Spatial and Temporal Patterns of Off-Highway Vehicle Use at the Dove Springs OHV Open Area, California

Prepared by

John R. Matchett[1], Leila Gass[2], Matthew L. Brooks[1], Amy M. Mathie[3], Robert D. Vitales[3], Michael W. Campagna[3], David M. Miller[3], and James F. Weigand[4]

[1] United States Geological Survey–Western Ecological Research Center, Las Vegas Field Station, 160 N. Stephanie St., Henderson, NV 89074

[2] United States Geological Survey–Southwest Geographic Science Team, 520 North Park Ave., Suite 106, Tucson, AZ 85719

[3] United States Geological Survey–Western Geographic Science Center, 345 Middlefield Rd., Menlo Park, CA 94025

[4] Bureau of Land Management–California State Office, 2800 Cottage Way, Sacramento, CA 95825

Report prepared for
Bureau of Land Management–California State Office
Sacramento, CA
11 February 2004

US Department of the Interior
US Geological Survey

Executive Summary

The Federal Land Policy and Management Act of 1976 mandates multiple use management of Bureau of Land Management (BLM) lands. Multiple-use "means the management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people" (United States Code, Title 43, Chapter 35, Subchapter 1, Sec.1702.C). The multiple-use mandate is integral to the BLM mission statement: "to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations". Thus, public lands management for multiple uses requires that the BLM provide balanced opportunities for various recreational, environmental, cultural, and economic uses, as long as those uses do not threaten the use and enjoyment of these lands for present and future generations.

Off-highway vehicle (OHV) recreation is a significant use of BLM lands. The California Desert Plan (Bureau of Land Management 1980, and subsequent amendments) recognizes the potential negative effects of OHV use on natural resources. The Plan has developed policies to balance the needs for OHV recreation opportunities with the needs for preserving the health, diversity, and productivity of natural resources. However, since the 1980s little research has evaluated the effectiveness of BLM policies related to OHV recreation, and it is largely unknown whether current policies will result in natural resource conservation.

The US Geological Survey (USGS) and Bureau of Land Management (BLM) have initiated a research program to evaluate the relationships between OHV use and natural resource conditions. This research is focused on developing and field testing protocols to (1) quantify past and current levels of OHV recreation; and (2) evaluate OHV effects on vegetation and wildlife. The field testing is being done at a site in the Mojave Desert of California. We focus on the first task in this report. Specifically, we describe a protocol for quantifying OHV use and report changes in the spatial and temporal patterns of OHV use at the test site. Our pilot study area is the Dove Springs OHV Open Area, located in the BLM Jawbone-Butterbredt Area of Critical Environmental Concern in the western Mojave Desert, Kern County, California. We used the results of this report to establish sampling stations to evaluate vegetation and wildlife responses to OHV use. Vegetation and wildlife responses to OHV use patterns will be described in subsequent reports.

Abstract. We quantified spatial and temporal patterns of OHV use at the Dove Springs OHV Open Area by mapping routes and areas of degraded vegetation from aerial photographs taken in 1965, 1982, 1994, and 2001. We documented a dramatic increase in OHV-related disturbance at the site during the study period. Total length of OHV routes increased from 49 km to 576 km between 1965 and 2001. Seven percent of the area exhibited some form of OHV disturbance in 1965, which increased to over 30% by 2001. OHV activity correlated positively with proximity to other linear features, such as large washes and utility rights-of-way. OHV use was also concentrated on lowlands and hill-slopes relative to uplands.

Introduction

Recreational off-highway vehicle (OHV) use involves dirt bikes, dune buggies, and four-wheel drive vehicle travel on unpaved surfaces. Widespread OHV use has occurred in the California deserts since the 1960s. Initially, land management agencies did not regulate OHV recreation, and large areas were open to unlimited use. When implementing the BLM California Desert Plan, the BLM developed specific policies to minimize negative OHV effects on other natural resources (Bureau of Land Management 1980, and subsequent amendments). Negative effects in desert ecosystems can include changes in soil properties that lead to accelerated erosion (Webb 1982, Webb et al. 1987), soil compaction (Adams et al. 1982), reductions in plant cover (Adams et al. 1982), and reductions in wildlife species abundance and richness (Bury et al. 1977, Luckenbach and Bury 1983). Recent directives have emphasized the need for BLM to monitor status and trend of OHV use and its effects on other natural resources (Bureau of Land Management 2001).

Attributing ecosystem effects to any single factor of human disturbance can be daunting, especially within a landscape with multiple, often interrelated, uses. For example, to evaluate OHV effects in the Mojave Desert one must distinguish them from effects caused by other land uses such as mining, cattle grazing, utility corridors, human settlement, and natural processes such as wildfire and floods. Some of these disturbances may have occurred over a century ago and may have subtle, lingering effects that are difficult to detect and quantify. Moreover, some disturbance factors, such as utility corridors and natural washes, may influence and be correlated with patterns of OHV recreation because they provide pre-existing paths facilitating OHV travel.

One way to evaluate OHV use independent of other disturbances is by directly surveying the number of OHV recreationalists using a given area during a given time interval. This method provides an index of OHV use, but it does not provide managers with explicit information about the spatial patterns of OHV use that is needed to evaluate correlations with ecosystem effects. In addition, determining past OHV use is impossible if surveys were not previously done. Variations in survey methods over multiple time periods may also prevent subsequent combined analyses. Thus, other methods are needed for evaluating past and current use patterns, and for modeling future OHV use scenarios.

OHV use intensity can also be evaluated by quantifying disturbed areas resulting from OHV use. Disturbed areas can include OHV routes and larger areas were individual routes cannot be distinguished due to intensive use (e.g., near camping areas and hill-climbs). OHV routes include improved dirt roads, unimproved dirt roads, two-track trails, single-track trails, and washes. Some routes are created to facilitate OHV travel (e.g. improved roads), whereas others are created by OHV use itself (e.g. trails) or are natural features that facilitate OHV travel due to relatively low plant cover (e.g. washes).

Measuring OHV-disturbed areas is an indirect measure of OHV use, but it is a metric amenable to spatial analysis, including correlation with ecosystem attributes. This method requires interpretation of ground-based or remotely-sensed data to identify disturbance features caused solely by OHV recreation, specifically the routes used by OHVs. Ground-based measurements of OHV tracks may be more reliable than remotely-sensed data, but they become cost-prohibitive when applied over large geographic areas.

For this study, we chose to map OHV tracks and disturbed areas using remotely-sensed data, specifically a sequence of historical digital orthophoto quadrangle (HDOQ) scenes beginning before widespread OHV recreation (1965) to current conditions (2001), with two intervals in between (1982 and 1994). The benefits of this technique include detecting spatial patterns in OHV use and changes in use over time, being a relatively cost-effective inventory of OHV use, and allowing one to correlate OHV use data with other ecosystem attributes such as soils, vegetation, and wildlife.

Methods

Study area

The Dove Springs OHV Open Area (35°18.36' N, 118°0.5' W) is located at the western edge of the Mojave Desert, just east of the Sierra Nevada Mountains and adjacent to Red Rock Canyon State Park in California (fig. 1). This area contains soils and geomorphic features ranging from young, coarse-textured soils in washes to old, fine-textured soils in uplands (Miller & Amoroso in review). Creosote bush (*Larrea tridentata*) communities dominate the vegetation at lower elevations, while blackbrush (*Coleogyne ramosissima*) shrubland and Joshua tree (*Yucca brevifolia*) woodland communities dominate upper elevations (fig. 2).

We defined our study area as the Dove Springs Open Area boundary (as delineated by the BLM) plus a 1-km band of area around its perimeter (fig. 1). We added this extra area because we observed that significant OHV activity extended beyond the formal open-area boundary, possibly

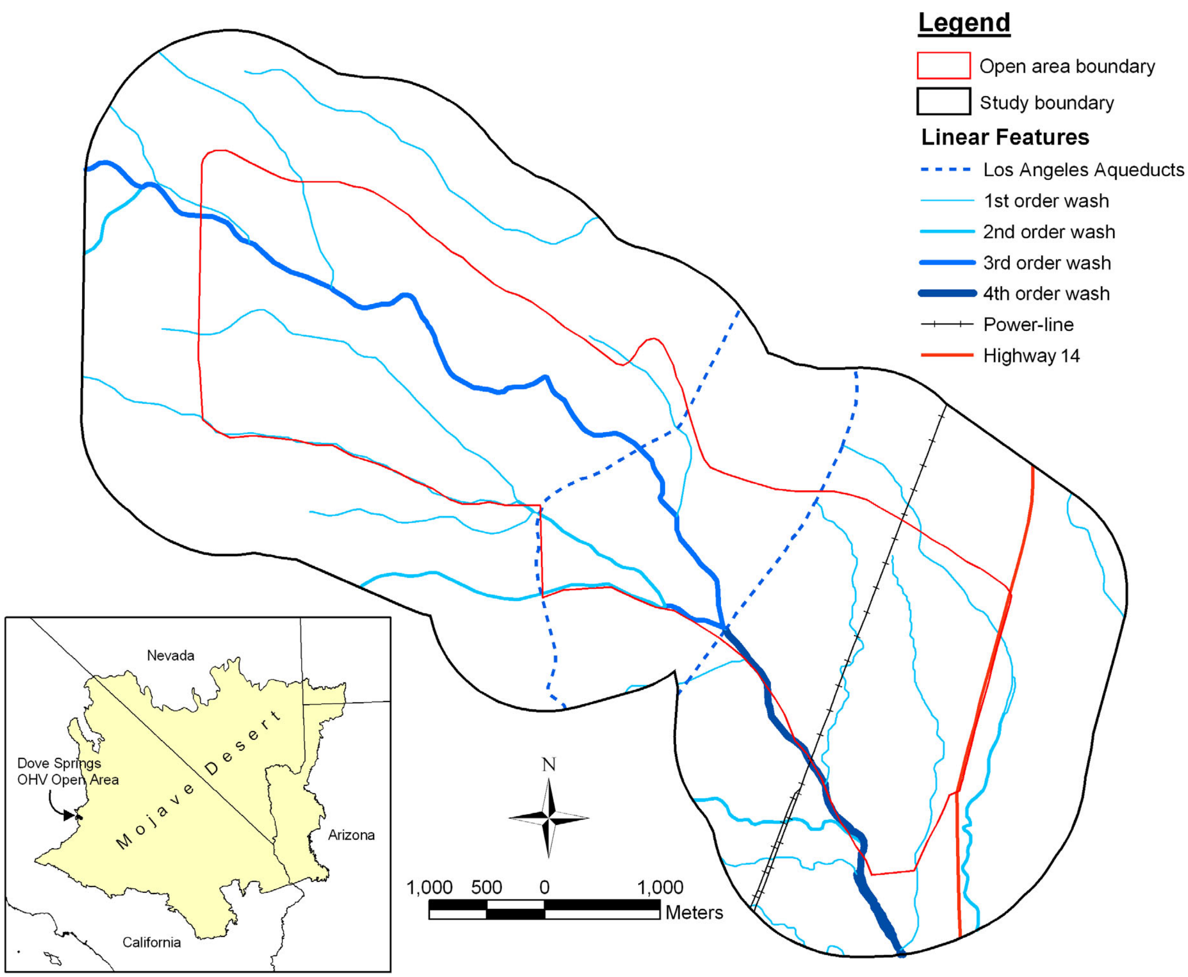


Figure 1. Location of the Dove Springs OHV Open Area study site.

because there was very little fencing or signage to constrain OHV travel. The study area was 3897 ha.

Historic aerial photographs

We obtained BLM and USGS aerial photographs for 4 years: 1965, 1982, 1994, and 2001. Before analysis, we digitally scanned and orthorectified the photographs to remove distortion caused by variations in camera height and angle. The study area required a total of six 3.75-minute × 3.75-minute quadrangles for complete coverage during each year.

The challenges inherent in this and other HDOQ projects include non-NAPP (National Aerial Photography Program) source imagery that may have non-standard flight heights and scales, photographs not centered on the quadrangles, and missing ground control and aero-triangulation points. To overcome these challenges, we used materials of known accuracy: 1st generation DOQs produced from black-and-white 1994 USGS NAPP photography (NP9402, May 28, 1:40000), digital elevation models (DEMs), published quadrangle maps, flight line diagrams, camera calibration reports, USGS black-and-white 1965 aerial photography (VBGZ, September 12, 1:32000), color infrared BLM 1982 photography (BLM CA-81CC, May 16, 1:24000) and natural color BLM 2001 aerial photography (BLM CA-01, August 11, 1:24000). We plotted photo centers and photo extents on 7.5-minute topographic quadrangle maps to determine optimum image coverage for the 3.75-minute DOQ cells.

Aerial photographs were digitally captured at a scanning aperture of 30 microns. During the scanning phase, we selected 2 representative images with clear fiducial marks (points with a known geographical coordinate) for measurement. We input these coordinates into transformation software and generated a camera calibration file for further processing and calculation of photo scales. In place of ground control or aero-triangulation, we used the 1994 DOQs to control the scanned images. For each image we selected and measured at least 9 widely distributed points of common, well-defined photo-identifiable features. At least 2 points were on the image edge, which ensured commonality between 2 or more adjoining images.

With the camera data, derived control files, DEMs, and source images as input, the Digital Orthophoto Processing System (DOPS) was used to create rectified image chips from raw aerial photographs. Individual rectified image chips were mosaiked together for the final HDOQs. We used

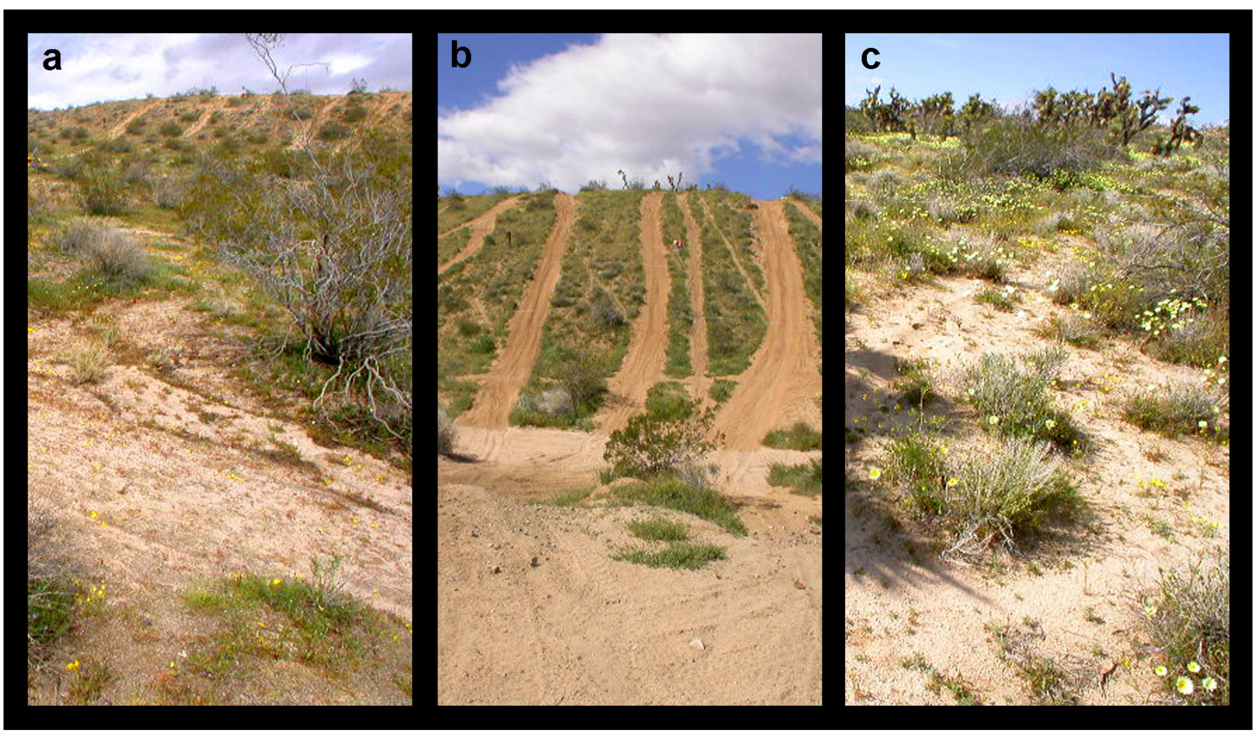


Figure 2. Examples of vegetation habitats at the study site: (a) creosote bush dominated lowlands and washes, (b) blackbrush dominated hill-slopes, and (c) blackbrush and Joshua tree dominated uplands.

many image chips repeatedly wherever chip coverage extended into multiple HDOQs. The USGS-developed mosaic programs MMM and CMM were used to locally adjust brightness values and minimize tonal variations along joined areas. Tone matching was done where adjacent HDOQs came together, but not across the entire area of each HDOQ. After chip mosaiking, we calculated and trimmed overlap areas between adjacent HDOQs, then embedded HDOQ datum quadrangle corner crosses. Finally, we edited the standard USGS keyword header and recorded source information for each image chip contained in the HDOQ.

Quality assurance and control measures consisted of HDOQ header verification, thorough image inspection of each individual HDOQ, and a comprehensive check of image geometry and general image radiometry. HDOQs with complete image coverage met standard USGS DOQ acceptance criteria for image data quality and accuracy, and were added to the national DOQ database maintained by the USGS Earth Resources Observation Systems (EROS) Data Center.

Mapping OHV use

Digitizing procedures

We spent 1100 person-hours digitizing and checking digitizing consistency. We mapped OHV routes and degraded areas via heads-up digitizing (i.e. digitizing from images displayed on a computer monitor) using ESRI ArcGIS version 8 software. All data were projected to Universal Transverse Mercator (UTM) units using the North American Datum of 1983 (NAD83). We also used USGS 1:100000 scale digital line graphs of hydrology and main roads to assist digitizing efforts.

We created two types of geospatial data: lines and polygons. Lines represented discrete linear OHV routes, whereas polygons represented larger areas of intensive OHV use where individual routes were not visually distinguishable. Using the HDOQs as background layers, we digitized features at scales between 1:2000 and 1:5000. Scales around 1:2000 were large enough to accurately identify features given the HDOQ resolution, while scales near 1:5000 were small enough to easily follow and trace features. We only delineated polygons larger than 100 m^2.

Spatial data structure

Data from each year were compiled as separate line and polygon data layers. Initially, we created these layers in ESRI coverage and shapefile formats, but later converted them to the newer personal geodatabase format. The geodatabase format provides advanced organization and topological (the spatial relationships between features) definitions, but users can export layers to a coverage or shapefile format if needed.

OHV route lines where classified either as *dirt* (lines most likely created for or by OHV use) or as *wash* (lines most likely created by water flow, but possibly used by OHVs). Intensive OHV use polygons were classified into one of several categories: (1) *densely tracked reticulate*, where lines were evident in a web-like pattern, but were too dense and overlapping to distinguish individually; (2) *densely tracked hill-climb*, where lines were evident on side slopes that OHVs drive up and down, but were too dense and overlapping to distinguish individually; (3) *densely tracked intersection*, where lines were evident where they came together at intersections, but were too dense and overlapping to distinguish individually; (4) *densely tracked right-of-way*, where lines were evident near pipelines, transmission lines, and highway rights-of-ways, but were too dense and overlapping to distinguish individually; (5) *densely tracked wash*, where lines were evident within washes, but were too dense and overlapping to distinguish individually; (6) *denuded hill-climb*, where lines were not readily evident on hill-climbs, but the preponderance of densely tracked areas in the vicinity indicated that OHV use was probably high within the polygon; and (7) *denuded staging*, where lines were not readily evident in relatively flat camping areas, but the preponderance of densely tracked areas in the vicinity indicated that OHV use was probably high within the polygon. Examples of these classifications are given in fig. 3.

Data accuracy

We visited the study area periodically between August 2001 and June 2003 to compare route locations and disturbed areas on the ground and on aerial photography. Because we used historic DOQs in this study, we could neither conduct formal ground truthing nor determine which routes

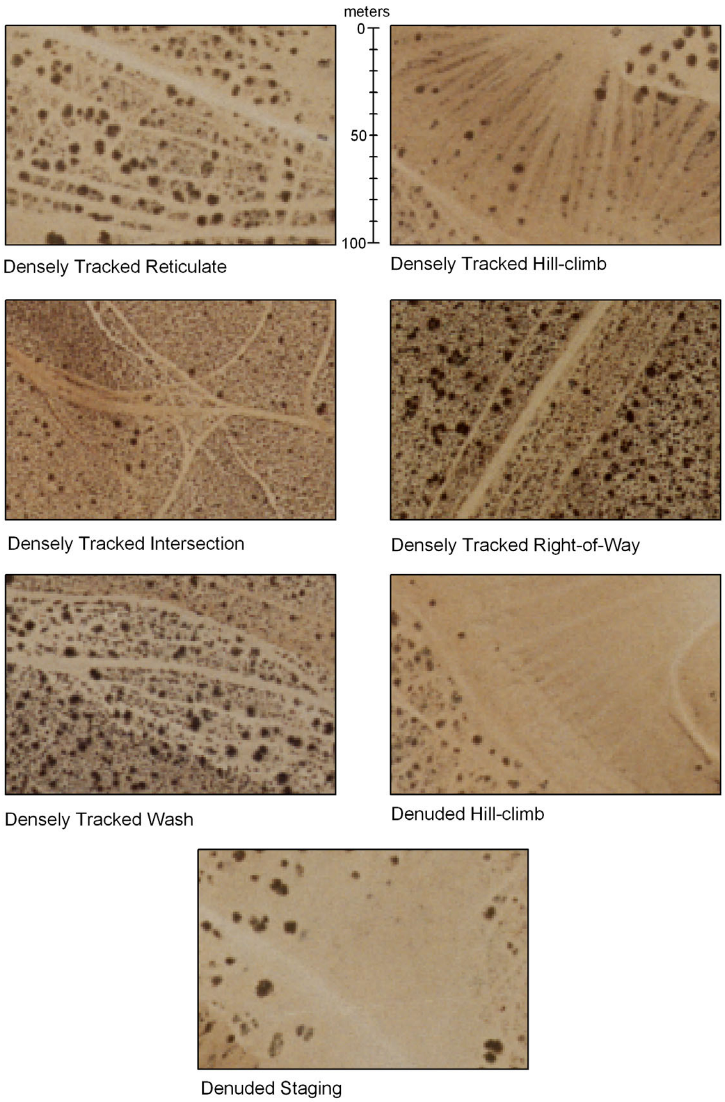


Figure 3. Examples of densely tracked and denuded classifications.

had been created after the most recent aerial photographs (11 August 2001).

Several factors influenced the spatial dataset's accuracy—mainly DOQ accuracy, the scale used to digitize features, and operator interpretation of DOQ imagery. USGS guidelines state "digital orthophoto quadrangles and quarter-quadrangles must meet horizontal National Map Accuracy Standards (NMAS) at 1:24000 and 1:12000 scale, respectively…90% of the well-defined points tested must fall within 40 feet ($^1/_{50}$ inch) at 1:24000 scale and 33.3 feet ($^1/_{30}$ inch) at 1:12000 scale…vertical accuracy of the source DEM must be equivalent or better than a level 1 DEM, with a root-mean-square-error (RMSE) of no greater than 7.0 meters." By applying these guidelines (available online at http://rmmcweb.cr.usgs.gov/public/nmpstds/ acrodocs/doq/2DOQ1296.PDF), we ensured that each HDOQ used had consistent accuracy.

The scale for digitizing features is also influenced by the accuracy of the base layer. We chose to digitize features at scales between 1:2000 and 1:5000 because this range of scales permitted us to identify and map features easily. Therefore, no assessments of feature location accuracy are valid if the data are displayed at scales larger than 1:2000.

Personal interpretations of DOQ imagery also affect accuracy. Individuals may differ in how they distinguish between presence or absence of tracks, categorize continuous variables, and interpret surface characteristics. Because several people worked on digitizing features, it was important to check the draft dataset for consistency. We assigned a single person to inspect the OHV route data layers from all 4 years, editing them for consistency and accuracy.

Accurate topology is an important component in reliable spatial datasets. We defined 3 topological rules: polygon features shall not overlap, route features shall not overlap, and polygon features shall not contain routes. By preventing the intensive OHV use polygons and the linear route features from self overlapping, we ensured that calculations based on route distance and polygon area were accurate. We checked the dataset for overlap rule violations using the topology validation feature in ArcGIS 8.3. A number of small overlaps were discovered and corrected. Because we defined polygon features as areas where we could not reliably digitize linear features, no routes should have existed inside a polygon. After the initial editing process, we found several routes that extended into polygons, which we removed by clipping out the routes within the polygon perimeters.

Data analyses

Our analyses consisted of maps displaying OHV routes and degraded areas, summary calculations of route length and degraded area, and route density calculations. We also analyzed changes between pairs of images from the different time periods, computed zonal statistics between route density and distance to other linear disturbances (i.e. washes, aqueducts, power line, and highway rights-of-way), and compared route densities across major geologic strata.

The Density command in ArcGIS Spatial Analyst was used to calculate route density. Density (m of routes per m^2 area) computations were based on 10 m × 10 m grid cells, using a search radius of 10 m. A cell's value was derived by summing all routes within the search radius then dividing by the search area. For visual display and summary calculations, density values were grouped into 4 categories: *zero* (0 m/m^2), *low* (>0–0.075 m/m^2), *medium* (>0.075–0.15 m/m^2), and *high* (>0.15–~0.32 m/m^2) (see fig. 4 for examples). In addition to these 4 classes, we added 2 classes of degraded polygons (*densely tracked* and *denuded*) to the density layer by grouping all densely tracked polygons (reticulate, hill-climb, intersection, right-of-way, and wash categories) and all denuded polygons (hill-climb and staging categories). These route density layers were used for change detection analyses and comparing density versus distance to other linear disturbances.

The 10 m search radius and cell size used for calculating route density were a conservative choice, because using larger search radii or cell

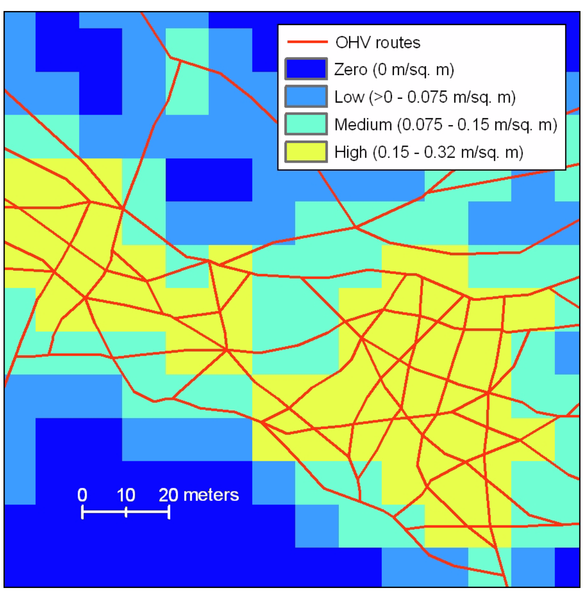


Figure 4. Examples of route density classifications.

sizes could have resulted in greater percentages of the area being classified as impacted. Depending on the subject of interest, a larger radius/cell size may be more appropriate. For instance, the home ranges of wildlife species are typically much larger than 10 m, and an analysis relevant for evaluating impacts on wildlife may want to use larger values.

Natural washes and rights-of-way may provide conduits for OHV use to proliferate throughout a landscape. By looking at the relationships between route density and pre-existing linear features, we can predict how these landscape features may affect spatial patterns of OHV use. Our study area contains a range of wash sizes; plus 2 aqueduct, 1 power-line, and 1 highway rights-of-way (fig. 1). We examined the hypothesis that route density is greater closer to these existing linear features by using zonal statistics. We first calculated distance of a cell midpoint (using the same 10 m × 10 m grid layout of the route density layers) from 1st, 2nd, 3rd, and 4th order washes and each of the 3 rights-of-way. USGS hydrographic maps define wash order: 1st order washes have no tributaries; 2nd order washes have two or more 1st order tributaries; 3rd order washes have two or more 2nd order tributaries; and 4th order washes have two or more 3rd order tributaries (Dunne and Leopold 1978). Features were represented as lines, and therefore distance of a cell to a feature was the measurement to the centerline of a wash or right-of-way. An exception to this was distance to the highway right-of-way. Because BLM does not consider paved highways part of the OHV route network and because highways are usually fenced-off, we computed cell distances from the edge of the highway right-of-way and not from the center.

The distances to features were then classified into 11 intervals: 0–50, 50–100, 100–150, 150–200, 200–250, 250–300, 300–350, 350–400, 400–450, 450–500, and >500 m. We chose intervals with 50 m wide zones based on the spatial resolutions of our datasets. The hydrographic layer, which was created at a 1:100000 scale, translated to a horizontal positional accuracy of at best ±40 m. Within each zone, we calculated cell frequency based on the 2001 classification of route density (zero, low, medium, high, densely tracked, and denuded).

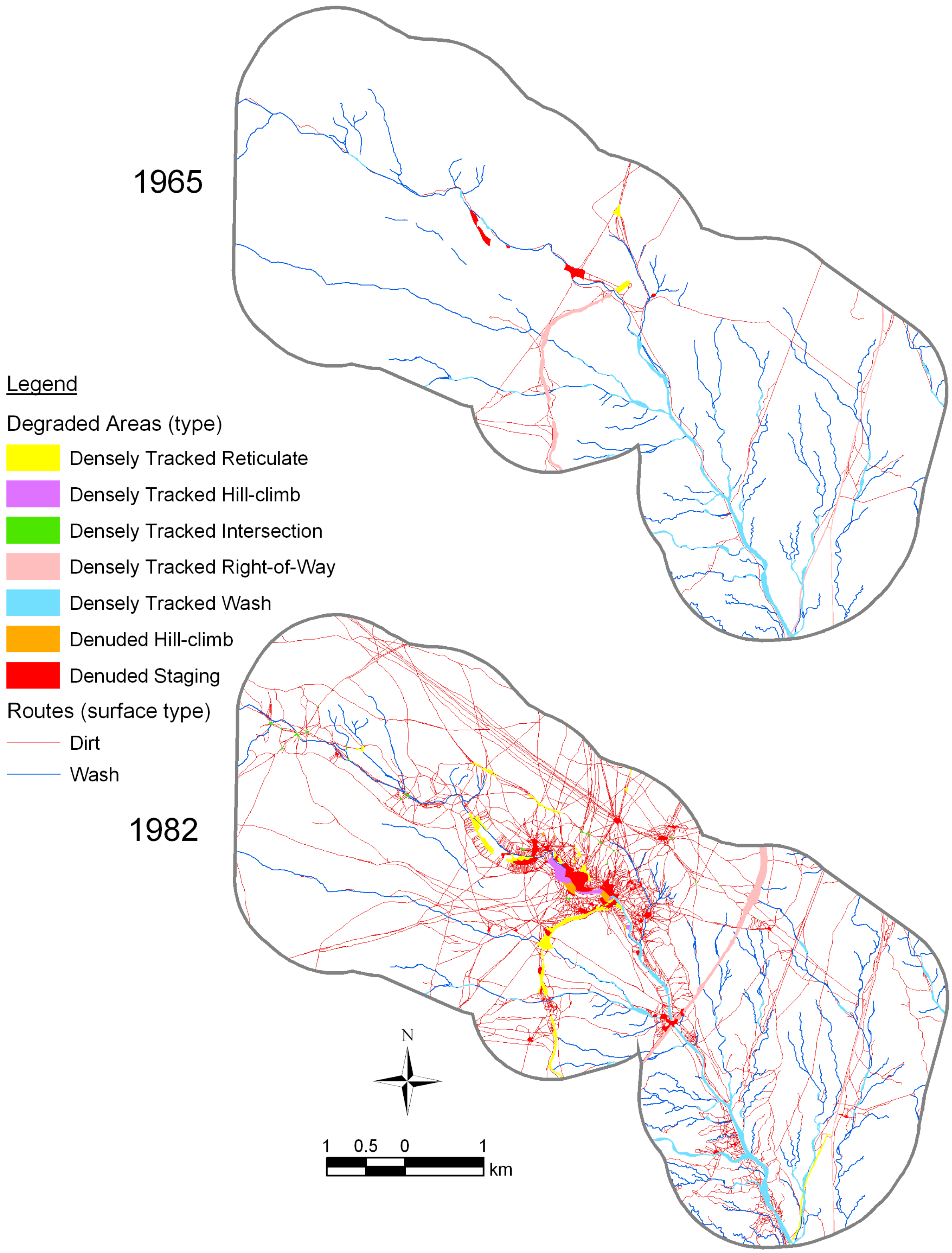


Figure 5. Mapped OHV routes and degraded areas in 1965, 1982, 1994, and 2001. (figure continued on next page)

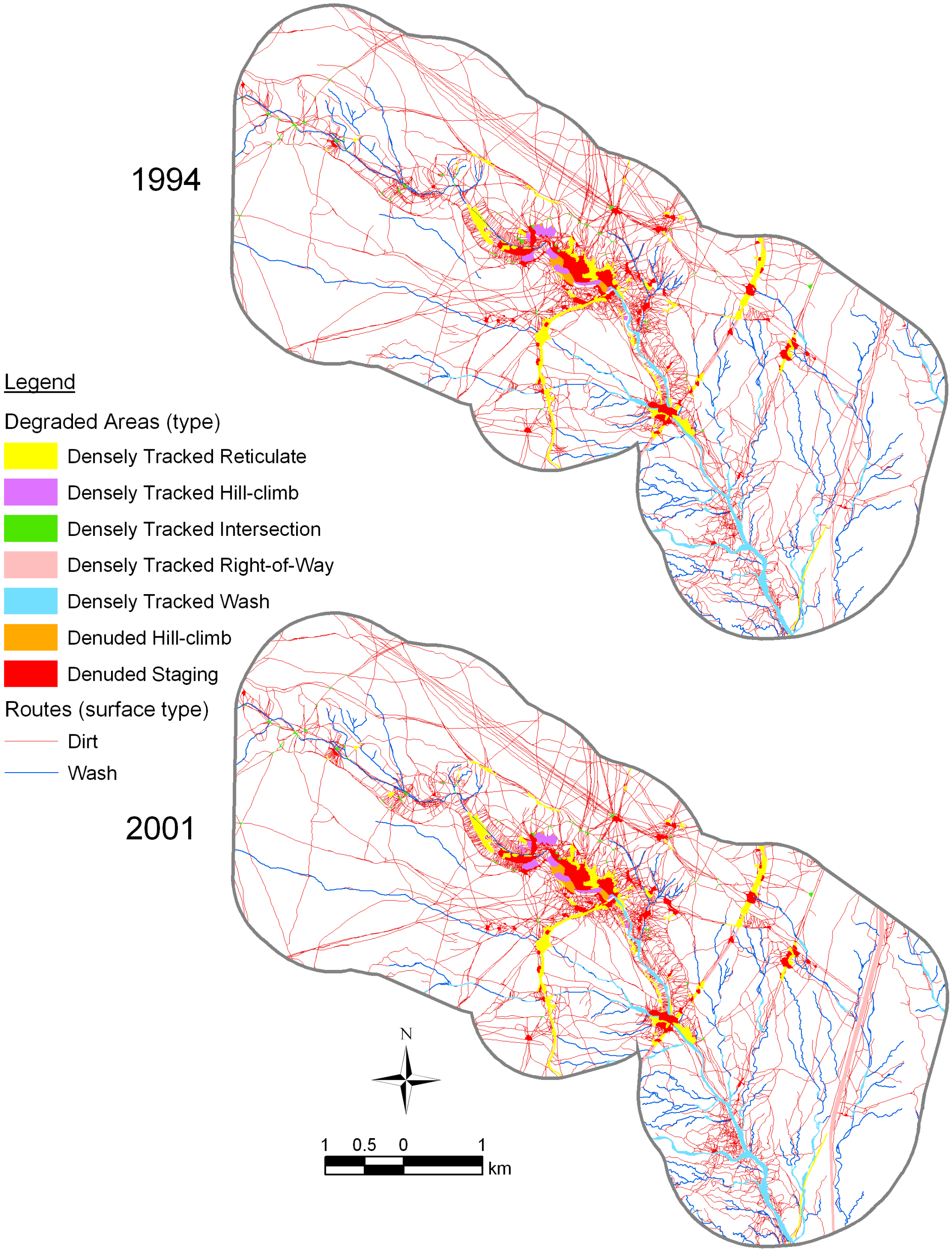


Figure 5. (continued from previous page)

OHV use patterns

Routes and degraded areas

We mapped more than 1900 km of OHV routes and 1100 ha of degraded areas across the 4 time periods. OHV routes proliferated dramatically over the time span studied, especially between 1965 and 1982 (fig. 5). The greatest route increases occurred along the lower reaches of Dove Springs Canyon and the upper reaches of Red Rock Canyon (3rd and 4th order washes), and areas adjacent to the Los Angeles Water and Power Department aqueducts. There were 49 km of dirt routes in 1965 and 576 km in 2001 (fig. 6a). In contrast, wash routes remained relatively constant, ranging from a low of 63 km in 1965 to a high of 77 km in 1982.

Denuded and densely tracked areas also expanded dramatically during the study period, increasing from a combined total of 66 ha in 1965 to 194 ha in 2001. This increase largely consisted of areas classified as denuded staging and densely tracked reticulate (fig. 6b&c). Denuded staging areas increased from 5 ha in 1965 to 49 ha in 2001, and densely tracked reticulate areas increased from 2 ha in 1965 to 56 ha in 2001. The densely tracked wash areas displayed no trend.

Route density & change detection

Route density increased substantially from 1965 to 2001 (fig. 7). Only 7% of cells had some form of OHV disturbance in 1965, which increased to over 30% by 2001. Cells classified as low route density (>0–0.075 m/m^2) increased the most, changing from 5% in 1965 to over 19% in 2001. Medium route density cells (>0.075–0.15 m/m^2) increased from 0.3 to 5.0%, and high route density (>0.15–~0.32 m/m^2) cells from 0 to 0.7% from 1965 to 2001. Densely tracked cells (where tracks were too dense to map) increased from 1.5% in 1965 to 3.6% in 2001, while denuded cells rose from 0.1% to 1.4% during the same period.

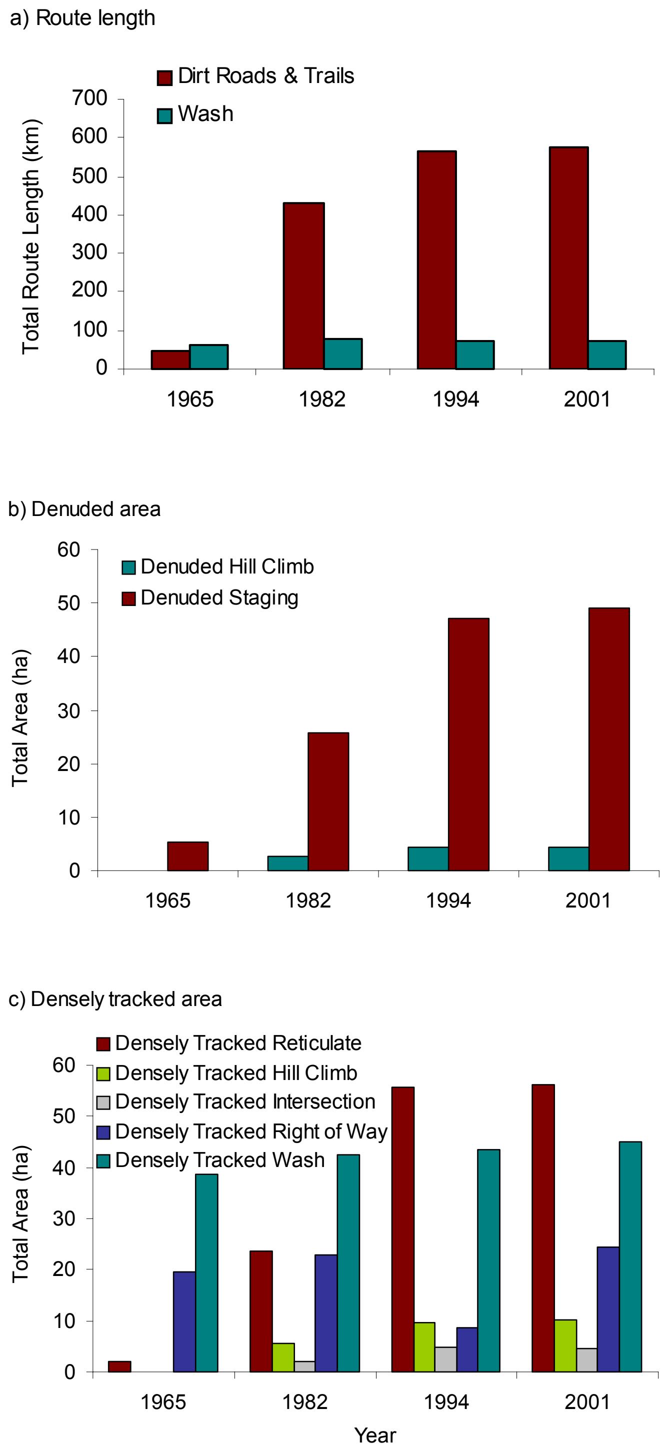


Figure 6. Yearly values for route length (a), denuded areas (b), and densely tracked areas (c).

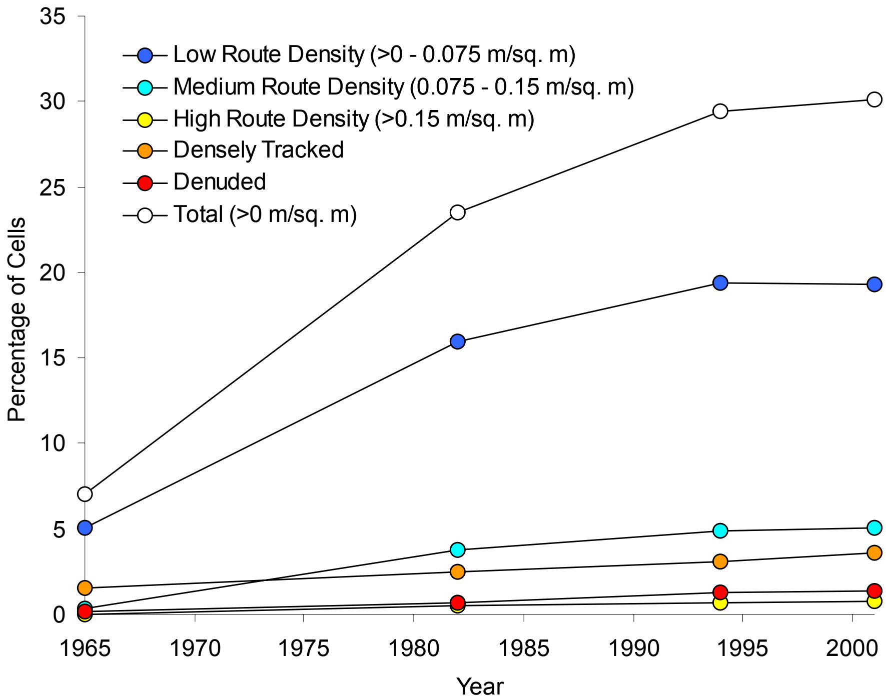


Figure 7. Percentage of total cells within each OHV disturbance category.

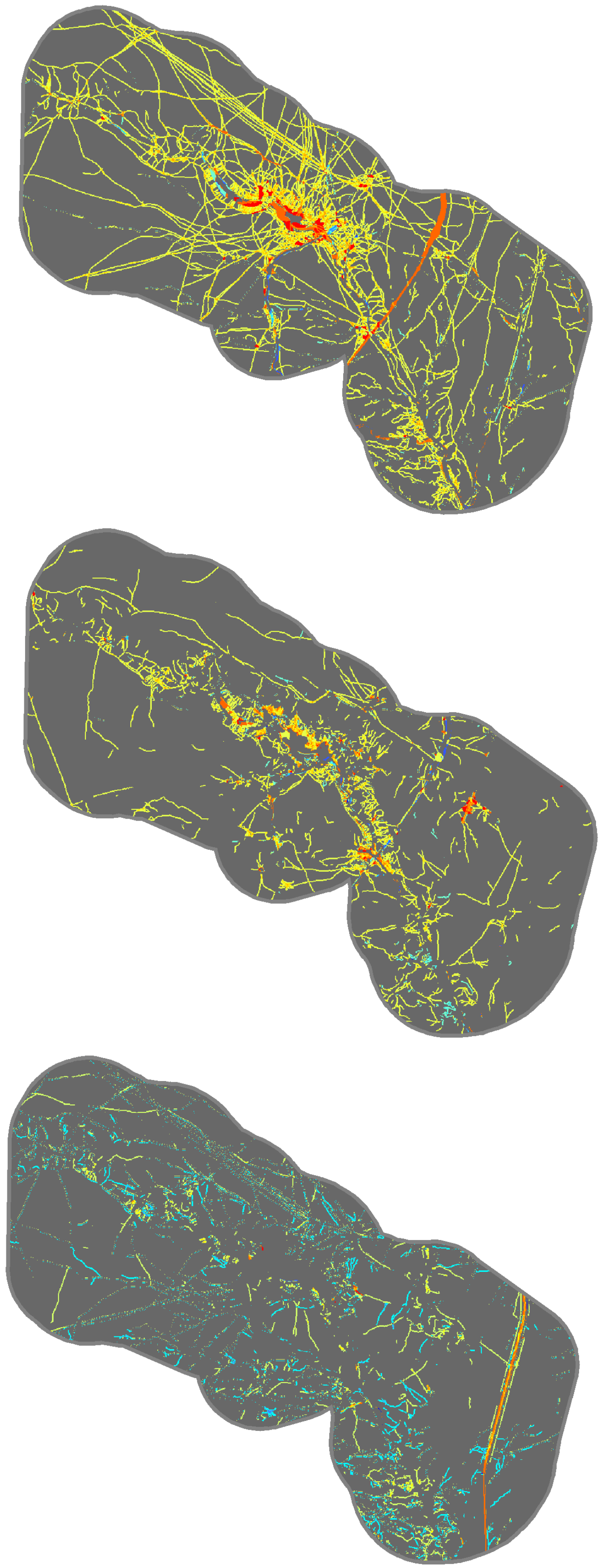
1st and 2nd order washes had only slightly higher track densities in the 0–50 m zone compared to further distances, and the difference was due to densely tracked polygons. Approximately 30 to 40% of cells at each distance interval had >0 m/m^2 track density. Track density displayed a somewhat bimodal response in relation to the highway right-of-way. About 40% of cells adjacent to the highway had OHV use, declining to about 10% at the 250–300 m zone, then increasing to about 35% at the >500 m zone. The increase at 500 m was an artifact due to increased proximity to the lower reaches (4th order wash section) of Dove Springs Canyon in the southeast part of the study area.

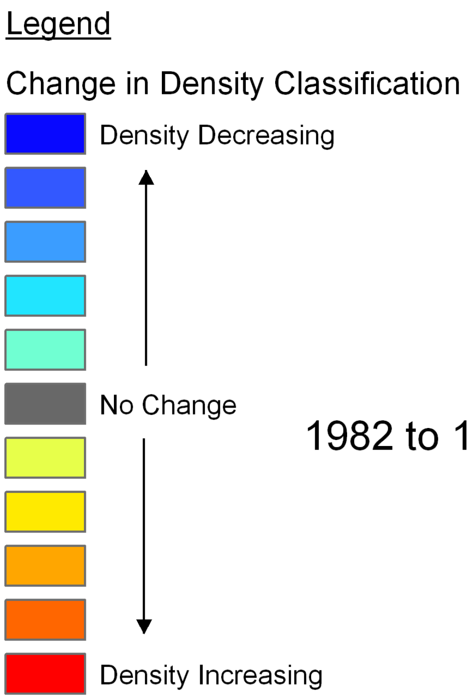
Responses of individual route density categories differed among the types of linear disturbances. The percentage of denuded area steadily decreased out to 350 m from the 3rd order washes, to 250 m from the aqueduct right-of-way, and to 100 m from the powerline right-of-way. The percentage of very high track density area declined steadily to 350 m from the 3rd order washes, to 100 m from the 1st, 2nd, and 4th order washes and the aqueduct and powerline right-of-ways. High track density area percentage declined slightly to 200 m from the 3rd order washes. Medium track density area percentage declined slightly to 450 m from the 3rd order washes, and more dramatically to 100 m from the powerline right-of-way. Low track density areas did not display any appreciable trend. The percentage of 0 track density area increased steadily to 500 m from the 3rd and 4th order washes, to a lesser degree to 500 m from the aqueduct and powerline rights-of-ways, and to 100 m of the 1st and 2nd order washes.

Change detection analyses revealed that the greatest change in OHV use occurred between 1965 and 1982, with a lesser increase from 1982 to 1994, and relatively little change from 1994 to 2001 (fig. 8). The net change in the proportion of cells with increased OHV use was 17% between 1965 and 1982, 8% between 1982 and 1994, and 2% between 1994 and 2001. Thus, the rate of increase appears to have recently subsided, although it is still increasing.

Relationships between OHV use and other linear disturbances

There was a clear trend between route density and both distance from larger washes (3rd and 4th order) and aqueduct and power-line rights-of-way (fig. 9). For 3rd order washes, over 80% of cells had >0 m/m^2 track density in the 0–50 m zone, which steadily decreased to about 25% by the >500 m zone. Fourth order washes and aqueduct and power-line rights-of-way exhibited a similar pattern, with between 60 to 80% of cells having >0 m/m^2 track density in the 0–50 m zone, declining to about 30% of cells by the >500 m zone. In contrast,





Percentage change in cell numbers between years

Classification change	65 to 82	82 to 94	94 to 01
(density decreasing) -5	0.0	0.0	0.0
-4	0.1	0.1	0.0
-3	0.1	0.0	0.0
-2	0.1	0.1	0.1
-1	0.5	0.6	3.1
(no change) 0	80.9	89.9	92.2
1	13.4	7.2	3.8
2	2.8	1.0	0.2
3	0.6	0.5	0.2
4	1.0	0.4	0.3
(density inceasing) 5	0.5	0.1	0.0

Figure 8. Change detection analysis of cell disturbance.

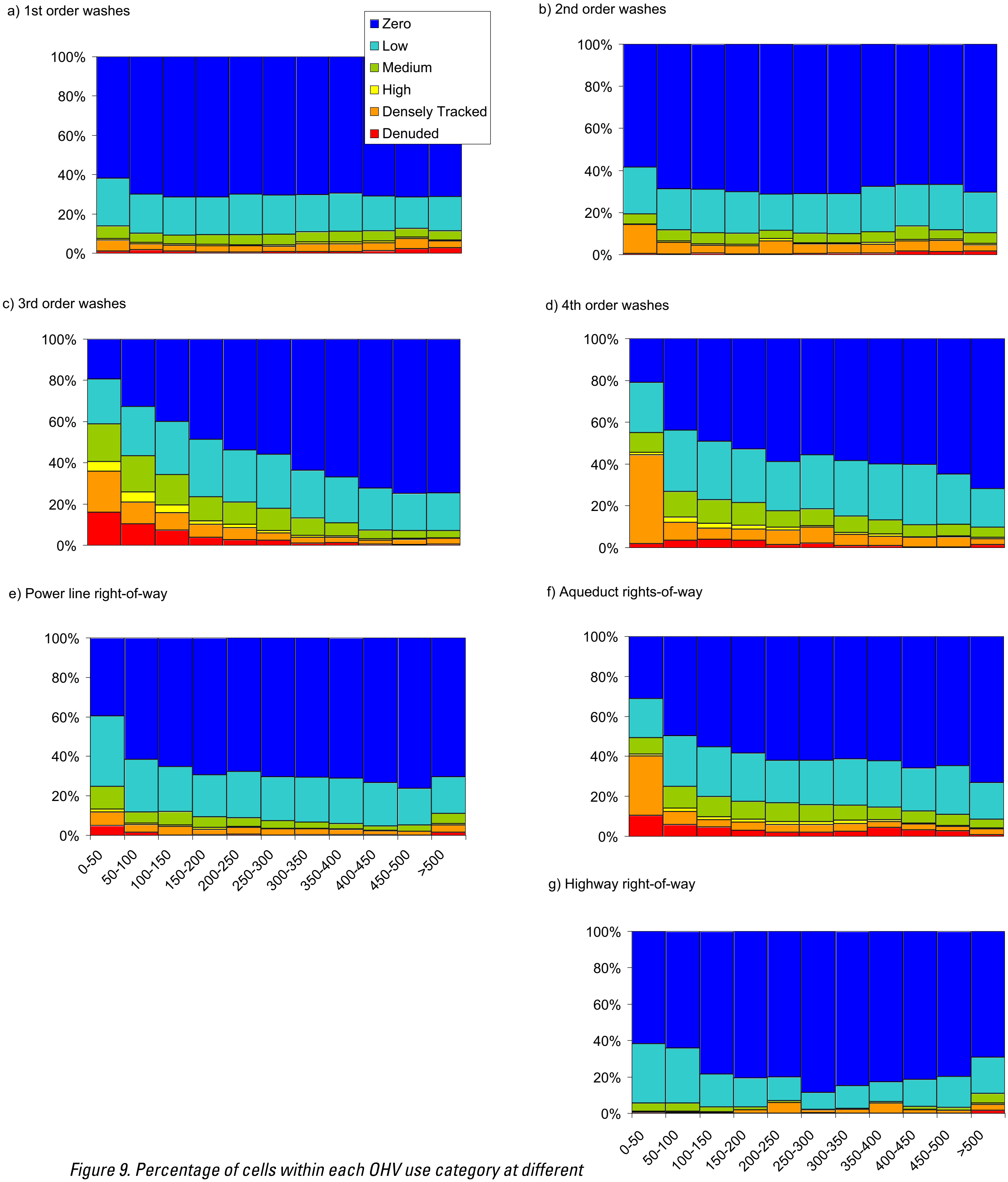


Figure 9. Percentage of cells within each OHV use category at different distance ranges (meters) from washes and linear features.

Relationships between OHV use and geologic strata

Within the Mojave Desert, geologic strata strongly control ecosystem structure and function because they influence basic soil physical and chemical properties, which in turn influence vegetation and wildlife community composition. OHV use trends among different geologic strata are an important factor when addressing OHV impacts on biotic communities at landscape scales. These specific impacts will be addressed in subsequent reports, but here we examined basic trends in OHV use across the major geologic strata at the study site.

The study site was stratified into 3 major geologic strata: *lowlands*, *hill-slopes*, and *uplands*. These 3 surface categories respectively covered 10, 1, and 27% of the study site. Details concerning the stratification process are contained in Miller and Amoroso (in review).

We calculated the percentage of cells with different OHV use density within each of these strata. Sixty-one percent of hill-slope cells had >0 m/m^2 track density, 51% of lowland cells, and 25% of upland cells. Denuded and densely tracked cells were especially more frequent on lowlands (12%) and hill-slopes (16%) than on uplands (1%).

Discussion

Inventorying & Monitoring

This project's main goal was to develop a monitoring protocol for OHV use on BLM lands in the California deserts. An understanding of current and past OHV activity is essential when formulating land management plans and implementing management actions. In this project we performed a detailed inventory of OHV activity over 30 years using historic aerial photography. There are both benefits and drawbacks to this approach.

Benefits

We mapped OHV routes using a sequence of HDOQs, which allowed us to record and analyze changes in route location and density over time. We were also able to obtain a 'baseline' level of dirt and wash tracks at a time when OHV effects were minimal. Because differentiating OHV routes from natural washes is difficult when interpreting aerial photography, a good baseline of existing washes prior to significant OHV use improves the ability to attribute route features in later photographs. Wash routes in our study remained fairly constant over time, suggesting that we correctly identified them from aerial photos, and did not mistake them for new routes created by OHV recreation.

Inventorying current routes from aerial photography is also more cost effective compared to ground-based mapping using GPS. Effectiveness is especially true in high OHV use areas such as Dove Springs. Ground-based mapping may be more cost effective in areas with lower OHV use levels and relatively few routes to inventory.

Drawbacks

A main drawback of aerial photographic analysis is data accuracy. Ground-based mapping can be more accurate both in terms of horizontal positional accuracy (especially if survey-grade GPS units are used) and, more importantly, in route attribution. For example, OHV use of washes could be definitively identified because vehicle tracks may be evident on the ground, but not from the air. Ground-based route mapping could be more detailed, especially in areas of dense tracking, and may be better at locating smaller single-track routes not visible on aerial photographs. Aerial-photograph mapping may also be biased relative to geologic strata. For example, mapping OHV activity on continually shifting geologic strata, such as dunes, may be better accomplished using ground-based mapping because tracks would be difficult to detect from the air.

Aerial photography is also not reliable for detecting certain other disturbances in the landscape. For example, we know of areas dominated by early seral shrub species, which indicate the presence of some other past disturbance, such as grazing, fire, or camping. Identifying those specific disturbances requires field mapping and knowledge of plant successional dynamics.

Predictive modeling

We found compelling relationships between OHV activity and linear landscape features (especially larger washes and utility rights-of-way) and across geologic strata (especially hill-slopes and lowlands). We urge caution in applying our results to other areas, because our site contains some potentially unique characteristics. For example, the moderately angled side-slopes of Dove Springs Canyon attract many OHV riders seeking hill-climbs, and the broad, flat bottom of this canyon is a popular camping area. These characteristics may not exist in other 3rd and 4th order washes.

Goodlett and Goodlett (1992) found similar relationships between existing linear features and OHV activity at a limited-use area in the Fremont Valley and Rand Mountains, approximately 30 km from our study area. They documented an increasing incidence of unauthorized OHV routes within 75 m of established, authorized routes. Existing linear features, whether they be natural (e.g washes), constructed (e.g. utility rights-of-way), or vehicular (e.g. authorized OHV routes), appear to promote the proliferation of OHV activity within this area of the Mojave Desert.

We found very slight relationships between OHV activity and distance from 1st and 2nd order washes. However, the resolution of our spatial datasets limited us to defining 50 m wide zones. OHV activity and its effects may concentrate in a narrower zone around these smaller washes. Higher resolution data (especially of hydrographic features) might reveal these types of relationships.

We documented preferential OHV use of hill-slopes and lowlands relative to uplands. We feel this is a real trend (as opposed to an artifact of biased mapping ability on different geologic strata) because these 3 strata have similar vegetation cover. Within undisturbed areas in the study area, total vegetation cover averages 35% and shrub cover averages 11%, with no significant differences between the 3 geologic strata (M. Brooks unpublished data). The reduction of vegetation cover by OHV use is visible on aerial photography; therefore, we would expect OHV routes and degraded areas to be equally identifiable within areas having similar cover.

Although we cannot speculate how OHV use may have varied at shorter intervals between the 4 sampled times, the decadal-scale trend in use levels indicated that the high rate of increase ended between 1982 and 1994, and increased only slightly between 1994 and 2001. We suggest that additional monitoring be done at 5 to 10 year intervals to track future trends in OHV use levels at the Dove Springs OHV Open Area.

Another type of predictive modeling may show managers and the public how the Dove Springs landscape may appear under differing assumptions of future OHV recreation and economic factors. Such assumptions include disposable income and energy prices, which affect people's recreation choices. This kind of modeling, now under development at the USGS (David Miller, Robert Vitales, and James Weigand) lets the public understand the consequences of cumulative recreational impacts on public lands. Computerized visualizations of future landscape appearances given different management scenarios may help the public and managers decide which management actions are likely to attain a desirable future condition.

OHV effects monitoring

Along with geomorphic data, this mapping project provides key baseline data for developing a monitoring program for wildlife and vegetation. We have established wildlife and vegetation monitoring plots across the OHV-use gradient and stratified across the three major geologic strata. These plots will allow us to investigate relationships between OHV activity, vegetation composition, and wildlife community structure. The results of these studies will be included in future reports.

Implications for Management

OHV use patterns correspond with key features of the landscape, including pre-existing infrastructure and washes. Washes are of particular concern because of their unique vegetation, bank structures, and sediment flows during rains. Currently, BLM has little information on the intensity of recreational travel in washes and on damage caused to wash properties from recreational travel. Based on information in this report, BLM managers will establish silt fences across major washes that cross into the adjacent Red Rock Canyon State Park. These fences will determine whether erosion from washes themselves and from hill-climbs upstream export abnormally high sediment flows into the Park.

At present, the California BLM Office is conducting a statewide inventory of all OHV trails. Methods applied in the study are useful as a costcutting alternative to map OHV routes, staging areas, and camping sites in the BLM California Desert District, where OHV recreation is particularly prevalent.

The BLM can also apply information from this study to refine the Dove Springs OHV Open Area boundaries, adjusting them based on actual recreational use and patterns. Since establishment of the Open Area in 1980, recreational preferences may have changed, and these changes may require readjusting boundaries and applying landscape design principles. The comparatively free access to the Open Area and its surrounding lands since the 1960s reveals the development of these human preferences. With revisions of management plans covering the Open Area, BLM planners may redraw its boundaries to add adjacent areas. In view of the unique plant assemblages, cultural burial sites, and paleontological resources within the current Dove Springs Open Area, a trade-off may be possible between additions of de facto open recreational riding areas immediately adjacent to the Open Area, and withdrawals of other areas to achieve greater resource protection. These types of trade-offs can help BLM to more effectively achieve the mission of promoting multiple uses and conserving multiple resources.

Acknowledgments

Kelly Burkle and Nadine Golden volunteered their time to assist with digitizing tracks and impacted areas, and with initial analyses. John Vogel assisted with field reconnaissance. The Bureau of Land Management–California State Office provided funding for this project through a grant awarded by the California Department of Parks and Recreation–Off-Highway Motor Vehicle Recreation Division. Julie Yee and Scott Jackson provided useful reviews and their suggestions were incorporated into the final document.

Literature Cited

Adams, J.A., L.H. Stolzy, A.S. Endo, P.G. Rowlands, and H.B. Johnson. 1982. Desert soil compaction reduces annual plant cover. California Agriculture.

Bureau of Land Management. 1980. The California Desert: Conservation Area Plan 1980 as amended. Riverside, CA. 133 pp. plus appendices.

Bureau of Land Management. 2001. National management strategy for motorized off-highway vehicle use on public lands. Washington, D.C. 26 pp. plus appendices.

Bury, R.B., R.A. Luckenbach, and S.D. Busack. 1977. Effects of Off-Road Vehicles on Vertebrates in the California Desert. Washington, D.C.: US Fish and Wildlife Service. 20 pp. plus appendices.

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman Co., New York, New York. 818 pp.

Goodlett, G.O., and G.C. Goodlett. 1992. Studies of unauthorized off-highway vehicle activity in the Rand Mountains and Fremont Valley, Kern County, California. In: Beaman, K.R. editor, Proceedings of the 1992 Desert Tortoise Council Symposium, pp. 163–187.

Luckenbach, R.A., and R.B. Bury. 1983. Effects of off-road vehicles on the biota of the Algodones Dunes, Imperial County. Journal of Applied Ecology 20:265-286.

Miller, D.M., and L. Amoroso. In review. Surficial geology of the Dove Spring off-highway vehicle open area, Mojave Desert, California. US Geological Survey Open File Report.

Webb, R.H. 1982. Off-road motorcycle effects on a desert soil. 1982. Environmental Conservation 9:197-208.

Webb, R.H., H.C. Ragland, W.H. Godwin, and D. Jenkins. 1987. Environmental effects of soil property changes with off-road vehicle use. Environmental Management 2:219-223.