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Research article

Drawing a line in the sand: Effectiveness of off-highway vehicle management in California's Sonoran desert

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ABSTRACT

Public land policies manage multiple uses while striving to protect vulnerable plant and wildlife habitats from degradation; yet the effectiveness of such policies are infrequently evaluated, particularly for remote landscapes that are difficult to monitor. We assessed the use and impacts of recreational vehicles on Mojave Desert washes (intermittent streams) in the Chemehuevi Desert Wildlife Management Area (DWMA) of southern California. Wash zones designated as open and closed to off-highway vehicle (OHV) activity were designed in part to protect Mojave desert tortoise (*Gopherus agassizii*) habitat while allowing recreation in designated areas. OHV tracks were monitored in washes located near access roads during winter and early spring holidays – when recreation is typically high – and at randomly dispersed locations away from roads. Washes near access roads had fewer vehicle tracks within closed than open zones; further away from roads, OHV tracks were infrequent and their occurrence was not different between wash designations. Washes were in better condition in closed zones following major holidays as indicated by less vegetation damage, presence of trash, and wash bank damage. Furthermore, the frequency of washes with live tortoises and their sign was marginally greater in closed than open wash zones. Collectively, these results suggest that low impacts to habitats in designated closed wash zones reflect public compliance with federal OHV policy and regulations in the Chemehuevi DWMA during our study. Future monitoring to contrast wash use and impacts during other seasons as well as in other DWMAs will elucidate spatial and temporal patterns of recreation in these important conservation areas.
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1. Introduction

Desert washes are important landscape features in the northeastern Colorado Desert of California. These washes generally flow from hillside or mountain slopes into valleys and are often eroded during extreme rain events (Averill-Murray and Averill-Murray, 2005). They are also known as "xeririparian" (also *xeroriparian*) habitats due to their intermittently wet, but mostly dry condition. As intermittent channels for the flow of surface and subsurface water, desert washes concentrate important resources for wildlife (Schwinning et al., 2010). A larger proportion of diverse seasonal plant biomass is found within, and on the margins of, washes than on surrounding upland areas (Marshal et al., 2005). The xeririparian vegetation communities (also known as microphyll woodland) of California's Mojave and Sonoran deserts are characterized by creosote bush scrub *(Larrea tridentata)* with component species including bursage (*Ambrosia dumosa*), rabbitbrush (*Ericameria paniculatus*), woolly brickelia (*Brickellia incana*), Mojave brickle-bush *(B. oblongifolia)*, desert cassia (*Cassia armata*), palo verde (*Parkinsonia microphylla*), ironwood (*Olneya tesota*), cat's-claw acacia (*Acacia greggii*), and desert willow (*Chilopsis linearis)* (Barbour et al., 1999; Lathrop and Rowlands, 1983; Schoenherr and Burk, 2007; Turner and Brown, 1982).

Xeririparian habitats in the Sonoran Desert of southern California provide an inordinate benefit to desert wildlife (Stebbins, 1974). Vegetation is typically taller, denser, and highly productive in washes providing nesting and breeding grounds, cover, and protection from predators for resident and migrant birds (Esque et al., 2013). Such enhanced habitat structure also provides protection for the threatened Mojave desert tortoise (*Gopherus*

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agassizii), which uses wash channels for traveling, burrowing, and foraging (Jennings, 1997; Todd et al., 2016). Tortoises commonly occur in wash habitats on the lower slopes of bajadas and forage on preferred food plants located exclusively in hill areas and washlet margins during the spring (Esque et al., 2014; Jennings, 1997; Luckenbach, 1982). Consequently, changes to habitat conditions by repeated anthropogenic disturbance within wash systems can have profound effects on wash structure and the wildlife that depend on these resources.

Desert washes are popular scenic byways for people that use off-highway vehicles (OHV) to access infrequently traveled desert lands and spend time in relative solitude or in social groups. Desert washes are also popular places to view wildlife, to access interesting destinations, and to challenge recreation enthusiasts as they test their equipment and skills on rugged terrain. Although desert washes are 'disturbance prone habitats' that support species that tolerate frequent flooding, recreational activities that remain unchecked can alter wash structure and denude vegetation, thus disrupting geomorphic and ecological processes (Schwinning et al., 2010).

The severity of damage in desert washes is dependent on the amount and types of OHV traffic. Heavy vehicles, such as trucks compared to all-terrain vehicles (ATV), produce a higher rate of compaction with fewer passes than lighter vehicles over the same area (Webb et al., 2013). Direct impacts include crushing of the foliage, root systems, and seedlings while shear forces related to tire action from heavy vehicles uproot small plants (Stebbins, 1974) and disrupt root systems of larger plants through soil compaction (Ryan et al., 2016; Wilshire et al., 1978). Soil compaction and flocculation, though not as persistent in wash channels due to the intermittent flow of water and higher sand content, can still be one of the most important and long-lasting effects OHV use has on soil (Webb, 1983; Webb et al., 2013). The magnitude of damage by soil compaction is dependent on the texture and moisture of any particular soil (Webb et al., 2013). Compaction can increase soil bulk density and reduce infiltration rate and porosity that can lead to soil erosion (Iverson, 1980; Mancilla-Leytón et al., 2016) and loss of plant cover. Furthermore, bank cuts made by OHVs may increase erosion, destroy tortoise burrows, or damage vegetation thereby diminishing food and cover important for habitat. Disturbed areas where native vegetation is removed are susceptible to weed invasions and erosion. Soil disturbances caused by OHV traffic and their effects on soil, moisture characteristics, and structure can alter production of desert annual plants (Adams et al., 1982; Brown and Schoknecht, 2001) – the primary food for the Mojave desert tortoise (Esque et al., 2014; Jennings and Berry, 2015). Ultimately, increased OHV traffic can modify natural communities and reduce biomass and diversity of animals living there (Bury et al., 1977; Wilson et al., 2009).

Ecological impacts of vehicular traffic also occur in arid landscapes around the world. In the Kabd area of Kuwait, off-road traffic and overgrazing degraded vegetation cover and soil porosity, permeability, and infiltration except in protected areas (Misak et al., 2002). Motorcycle races and hill-climbing events peripheral to Mojave Desert washes compact soils and decrease abundance of native vegetation, insects, and animal populations (Lathrop, 1983; Wilson et al., 2009). In the Namib Desert in Africa, vehicle use threatened breeding grounds of the Damara Tern (*Sterna balaenarum*) by destroying ground nests of this Near Threatened species (Braby et al., 2009). Overall breeding success was improved by restricting vehicle access during nesting. Vehicle traffic likely impacts soils and terrestrial life in arid environments worldwide, but few policies exist to protect them or have been evaluated for their effectiveness.

The Northern and Eastern Colorado Desert Management (NECO) Plan was released in 2002 and provides specific guidance on land use activities and conservation of 1.6 million acres of Bureau of Land Management (BLM) desert lands in California (BLM, 2002). The plan designates areas that are closed or open to vehicle traffic in desert washes hereafter referred to as "open and closed wash zones," which is more feasible than placing signage that designates every wash as open or closed. Driving within open zones is restricted to washes considered navigable: if motorized travel within a wash would result in unavoidable disturbance to the wash bank, vegetation, or soil, then the wash is not considered a travel route (BLM, 2002).

We evaluated the effectiveness of the NECO plan by quantifying the differences in OHV activity among desert washes in open and closed wash zones, by identifying wash condition associated with OHV activity, and by characterizing patterns of OHV activity among four periods of "high use" during winter/spring holidays (Thanksgiving, New Year's, President's Day and Easter). The NECO plan requires monitoring OHV activity to evaluate the effectiveness of current management. Compliance with other national environmental laws (e.g. Endangered Species Act, Federal Lands Policy and Management Act) requires monitoring the impacts of OHV use in desert washes to protect sensitive species, such as the desert tortoise, and for the general sustainability of the environment.

We addressed several questions on OHV impacts in the northern and eastern Colorado Desert of southern California: 1) Are resource users generally complying with regulations in the open and closed wash zones?, 2) Are closed wash zones maintaining lower vehicle use than open wash zones?, and 3) Is wash condition in closed wash zones better than open wash zones, and how so?

2. Methods-materials

2.1. Study area

The Chemehuevi Desert Wildlife Management Area (DWMA) covers approximately 874,843 acres (3540 km^2) of US Department of Interior, BLM, state, and private land in southern California. The DWMA contains approximately 218,711 acres (25%; 885 km^2) of open wash zones and 656,132 acres (75%; 2655 km^2) of closed wash zones designated for OHV access (Fig. 1) (BLM, 2002). This DWMA lies north of highway 62 and south of Interstate 40, east of Kelbaker/Amboy Road and west of the Colorado River with US Highway 95 bisecting the area on a north-south axis. At the beginning of our study, roads within the DWMA were characterized as either open or closed in accordance with a road map layer from the Needles, California BLM Field Office (J. Weigand, California State Office and M. Margosian, BLM California Desert District, personal communication).

2.2. Potential habitat for the desert tortoise

To relate the designated OHV areas with desert tortoise habitat, we overlaid the wash zones onto a spatial model of desert tortoise habitat suitability (Nussear et al., 2009). The resolution of the model is 1 km^2, and the model provides habitat scores of 0 (unsuitable) to 1 (highly suitable) across the entire study area. We used ArcGIS (ver. 9.3.1) to determine habitat suitability in wash zones by calculating an average index score of the raster cells within each open or closed polygon. We then created a point in every raster within the DWMA and exported the index scores to compare mean habitat suitability between open and closed areas using a two sample *t*-test in R (R Core Team, 2013).