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Argania spinosa and *Tetraclinis articulata* seedling regeneration factors in the lower valley of Wadi Tamri (Morocco)

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INTRODUCTION

This study focuses on the seedling regeneration factors of Argania spinosa (Argan) and Tetraclinis articulata (Thuya) in the lower valley of Wadi Tamri, (Morocco). It aims to understand the ecological processes governing the regeneration of these two important tree species and their implications for forest ecosystem dynamics and conservation efforts. It also aims to identify the characteristics of this natural regeneration as a landscape dynamic of the argan forest in the lower valley of the Oued Tamri, in a mountainous area relatively preserved as a site of biological and ecological interest in Tamri-Cap Ghir. So, the main objectives are to understand the environmental conditions and assess the human and natural impacts on the regeneration of argan and cedar seedlings in order to make better decisions about strategies to promote natural regeneration and improve the resilience of forest ecosystems. We, therefore, examined the implications of the results for formulating a conceptual framework describing the natural regeneration process of Argan and Thuya seedlings with a dual objective: firstly, to assess the natural regeneration potential of Argania spinosa and Tetraclinis articulata in the region and, secondly, to identify the key factors influencing their regeneration. To achieve these objectives, a comprehensive methodology was employed, including field surveys, vegetation measurements and spatial analysis using Geographic Information Systems (GIS).

METHODOLOGY

Firstly, extensive field surveys were conducted to gather primary data on the vegetation and environmental conditions. This included the identification and measurement of seedlings of Argania spinosa and Tetraclinis articulata, as well as the assessment of various ecological parameters. Additionally, vegetation inventory

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was taken to quantify the diversity of plants and the distribution of seedlings across two landscape units. The delimitation of these two forest landscape units is based primarily on the identification of various geographical, topographical, bioclimatic, biogeographical and anthropogenic criteria that influence the natural regeneration of the argan and Thuya trees. Although the density of tree cover within these landscape units is low, the diverse flora of the argan and Thuya understory helps to maintain the functionality of these woodland landscapes, allowing the natural regeneration of both species. Furthermore, spatial analysis techniques using geographic information systems (GIS) were employed to analyse the collected data. Utilizing GIS and statistical analysis offers a robust toolbox for assessing the state of forest landscape regeneration. The data underwent preprocessing using Excel and ArcGIS software, encompassing tasks such as geometric corrections, data integration, and spatial interpolation methods. In our processing analysis, we adopted the IDW method (Inverse Distance Weighted) for predicting and generalizing our results. This is one of the simplest and most readily available methods. It is based on an assumption that the value at an unsampled point can be approximated as a weighted average of values at points within a certain cut-off distance or from a given number of the closest points (*typically 10 to 30*). Additionally, physical analysis of the digital elevation model was conducted, coupled with visual interpretation using SAS.planete images. This approach aimed to validate specific physical conditions and provide a comprehensive overview of the study area. GIS allowed for the integration of spatial information, such as topography, regenerated seedlings, exposure, cover tree density and slope aspect, with vegetation data to identify patterns and relationships within the landscape. This spatial analysis provided insights into the factors influencing the natural regeneration of Argan and Thuya seedlings. Overall, the combination of field surveys, vegetation measurements and spatial analysis using GIS facilitated a comprehensive understanding of the natural regeneration processes of Argania spinosa and Tetraclinis articulata in the concerned region.

RESULTS

The main results of the study indicate a diverse range of factors influencing the regeneration of Argania spinosa and Tetraclinis articulata. These factors include tree cover density, elevation, slope exposure, and anthropogenic activities such as grazing and agricultural practices. The main results of the study indicate that various factors influence the regeneration of the two forest species Argania spinosa and Tetraclinis articulata. These factors depend on the density of the vegetation cover, the topography and human activities as grazing and agricultural practices. The analysis reveals varying degrees of natural regeneration potential across different landscape units, with certain areas exhibiting higher seedling densities than others. The fieldwork carried out in the lower valley of Wadi Tamri reveals the occurrence of natural regeneration of Argan and Thuya trees through seedlings in various open-range areas. Young seedlings have been observed regenerating in various fields including high altitudes, topographic depressions, steep slopes, flat grounds and abandoned agricultural terraces. Notably, stronger natural regeneration may occur in well-conserved areas with dense tree cover and minimal human impact. Consequently, the dynamics of natural regeneration are intricately linked to specific site conditions, encompassing both biotope and geosystem characteristics. The young argan and Thuya trees regenerated by seeding have an almost similar morphology, with heights varying from 30 to 150 cm depending on the age of the regeneration. Some of the young seedlings have a tufted shape, indicating the effect of grazing. Indeed, many young seedlings of the Argan and Thuya trees have been successfully initiated with nursery plants such as *Lavandula dentata*, *Genista tricuspidata*, *Genista ifniensis*, *Salsola vermiculata*, *Pistacia lentiscus*, *Periploca laevigata,* of which about 39% for young seedlings of Argan tree and almost 41% for regenerated seedlings in the forest unit with dominant Thuya.

In both landscape units, boulders provide important shelters for the germination of young seedlings. Around 33% of seedlings in the forest unit with moderately dense argan trees and 17% in the dominant Thuya class are affected by such conditions. In addition, 43% of natural regeneration was observed on the crest of the Anklout anticline. Similarly, the topographical element has an influence on the natural regeneration of Argan and Thuya. More than 36 argan seedlings and around 118 Thuya saplings were regenerated

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on slopes ranging from less than 15% to 45%. The highest percentage of argan seedlings was recorded on medium slopes (40%), followed by 24% on upper slopes and 20% on lower slopes, while ridges accounted for only 13% of natural regeneration. In the Thuya unit, seedlings were predominantly regenerated on mid-slopes (50%) and ridges (43%), while they became scarce on lower slopes due to the extremely steep terrain. The influence of geomorphology and topography is evident in the relationship between slope exposure and altitude. In the Argan tree unit, a notable presence of seedlings is observed on slopes facing West, North, North-West, and South-West, with over 38 seedlings noted. Additionally, within the forest unit dominated by Thuya trees, 78 young seedlings were identified. In particular, the argan tree shows significant regeneration between altitudes of 200 and 300m and above 300m in the study area. However, altitude remains positive for the regeneration of the dominant Thuya forest unit, particularly at altitudes of between 500 and 700m. Climate is another important factor affecting the natural regeneration process. Affected by global climate change, precipitation in the region decreased to some extent, with an average rainfall of 300 mm. In addition to the seasonal irregularity of rainfall between the driest and wettest months, climatic conditions are precarious due to the recurrence of dry spells.

The results of the analysis indicate that the argan and Thuya forests in the lower Wadi Tamri valley have a low rate of natural regeneration. This phenomenon is linked to the conditions of this environment, such as the exposure of the slopes, the density of the plant cover, the climatic conditions and human pressure. The regeneration process of a forest species comprises several stages, including fruiting, germination and seedling development. Each stage is closely influenced by environmental factors such as climate, biotic interactions and soil conditions. The significance of these factors varies, with the successful establishment of a young plant contingent upon both seed germination and seedling survival, marking the initial and most precarious phase of natural regeneration. In this context of the dominance of drought and intense pressure on the tree and its flora, the natural regeneration of Argan and Thuya appears as a phenomenon reversing the evolutionary trends of this landscape, which knows an increased degradation. For natural regeneration to take place, the argan and Thuya nuts need to be spared from systematic collection, from livestock and squirrels and from the periods of drought that often mark the region. If these conditions are fulfilled and the seedling resists, the young seedlings could then resist and pass the endangered stage in coincidence with rainy years. Furthermore, the spatial arrangement and prevalence of mature trees next to the shrub layer create environments conducive to seed dispersal, influencing significantly the likelihood of successful establishment of young seedlings.

CONCLUSION

In conclusion, the study highlights the importance of understanding the seedling regeneration dynamics of Argania spinosa and Tetraclinis articulata for effective forest management and conservation in the lower valley of Wadi Tamri. By identifying the key factors influencing seedling regeneration, the research provides valuable insights into the sustainable management of these forest ecosystems. The results of this research may contribute to the development of conservation strategies aimed at preserving the biodiversity, ecological integrity and natural regeneration of the Moroccan forest landscape in general, and supporting, in particular, the long-term viability of argan and Thuya in the lower valley of Wadi Tamri.

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