Biogeography of woody encroachment: why is mesquite excluded from shallow soils?

Kathleen D. Eggemeyer* and Susanne Schwinning

Biology Department, Texas State University, San Marcos, 601 University Drive, San Marcos, TX 78666, USA

ABSTRACT

While some studies aim to generalise the attributes of woody encroachers, examining their functional differences across biogeographic regions may also be instructive. Most of Texas is encroached by Prosopis glandulosa, but on the eastern Edwards Plateau, a limestone plateau with thin soils, P. glandulosa is rare and Juniperus ashei is dominant. We hypothesised that P. glandulosa is excluded from sites where bedrock at a depth of 1 m or less restricts the development of taproots, thus rendering this normally deep-rooted species too vulnerable to drought. To test this idea, we monitored the physiological status of two species on a site where both species were encroaching and the soil was 1.5–2.5 m deep, thus relatively deep for the Edwards Plateau region but not for regions where P. glandulosa dominates. Data were collected across three tree size classes from May to November 2006. Stem water potentials were similar across species and water potentials and photosynthetic rates decreased with tree size. Based on isotopic evidence, the effective rooting depth of P. glandulosa increased with tree size, but not in J. ashei. P. glandulosa had a higher rate of leaf gas exchange overall as expected for a drought-avoider; except for large trees during a summer drought, when species differences in photosynthesis rates diminished and the stomatal conductance for J. ashei exceeded that of P. glandulosa. We speculate that restrictions of soil depth may limit the invasiveness of P. glandulosa in part through negative effects on large trees, which may lower fecundity. Copyright © 2009 John Wiley & Sons, Ltd.

KEY WORDS Edwards Plateau; gas exchange; groundwater recharge; Juniperus ashei; Prosopis glandulosa; rooting depth; stable isotopes; woody encroachment

Received 29 September 2008; Accepted 30 November 2008

INTRODUCTION

Woody encroachment is the expansion of woody plants into grasslands and open savannas with usually negative consequences for rangeland productivity and water resource management (Kraaij and Ward, 2006; Wilcox et al., 2008). It is a world-wide phenomenon that has been occurring over the past 100–200 years (Bragg and Hulbert, 1976; Archer, 1995; Van Auen, 2000; Wilcox et al., 2008). The reasons for woody encroachment are still debated. While there is wide agreement that the introduction of live stock and fire suppression aided woody encroachment in many parts of the world (Van Auen, 2000), some argue that woody encroachment would have occurred even without these facilitating factors, based on changes in climate (Reich et al., 2001), increase in atmospheric CO2 concentration (Bradley and Fleishman, 2008), landscape fragmentation (Briggs et al., 2007), and a decrease in harvest rates for food and lumber by native people (Fredrickson et al., 2006).

Typically, very few species out of a much larger community of woody plants become woody encroachers, while other species do not change or even decline in abundance. Thus, whatever regime change occurred a century and a half ago benefited only a small minority of species. Determining what characteristics may have predestined these species to become woody encroachers may help us better understand the causes for woody encroachment, indicate avenues for more effective rangeland management, and aid in predicting future vegetation changes.

The characteristics of woody encroachers vary substantially between biogeographic regions. Morphological and physiological features that appear to make one species a successful encroacher in one region are not necessarily the same that make another species successful in a different region. For example, large portions of the Intermountain West have been encroached by Western juniper (Juniperus occidentalis) at mid- to low-elevations (Miller and Rose, 1995; Weisberg et al., 2007; Bradley and Fleishman, 2008), while semi-arid grasslands of the south-west at lower elevations have been encroached by velvet or honey mesquite or their hybrids (Prosopis velutina and Prosopis glandulosa; Archer et al., 1988; Schlesinger et al., 1990; Van Auen, 2000; Browning et al., 2008). J. occidentalis is a drought tolerant evergreen tree with an extensive but shallow root system and no central taproot (Hall, 1952; Dealy, 1990), while members of the Prosopis genus are among the most deep-rooted tree species in the world (Phillips, 1963). Prosopis trees are winter-deciduous drought avoiders, while members of the Juniperus genus are evergreen drought tolerators. How can two so distinct genera be both among the most prolific woody encroachers in North America?

*Correspondence to: Kathleen D. Eggemeyer, Biology Department, Texas State University, San Marcos, 601 University Drive, San Marcos, TX 78666 USA. E-mail: keggemeyer@txstate.edu

Copyright © 2009 John Wiley & Sons, Ltd.