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Trees shifting from competition to facilitation due to apparent climatic change

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Soil water is a key component of ecosystems, modulating ecohydrological cycles across scales. Coupled ecological-hydrological data can provide key insights in understanding long-term population dynamics as well as the role of water resources in tree survival strategies over time. While the role of soil water is elementary for vegetation growth and survival, its importance is often hard to quantify due to differing time scales of long-lived plants such as trees. Thus the role of soil water availability or reciprocally tree mortality and competition under water stress are hard to quantify. Recent technological advancements regarding digital imagery and remote sensing, as well as significant progress in data analytics and data mining, have provided large spatio-temporal datasets as well as computational power and novel techniques for their analysis. Here we generate a long-term dataset (spanning from 1984 to 2001) using remote sensing techniques to identify tree individuals through time and couple it with Normalized Difference Vegetation Index (NDVI), Soil Moisture Index (SMI), and monthly precipitation data. Using this dataset of trees following over 100,000 tree individuals over time in the Kalahari, Southern Africa, we quantify tree survival as a function of soil surface water and tree density. During the same period, rainfall decreased as well as the variance in precipitation values increased. This resulted in soil water availability becoming both lower and more unpredictable throughout the duration of the study. Our analysis indicates that trees were initially competing with their nearest neighbours, as indicated by decreasing probability of survival with decreasing distance to the nearest neighbouring trees, and this coincided with the period of high soil water availability. During the latest period when soil water availability decreased, tree survival increased with decreasing distance to the nearest neighbouring trees i.e. trees that were initially competing against each other were latter on facilitating each other's survival. The suggested mechanism for driving facilitation is increased soil water availability at locations where trees form patches. The implications of these results are discussed both in terms of tree mortality as well from an ecohydrological perspective under climatic changes.

Keywords: tree survival strategies, soil moisture