*Research Note*

# Influence of Precipitation on Pronghorn Demography in Texas

**DAVID C. SIMPSON,** *Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79832, USA*
**LOUIS A. HARVESON,**[1] *Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79832, USA*
**CLAY E. BREWER,** *Texas Parks and Wildlife Department, P.O. Box 2083, Fort Davis, TX 79734, USA*
**RYAN E. WALSER,** *Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79832, USA*
**AARON R. SIDES,** *Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79832, USA*

**ABSTRACT** Ungulate populations in desert environments are thought to be regulated by precipitation. Pronghorn (*Antilocapra americana*) populations in Trans-Pecos, Texas, USA, experienced a 70% decline between 1977 and 2001. The causative factors associated with the decline are unknown but appear to be related to drought. We evaluated the relationships between pronghorn abundance and productivity and precipitation (i.e., raw precipitation, Palmer Drought indices) for the Trans-Pecos district of Texas from 1977 to 2004. Pronghorn productivity (range = 305–4,407) and abundance (range = 5,061–17,266) showed high variability. Precipitation was also highly variable, ranging from 18 cm to 57 cm. Pronghorn abundance was positively influenced by precipitation indices ($R = 0.790$, $P < 0.001$). The relationship between fawn production and raw precipitation ($R = 0.869$, $P < 0.001$) suggested that fawn production may be more closely related to immediate moisture conditions, whereas pronghorn abundance was more influenced by long-term population trends. Management plans for pronghorn populations in more arid regions should include drought contingencies including reduced stocking rates and harvest quotas. (JOURNAL OF WILDLIFE MANAGEMENT 71(3):906–910; 2007)

DOI: 10.2193/2005-753

**KEY WORDS** *Antilocapra americana*, density independence, drought, Palmer indices, precipitation, pronghorn, Texas, Trans-Pecos.

Ungulate populations in North America are regulated by density-dependent and density-independent factors (Krebs 1985). Density dependency can regulate populations of mule deer (*Odocoileus hemionus*; White and Bartmann 1998), bighorn sheep (*Ovis canadensis*; Leslie and Douglas 1982, Wehasusen et al. 1987), and pronghorn (*Antilocapra americana*; Shenk 1995). However, density-independent factors (e.g., precipitation) appear to be more prevalent in regulating mule deer (McCulloch and Smith 1991, Lawrence et al. 2004), bighorn sheep (Douglas and Leslie 1986, Wehausen et al. 1987, McKinney et al. 2001), and pronghorn populations (Hailey et al. 1966, Beale and Smith 1970, Bright and Hervert 2005) in the southwestern United States.

Pronghorn populations have declined in numbers and distribution throughout North America (Yoakum and O'Gara 2000). Yoakum and O'Gara (2000) suggest that pronghorn populations in North America have declined from >30 million in the 1800s to <700,000 in 1997. Similar patterns in pronghorn distribution and abundance have been reported for Texas, USA. Historically, pronghorn populations were distributed over approximately two-thirds of Texas (Buechner 1950; Fig. 1A) and were reduced to a fraction of the original distribution by 1945 (Fig. 1B). The distribution of pronghorn in Texas has remained relatively stable since the 1950s (Fig. 1C) and currently is limited to the Panhandle, Trans-Pecos, and Possum Kingdom wildlife districts. Historically, 75% of the pronghorn in Texas occurred in the Trans-Pecos region. Pronghorn estimates in the Trans-Pecos have been as high as 17,000 individuals (1987), but that estimate has been reduced by 70% during the past decade (2001; Lucia 2004).

Many factors have contributed to the decline in pronghorn distribution and abundance in Texas. The decline during the 1800s was attributed to overgrazing of pronghorn habitat by livestock and unregulated hunting (Schmidly 2002). Other authors have implicated overhunting that occurred before the implementation and enforcement of harvest regulations of pronghorn leading to population declines (Buechner 1950, Yoakum and O'Gara 2000). Hypotheses abound to explain the recent decline, including predation and habitat deterioration due to fire suppression and overgrazing (Sullins 2002). However, most hypotheses that may explain declining pronghorn populations are thought to be associated with weather patterns (e.g., drought; Sullins 2002). Therefore, we initiated a study to evaluate the relationship between precipitation and pronghorn demography in Trans-Pecos, Texas.

## STUDY AREA

The Trans-Pecos region of Texas contained diverse habitat and natural resources. The Trans-Pecos region was within the Chihuahuan Desert Biotic Province and comprised approximately 7.3 million ha. The Trans-Pecos was bordered to the north by New Mexico, to the south and west by the Rio Grande, and to the east by the Pecos River (Hatch et al. 1990). Elevation ranged from 762 m to 2,667 m with scattered desert islands. Lowlands and basins received 20–30 cm of precipitation, whereas the higher elevations were more mesic with 30–46 cm of annual precipitation. Various soils were found in this region with shallow rocky soils on the slopes and mountains, gravel in

[1] *E-mail: harveson@sulross.edu*

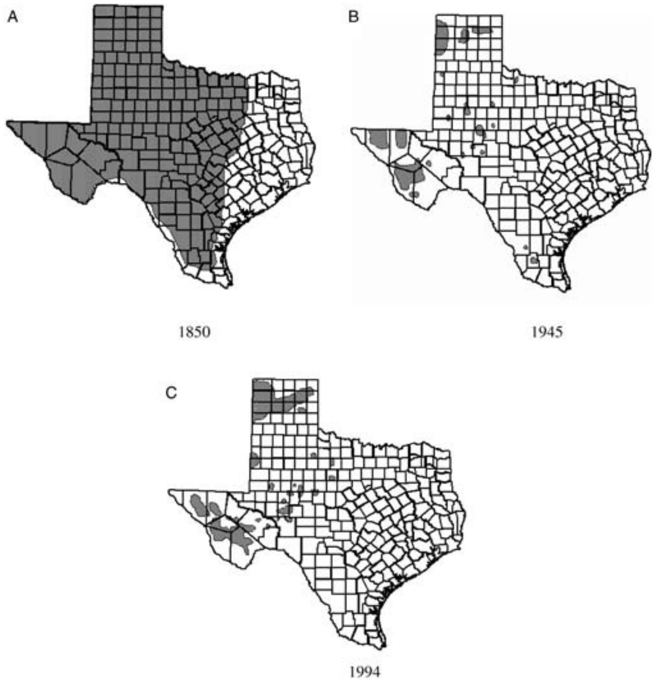


**Figure 1.** Estimated distribution of pronghorn in Texas for circa 1850 (A; adapted from Texas Game, Fish, and Oyster Commission 1945, Buechner 1950, Davis and Schmidly 1994), 1945 (B; adapted from Texas Game, Fish, and Oyster Commission 1945), and 1994 (C; adapted from Davis and Schmidly 1994).

the lowlands, and deep sands in the desert washes (Harveson 2007). Pronghorn habitat generally consisted of open, low-rolling grasslands or shrub–steppes (O'Gara and Yoakum 1992). Within the Trans-Pecos, pronghorn were directly associated with the Desert Grassland Biotic District (Buechner 1950). Vegetation types common in the study area included yucca (*Yucca* spp.) savannahs, grama (*Bouteloua* spp.) grasslands, and creosote (*Larrea tridentata*) shrublands (Correll and Johnston 1970, Canon and Bryant 1997*a*). Land use practices vary across the region, but most rangelands were used for agricultural purposes (i.e., livestock grazing or wildlife enterprises; Harveson 2007).

## METHODS

Texas Parks and Wildlife Department conducted 27 years (1977–2004) of aerial surveys for pronghorn in the 7 counties (Brewster, Jeff Davis, Pecos, Hudspeth, Culberson, Reeves, and Presidio) of the Trans-Pecos. We established pronghorn transects throughout the area and flew them late July–August. We made aerial counts by flying transects spaced at 400 m and at an altitude of 30 m. We first categorized individuals as adult or juvenile, and we further delineated adults by gender. Surveys provided demographic characteristics on pronghorn populations, including abundance, sex ratios (M:F), and fawn production (no. of fawns estimated in population).

Raw precipitation is the simplest precipitation trend but does not take into account other climatic variables that are included in the Palmer indices, including evapotranspiration, soil runoff, and regional climatic conditions. The Palmer Drought Severity Index (PDSI) was designed by Palmer (1965) to assess regional departure from normal moisture supply using precipitation, temperature, evapotranspiration, runoff, soil recharge, and average regional conditions (Palmer 1965, Heddinghaus and Sabol 1991, Bridges et al. 2001). The Palmer Modified Drought Index (PMDI) is a variation of the PDSI and uses intermediate parallel monthly index values to determine the probability that a dry or wet spell is beginning or ending to make more accurate forecasts. The Palmer Hydrological Drought Index (PHDI) includes the principle of moisture supply and demand. The Moisture Anomaly Index (ZNDX) is a monthly measure of departure from normal moisture levels and is sensitive to moisture fluctuations within a dry or wet period.

We obtained precipitation data from the National Climatic Data Center (National Oceanic and Atmospheric Administration 1977–2004) for the Trans-Pecos climatic region. We obtained annual raw precipitation, PDSI, PDMI, PHDI, and ZNDX values from 1977 to 2004. We converted monthly data for the Palmer indices to annual data by summing the data for the period of August to July for the years before aerial surveys. Although the ecological region does not exactly match the climatic region, we used single values to represent regional-scale weather conditions, and we, therefore, deemed these differences negligible (Bridges et al. 2001).

We evaluated relationships between precipitation (raw and indices) and pronghorn productivity and abundance using Pearson's correlation coefficients (MINITAB statistical software, Release 13.31; MINITAB, State College, PA). Distributions for all time series were normal. We then ran cross-correlations between population data and all precipitation measures to evaluate whether any important lag-time needed to be factored in (MINTAB). No lag-time was necessary between data sets. We calculated coefficients of variation for pronghorn abundance, fawn production, and precipitation in the Trans-Pecos wildlife district.

## RESULTS

From 1977 to 2004, annual raw precipitation ranged from 56.6 cm (1987) to 18.1 cm (2000) and averaged 33.1 cm (Fig. 2). During the same time, the pronghorn population in the Trans-Pecos ranged from 5,061 to 17,226 ($\bar{x} = 10,699$; Fig. 3). Annual fawn production averaged 1,976 and ranged from 305 (2000) to 4,407 (1985). Pronghorn sex ratio (M:F) ranged from 1.44 to 2.05 and averaged 1.71. Precipitation and pronghorn populations were moderately variable (CV = 33.73, CV = 36.84, respectively), and fawn production was especially variable (CV = 64.57). The pronghorn population trend in the Trans-Pecos increased from 1977 until the peak in 1987 and then decreased until 2002 (Fig. 3).

Population abundance and fawn production were positively correlated with all precipitation indices ($R \geq 0.607$, $P \leq 0.001$). In general, Palmer indices were more strongly correlated to population abundance than was raw precipitation (Table 1). The strongest correlation was between the PHDI and population abundance ($R = 0.793$, $P < 0.001$);

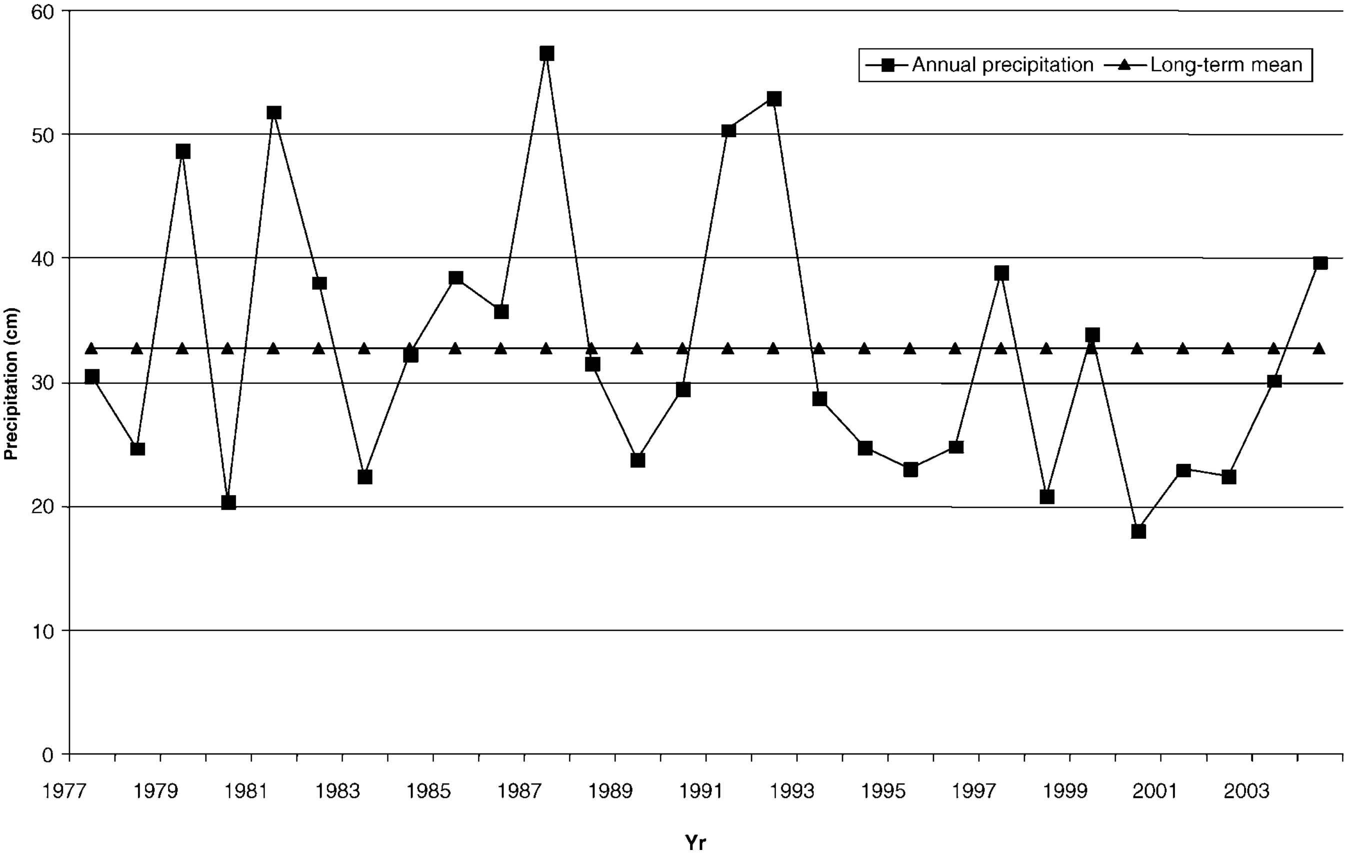


**Figure 2.** Annual (Aug–Jul) and long-term average precipitation in Trans-Pecos, Texas, USA, 1977–2004.

the weakest correlation was between raw precipitation and population abundance ($R = 0.687$, $P < 0.001$). All Palmer indices were more weakly correlated to fawn production than raw precipitation, with the strongest correlate being raw precipitation ($R = 0.869$, $P < 0.001$) and the weakest correlate being PHDI ($R = 0.692$, $P < 0.001$).

## DISCUSSION

The relationship between pronghorn abundance and precipitation measures suggests that the population in the Trans-Pecos is closely related to long-term moisture conditions. In the Trans-Pecos, the high variation in precipitation suggests that pronghorn demographics are more susceptible to drought conditions than other populations of pronghorn (Simpson 2005). The strongest correlate to the population abundance was the PHDI, whereas the weakest correlate was raw precipitation. The PHDI can be characterized as a more long-term index than the ZNDX or raw precipitation (Palmer 1965, Heddinghaus and Sabol 1991), which would suggest that overall population size in the Trans-Pecos is more closely related to long-term precipitation trends.

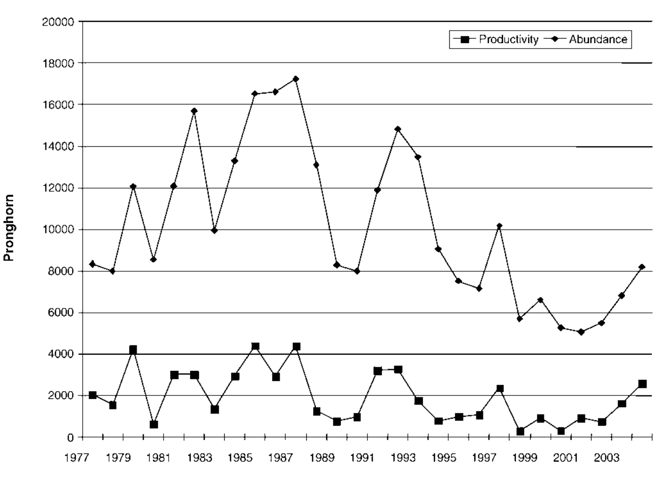


**Figure 3.** Estimated pronghorn abundance and productivity in Trans-Pecos, Texas, USA, 1977–2004.

**Table 1.** Relationships between pronghorn population abundance, productivity, and precipitation indices in Trans-Pecos, Texas, USA 1977–2004.

| | Trans-Pecos | | | |
|---|---|---|---|---|
| | Abundance | | Productivity | |
| Index[a] | *R* | *P*-value | *R* | *P*-value |
| Precipitation | 0.687 | <0.001 | 0.869 | <0.001 |
| PDSI | 0.607 | 0.001 | 0.763 | <0.001 |
| PMDI | 0.778 | <0.001 | 0.753 | <0.001 |
| PHDI | 0.793 | <0.001 | 0.692 | <0.001 |
| ZNDX | 0.702 | 0.001 | 0.859 | <0.001 |

[a] Palmer Drought Severity Index (PDSI), Palmer Modified Drought Index (PMDI), Palmer Hydrological Drought Index (PHDI), and Z Index or Moisture Anomaly Index (ZNDX).

In contrast, the relationship between fawn production and precipitation indices suggests that fawn production in this region may be more closely related to immediate moisture conditions. The strongest relationships to fawn production were with annual raw precipitation and the ZNDX. These 2 measures of moisture are the most reflective of immediate moisture conditions (Palmer 1965, Heddinghaus and Sabol 1991). On the other hand, the PHDI, which is most reflective of the long-term moisture supply, had the weakest relationship to fawn production. Fawn production is vital to the overall population, and fawn production is closely related to spring forage availability (Yoakum and O'Gara 2000).

Our results suggest that pronghorn populations and fawn production are affected by long-term and short-term drought. Previous research has also suggested similar relationships between pronghorn and precipitation (Buechner 1950, Hailey et al. 1966, O'Gara and Yoakum 1992, Yoakum and O'Gara 2000). Similarly, Bridges et al. (2001) found significant correlations between the PMDI and scaled quail (*Callipepla squamata*) populations in several regions of Texas. This suggests that in more extreme reaches of pronghorn range (i.e., marginal habitats), such as the Trans-Pecos, precipitation may be more of a limiting factor than in more moderate ranges (Simpson 2005).

Weather, habitat, and nutrition directly and indirectly influence a variety of limiting factors including fawning cover, forage availability, and competition with livestock (New Mexico State University 1990, Perry 1996, Canon and Bryant 1997*b*, Bright 1999). Weather patterns (e.g., rainfall) determine the amount of plant growth in the Trans-Pecos and other desert environments (Schmidly 1977, Goldberg and Turner 1985). The amount of plant production in turn influences pronghorn productivity and abundance. During years of drought, limited vegetative production in turn limits the production of pronghorn and other ungulates in arid environments, such as the Trans-Pecos. However, such limitations do not seem to occur in areas of higher and less-variable rainfall (Simpson 2005). Our results suggest that precipitation influences the quality of habitat, which in turn influences the production and abundance of pronghorn in the Trans-Pecos.

## MANAGEMENT IMPLICATIONS

The strong relationship between precipitation indices and pronghorn abundance and fawn productivity make these indices useful management tools for predicting population trends. Although a variety of precipitation indices are available, the ZNDX and PHDI indices show promise for predicting short-term (productivity) and long-term (abundance) pronghorn trends in arid regions, respectively. The predictive capability of the precipitation indices may allow land managers to mitigate the effects of drought by setting more conservative stocking rates before the onset of drought. By removing or reducing livestock early in a drought, essential components of pronghorn habitat (cover and forage) may be conserved, thus allowing for increased productivity and abundance of pronghorn.

## ACKNOWLEDGMENTS

Funding and logistical support were provided by Texas Parks and Wildlife Department (TPWD) and Sul Ross State University. We are indebted to numerous TPWD employees that collected this data and especially T. L. Bone, M. D. Hobson, and B. Tarrant for assisting with data compilation. R. J. Kinucan, B. J. Warnock, and P. M. Harveson made comments to improve this manuscript.

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*Associate Editor: Morrison.*