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Recruitment and decay rate of Acacia seedlings in the hyper-arid Arava Valley, Israel

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ABSTRACT

Acacia trees, including *Acacia pachyceras*, *Acacia raddiana*, and *Acacia tortilis*, constitute some of the main keystone species throughout the hyper-arid Arava Valley of Israel. Several studies performed over the last several decades have revealed drastic changes in the acacia populations, with high mortality rates and low recruitment rates. The objective of this study was to examine the patterns of survivability – through measuring the decay rate – of acacia seedlings during the first year after germination. Following the 2012–2013 rainy season, we measured – over one entire year – the survivability of acacia seedlings in 12 ephemeral rivers (wadis). Data analysis revealed that the main impediment to the recruitment and survival of acacia seedlings is their desiccation, resulting in their mortality. This limiting factor was predominant despite the above-average and well-distributed precipitation during the year of the study. Another, secondary impediment is imposed by erosional and depositional processes under heavy flash floods, resulting in either the uprooting of the seedlings or their burial under deposited soil and fine pebble sediments. Therefore, the novelty of this study stems from the identification, quantification, and modeling of two different mechanisms that determine the decay of acacia seedlings: one with a constant mortality rate that is caused by drying, and the second with a mortality rate that grows with time, which is caused by fluvial processes. The mortality due to drying revealed high fitting to an exponential decay, while the mortality due to fluvial processes closely fits a Gaussian decay function.

1. Introduction

The *Acacia* genus comprises some of the keystone tree species in the hyper-arid Arava Valley of Israel, as well as in other Middle Eastern and North African drylands. During the last several decades, the acacia populations in southern Israel, including *Acacia tortilis*, *Acacia raddiana*, and *Acacia pachyceras*, have experienced dramatic phenological changes, particularly displaying high rates of mortality. The earliest documentation of this trend was released in the mid-1990s, with emphasis on this problem occurring throughout the Arava region (Ashkenazi, 1995). In addition to the high mortality rates, low rates of recruitment have also been highlighted. Previous studies investigated the causes for these low recruitment rates. For example, Ward and Rohner (1997) noted the decrease in the populations of large mammalian herbivores that consume the pods and enhance the germination capacity of seeds through scarification of their hard coats during digestion. Other studies proposed that infestations of insects, such as the bruchid beetle, increase the vulnerability of seeds to predation, resulting in reduced rates of germination (e.g., Or and Ward, 2003). These studies are in accord with a recent research project in several wadis throughout the Arava Valley that revealed little occurrence of young acacias, suggesting a low rate of recruitment (Stavi et al., 2014).

Drastic demographic changes in the acacia populations have also been observed in other Mediterranean drylands, such as in Egypt (Andersen and Krzywinski, 2007) and Tunisia (Noumi and Chaieb, 2012). Yet, despite the extensive research on trends in the acacia populations, very little is known about the mechanisms that affect the survivability of acacia seedlings after germination. Therefore, this study is of wide interest and relevance to the understanding of ecosystem dynamics in African and the Middle Eastern drylands where the *Acacia* genus has been prevalent. Moreover, the importance of acacias in drylands also stems from their positive impact on the physical quality of the soil underneath their canopy, improving the soil–water status and supporting the establishment of understory vegetation (De Boever et al., in press). We believe that the results of this study are not limited to the region in which it took place but that they also shed light on the general mechanisms of the germination and survivability of tree seedlings in dryland riverbeds.

The 2012–2013 rainy season was relatively wet throughout the Arava Valley, reaching a cumulative precipitation rate that was comparatively larger that the long-term inter-annual means (Central Arava R&D website) and that yielded high germination rates of acacia seedlings. The objective of this study was, therefore, to explore the survivability of

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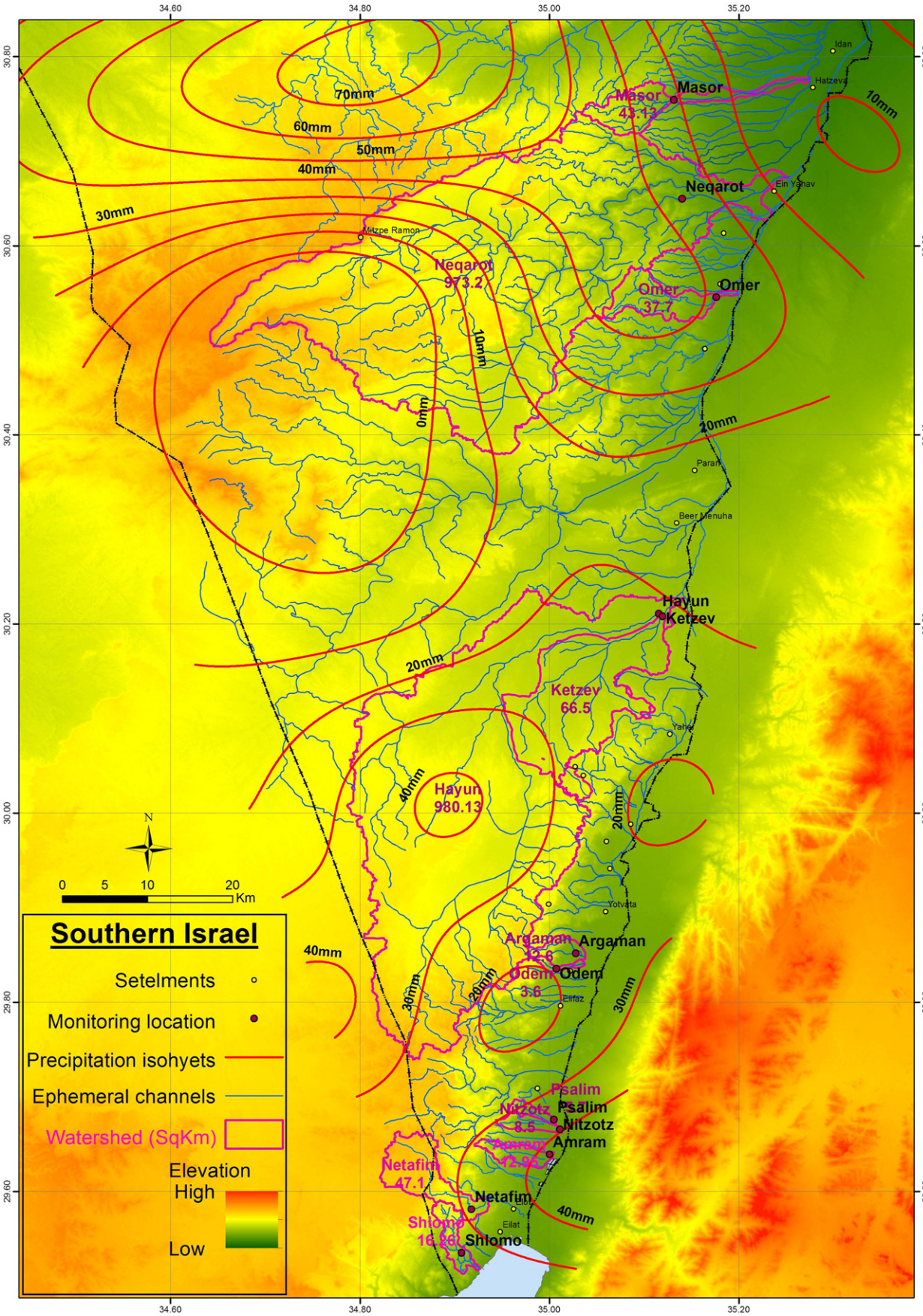

Fig. 1. Map of the study region, with cumulative precipitation isohyets for the 2012–2013 rainy season, and with circumference of the relevant basins. Rainfall data obtained from the Central Arava R&D website. Red dots represent the study's plots. Yellow dots represent rain gauges.