From "Digital Mapping Techniques '10—Workshop Proceedings"
U.S. Geological Survey Open-File Report 2012–1171
http://pubs.usgs.gov/of/2012/1171/

Assessing Erosion Potential and *Coccidioides immitis* Probability Using Existing Geologic and Soils Data

By Will J. Harris and Peter D. Roffers

California Geological Survey
801 K Street, MS 13-40
Sacramento, CA 95814
Telephone: (916) 445-0818
Fax: (916) 323-9264
email: *Will.Harris@conservation.ca.gov*, *Peter.Roffers@conservation.ca.gov*

Introduction

One of the primary benefits of a geographic information system (GIS) is its ability to analyze multiple overlapping layers of spatial data and create new derivative products that provide needed information or answer questions of interest. This new information can then be presented in a clearly understandable way for use by decisionmakers as well as the general public.

An example of this type of process is an assessment conducted by the California Geological Survey (CGS, 2006) on a property in the Bakersfield area that was being considered by the California State Parks Off-Highway Motor Vehicle Recreation Division as a possible State Vehicle Recreation Area (SVRA).

The property is located within a region that has an elevated incidence rate of coccidioidomycosis, or valley fever. Valley fever is caused by inhalation of spores of the pathogenic fungus *Coccidioides immitis*. The spores exist in soils in certain parts of the Southwestern United States, northern Mexico, and a few other areas in the Western Hemisphere. Valley fever contracted by mammals typically produces flu-like symptoms and in some cases causes chronic pulmonary infection and (or) disseminated infections in soft tissue and bones (CDC, 2005; NIH, 2006).

The purpose of this study was to utilize existing geologic, soils, hydrologic, vegetation, and topographic data layers and a GIS modeling approach based on a published erosion hazard rating system to assess both the erosion hazard potential of soils found within the site and the relative likelihood that spores of the *Coccidioides immitis* fungus exist in the soils. The findings would then need to be conveyed in a simple and effective manner to resource managers, political representatives, and the general public.

Methods

The methods used in this study are discussed in two sections, the first describing the modeling process for erosion hazard potential, and the second describing the assessment used to evaluate the relative likelihood of *Coccidioides immitis* spore presence across the project area. Data layers that were used as input for the GIS modeling process include existing data on geology, soils, hydrology, vegetation, topography, and physiography.

Erosion Hazard Potential

Erosion hazard potential was assessed using the Erosion Hazard Rating (EHR) System presented in the Soil Conservation Guidelines/Standards Off-Highway Vehicle Recreation Management (Division, 1991) and preliminary soil survey data provided by the Natural Resources Conservation Service (NRCS, not dated).

The EHR assessment method is described in detail in the Soil Conservation Guidelines/Standards (Division, 1991). The method utilizes information on soil type, vegetation cover, slope, and precipitation to derive an EHR. The assessment for the site was conducted in accordance with the Division (1991) method and utilized a model developed in ArcGIS to prepare data for EHR calculations.

The EHR method determines the relative risk of surficial erosion from runoff drainage on an existing soil-covered surface. It provides a first measure of erosion risk, thereby enabling land managers to assess baseline soil-erosion conditions, as well as to evaluate, design, and plan soil-disturbing activities so that erosion hazard risk is minimized.

Table 1. Soil units in the project area (from National Resources Conservation Service).

Unit	Soil Unit Name	Soil Texture
138	Hesperia	Sandy loam, fine sandy loam
174	Xeric Torriorthents-Calcic Haploxerepts Association	Silt loam, silty clay
187	Trigo-Chanac Association	Fine sandy loam
193	Chanac-Pleito Complex	Sandy clay loam
201	Pleito-Chanac-Raggulch Complex	Sandy clay loam, loam, sandy loam, weathered bedrock
205	Pleito-Trigo-Chanac Complex	Sandy clay loam, fine sandy loam, loam
261	Blasingame-Arujo-Cieneba Association	Sandy loam, sandy clay loam
265	Arujo Sandy Loam	Sandy loam, sandy clay loam
267	Cieneba-Vista-Rock Outcrop Complex	Sandy loam, granite
277	Feethill-Vista-Walong Association	Sandy loam, sandy clay loam
297	Walong-Blasingame-Rock Outcrop Association	Sandy loam, sandy clay loam, granite
302	Feethill-Cibo-Cieneba Complex	Sandy clay loam, clay loam, sandy loam
305	Chanac-Pleito-Premier Association	Loam, sandy clay loam, clay loam
306	Xerofluvents, Occasionally Flooded-Riverwash Complex	Sand, gravel, clay
313	Landfill	

The NRCS-assigned soil unit names, soil unit numbers, and soil texture are provided in table 1. To calculate EHR, soil textures are assigned values which depend on the slope steepness. Other NRCS factors used in the EHR calculation include infiltration and permeability ratings, and depth to restrictive layer (that is, bedrock).

Six-hour precipitation intensity, soil cover, and slope length are also factored into the EHR rating. The precipitation intensity value was based on data obtained from a weather station in Glennville, approximately 20 miles northeast of the site. The Glennville weather station data were used to provide somewhat conservative precipitation information. Glennville is at a higher elevation than the site, and precipitation there is generally greater than in the lower elevations of the southern San Joaquin Valley.

Soil vegetative cover was assumed constant throughout the site. The assigned cover value was based on a mix of groundcover vegetation, exposed soil, and shrub and tree canopy.

The slopes at the site are generally smooth. There is little significant microrelief and organic debris such as logs and large branches that may act to disrupt surface-water flow. Accordingly, the slope length value was held constant in the ArcGIS model, which utilized a 10-meter digital elevation model (DEM) to illustrate the topography of the site and surroundings. To more accurately reflect the topography represented by the 10-meter DEM, the slope length range value used in the EHR assessment was based on slopes greater than 50 feet in length. The results of the EHR assessment for the site are illustrated in figure 1.

Assessment of *Coccidioides immitis* Spore Presence

The soils in the southern San Joaquin Valley, particularly uncultivated native soils on the valley flanks, are known to contain *Coccidioides immitis* spores (F.S. Fisher, U.S. Geological Survey, retired, oral commun., 2006); NIH, 2006). Research conducted by others indicates that within a region known to have the spores, there are variables which increase or decrease the likelihood that the spores may be present at a given locality within the region (Bultman and others, 2005; F.S. Fisher, U.S. Geological Survey, retired, oral commun., 2006).

A general ArcGIS-based assessment was made of the site using several of these variables to rate the relative likelihood that *Coccidioides immitis* spores are present in the different soils on the site. To do this, a simplified scoring system was used. Variables were weighted with points ranging from one

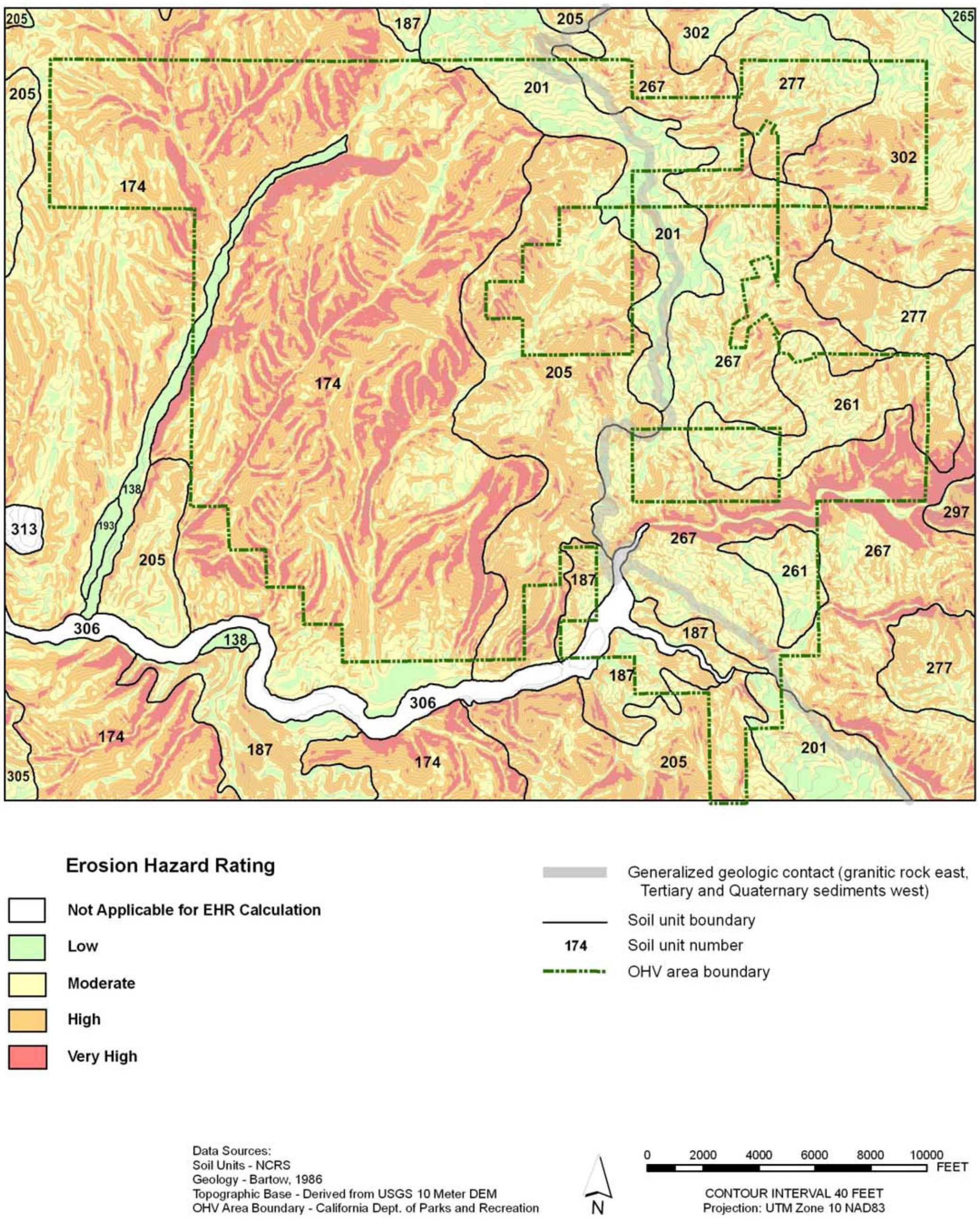

Figure 1. Erosion Hazard Rating map.

to three. Generally, each variable represents a characteristic of the soil type (for example, soil texture) or the physiography of the area (for example, seasonal drainage along a canyon bottom). These variables were given values of one or two. If the variable corresponds with a percent content, such as clay content, or a range, such as pH, the value given ranged from one to three, depending on percent content or range. This methodology is derived from work presented by Bultman and others (2005), and based on discussions with F.S. Fisher (U.S. Geological Survey, retired, oral commun., 2006). Higher values were given for conditions that would promote the growth of the spore, such as soils in a wash, which is subject to wetting and drying. Lower values were given for ground where the spore is unlikely to propagate, such as a granite outcropping on ridgeline. The results of the *Coccidioides immitis* spore presence assessment are illustrated in figure 2.

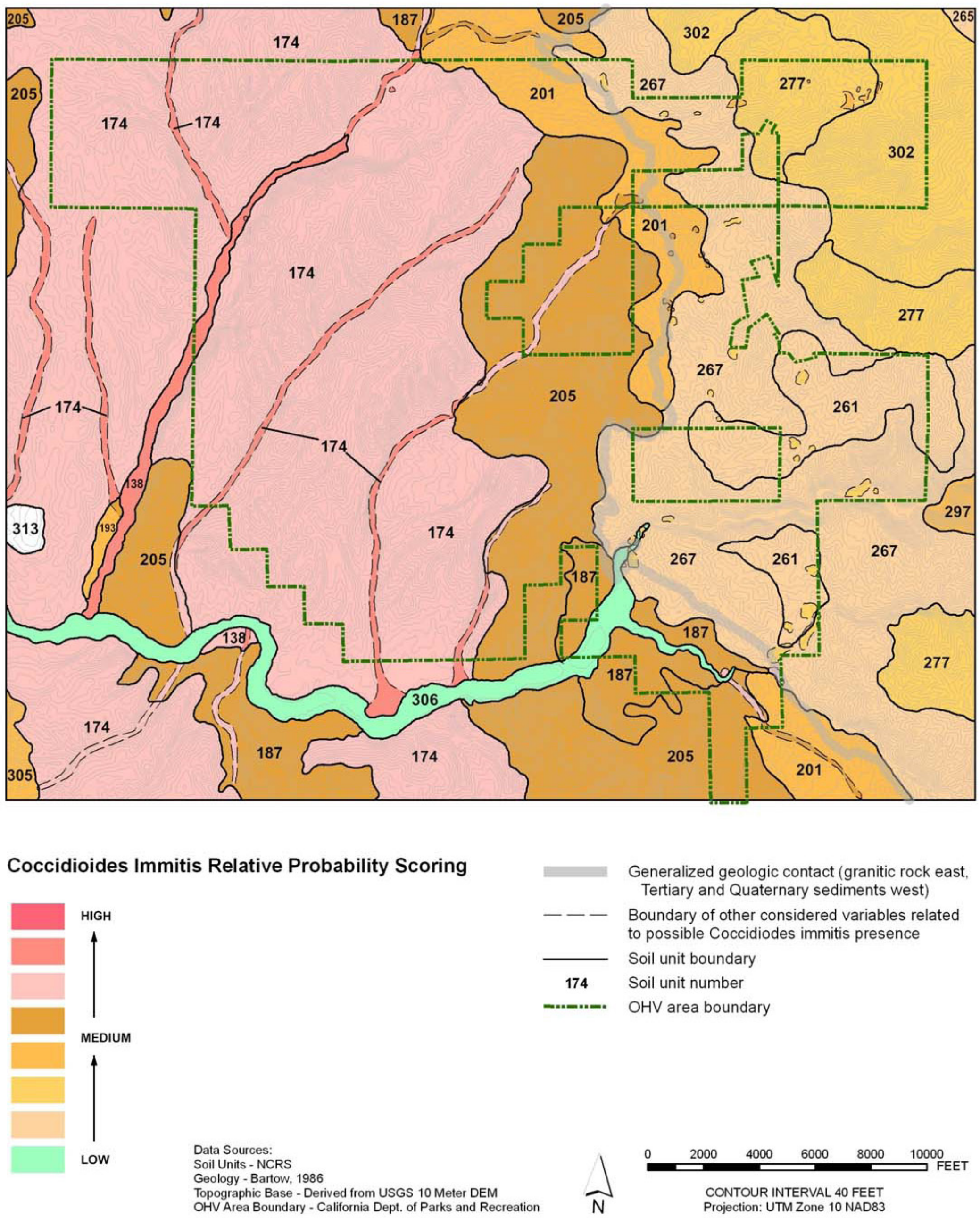

Figure 2. *Coccidoides immitis* relative probability map.

FINDINGS

Erosion Hazard Potential

Soils derived from Tertiary sediments, especially soil unit 174 (see table 1), appear to be the most susceptible to erosion as measured by the applied EHR method (fig. 1). These soils cover approximately the western two-thirds of the site, with soil unit 174 covering most of that area. An analysis of EHR values assigned to pixels within soil unit 174 shows that the EHR for this soil is Very High when it drapes a slope of 25 degrees (50 percent) or more. Correspondingly, this area, which consists of rolling hills and incised drainages, is mostly shaded orange and red, indicating an EHR risk of High and Very High (fig. 1).

Soils derived from the granitic bedrock on the east, which is mostly soil unit 267, appear to be comparatively less susceptible to erosion. This is due to the less varied topography of the granitic terrain; steep slopes are generally limited to the flanks of Poso Creek, which can be traced trending east to west along the lower half of figure 1. Elsewhere, slopes in the terrain are rarely steeper than 25 degrees. An analysis of EHR values calculated for soil unit 267 shows that the EHR for this soil is Very High when it is on slopes of 30 degrees (57 percent) or more, which is only 5 degrees steeper than the soil unit 174 discussed above.

Assessment of *Coccidioides immitis* Spore Presence

As illustrated in figure 2, soils west of the granitic bedrock have a greater likelihood of containing *Coccidioides immitis* fungal spores. These soils are mostly derived from Tertiary sediments. Again, soil unit 174 is the focus. This soil stands out because its silt and fine sand content, salinity, and favorable clay content and a corresponding water holding capacity are favorable for the growth of the fungus. Additionally, four prominent seasonal drainages run through the terrain covered by soil unit 174. Because these drainages provide a seasonal routine of wetting and drying the underlying soil, the likelihood that *Coccidioides immitis* fungus is in the soil is increased (F.S. Fisher, U.S. Geological Survey, retired, oral commun., 2006).

The likelihood that the *Coccidioides immitis* fungus is present in the fluvial sediments of Poso Creek (soil unit 306) is considered relatively low because this area is densely vegetated and the creek typically flows year-round; both of these factors inhibit the establishment and propagation of the fungus (F.S. Fisher, U.S. Geological Survey, retired, oral commun., 2006).

Discussion And Conclusions

The Tertiary sediments that underlie the soils in the western two-thirds of the site consist of fine sandstones, siltstones, and claystones (CGS, 2006), are generally soft, and are susceptible to erosion from concentrated runoff. Short of prohibiting OHV travel on the slopes in this area, reducing the erosion hazard risk to an acceptable level would be a significant mitigation effort. The soils in the western two-thirds of the site also have the highest relative likelihood of containing the *Coccidioides immitis* fungal spores (fig. 2).

It is unclear how to mitigate against the inhalation hazard of *Coccidioides immitis* spores when considering OHV recreation in this area. Dust suppression by spraying water on trails is ill-advised, as the frequent wetting and drying of soil may promote fungal growth and spore production (F.S. Fisher, U.S. Geological Survey, retired, oral commun., 2006).

In summary, this study provides an example of how existing geospatial data can be utilized in conjunction with known modeling factors to generate valuable information and potentially gain new insights. Through the proper use of such techniques, it is possible to distill a variety of related factors into an easily understood product to inform decisionmakers as well the layperson without any specialized GIS knowledge. In this case, the modeling process made use of existing data related to geology, soils, hydrology, vegetation, topography, and physiography, and provided information that assisted natural resource management and disease-mitigation efforts.

References

Bultman, M.W., Fisher, F.S., and Pappagianis, D., 2005, The ecology of soil-borne human pathogens, *in* Selinus, O., ed., Essentials of medical geology: Impacts of the natural environment on public health: New York, Elsevier Academic Press, p. 481-511.

California Geological Survey (CGS), 2006, Preliminary hydrologic assessment of potential off-highway vehicle recreation area, approximately 10 miles northeast of Bakersfield, California: California Geological Survey letter report by Will Harris to Rick LeFlore, to authorities of the California State Parks, August 11, 2006.

California State Parks Off-Highway Motor Vehicle Recreation Division (Division), 1991, Soil conservation guidelines/standards for off-highway vehicle recreation management: California State Parks Off-Highway Motor Vehicle Recreation Division, November 14, 1991.

Centers for Disease Control and Prevention (CDC), 2005, Coccidioidomycosis: U.S. Department of Health and Human Services, updated October 6, 2005, accessed at *http://www.cdc.gov/ncidod/dbmd/diseaseinfo/coccidioidomycosis_t.htm* (link subsequently updated to *http://www.cdc.gov/nczved/divisions/dfbmd/diseases/coccidioidomycosis/)*.

Geomatrix, 2006, Soils and hydrologic studies, Bakersfield State Vehicle Recreation Area, included as Appendix F of the Draft Environmental Impact Report for the Proposed Bakersfield State Vehicle Recreation Area: Irvine, Calif., Michael Brandman Associates, June 7, 2006.

National Institutes of Health (NIH), U.S. National Library of Medicine, 2006, Valley fever: U.S. Department of Health and Human Services, accessed at *http://www.nlm.nih.gov/medlineplus/ency/article/001322.htm*.

National Resources Conservation Service (NRCS), not dated, Preliminary soil survey data, soil survey of Kern County, northeastern part and southeastern part of Tulare County: Natural Resources Conservation Services Staff.