.

A useful comparison of the DEM(s) used in each project (1-5) can be found in Table 2.

The United States Geological Survey (USGS) website, at http://www.usgs.gov, directs requests for Digital Elevation Models to the GeoComm International Corporation website at http://data.geocomm.com/dem/. DEM downloads are available free of charge at this website for all of San Diego County (and all counties across the U.S., Alaska and Hawaii) in 7.5 minute (1:24,000 scale) tiled data. The DEMs are packaged in Spatial Data Transfer Standard (SDTS) form, which requires a series of steps to unpack for use in ArcView. From the website http://data.geocomm.com/dem/, one can choose state, county, and DEM. Let us use Hot Springs Mountain DEM in San Diego County, California as an example. An account is necessary to log in and retrieve the data file. You will not be asked for your account information until you try to download a file. Enter your login information. Scroll to the file you want to download (again) and click on the green arrow button (that is

Table 2. DEMs Used for Projects

	DEM	Project 1	Project 2	Project 3	Project 4	Project 5
1	Margarita Peak		x			
2	Las Pulgas Canyon		x			
3	Oceanside		x			
4	Fallbrook		x			
5	Morro Hill		x			
6	San Luis Rey		x			
7	Temecula		x			
8	Bonsall		x			
9	San Marcos		x			
10	Pechanga		x			
11	Pala		x			
12	Valley Center		x			
13	Vail Lake		x			
14	Boucher Hill		x			
15	Rodrigiez Mountain		x			
16	Aguanda		x	x		
17	Palomar Observatory		x	x		
18	Mesa Grande		x	x		
19	Beauty Mountain		x	x	x	
20	Warner Springs		x	x	x	
21	Bucksnort Mountain		x	x	x	
22	Warners Ranch		x	x	x	x
23	Hot Springs Mountain	x	x	x	x	x
24	Ranchita		x	x	x	
25	Collins Valley		x	x	x	
26	Borrego Palm Canyon		x	x	x	
27	Tubb Canyon		x	x	x	
28	Santa Ysabel			x	x	
29	Julian			x	x	
30	Earthquake Valley			x	x	
31	Ramona			x		

Key: Project 1 = Pilot Project; Project 2 = San Luis Rey Watershed; Project 3 = 16 DEMs; Project 4 = 12 DEMs; Project 5 = SCIC Data.

the free version). Choose either the 10-meter or 30-meter resolution DEM file by right clicking on the file name. Save it to a folder at the root of your C drive which is named the same name as the DEM you are downloading (in my case, HotSpringsMountain is the name of my folder). Do not use spaces in any folder names or file names when working with DEM files.

After your file has downloaded, open the folder and minimize it. Go back to the download page and save the accompanying text file. The text file has information about the DEM file that you may need, such as the name of the quad, the resolution, the units of measure (feet or meters), the datum, and so on. Open the folder and click on your downloaded DEM file to extract the file from zipped format in WinZip or another zip program (I use ZipGenius, a free online download). Everything is a lot easier to keep track of if you download the extracted files to a folder with the same name as the file number (create the new folder inside the folder with the zip file in it).

Now go to ArcCatalog and find your unzipped file in the menu. From the Conversion Tools menu, choose STDS Raster to Grid. In the pop up menu, find your downloaded file folder and click on it. A four-digit number should appear in the "Select one Prefix" text box. Select that four-digit number; it will be placed in the menu in "Input Prefix." Name your "Output Grid" in the folder where you would like it to be created; leave the "Record No" at the default name. Click OK. The ArcView software executes the transformation for you. This creates a readable DEM raster with eleven accompanying files. In ArcCatalog, the file is black and white and looks like a negative. The black and white flat image must be given color and depth in ArcMap. Figure 8 shows an example of the Hot Springs Mountain DEM after transformation from SDTS to a grid readable in ArcView.
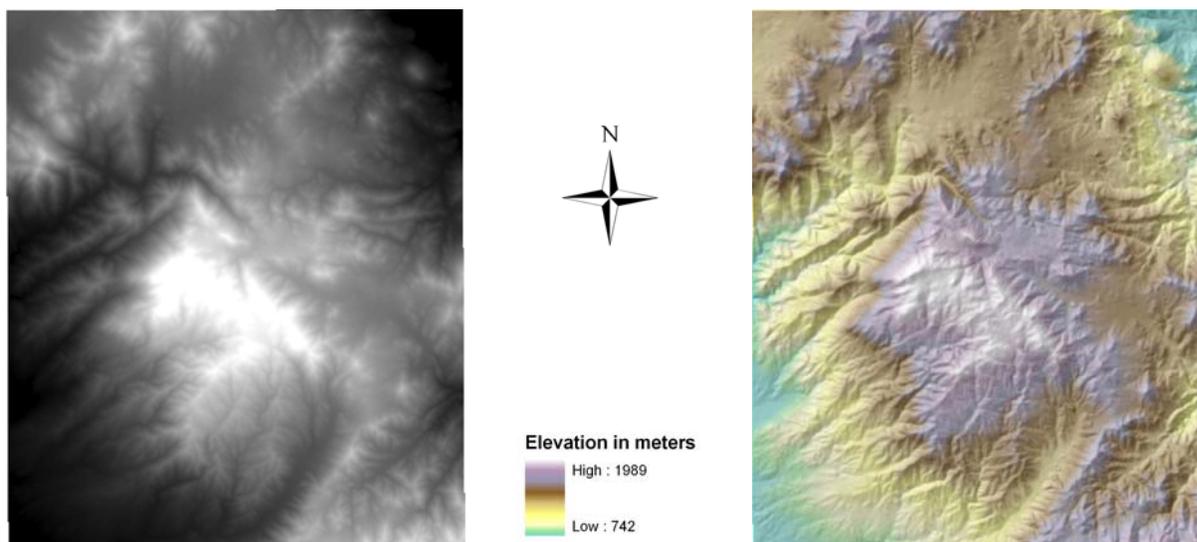

Figure 8. Example of a DEM after transformation from SDTS format to a grid readable in ArcView on left. Right, after adding color and manipulating visual for hillshade to give depth.

If there was more than one DEM used in my project, they were mosaicked in ArcCatalog into a solid block. All of the transformed DEMs were prepared through geoprocessing for hillshade, slope, and aspect using the Spatial Analysis Extension for ArcView 9.2.

Following the work of Wheatley and Gillings (2002) who use GIS in archaeological analysis, the instructions of Mitchell (1999:142-144) on geographic patterning in the data and cost layers, and the ideas of Pletka (2005) in least-cost path analysis as applied to a problem in the archaeology of the Santa Barbara coast, least-cost path analyses were completed in several steps. The work of Whitley and Hicks (2002) was extremely influential in the latter rounds of least-cost path analysis.

OTHER DATA LAYERS

Shapefiles for the beginning and endings of paths were created and differed in number depending on the size of the DEM blocks or the nature of the terrain in the case of the San Luis Rey watershed (Fig. 4). Shapefiles for streams or other hydrologic features, county boundary, and watershed boundaries, were downloaded from www.sandag.com (San Diego Association of Governments), and those for roads were downloaded from www.sangis.com (San Diego Geographic Information Source).

Once the necessary files were collected, the analysis environment was configured in ArcView 9.2 by creating a geodatabase for each collection of files and images used for this project and directing the analysis environment to these databases.

LEAST-COST PATH ANALYSES

Each least-cost path was created between a pair of points. Within each pair of points, there was one point for starting and one point for ending the path. The number of pairs of start and end point pairs represents the number of least-cost paths desired for each project.

Raster format is necessary for the algorithm for least-cost path analysis to function on the data layers. An algorithm is "a procedure that provides a solution to a problem and consists of a set of unambiguous rules which specify a finite sequence of operations" (Longley et al. 2005:342); the ArcView 9.2 software provides the algorithm. The algorithm allows the creation of the least-cost path by determining which of the eight directions (from

each grid square in the raster file for the DEM) is going to require the least amount of effort in which to move (hence the least-cost path).

The DEM is first processed to produce the several iterations of data layers that are required for a least-cost path analysis. The required layers include the following:

1. A derived slope in percent rise and reclassified to equal intervals.
2. A derived total cost layer from the reclassified slope layer.
3. A derived cost distance and cost direction for each pair of points using the start point shapefile and total cost layer.
4. A derived least-cost path for each pair of start and end point shapefiles over the cost distance layer combined with the cost direction layer.

The framework for this study was based on the availability of site locations, maps, ethnographies, and a GIS program (ArcView 9.2). Part of the theoretical framework is the possibility that people follow the path of least resistance to get from point a to point b. Do people follow the least-cost path? The DEM was the primary source of data. I also collected data for site locations for the area of coverage for two DEMs from South Coastal Information Center (SCIC). Information on trade and trails in the literature was read for comparison to the derived least-cost paths. The data used for site locations in the Cahuilla area was based on Bean, Vane, and Young (1991) for further comparison (Figure 9). People traveling through the country may be following the natural topography of the land. The least-cost paths follow the natural topography. If we use the topography as a starting point, the watershed boundary will be the highest point between two regions. Low points will dictate the direction and amount of water flow. If people did follow the watershed, low points would be in the area of most likely water flow. In many places trails follow along the edges of rivers and streams, then jump over high spots to follow the watercourse of the next canyon. Across open expanses of flat ground, there is less pressure to follow a single path. Paths will spread out to cover a swath of area. There are descriptions of footpaths being deep across the desert as in this description of the Mojave trade route by Malcolm Farmer: "the route of this old trail is not difficult to trace; in fact some of our modern highways cross it, and in some places follow its foot worn course" (1935:155). This also points out the evolution of frequently used paths being altered and upgraded for more and more modern travel.

CHAPTER CONCLUSION

This study has been iterative and thus methods and results from one phase (or project) led to the methods and results for a subsequent phase/project. This has led to problems in the separation of methods and results. In the interest of organizational quality, in the next chapter I concentrate on the results of the final project only. The first four iterations (projects) have been placed in the Appendix, where the reader can peruse them as interest demands. They include the following titles: Pilot Project, San Luis Rey Watershed, Large Block Around Cupeño Territory, and Reducing the Boundary for Cupeño and Adjacent Territory.
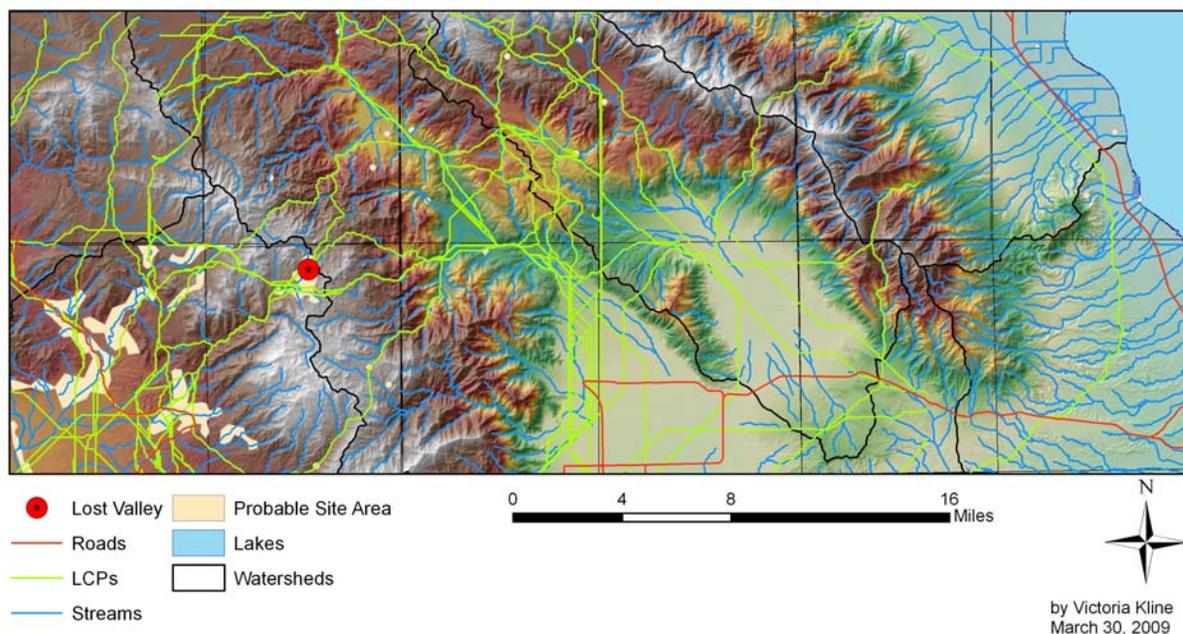

Figure 9. An alternate 12-DEM block, showing least-cost paths compared to probable site areas.