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Ecosystem services of the Big Bend region of the Chihuahuan Desert

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ABSTRACT

Ecosystem services estimates have not been published for some biomes, notably desert ecosystems. The Chihuahuan bioregion, which is the largest desert in North America, exhibits high biodiversity and important cultural significance for parts of Mexico and the United States. With low levels of development, the Big Bend region is a relatively unmodified ecosystem, which makes it a good representative landscape to study desert ecosystem services. We found that this region has $504 (2015 USD) of annual value per hectare ($1.61 billion for entire study area), with raw materials, climate regulation, ornamental services, and cultural services contributing the most value. This estimate is markedly lower than published values for other terrestrial biomes, which is not surprising considering deserts are low productivity environments. However, given the size of the Chihuahuan Desert, the ecosystem services value for the entire bioregion is likely considerable. The Chihuahuan Desert is facing numerous threats, including energy development and overuse of natural resources. Projected growth in oil, gas, and wind energy could further degrade the services provided by this region. The relatively low ecosystem services values for this desert environment also indicate that the widespread desertification occurring globally is causing large decreases in ecosystem services across many landscapes.

1. Introduction

Global annual ecosystem services have been estimated at over $100 trillion (Costanza et al., 2014; de Groot et al., 2012). However, studies have not been conducted to estimate comprehensive ecosystem services values for several biomes, indicating that current estimates undervalue the global total. The desert biome is underrepresented in the literature, which is noteworthy because it occupies about 13% of the Earth's land surface (Costanza et al., 2014) and can contain a considerable amount of biodiversity (Johnston, 1977). For instance, deserts and xeric shrublands contain about 25% of the world's terrestrial vertebrate species (Safriel et al., 2005). While deserts support a relatively small portion of the total human population, the growth rates in many desert areas are high (Ezcurra, 2006). In addition, deserts may be particularly sensitive to, and slow to recover from, ecological disturbance (Scheffer et al., 2001). Therefore, it is surprising that there are no published values for ecosystem services, with the exception of some "willingness to pay for conservation" studies (Barnes et al., 1999; Batker et al., 2014; Eslamian et al., 2016; Richer, 1995), for these globally important bioregions.

Deserts are low productivity environments (Hadley and Szarek, 1981) that likely have smaller contributions to some ecosystem services (e.g., food, water) compared to other biomes, although the contributions of native plants should not be underestimated (Bidak et al., 2015). Deserts often have important cultural services for recreation, art, and spiritual purposes, resulting in potentially high ecosystem services values for such categories (Mendes and Proença, 2005; Richer, 1995; Weiler and Seidl, 2004). It is unclear how these different predictions for ecological versus cultural ecosystem services values will affect the total economic value (TEV) of deserts. This uncertainty is exacerbated by the fact that desert areas are growing in size from the desertification of adjacent biomes (mostly savannas, Le Houérou, 1996). Desertification tends to reduce productivity, alter soil chemistry, and radically change vegetation patterns, which can lead to major changes in ecosystem services (D'Odorico et al., 2013). Under the assumption that these changes will result in lower ecosystem services values, this shifting land cover could radically modify current global estimates of ecosystem services.

The Chihuahuan Desert covers 647,500 km^2 (Hoyt, 2002) in parts of northern Mexico (most of the state of Chihuahua and smaller portions of Coahuila, Durango, and Zacatecas) and the southwestern United States (west Texas, southern New Mexico, and southeast Arizona). It is the largest of the four deserts within North America (others being the Sonoran, Great Basin, and Mojave). This region

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produces valuable raw materials (Arato et al., 2014; Zapien Barragon, 1981), hosts unique ecological communities (Dinerstein et al., 2000; Hernández and Gómez-Hinostrosa, 2005; Johnston, 1977), and harbors rare and globally declining species (Morafka, 1977). Given the Chihuahuan Desert's relatively low human population density (Bell et al., 2004; Karges, 2012), it might be expected to retain many of its ecosystem services. However, it is negatively impacted by two major factors: oil and gas development and overgrazing (Gibbens et al., 2005; Kerley and Whitford, 2000). Currently, there are over 90,000 wells across the Permian Basin oil and gas field which covers over 40,500 km^2 of Chihuahuan Desert habitat in Texas and New Mexico (DrillingInfo.com, 2017). Future drilling areas are also being proposed that could severely threaten other parts of the bioregion (Lamm et al., 2014; Moran et al., 2017). In terms of overgrazing, estimates indicate that about 20% of the Chihuahuan landscape has been overgrazed severely enough to convert from desert grasslands to desert shrublands (Curtin et al., 2002).

In our study, we estimated total ecosystem services for the Big Bend region of the Chihuahuan Desert, which represents the first complete estimate of desert ecosystem services values. This region has long been described as including the counties of Brewster, Presidio, and Jeff Davis Counties (Anthony, 1954; Gloyd, 1958), which are located on the northern side of the Rio Grande in southwest Texas, USA. We chose this region because it has low human population density and has seen limited industrial, residential, or agricultural development (except for cattle grazing), and is currently outside of major oil and gas production areas. It has numerous protected areas and is generally considered one of the best examples of the Chihuahuan Desert in its natural condition (UNESCO, 2015). However, our study area is under threat of increasing energy development and population expansion. Therefore, understanding the ecosystem services value of this location is important for decision making regarding conservation in the region.

2. Materials and methods

2.1. Study site

We studied the Big Bend region of the Chihuahuan Desert, located in Brewster, Presidio, and Jeff Davis Counties of Texas (Fig. 1). This area is noted for its high biodiversity (Goodwin, 2000; Gray and Page, 2008), unique culture (Tyler, 1975), and considerable conservation interest (Goodwin, 2000). There is substantial topographical variation (548–2387 m), which creates several different habitats. This landscape variation is responsible for three major habitat types: desert shrub, desert grassland, and desert woodland (Fig. 2), each of which likely benefits the human population. Desert grasslands comprise the largest proportion of the area (over 50%), while desert woodland occupies the smallest proportion (Fig. 1). Numerous protected areas exist (about 15% of total study area), which are biologically linked to extensive conservation areas in Mexico, making the Big Bend region important for ecotourism, recreation, and biodiversity protection.

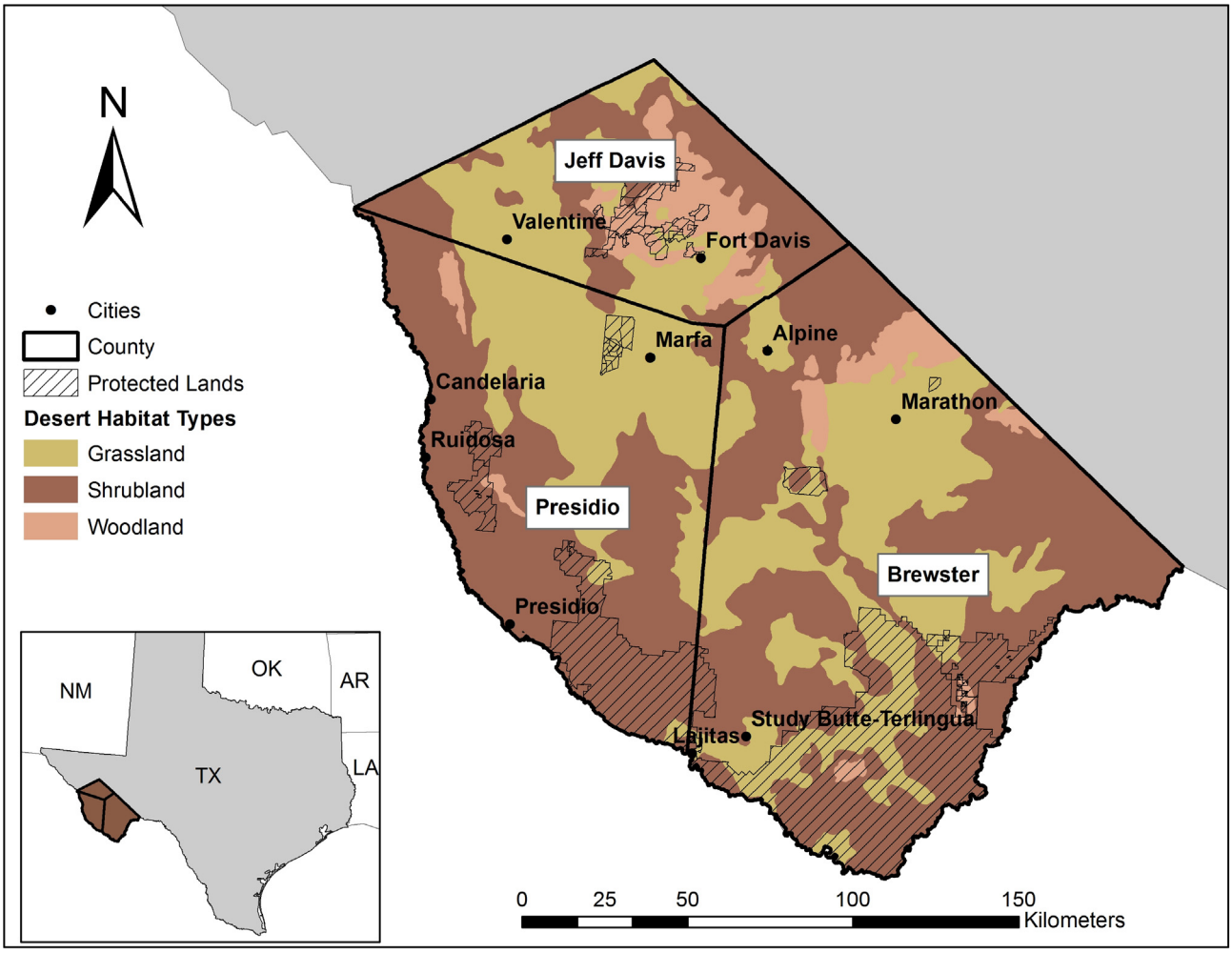

Fig. 1. Distribution of cities, protected lands, and desert habitat types across the three Texas counties making up the study area of the Big Bend region of the Chihuahuan Desert. Protected lands include state and federal parks, wildlife management areas, and lands owned by The Nature Conservancy.