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Habitat use by a desert ungulate: Predicting effects of water availability on mountain sheep

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ABSTRACT

Provision of surface water has been a long-standing management strategy to enhance habitat for large mammals in southwestern North America. In this paper, we use a resource selection function (RSF) developed from telemetered mountain sheep (*Ovis canadensis*) in three occupied mountain ranges in the Sonoran Desert, California, USA, to examine the effects of water development on habitat quality within those ranges. Further, we apply that model to four nearby and similar mountain ranges, but for which telemetry data are not available, and again examine the effects of water development. When distance to water was decreased to 2,000 m from an average of 3033 m (±522 [SD]) in three occupied mountain ranges, availability of high-quality habitat increased by as much as 92%. When distance to water was decreased to 2,000 m from an average of 3660 m (±799 [SD]) in three mountain ranges not occupied permanently by mountain sheep, and one occupied range for which telemetry data were not available, the proportion of high-quality habitat resulting from application of our model indicated increases that varied from 116 to 508%. We conclude that development of additional sources of surface water can increase availability of high-quality habitat for mountain sheep inhabiting Sonoran Desert mountain ranges, and that the technique has implications for population persistence and conservation of those large, specialized ungulates.

1. Introduction

Large herbivores inhabiting arid environments face unique challenges when securing resources, including forage and water (Leopold, 1933), which are necessary for survival and reproduction and that ultimately influence population dynamics and persistence. In such systems, water is scarce and precipitation is unpredictable in timing, amount, and spatial distribution (Noy-Meir, 1973; Schwinning and Sala, 2004). As a consequence, there is high variability in the quantity, quality, and distribution of resources that sustain populations (Marshal et al., 2005a,b; Owen-Smith, 1990; Robertson, 1987), as well as in habitat quality (Andrew et al., 1999; Bleich et al., 1997; Marshal et al., 2006a; Rautenstrauch and Krausman, 1989).

In an effort to manage this variability, wildlife managers in the southwestern USA have, for decades, provided permanent or semi-permanent surface water via wildlife water developments (Bleich et al., 2005; Broyles, 1995; Kie et al., 1996; Krausman et al., 2006; Rosenstock et al., 1999), and there is abundant evidence that water sources strongly influence habitat use by arid-land ungulates in North America. For mountain sheep (*Ovis canadensis*) and mule deer (*Odocoileus hemionus*), proximity to surface water during summer (Andrew et al., 1999; Bleich et al., 1997; Blong and Pollard, 1968; Oehler et al., 2005; Ordway and Krausman, 1986; Turner et al., 2004), visitation rates (Blong and Pollard, 1968; Hervert and Krausman, 1986; Marshal et al., 2006a; Turner, 1973), seasonality of use (Bleich et al., 1997; Bristow, 1998; Waddell et al., 2007), and water consumption rates (Hazam and Krausman, 1988; Turner, 1970, 1973) all demonstrate the importance of surface water to those ungulates. Moreover, Turner (1973) demonstrated that water content of mountain sheep diets during summer is insufficient for meeting evaporative water losses; as a result, those ruminants must rely on sources of free water to maintain water balance.

As important as water might be in the habitats of some arid-environment species, it is but one of a number of resources or conditions that can influence distribution and habitat use by individuals. Habitat use by mountain sheep, for example, is related to availability of steep, rocky terrain (McKinney et al., 2003), openness (Risenhoover and Bailey, 1980), vegetation type (Andrew et al., 1999; Bleich et al., 1997; Oehler et al., 2005), and forage quality

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(Bleich et al., 1997; Wehausen, 1992). Moreover, habitat use and distribution can be affected by human disturbance (Bleich et al., 1994; Jorgensen, 1974; Leslie and Douglas, 1980; Papouchis et al., 2001), and fire history (Bleich et al., 2008). The influence of each of these factors is not necessarily independent of the others; the parameters interact in a multivariate way to influence habitat selection by those specialized ungulates.

Understanding the relative importance of individual habitat components is necessary for making predictions about influences of changes in any of the aforementioned components. Resource selection functions (RSFs) are tools that can facilitate such an understanding, and do so by treating each habitat component as a variable that contributes to explaining overall variation in habitat use exhibited by an animal moving across a landscape (Boyce et al., 2002; Johnson et al., 2006; Manly et al., 2002). Given an estimated RSF, investigators can further predict how changes in one or more of those components might influence an animal's distribution (Johnson et al., 2005; McDonald and McDonald, 2002). Thus, RSFs can be used to predict effects of changes in one or more of the resources or conditions encompassed by the model, such as loss or change in habitat, or efficacy of a proposed management action.

In this paper, we examine how the hypothetical provision of additional water sources could affect the overall quality of habitat for mountain sheep in a desert ecosystem. To do this, we used aerial telemetry data from three mountain ranges in the Sonoran Desert of southeastern California, and developed a RSF for mountain sheep. We then applied the RSF to four nearby and ecologically similar mountain ranges to predict how habitat quality for those large herbivores would change with additional surface water in those ranges. Finally, we used the models to examine predicted changes in the proportion of each of those mountain ranges that would be categorized as high-quality mountain sheep habitat as a result of provision of additional water sources.

2. Methods

2.1. Study area

We conducted our research in the Lower Colorado River Subdivision of the Sonoran Desert in Imperial and Riverside counties, California, USA (33°40″ N and 115°59″ W × 32°40″ N and 114°28″ W). The study area was bounded roughly by the Coachella Canal on the west, Interstate Highway 10 on the north, the Colorado River on the east, and Interstate 8 on the south (Fig. 1). The entire region can be characterized as hot and arid, and with a bimodal peak in seasonal rainfall (Western Regional Climate Center, 2007; Fig. 2). Average monthly rainfall and average monthly temperature each were highly correlated ($r \geq 0.678$ and $r \geq 0.997$, respectively) among weather stations distributed across the study area.

Within the study area are seven mountain ranges (Fig. 1) that either are occupied by mountain sheep ($n = 4$), or that historically supported populations of those large herbivores ($n = 3$). At the time of our study, mountain sheep occupied the Orocopia, Chuckwalla, West Chocolate, and East Chocolate mountains on a year-round basis (Epps et al., 2003). The Cargo Muchacho, Palo Verde, and Little Chuckwalla mountains did not support permanent populations (Epps et al., 2003) but mountain sheep, primarily males, occasionally were observed in those ranges (V. C. Bleich and N. G.

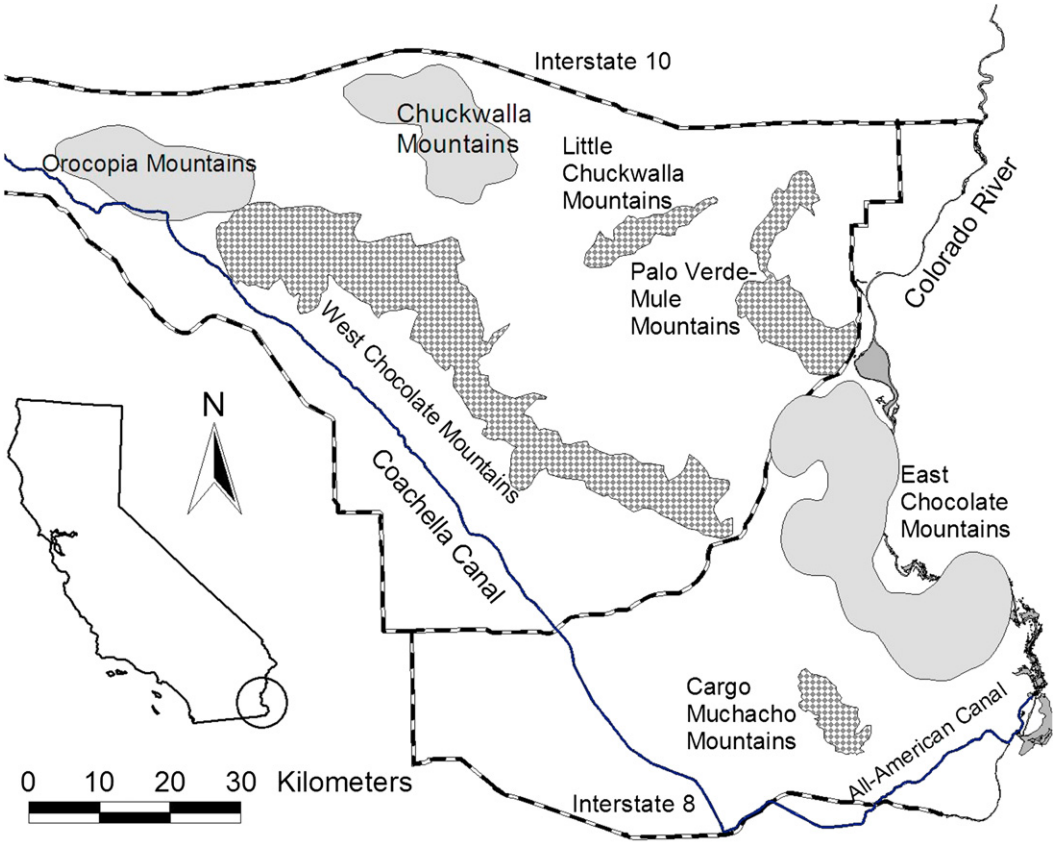

Fig. 1. Location of model ranges (Orocopia, Chuckwalla, and East Chocolate mountains) and prediction ranges (West Chocolate, Little Chuckwalla, Cargo Muchacho, and Palo Verde-Mule mountains) in the Sonoran Desert study area, Imperial and Riverside counties, California, USA.