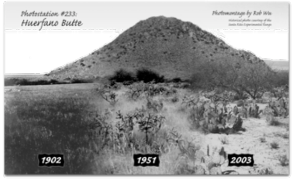

Trends in woody plant (*Prosopis velutina*) biomass, 1932 to 2006: Effects of grazing and herbicide treatments

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Photo by C. Cribbs, 1937: McGinnies Plots on SRER.

Problem:

Increases in the abundance and distribution of woody plants in grasslands and savannas have been documented worldwide (Archer 1995). It is widely assumed that livestock grazing promotes woody plant encroachment. However, there is little quantitative data on how livestock grazing influences woody plant community structure and dynamics and affects aboveground biomass and terrestrial carbon pools.

Research Questions:

Does livestock grazing promote velvet mesquite (*Prosopis velutina*) encroachment, stand development, and aboveground biomass accumulation in desert grasslands?

Do spatial patterns of mesquite encroachment differ in areas experiencing contrasting livestock grazing regimes?

Approach:

Two - 1.8 ha plots were established on a desert grassland site at the Santa Rita Experimental Range in southeastern Arizona (Fig. 1) by W. McGinnies in 1932. Livestock grazing was excluded on half of the plots. The location and canopy area of each mesquite plant in each plot was recorded.

Glendening (1952) re-measured these plots in 1948-49. Both plots were treated with aerial herbicides in 1964 and 1965 (Martin and Ward 1966). In 2006, we mapped and measured canopy dimensions of all mesquite plants in a 0.8 ha (40-m x 200-m) subset of one plot.

Fig. 1: Location of Santa Rita Experimental Range (SRER), established in 1903, in southeastern Arizona. This study was conducted at 1,100 m elevation on sandy clay loam soil surfaces of late Pleistocene age.

An allometric relationship between mesquite canopy area and aboveground biomass ($R^2 = 0.97$, $n = 32$ trees) (Archer et al., *in prep*) was used to estimate biomass accrual over time.

Spatial arrangement of mesquite plants was quantified using a Neighborhood Density Function (NDF; Condit et al. 2000) by grazing treatment and year. The NDF was used instead of Ripley's K function (Ripley 1976) because the NDF corresponds to linear, rather than cumulative distances (Perry et al. *in press*).

Results:

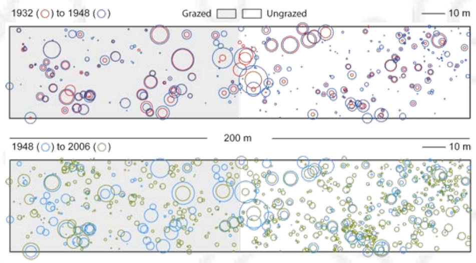

Fig. 2. Temporal dynamics of velvet mesquite canopy cover from field measurements of all plants within a 200-m X 40-m plot. Red circles represent plant canopies in 1932, blue = 1948, and green = 2006. Livestock grazing ceased in 1932 on 0.4 ha (shaded in gray). The entire plot was treated with aerial herbicides in May 1964 and 1965. Concentric circles represent mesquite canopies. Note general trend of canopy growth from 1932 to 1948 (A) (red within blue); and trend of canopy loss from 1948 to 2006 (B) (green within blue) following herbicide applications in 1964-65.

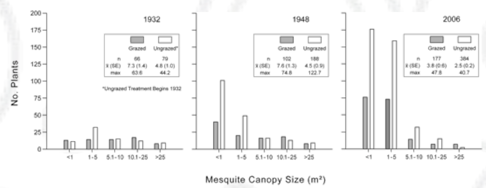

Fig. 3. Size class distribution of mesquite canopies derived from field measurements in 1932, 1948 and 2006 of all trees within a 0.8-ha plot. Half of the plot was excluded from livestock grazing starting in 1932 (white); livestock grazing was continued on the other half (gray).

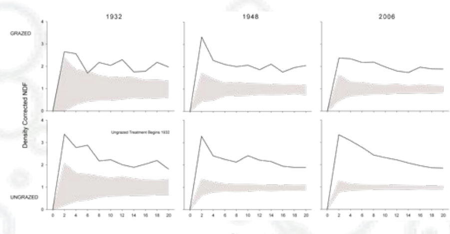

Fig. 4. Density corrected Neighborhood Density Function (NDF) (Condit et al. 2000) for mesquite plants on grazed and ungrazed portions of a 0.8 ha study plot on the SRER. The entire plot was grazed by livestock until an exclosure was established in 1932 on half of the area. NDFs were generated using SpPack (Perry 2004) using a weighted edge correction (Goreaud and Pelissier 1999) and 500 iterations to generate 99% confidence envelope (depicted in gray). Values above the confidence envelope would represent an aggregated pattern, while those occurring below it would represent a dispersed pattern.

- The period 1932 to 1948 was marked by growth (Fig. 2A) while 1948 to 2006 was marked by canopy die-back (presumably due to herbicide treatment) and of establishment of new plants (Fig. 2B).
- Mesquite stands were even-aged in 1932. Recruitment has been high since 1932 with more plants established on ungrazed than on grazed plots (Fig. 3).
- In all years, plants were clustered beyond that expected under complete spatial randomness at all distances with peaks in clustering occurring at short distances (2 m), suggesting preferential recruitment in the immediate vicinity of existing trees (Fig. 4).
- The spatial pattern in 1948 was similar for grazed and ungrazed plots. The peak in clustering at 2 m was maintained through 2006 on ungrazed plots, while the effect was dampened on grazed plots (Fig. 4).

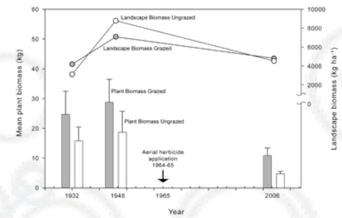

Fig. 5. Trends in plant- and landscape-scale aboveground mesquite biomass derived using field measurements of plant canopy area in 1932, 1948, and 2006. Plant-scale estimates are based on mean size of plants in plots; landscape-scale estimates represent the sum of biomass values for all mesquite plants in the plot.

- Although mean plant biomass (kg) was consistently higher on grazed plots, landscape-level biomass (kg/ha) on ungrazed plots was comparable to or higher than that on grazed plots (Fig. 5).
- Decreases in biomass from 1948 to 2006 ostensibly reflect the 1964-65 herbicide applications.
- Biomass estimates were heavily influenced by the fate of large plants.

Implications:

1) The dynamic re-arrangement of mesquite cover over the 74 y period points to the need for spatially-explicit monitoring.
2) Exclusion from grazing for 16 y had little effect on spatial patterns in the 1948 plots; but by 2006 (after 74 y) spatial patterns showed signs of differentiating. Results illustrate the importance of long-term studies in revealing population dynamics of this long-lived species.
3) Trends in biomass using historic field measurements coincide with those using time-series aerial photography (Browning et al., *in prep*), providing a potential link for tracking changes over larger spatial scales.
4) Past land uses (i.e., grazing and brush management) profoundly impacted mesquite biomass and population structure, thus affecting terrestrial carbon pools and storage potential. The common assumption that livestock grazing promotes increases in woody plant cover/biomass was not supported in this desert grassland system.

Acknowledgments:

The historic legacy of W. McGinnies and G. Glendening is recognized and extraordinary. G. Perry provided advice on spatial analysis and SpPack software. R. Wu and C. McMurtry provided assistance collecting field data and R. Wu's efforts with compiling historic data are appreciated. The Advanced Resource Technology Laboratory provided logistical assistance. Funding was provided through EPA STAR Graduate Fellowship Program and T&E, Inc. Grant for Conservation Research to DMB.

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