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INVESTIGATING THE FOREST COMMUNITY DISTRIBUTION IN RELATION TO SOIL PROPERTIES

Geetika Bhatia
Department of Humanities, Graphic Era Hill University, Dehradun, Uttarakhand, India 248002

ABSTRACT

The distribution of species is not uniform throughout the globe. While several studies have shown that soil quality has an impact on species diversity, the geographical variations of these soil characteristics have seldom been assessed. Thereafter, Principal Component Analysis and Norm Value Determination were used to generate the barebones set of soil property data that adequately represents the whole set. According to the results, the soil MDS mirrored the soil TDS precisely and was made up of the soil salt content (SSC), soil total phosphorus (STP), soil accessible phosphorus (SAP), soil organic carbon (SOC), and soil nitrate nitrogen (SNN). By analyzing soil factors, the RF model may potentially foretell the regional variation in species richness. The geographical connection between soil conditions and plant species diversity is an understudied area, and our research offers a new scenario and insight into this area of study. In this article, we compared a nearly pristine natural forest to one that had undergone forest degradation (DNF) and one that had been replanted with four indigenous species.

KEYWORDS VNF, forest Community, Soil Properties,

INTRODUCTION

The Eastern Himalayan and Western Ghats areas of India are recognized as some of the most biodiverse and endangered forests in the world. India has 593 national parks and wildlife sanctuaries, which together safeguard a substantial portion of the country's diverse plant and animal life. Communities living within and around these reserves place significant anthropogenic stresses on them. It is believed that more than five million people live in these protected areas. For thousands of years, people in India have been making use of the woods for a wide range of purposes. Yet, until recently, there were not many quantitative research on the effects of forest disturbance in India. Most of these studies have only looked at how it affects plants. The effects of deterioration on soils, or on soils and plants, are little studied. When trees are cut down, more rain falls directly on the ground, leaving the soil more susceptible to erosion. There is a net loss of nutrients and organic matter due to increased erosion, in addition to the removal of biomass. Trampling may cause soil to become more compacted and less permeable, leading to more surface runoff and drier conditions. Only small, humid headwater watersheds have been the focus of controlled deforestation/afforestation studies, hence the impacts of disturbance on watershed-scale hydrology have not been studied. Trails are another kind of land use that is often seen in woods, although little is known about their effects in Indian literature. Soil and water dynamics may be drastically altered by trails cut through forests for grazing animals or by Forest Service workers.

LITERATURE REVIEW

Shiekh Marifatul Haq et.al (2022) Edaphic elements' importance in characterizing forest vegetation patterns is gaining ground, which has major ramifications for the categorization of biomes and the description of biogeographic areas, as well as for regional abundance and growth patterns. Vegetation association and edaphic characteristics in the Zabarwan Mountains of the Western Himalayas are studied here. We collected information on different kinds of forests by randomly picking 60 plots (0.1 ha) from across five different kinds of forests. We used ordination and cluster analysis to examine the data after generating the important value index for each plant species and edaphic data from forests. The 76 plant species found were representative of a wide range of plant groups. The rose family was the most common, followed by the legume family and the daisy family. Types of scrub forest often have lower diversity indices than broad-leaved forest types. Using indicator species and a two-way cluster analysis, the forest flora of the Zabarwan mountains was split into two distinct categories. Canonical correspondence analysis (ordination) revealed that various gradations of soil characteristics had varying impacts on vegetation associations. The species distribution in the various forest types was mostly determined by the soil pH and calcium concentration. Coniferous forest types had more phytosociological traits (base area; 74.49 m2ha1) than broad-leaved (58.63 m2ha1) or scrub forest types (15.4 m2ha1). In order to provide evidence-based management alternatives for protecting forest ecosystems in the Himalayas, this study seeks to improve our knowledge of how different soil components affect forest composition and linkages.

Alice Cristina Rodrigues et.al (2021) It is crucial for local forest management techniques to be based on an understanding of how soil fertility varies with topographical circumstances and forest features. We examined the impact of topography and forest characteristics on soil fertility over a narrow topographic gradient in the Brazilian Atlantic Forest. We postulated that differences in topography and forest features had a beneficial effect on soil fertility (structure and diversity). We measured forest characteristics such as species diversity, tree canopy cover, and above-ground biomass. We looked at two 1-hectare (ha) forest areas with different elevation profiles. To determine the most important factors influencing soil fertility, we employed many linear mixed effects models (LMMs). More topographic diversity was shown to be the determining factor in soil fertility along a fine-scale gradient. There was a positive correlation between the first axis (PCA1) and soil parameters linked to fertility, while the second axis (PCA2) accounted for the remaining 32.2% of the variance in the soil data. PCA2 explained 17.2% more of the variation in the topographic data and showed positive correlations with both elevation and convexity. Our most accurate models indicated that elevation and convexity are the primary determinants of localized soil fertility. Our research shows that fine-scale soil fertility in an Atlantic Forest is determined by topographic heterogeneity, namely elevation and convexity. These findings expand our knowledge of how changes in topography and soil qualities, both of which are context dependent, may cause differences in forest features. The considerable diversity of environmental factors at the fine scale may also make the data gathered in this study useful for planning passive and active forest restoration initiatives.

Aleš Kučera et.al (2020) The water cycle and the soil's inherent capabilities are inextricably linked thanks to forests. Water in the soil has several effects on plant development throughout habitats, including forest stability and run-off and evaporation. Relationships between water, soil, and rock are examined, as well as the local water cycle within a catchment basin and the global water cycle across ecosystems as they pertain to the forest soil water balance. Human-caused changes may have far-reaching effects, such as increased erosion, eutrophication, salinization, the proliferation of monocultures, and alterations in ecological regimes. Water mobility in soil environments is regulated by forests because they lessen the force of run-off. By reducing the rate of runoff, we can reduce the likelihood of flash floods and provide a steady supply of water for agriculture and human use. The soil organic matter balance affects the amount of soil water that takes part in the forest's element cycle. Water balance restoration must be prioritized in every watershed basin that contains the local element cycle if forest soil hydric functions are to be preserved. More fundamentally, it is of paramount importance to work toward creating a system that is synergistically integrated and based upon the soil-forest-water-civilization nexus.

Philipp Goebes.et.al (2019) Plant productivity and community assembly are two phenomena that may be explained and modeled in large part by factors such as soil conditions and topographical features. Studies that just gather topsoil samples may be missing out on important variety found deeper in the soil. As such, we set out to determine the soil depth at which the largest links existed between soil attributes and P&CA as a result of the best interaction between soil qualities and topographical features. In a subtropical Chinese forest with varying tree and herb layer species richness and tree production, we analyzed 29 soil characteristics across 6 depth columns and 4 elements of the topography on 27 plots. The soil's characteristics and the interactions between them changed with depth. Critical soil depths, determined by the non-linearity of soil parameters, best explain various P&CA features (using coefficients of determination). It was shown that a soil column ranging from 0 to 16 centimeters had the greatest link with most P&CA parameters (adj. R2 0.7). So, one has to modify the soil depth sampled based on the kind of biological signal of interest. When thinking about P&CA in secondary subtropical broad-leaved forests, we advise taking a single bulk sample from the surface down to a crucial soil depth of 16 centimeters.

Vivekananthan Kokulan.et.al (2018) The environmental ramifications of site-specific management are affected by factors such as the topography of the area and the spatial variability of soil qualities. This research looked at how the micro-topography of a Canadian Prairies farmland affected soil characteristics spatially. Digital elevation models were used to determine the relationship between topographical parameters and soil characteristics. In the upper layers, texture was highly reliant on location, but this spatial dependence diminished with depth. The sand content's spatial autocorrelation decreased from 96% at the soil's surface (0-15 cm) to 90% at 30–45 cm and 53% at 75–90 cm. The autocorrelation structure of SWC, TC, TN, and SOC was quite comparable. Partial least squares analysis revealed a correlation between elevation, relative slope position, and vertical distance to the channel network, albeit this effect diminished with depth. Environmental assessments at the micro-scale should take into account the relationship between terrain features and the spatial variability of soil variables.

METHODS

Academic Focus The ELWNR in the Xinjiang Uygur Autonomous Region in Northwest China was the study's location of choice. The examined area has a typical northern temperate continental desert climate, with mean annual precipitation below 100 mm and mean annual evaporation over 1500 mm. We average 7.8 degrees Celsius a year. In the hottest of summers, temperatures may reach 36.4 degrees Celsius, while the coldest of winters can drop to -41.3 degrees Celsius. Rivers and groundwater are the primary sources of recharging soil water in areas with little precipitation. The low levels of local plant cover and forest biomass have an effect on the soil's organic matter content, which is only around 0.28–5.46%. Gray desert soil, aeolian sand soil, and gray brown desert soil are the most common soil types in the research region. Plant communities, especially those composed of xerophytic desert species, have flourished thanks to the wide range of soil types. Supplemental Table S1 displays the occurrence frequencies of several plant species.

Soil sampling and measurements

Sampling site

The local desert riparian forest is quite widely distributed, accounting for around 58.44% of the entire area of the ELWNR, thanks to the inclusion of seven rivers with annual flow more than 1 108 ma-1. The Aqikesu River is the longest river in the ELWNR, and its banks are home to the most extensive and representative riparian forest in the region. In this research, the height of the local plant growing season was selected to conduct neighborhood surveys and set up sample plots, allowing for a more comprehensive assessment of the area's flora.

The plant community on the north bank of the Aqikesu River was sampled in a 1-hectare (100 m 100 m) patch. The land was then subdivided into 400 identical 25 m2 (5 m 5 m) quadrats (Figure 1). The vegetation in each quadrat was surveyed. Each quadrat's height, latitude, number of plant species, and number of individual plants were noted. Since this area included the greatest variety of desert plant species and community types, a 1 ha plot was selected to study the spatial heterogeneities of species diversity and the soil MDS. There was less variation in soil quality than the length of the 1 ha plots could contain (100 m). The one hectare tract was split into 400 25 m2 quadrats so that geographical statistical analysis could be performed. The analytic objects (geographic grids) used to examine the geographical heterogeneity of species diversity must be physically close to one another, but in separate locations. Differentiating characteristics exist for each grid. Unlike the 100 m2 or 400 m2 sample sizes used in many temperate forests and mountain coniferous forests, the minimum sample area for desert riparian forests in arid conditions was found to be 25 m2.

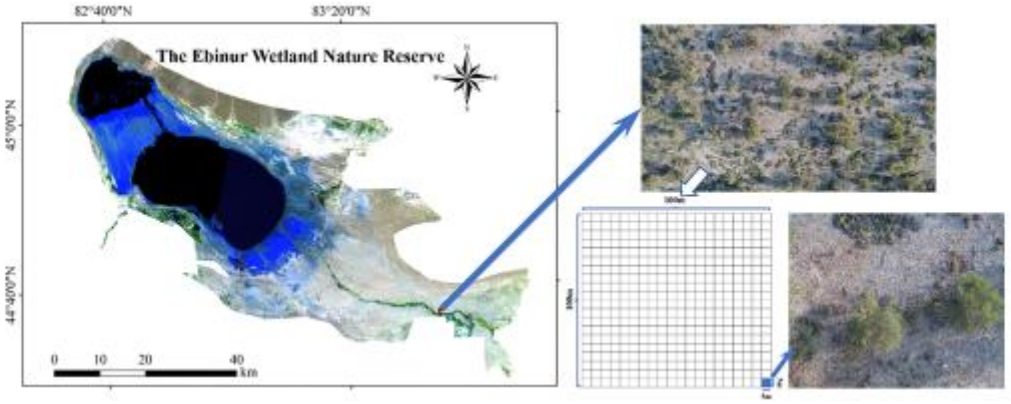
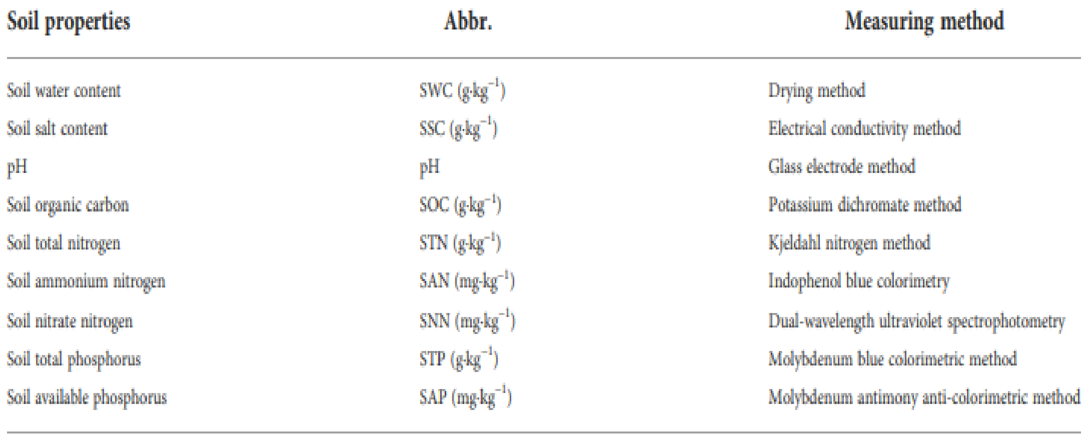


FIGURE 1 Sampling sites and the division of 1 ha sampling plot.

Sampling and measurements

The centers of the quadrats were marked as sampling stations for soil samples. Our sample object was the top 20 centimeters of soil, as recommended by Tian et al., since this layer has the greatest concentration of soil nutrients. The samples were packed into their respective aluminum containers, weighed, and returned to the lab. Soil water content was determined after collecting, drying, and weighing samples (SWC). Another set of soil samples was also collected and sieved in the lab to remove particles larger than 2 millimeters before being analyzed (Table 1).

Table 1 Measurement methods of soil properties



Soil properties	Abbr.	Measuring method
Soil water content	SWC ($g \cdot kg^{-1}$)	Drying method
Soil salt content	SSC ($g \cdot kg^{-1}$)	Electrical conductivity method
pH	pH	Glass electrode method
Soil organic carbon	SOC ($g \cdot kg^{-1}$)	Potassium dichromate method
Soil total nitrogen	STN ($g \cdot kg^{-1}$)	Kjeldahl nitrogen method
Soil ammonium nitrogen	SAN ($mg \cdot kg^{-1}$)	Indophenol blue colorimetry
Soil nitrate nitrogen	SNN ($mg \cdot kg^{-1}$)	Dual-wavelength ultraviolet spectrophotometry
Soil total phosphorus	STP ($g \cdot kg^{-1}$)	Molybdenum blue colorimetric method
Soil available phosphorus	SAP ($mg \cdot kg^{-1}$)	Molybdenum antimony anti-colorimetric method

RESULT

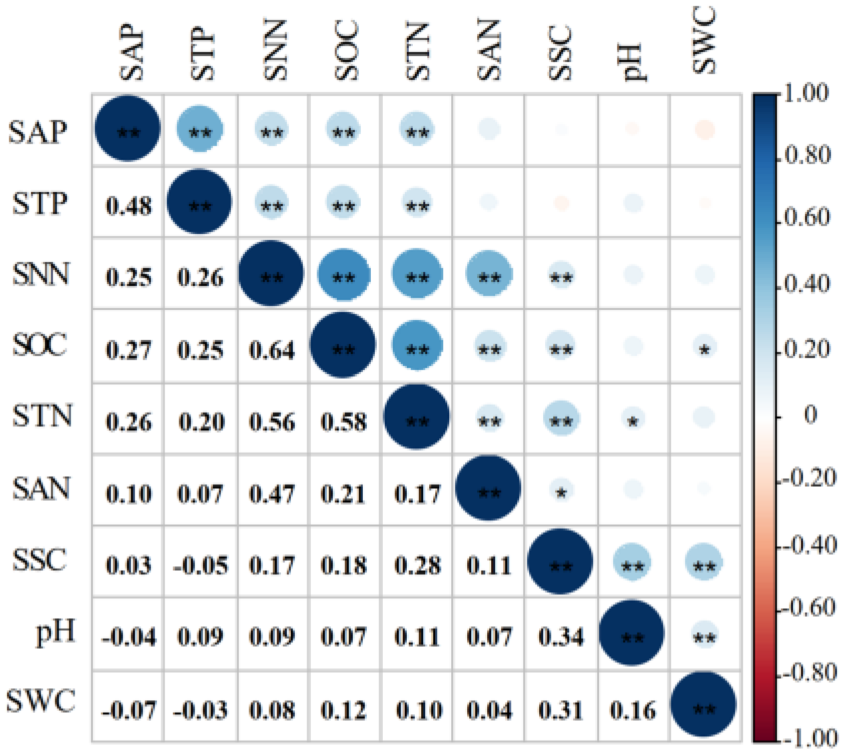
Table 2 displays descriptive data for various soil characteristics. Standardized variability, or CV, is the ratio of the standard deviation to the mean value. Soil parameters had CV values between 3.90% (pH) to 57.20%. (SOC). Soil characteristics may be divided into two groups depending on their CV values, as described by Hillel (1980) and Nielsen and Bouma (1985): those with low CV values and those with intermediate CV values.

TABLE 2 Descriptive statistics of soil properties

Indicators	Maximum	Minimum	Mean ± SD	SE	CV (%)	Normal distribution
SWC (g·kg−1)	26.11	5.18	13.12 ± 3.70	0.19	18.50	L.N.
SSC (g·kg^{-1})	10.21	1.33	5.59 ± 2.44	0.12	43.60	N
pH	8.94	7.22	8.07 ± 0.32	0.02	3.90	L.N.
SOC (g·kg^{-1})	27.73	2.04	9.57 ± 5.51	0.27	57.20	N
SAP (mg·kg^{-1})	89.76	11.67	38.19 ± 14.99	0.75	39.10	L.N.
STP (g·kg^{-1})	2.17	0.83	1.31 ± 0.25	0.01	19.30	N
STN (g·kg^{-1})	9.98	0.51	2.05 ± 0.75	0.04	36.60	L.N.
SAN (mg·kg^{-1})	10.21	0.60	2.48 ± 1.27	0.06	51.60	L.N.
SNN (mg·kg^{-1})	43.97	2.03	12.51 ± 7.12	0.36	57.00	L.N.

The K-S test results showed that the SSC, SOC, and STP all had normal distributions, indicating that the variances among them were small and there were no extreme values. As the SWC, pH, SAP, STN, and SAN data did not follow a normal distribution, a logarithmic transformation was performed on them (Table 2).

Correlation coefficients between soil parameters (shown in Figure 2) were mostly significant at the 0.01 and 0.05 levels, suggesting that the soil TDS was superfluous. The MDS of the soil may then be calculated from the TDS.



	SAP	STP	SNN	SOC	STN	SAN	SSC	pH	SWC
SAP	**	**	**	**	**				
STP	0.48	**	**	**	**				
SNN	0.25	0.26	**	**	**	**	**		
SOC	0.27	0.25	0.64	**	**	**	**		*
STN	0.26	0.20	0.56	0.58	**	**	**	*	
SAN	0.10	0.07	0.47	0.21	0.17	**	*		
SSC	0.03	-0.05	0.17	0.18	0.28	0.11	**	**	**
pH	-0.04	0.09	0.09	0.07	0.11	0.07	0.34	**	**
SWC	-0.07	-0.03	0.08	0.12	0.10	0.04	0.31	0.16	**

FIGURE 2 Correlation coefficients of soil properties.

The SAP, SOC, and SNN correlation coefficients were all lower than 0.5. (Figure 2). The soil MDS was populated with data on five different soil properties: SSC, STP, SAP, SOC, and SNN.

THE MDS COMPOSITION OF SOIL PROPERTIES

Water and salt were the key factors limiting environmental parameters in the arid desert ecosystem. There is a connection between plant growth, nitrogen cycling, and biological activity and soil water content (SWC). The MDS did not take into consideration the soil water content (SWC). The limiting impact of SWC on biological processes may have been obscured since the riparian forest under research was located near a river, where SWC was rather high in compared to other dry areas. In addition, SWC was positively correlated with salinity in the dry desert. Due to data redundancy, the MDS eliminated SWC when soil salinity (SSC) was included. This article demonstrates that SSC is significantly correlated with SWC.

As STP is crucial to plant biochemical processes and nutrient cycling, it was also deemed a limiting factor in the dry desert environment and included in the MDS. Phosphorus availability could not be accurately predicted using STP. SAP was very water-soluble, desorbed quickly, and exchanged quickly. Hence, SAP was widely employed in the assessment of soil fertility as one of the best features of soil phosphorus supply. Higher Norm values for SAP within group 3 made it clear that it was the soil MDS indicator of choice (0.82). Biological processes were affected differently by ammonium and nitrate nitrogen, two of the types of nitrogen present in soil. The MDS in this research only contained SNN, leaving out STN and SAN. This was due to the fact that, unlike the other two forms, SNN may be quickly and immediately absorbed by plants. Soil nitrogen availability (SNN) was an immediate indicator of whether or not poor soil could provide plants with nitrogen. Soil organic matter (SOM) was the foundation of soil fertility because of the positive effects it had on the soil's physical, biological, and structural health. Our research indicated that SOC is a favored component of desert riparian forest soil MDS.

Based on our findings, the MDS of soils includes SSC, SOC, STP, SAP, and SNN. Our soil MDS may replace soil TDS in expressing the condition of soil properties, as shown by the strong correlation between SPIMDS and SPI-TDS (R2 = 0.62). This is to say, the created soil MDS may give enough data to foretell the spatial variance in plant variety. Soil MDS construction allowed for a reduction in the number of soil properties from nine to five. While some valuable soil information may be lost in the process, the soil MDS simplified the soil TDS and set a precedent for future efforts along these lines.

Litter and soil properties

The properties of the litter and soil were found to vary significantly amongst forest cover types (Fig. 3, Tab. 3). CSP stands had a substantially greater (p 0.05) mean litter layer thickness (3.57 cm) than the other forest cover types tested (especially when compared to the ASP means) (1.04 cm). Litter C

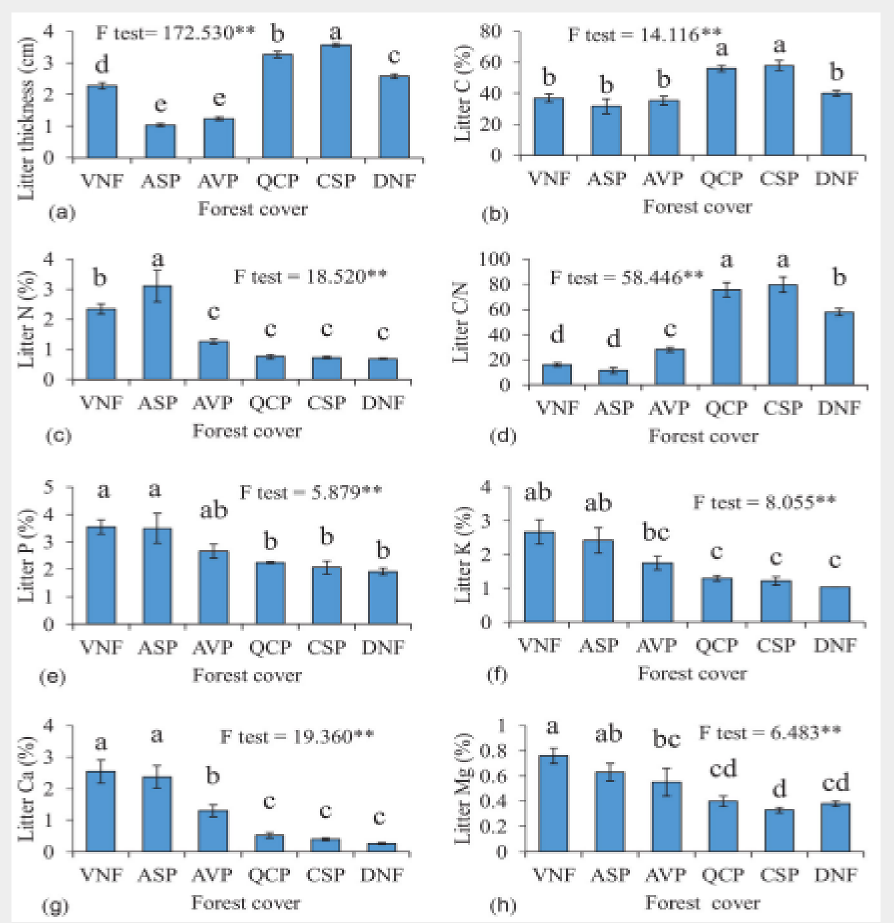
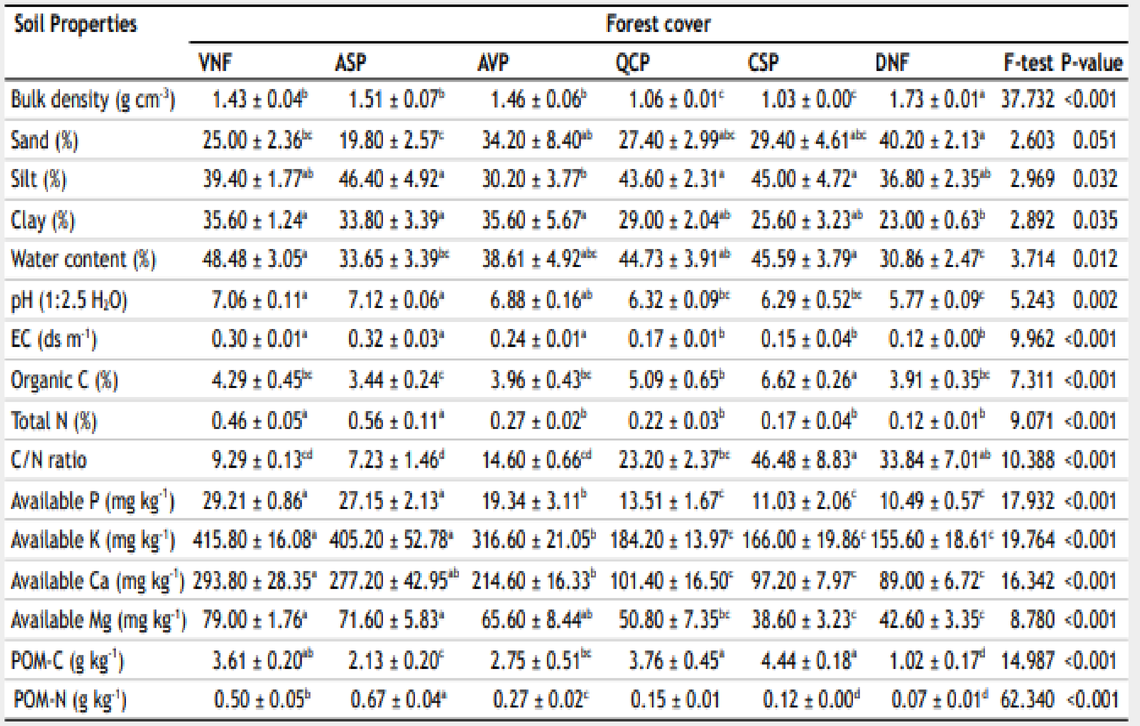


Fig. 3 - Mean values of the litter properties across different forest covers.

Tab. 3 - Mean (± standard error, SE) of the soil physical, chemical and biological properties analyzed under different forest covers.



Soil Properties	Forest cover							
	VNF	ASP	AVP	QCP	CSP	DNF	F-test	P-value
Bulk density (g cm^{-3})	1.43 ± 0.04^{b}	1.51 ± 0.07^{b}	1.46 ± 0.06^{b}	1.06 ± 0.01^{c}	1.03 ± 0.00^{c}	1.73 ± 0.01^{a}	37.732	<0.001
Sand (%)	25.00 ± 2.36^{bc}	19.80 ± 2.57^{c}	34.20 ± 8.40^{ab}	27.40 ± 2.99^{abc}	29.40 ± 4.61^{abc}	40.20 ± 2.13^{a}	2.603	0.051
Silt (%)	39.40 ± 1.77^{ab}	46.40 ± 4.92^{a}	30.20 ± 3.77^{b}	43.60 ± 2.31^{a}	45.00 ± 4.72^{a}	36.80 ± 2.35^{ab}	2.969	0.032
Clay (%)	35.60 ± 1.24^{a}	33.80 ± 3.39^{a}	35.60 ± 5.67^{a}	29.00 ± 2.04^{ab}	25.60 ± 3.23^{ab}	23.00 ± 0.63^{b}	2.892	0.035
Water content (%)	48.48 ± 3.05^{a}	33.65 ± 3.39^{bc}	38.61 ± 4.92^{abc}	44.73 ± 3.91^{ab}	45.59 ± 3.79^{a}	30.86 ± 2.47^{c}	3.714	0.012
pH (1:2.5 H_2O)	7.06 ± 0.11^{a}	7.12 ± 0.06^{a}	6.88 ± 0.16^{ab}	6.32 ± 0.09^{bc}	6.29 ± 0.52^{bc}	5.77 ± 0.09^{c}	5.243	0.002
EC (ds m^{-1})	0.30 ± 0.01^{a}	0.32 ± 0.03^{a}	0.24 ± 0.01^{a}	0.17 ± 0.01^{b}	0.15 ± 0.04^{b}	0.12 ± 0.00^{b}	9.962	<0.001
Organic C (%)	4.29 ± 0.45^{bc}	3.44 ± 0.24^{c}	3.96 ± 0.43^{bc}	5.09 ± 0.65^{b}	6.62 ± 0.26^{a}	3.91 ± 0.35^{bc}	7.311	<0.001
Total N (%)	0.46 ± 0.05^{a}	0.56 ± 0.11^{a}	0.27 ± 0.02^{b}	0.22 ± 0.03^{b}	0.17 ± 0.04^{b}	0.12 ± 0.01^{b}	9.071	<0.001
C/N ratio	9.29 ± 0.13^{cd}	7.23 ± 1.46^{d}	14.60 ± 0.66^{cd}	23.20 ± 2.37^{bc}	46.48 ± 8.83^{a}	33.84 ± 7.01^{ab}	10.388	<0.001
Available P (mg kg^{-1})	29.21 ± 0.86^{a}	27.15 ± 2.13^{a}	19.34 ± 3.11^{b}	13.51 ± 1.67^{c}	11.03 ± 2.06^{c}	10.49 ± 0.57^{c}	17.932	<0.001
Available K (mg kg^{-1})	415.80 ± 16.08^{a}	405.20 ± 52.78^{a}	316.60 ± 21.05^{b}	184.20 ± 13.97^{c}	166.00 ± 19.86^{c}	155.60 ± 18.61^{c}	19.764	<0.001
Available Ca (mg kg^{-1})	293.80 ± 28.35^{a}	277.20 ± 42.95^{ab}	214.60 ± 16.33^{b}	101.40 ± 16.50^{c}	97.20 ± 7.97^{c}	89.00 ± 6.72^{c}	16.342	<0.001
Available Mg (mg kg^{-1})	79.00 ± 1.76^{a}	71.60 ± 5.83^{a}	65.60 ± 8.44^{ab}	50.80 ± 7.35^{bc}	38.60 ± 3.23^{c}	42.60 ± 3.35^{c}	8.780	<0.001
POM-C (g kg^{-1})	3.61 ± 0.20^{ab}	2.13 ± 0.20^{c}	2.75 ± 0.51^{bc}	3.76 ± 0.45^{a}	4.44 ± 0.18^{a}	1.02 ± 0.17^{d}	14.987	<0.001
POM-N (g kg^{-1})	0.50 ± 0.05^{b}	0.67 ± 0.04^{a}	0.27 ± 0.02^{c}	0.15 ± 0.01	0.12 ± 0.00^{d}	0.07 ± 0.01^{d}	62.340	<0.001

greater than in any other kind of forest cover (57%). While comparing forest types, ASP had the lowest litter C (31.68%) and QCP had the highest (56%). In contrast, when ASP was established, the concentration of litter N increased to 3.11 percent, which was greater than any of the other forest cover types. The Litter C/N ratio varied greatly amongst forest types, with ASP having the lowest value and being most similar to VNF. The largest concentrations of Ca, P, K, and Mg were found in VNF, although there was no statistically significant difference between VNF and ASP (Fig. 2).

Soil physical and chemical parameters also varied significantly across forest cover types. DNF had the highest bulk density (1.73 gr cm-3) of any forest cover studied, whereas CSP (1.03 gr cm-3) and QCP (0.98 gr cm-3) had the lowest (1.06 gr cm-3). Several types of forest cover were found to have significantly different soil textures. The sand content ranged from 19.8% in ASP to 40.2% in DNF. DNF included much less clay than VNF, ASP, and AVP, but ASP and AVP contained significantly more silt (Tab. 1).

Both VNF and CSP had considerably greater soil water content than DNF (48.48% and 45.59%, respectively). The soil pH was similarly quite low in DNF (5.77), whereas the highest values were seen in ASP and VNF. Soil organic carbon (SOC) and the carbon to nitrogen (C/N) ratio were both highest at CSP. VNF had the highest available soil Ca, whereas VNF and ASP had significantly higher total N, P, K, and Mg. Soil total nitrogen, phosphorus, and potassium levels were all lowest in DNF. Consistent with the distribution of soil organic C and total N, the average POM-C was 4.44 0.18 in CSP and the average POM-N was 0.67 0.04 in ASP. (Tab. 1).

CONCLUSION

The RF model's precision was much higher than that of the MLR model. Our research showed that RF projections derived from the soil MDS closely resembled the actual diversity pattern. Plant species diversity differed across space according to the multidimensional scaling (MDS) of soil parameters. The distribution of species was heavily influenced by SSC and SOC. One of the most crucial functions of an ecosystem is productivity, which in turn is linked to the variety of species present in a given community. It is also an interesting research subject whether or not species variety influences production in desert riparian forests. But we did not put this theory to the test here. Based on our findings, both near-pristine natural forests and A. subcordata plantations had considerably greater levels of soil nutrients.

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