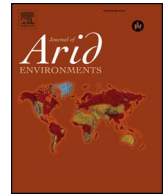




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An ecohydrological stream type classification of intermittent and ephemeral streams in the southwestern United States

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ABSTRACT

An ecohydrological stream type classification was developed to improve decision making for ephemeral and intermittent streams at four military reservations in the southwestern U.S.: Fort Irwin, Yuma Proving Ground (YPG), Fort Huachuca, and Fort Bliss. Agglomerative hierarchical cluster analysis was used to classify stream reaches by ecohydrologic properties (vegetation, hydrologic, and geomorphic attributes derived using geographic information system analyses), and Classification and Regression Trees (CART) were used to determine thresholds for each variable for a predictive model. Final stream types were determined from statistical analyses, cluster validity tests, examination of mapped clusters, and site knowledge. Climate regime and geomorphology were most important for YPG and Fort Irwin where annual precipitation is low. Vegetation variables were important at Fort Bliss and hydrologic variables were important at Fort Huachuca where higher annual precipitation and a bimodal rainfall pattern occur. The classification results and input variables are spatially linked to specific stream reaches, allowing managers to identify locations with similar attributes to support management actions. These methods enable the development of a stream type classification in gauged or ungauged watersheds and for areas where intensive field data collection is not feasible.

1. Introduction

The Department of Defense (DoD) manages over 35,600 km² (3.56 million ha) of arid and semi-arid land in their Southwest Region (Fig. 1) to meet its mission of providing national defense and to maintain its commitment to stewardship of its lands. The DoD recognizes the importance of maintaining the environmental quality and integrity of its installations for continued support and sustainment of training and testing exercises. This includes protection of natural resources and conservation of biological diversity through programs such as the Sustainment of Ranges and Operating Areas (DoD Directive 3200.15; Benton et al., 2008), and compliance with the Endangered Species Act to conserve the federally listed threatened and endangered species that occur on those lands (Rubinoff et al., 2006). Biological and habitat diversity is known to be considerably higher along ephemeral and

intermittent stream corridors in comparison to adjacent uplands. Many of DoD's largest training installations are located in the Southwest Region where ephemeral and intermittent streams are the predominant fluvial forms, yet knowledge of how these streams function and their effect on adjacent flora and fauna is limited. Understanding the hydrologic regime and related biotic features of these systems is an important task for management.

To provide an additional tool for DoD managers, an ecohydrologically-based stream type classification was developed for ephemeral and intermittent streams at four military reservations in the southwestern United States representing the four Level III ecoregions (Omernik and Griffith, 2014) that occur here: Fort Irwin National Training Center (Mojave Basin and Range), Yuma Proving Ground (YPG; Sonoran Basin and Range), Fort Huachuca (Madrean Archipelago), and Fort Bliss (Chihuahuan Desert) (Fig. 1). Ecoregions provide a

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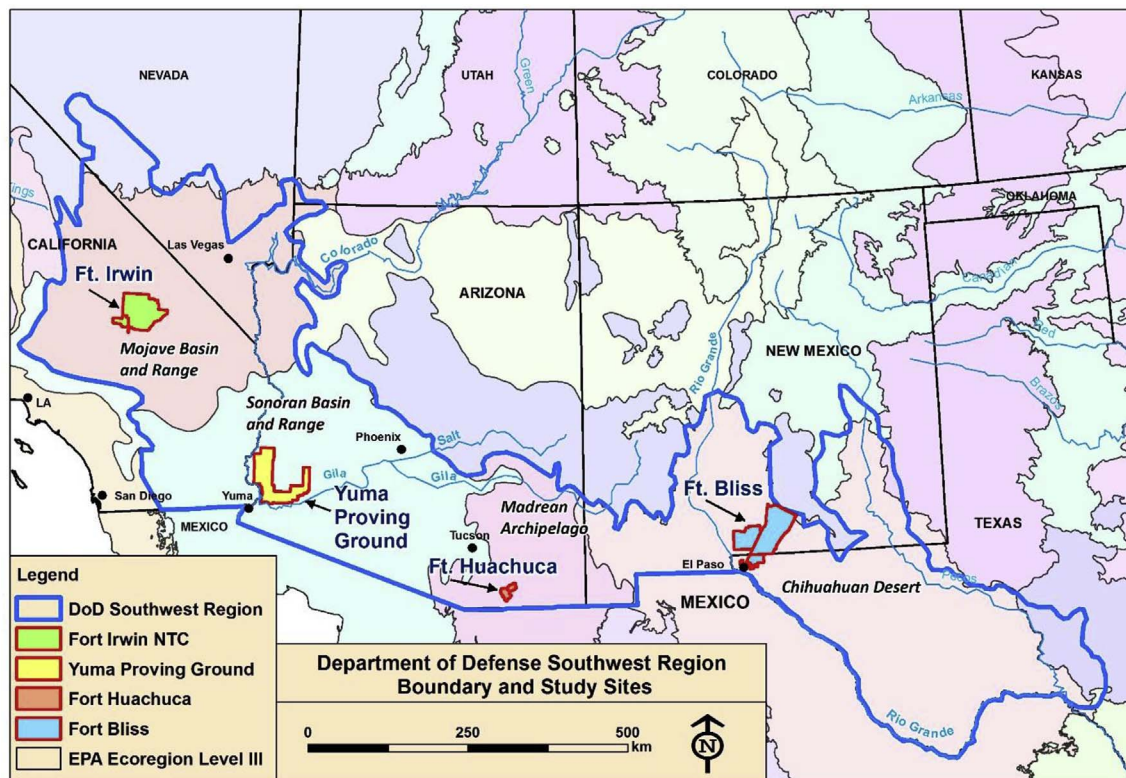


Fig. 1. Map of the Department of Defense Southwest Region, ecoregions, and study locations: Fort Irwin National Training Center, Yuma Proving Ground, Fort Huachuca, and Fort Bliss.

geographic framework for managing and understanding ecosystems by defining spatial units based on similar abiotic and biotic components (Omerik and Griffith, 2014). The stream types are based on vegetation, hydrologic, and geomorphic attributes derived from geographic information system (GIS) analyses and hydrologic modeling that can be used in defining ecohydrological relationships for management of wildlife habitat, including guiding wildlife surveys and monitoring, and other land management and planning actions. This paper presents the stream type classifications for the four installations and a comparison of the results. See Hammer (2014) and Levick et al. (2015) for the wildlife habitat and species associations using the stream type classifications and ecohydrological variables.

1.1. Study sites descriptions

1.1.1. Fort Irwin National Training Center, California (2590 km²)

Fort Irwin is located in the Mojave Basin and Range ecoregion, just south of Death Valley National Park, and north of Barstow, California. Elevations range from 240 to 1860 m. Terrain includes steep, rugged mountains, broad alluvial fans and bajadas, sandy plains, rolling hills, and playas. Fort Irwin receives approximately 110 mm (4.13 in.) of annual precipitation, with about half occurring during the winter as widespread, long duration events enhanced by El Niño conditions, and about 20% occurring during the summer. Rainfall is generally light, although thunderstorms can occur.

There are no perennial surface flows at Fort Irwin; however, 14 (fourteen) springs are monitored regularly by Fort Irwin natural resources staff. Vegetation is shrub-dominated, with large areas of creosote-dominated alluvial fans and sandy, gently sloping surfaces, identified as Sonoran-Mojave Creosotebush-White Bursage Desert Scrub.

Riparian vegetation may be restricted to the channel banks, located only within the stream channel, or may not be present at all. Creosote frequently marks the division between the upland and channel, and is sometimes the upland vegetation identifier. Vegetation along the channel is frequently taller and denser than the same vegetation on the uplands. Listed threatened, endangered, and special status species include the threatened Desert tortoise (*Gopherus agassizii*), the federally listed endangered Land Mountain milkvetch (*Astragalus jaegerianus*), and federal species of concern Desert Cymopterus (*Cymopterus deserticola*). Military activities include training for heavy armor, mechanized infantry, Stryker, armored cavalry, and medium and light infantry units.

1.1.2. Yuma Proving Ground, Arizona (3367 km²)

Yuma Proving Ground is located in the Lower Colorado River Valley Subdivision of the Sonoran Basin and Range ecoregion, with elevations ranging from 54 to 868 m. YPG receives about 92.7 mm (3.65 in.) of rainfall per year in a bi-modal pattern, with about one-third occurring as high-intensity, short-duration summer monsoon thunderstorms, and about 40% occurring as gentle frontal systems during the winter months. There is no perennial surface flow; however, tinajas (natural rock water tanks) may be found in the mountains in various locations. Most of YPG is classified as Sonoran-Mojave Creosotebush-White Bursage Desert Scrub, and Sonoran Paloverde-Mixed Cacti Desert Scrub. Mesquite bosques occur in some areas. Riparian vegetation may be restricted to the channel banks, located only within the stream channel, or may not be present at all. Plants normally restricted to the uplands in wetter areas may only be found along the channels at YPG. Landforms include steep rugged mountains, alluvial fans, bajadas, sandy plains, sand dunes, and desert pavement covered piedmonts (fan

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