Journal of Arid Environments 72 (2008) 1562–1572

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Patterns of mast production in pinyon and juniper woodlands along a precipitation gradient in central New Mexico (Sevilleta National Wildlife Refuge)

R.I. Zlotin [a,*], R.R. Parmenter [b]

[a] Indiana University, Bloomington, IN 47405, USA
[b] Valles Caldera National Preserve, Jemez Springs, NM 87025, USA

ARTICLE INFO

Article history:
Received 29 September 2006
Received in revised form
5 December 2007
Accepted 27 February 2008
Available online 18 April 2008

Keywords:
Arid ecosystems
Juniper monosperma
Pinus edulis
Quercus turbinella
Sevilleta LTER

ABSTRACT

This paper reports on an 8-year continuing project with the Sevilleta Long-Term Ecological Research program (LTER) in central New Mexico aimed at the study of dynamics of woodland ecosystems. The study of mast production was conducted at six experimental woodland sites situated across an elevational gradient of 1500–2000 m in proximity to permanent meteorological stations. The dominant woody species were *Juniper monosperma*, *Pinus edulis*, and *Quercus turbinella*. Functioning of arid ecosystems of the Southwest undergoes seasonal, annual and multidecadal fluctuations which link to corresponding dynamics of available moisture. Results of the 1997–2004 study show a gradual decrease in mast production of all three species at all six sites, due to a continuing drought in this period. Mast production in a given year is determined to a considerable extent by available moisture during the entire growth year, from the previous spring to the current summer. The areas of oak–pinyon–juniper woodlands with higher elevation and highest precipitation generally have the highest yield of juniper berries, pinyon nuts and acorns. The severe drought of 2001–2003 has been accompanied by a mass dying of mature pinyon pines and loss of foliage in junipers. According to our observations, there is no correlation between mast production and amount of precipitation in the current year's monsoon period (June–September). A high correlation between acorn production and non-monsoonal precipitation (October–May) was established, but no such correlation was found for juniper berries and pinyon nuts. Weather conditions (wind, temperature, and moisture) of late May are a critical factor determining the success of fertilization and subsequent mast production in all three species.

Published by Elsevier Ltd.

1. Introduction

Arid woodlands are one of the world most widespread biomes occupying significant area of subtropical thermal belt on each of six continents (Walter, 1979). They represent the most widespread natural biome in the North American Southwest where ecosystems of this kind cover about one-third of the total area in the region (West and Young, 2000). However, despite of broad geographic range of arid woodlands, they have been little studied with respect to production, particularly fruiting mast.

* Corresponding author. Tel.: +1 812 855 6303; fax: +1 812 855 1661.
E-mail addresses: rzlotin@indiana.edu (R.I. Zlotin), bparmenter@vallescaldera.gov (R.R. Parmenter).

0140-1963/$ - see front matter Published by Elsevier Ltd.
doi:10.1016/j.jaridenv.2008.02.021

Dominant trees in coniferous–deciduous mixed woodland ecosystems of central New Mexico include one-seed juniper (*Juniper monosperma*), Colorado pinyon pine (*Pinus edulis*), and shrub live oak (*Quercus turbinella*). Juniper berries, pinyon nuts and acorns are an essential part of total primary production in woodland ecosystems. Seeds of juniper, pinyon and oak are the only source of tree recruitment in woodlands (Chambers et al., 1999); they also serve as a vital food staple for numerous animals species (Christensen et al., 1991; Forcella, 1981; Hope and Parmenter, 2007).

The aim of this study is to determine if there is a significant correlation between mast production of three dominant tree species (juniper, pinyon pine and oak) and patterns of moisture distribution. The study began in 1997 as a part of Sevilleta LTER program, continued through 2004, and is ongoing.

2. Methods

2.1. Study area

The area of our study is located within the Sevilleta National Wildlife Refuge (NWR), Socorro County, in central New Mexico, approximately 80 km south of Albuquerque. The severe drought of the 1950s had considerable impact on tree density and age structure of woodland ecosystems at the Sevilleta NWR. Significant numbers of juniper trees and many pinyon pines died during the drought. The area was a sheep and cattle ranch in the past, and the signs of intensive grazing are still noticeable. Following transfer of the Sevilleta lands to the US Department of the Interior, Fish and Wildlife Service in 1974, the land received the status of National Wildlife Refuge, and since then has been managed in its natural state.

In an arid environment of the Southwest, water is the most significant abiotic driver of ecosystem functioning. The climatic conditions in the Sevilleta area are characterized by two major patterns (Milne et al., 2003): (a) a multi-decadal variability in precipitation associated with approximately 50-year cycles of the Pacific Decadal Oscillation, and (b) annual dynamics in moisture influenced mostly by 3- to 4-year El Niño Southern Oscillation. There is also a seasonal pattern: non-monsoon precipitation of October–May, and monsoon rains of June–September. The summer monsoon brings about 60% of total precipitation (Sevilleta LTER web site: www.sev.lternet.edu).

This general climatic pattern varies significantly from year to year, resulting in high variability of seasonal and annual water inputs. During the period of study, the Sevilleta area and the rest of the southwestern US were under the influence of severe drought, that has characteristics of the drought of the 1950s.

In order to account for diversity of the Sevilleta woodland ecosystem with respect to mast production, we chose six research sites which differed in their location, elevation and composition of dominant woody species. The presence of a meteorological station nearby was a main selection criterion. Six permanent plots of 1 ha each was chosen in the vicinity of local meteorological station (Fig. 1). The six plots represented a range of woodland sites across the elevation/precipitation gradient: (a) oak–pinyon–juniper woodland, Cerro Montoso site (CM), 1971 m, (b) pinyon–juniper woodland, West Mesa

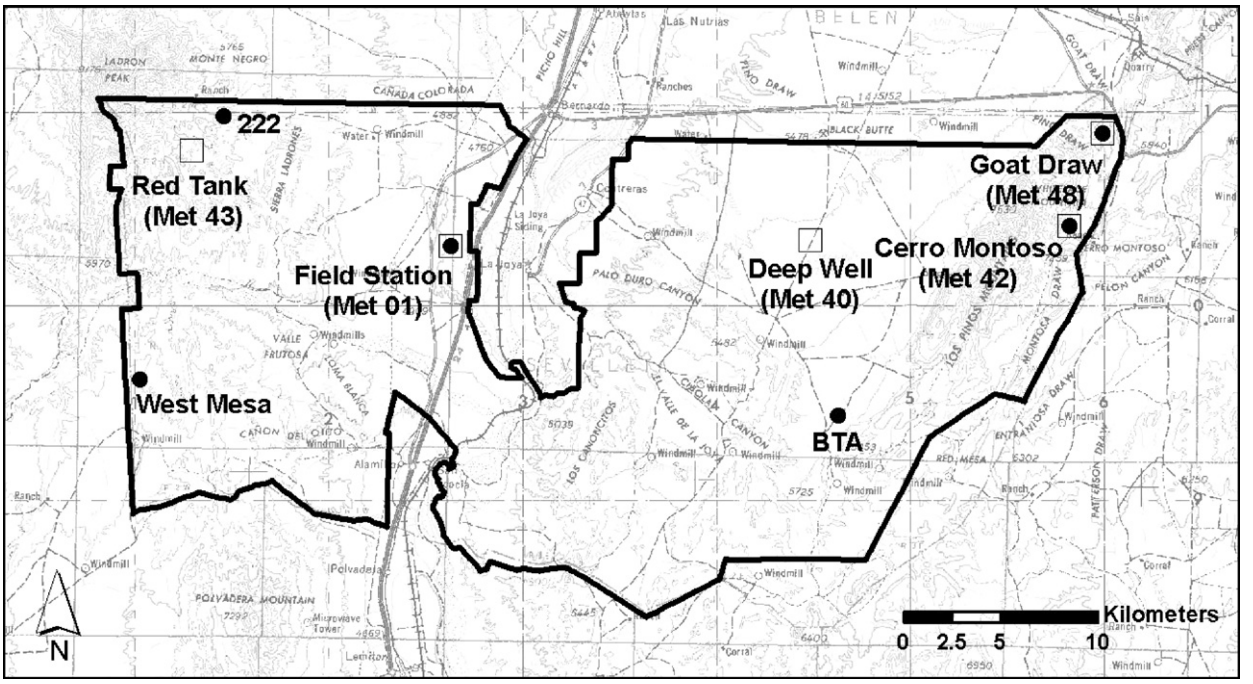

Fig. 1. Map of the Sevilleta National Wildlife Refuge with location of mast production research sites and meteorological stations (www.sev.lternet.edu).