

# Defining Boundaries Across Borders: A Case Study Extending a Major Land Resource Area Into Mexico

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**Abstract**—*Geographic information science (GIS) and field work were applied to extend Major Land Resource Area (MLRA) 41, Southeastern Arizona Basin and Range, from Arizona and New Mexico into Sonora and Chihuahua, Mexico. The result of this analysis is a tentative boundary line that delineates MLRA 41 for both the United States and Mexico based on elevation, soils, temperature, precipitation, and vegetation. This delineation will allow for a more effective linkage of research and increased availability of information across the international border.*

## Introduction

The United States and Mexico not only share a border, but also many natural, economic, and cultural resources. The Chihuahuan and Sonoran Deserts occupy significant areas on both sides of the border and demonstrate similar climate, geology, soil and water resources, and vegetation. Comprised of arid and semi-arid regions, the area includes California, Arizona, New Mexico, and Texas and is divided by botanists into three deserts (EPA 2002) and by the USDA Natural Resources Conservation Service (NRCS 1978) into three corresponding Major Land Resources Areas (MLRAs) for land management purposes (figure 1).

The NRCS defines MLRA 40, Central Arizona Basin and Range, as primarily Sonoran Desert, with no perennial water and vegetation dominated by desert shrub and cacti, especially the Giant Saguaro cactus. Winters are warm, and precipitation and elevation are relatively low, with a few mountain peaks reaching 1,400 meters.

MLRA 42, Southern Desertic Basins, Plains, and Mountains, dominates southern New Mexico and part of western Texas. A large portion of this area is the Chihuahuan Desert, and thus is home to only a few perennial watercourses, the Rio Grande, Conchos, and Pecos Rivers. Winters are cold, with elevation ranges from 800-1,500m, and precipitation falls primarily in the summer. This area is also dominated by desert shrub and grass, but has several species of deciduous and coniferous trees at higher elevations.

The focus of this study, MLRA 41, Southeastern Basin and Range, encompasses southeastern Arizona and a small portion of southwestern New Mexico. MLRA 41 is a very diverse ecological area in the transition zone between the Sonoran and Chihuahuan Deserts, with a relatively homogeneous pattern of topography, soil, climate, water resources, and land use, consisting of a series of isolated mountain chains and arid river basins. There are three Land Resource Units (LRUs) defined by the NRCS (1978) within MLRA 41. LRU 41-1: Mexican oak-pine woodland and oak savannah is found in the higher range of elevations, above 1,300m, the precipitation ranges from 400-800 mm, and the vegetation is dominated by oak savannahs and perennial grasses, with conifer woodlands in the higher elevations, above 1,700m where there is greater than 500 mm of precipitation. The relatively small area of land, consisting primarily of river valleys, with elevation ranging from 880-1,440 m and annual precipitation ranging from 200-300 mm is classified as 41-2: Chihuahua-Sonora Desert shrub mix due to its sparse cover of perennial grasses and shrubs and only a few trees. The third LRU, 41-3: Arizona semi-desert grassland, is by far the largest, and covers the mid-range of elevation from 975-1,500 m, and of precipitation from 300-400 mm. The vegetation here is characteristically warm season perennial grasses, shrubs, and cacti, with a few summer annuals.

The need for a common land classification scheme between the United States and Mexico is discussed in Heilman et al. (2000), which proposes a method to link NRCS ecological sites with the Comisión Técnico Consultiva de Coeficientes

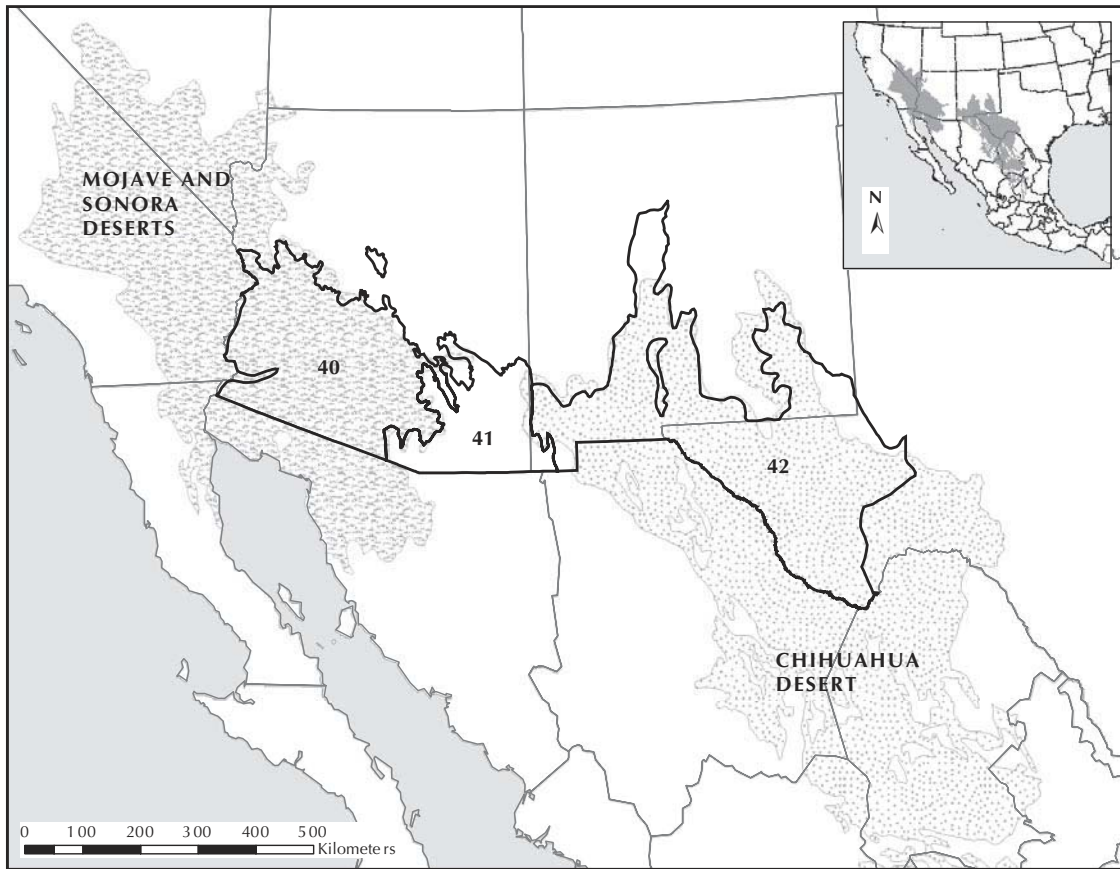


Figure 1—Major Land Resource Areas and deserts in the Southwest.

de Agostadero (1978) (COTECOCA-Technical Commission for Stocking Rates) Sitios de Productividad Forrajera (Forage Production Sites). COTECOCA was chosen because of its correspondence with ecological sites, and more detailed level of classification. This linkage will allow land managers and investigators in Mexico to take advantage of the existing data for MLRA 41, and thus future resource data could be more easily shared across the border, reducing time and cost to both sides.

## Data

### Arizona and New Mexico

#### Precipitation and temperature

The precipitation and temperature data used for the United States were obtained from the Oregon Climate Service's Spatial Climate Analysis Service, which applies **PRISM** (Parameter-elevation Regressions on Independent Slopes Model) to adapt orographic effects into the interpolation of temperature and precipitation (Daly 1996).

#### Vegetation and soils

The National Gap Analysis Program (2003), a geographic planning tool that identifies gaps between land areas that are

managed by conservation and those naturally bio-diversely rich, was completed for the State of Arizona, but not New Mexico; therefore, vegetation and land use data at a scale of 1:100,000 were only available for Arizona. Soil data was obtained from the USDA-NRCS (1994) State Soil Geographic (STATSGO) Database, which has a scale of 1:250,000 for the conterminous United States.

### Sonora and Chihuahua

#### Precipitation and temperature

Precipitation data were obtained from Comisión Nacional para el Conocimiento y uso de la Bioversidad (CONABIO) and Instituto Mexicano de Tecnología del Agua (IMTA). Data from these sites that were available included both monthly and annual minimums, maximums, and averages in predefined ranges.

#### Vegetation and soils

The initial vegetation information was created by digitizing a Brown and Lowe (1994) vegetation map of both Sonora and Chihuahua. Site maps developed by COTECOCA (1978) were then used to compare vegetation found through field observations with the digitized Brown and Lowe information for verification and adjustment of vegetation communities. Numerous sites were sampled comparing soil descriptions in

Arizona with soils in Chihuahua and Sonora. Vegetation and soils maps from INEGI (2004) were also used to reference the field observations and other sources. Their more general classifications are consistent with those of the specific COTECOCA in that MLRA 41 includes pastizal (grassland) and bosques de encino (oak forests), and has a southern boundary north of the selva caducifolia (thorn forest) and bosques de coníferas (conifer forests).

## Elevation

The Digital Elevation Model (DEM) was retrieved from the National Elevation Dataset center, and then converted from decimal degrees to meters, having a resolution of approximately 900 m. The DEM covers the western coast of the United States, and extends down into Mexico to include the States of Sonora and Chihuahua.

## Field Data

Field data were collected on several occasions. This included collecting GPS points that indicated changes in vegetation or landform, vegetation field notes, and soil/site correlation data. Pictures were also taken to document differences or similarities in vegetation and landform within MLRA 41 in the United States (figure 2).

## Methods

Zonal statistics in ArcMap were applied using the elevation data to calculate the range for all three LRUs. These ranges were used to determine areas in Northern Mexico that were

within the elevation and precipitation limits of MLRA 41. This large area was further divided by use of the field notes that stated an area was possibly characteristic, or not indicative of, any of the three LRUs of MLRA 41 and then compared to the vegetation data for Mexico. Vegetation was one of the biggest factors in determining the extent of MLRA 41. Elevation and, to a degree, precipitation were then used to separate the area into the three LRUs based on the NRCS defined and statistically determined ranges.

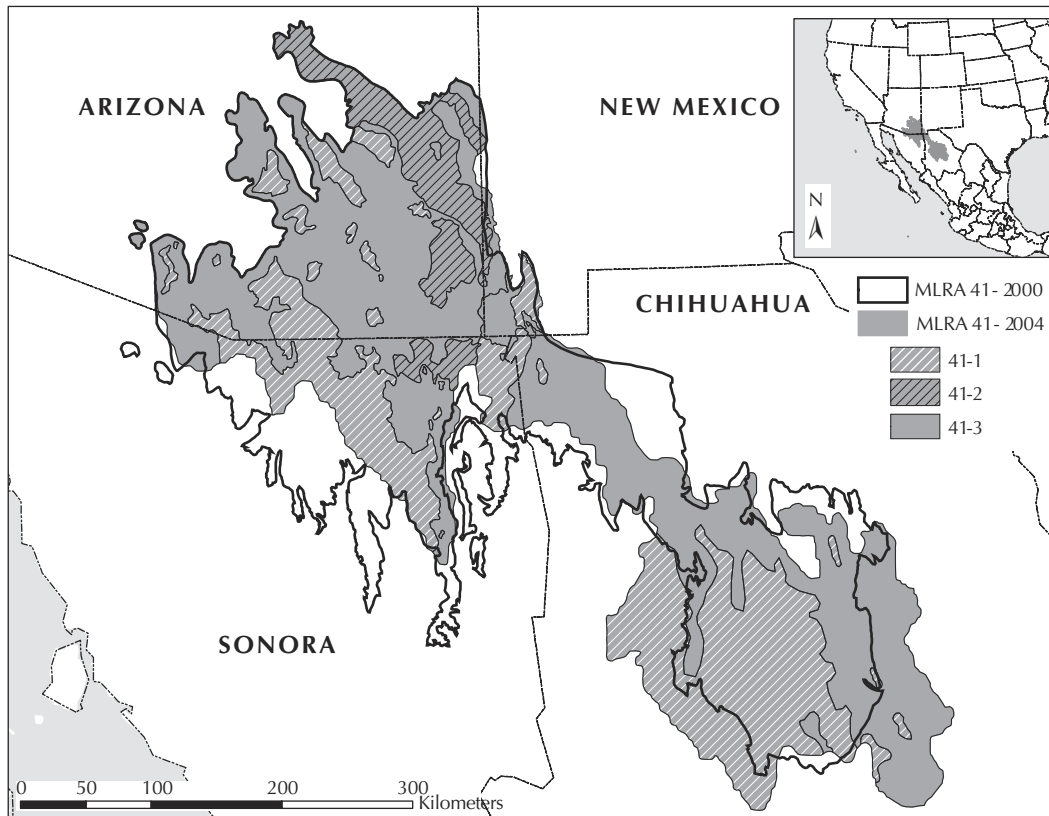
## Results

The elevation range was found to be 716 to 3,261m. The published elevation range is 800-1,800 m in the mountains, with the highest peaks around 3,300 m. This indicates the ranges determined from the statistics are within the parameters set by the NRCS, and could be applied to the Mexico side. We were also able to determine that MLRA 41 had annual precipitation ranging from 229-1,143mm, minimum temperatures ranging from 1.47-12.91 °C, and maximum temperatures ranging from 15.93-28.86 °C. These values being similar to the USDA-NRCS published data, which includes having an average annual precipitation range of 275-375mm, but as much as 900 mm in higher elevations, an average annual temperature of 13-17 °C with lows below freezing and highs above the 37.8 °C, allowed us to apply similar techniques to the Mexico data sets.

Through field observation it was discovered that the western part of Sonora, like that of the Arizona/California border, is more typical of the Sonoran Desert, like that of MLRA 40, and is accordingly the western limit. The vegetation of the Chihuahuan Desert becomes more evident toward Texas, as



**Figure 2**—Example of vegetation indicative of MLRA 41-1 in Sonora, Mexico.



**Figure 3**—New MLRA 41 area and previous boundary.

in the vegetative composition of MLRA 42; and thus becomes the eastern boundary of MLRA 41. The southern boundary was drawn where the thorn forests begin.

The result of this analysis is an updated boundary, slightly different than the boundary proposed in Heilman et al. (2000) that was based solely on the Brown and Lowe vegetation map and COTECOCA forage sites. This new boundary of MLRA 41 does not extend as far west or south as the previous boundary, as the ecological and forage sites may have eluded (figure 3). This boundary should still be considered tentative until confirmed by vegetation experts in Sonora and Chihuahua.

## Conclusions

Discontinuities between the LRU boundaries across the border were seen, especially within LRU 41-1. The areas with discontinuities need to be field checked for vegetation and elevation change on both the United States and Mexico sides of the border. The boundary could then be adjusted accordingly. The southeastern boundary of MLRA 41 in Chihuahua also needs to be examined further for changes in vegetation to better define the LRU boundaries.

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