Revista de Economia, Empresas e Empreendedores na CPLP
Journal of Economics, Business and Entrepreneurship in the CPLP
ISSN 2183-7201 | V12 | Special Issue, Vol, 1 | 2026

Forests of Polylepis in Moquegua, Peru: An urgent call for their conservation

Bosques de Polylepis en Moquegua, Perú: Un llamado urgente para su conservación

Jorge Luis Tomas Florez Salas [1], **Elizabeth Marina Ramos Saira** [1], **Víctor Yapuchura Platero** [2], **Fabrizio Del Carpio Delgado** [1], **Mariela Fresia Caihuaray Silva** [2], **Suheily Corina Lanchipa Quiroga** [3], **Kevin Mario Laura De La Cruz** [2]

[1] Universidad Nacional de Moquegua, Peru
[2] Universidad Nacional Jorge Basadre Grohmann, Peru
[3] Universidad Privada de Tacna, Peru

Corresponding author: Kevin De La Cruz | klaurac@unjbg.edu.pe
ORCID: https://orcid.org/0000-0002-7083-1825
DOI: https://doi.org/10.29073/e3.v12i3.1086

Received: 12/03/2026 | **Accepted**: 17/03/2026 | **Published**: 01/05/2026

Abstract

The purpose of this study is to identify and calculate the most precise conceivable spatial distribution area for Polylepis species in the Moquegua department. Despite the importance of Polylepis forests in the provision of services linked to human well-being, these are mainly threatened by the lack of knowledge that exists about them, that there are no studies available on the spatial distribution, surface and environmental variables that require for their normal development, for which they use the software ArcGIS 10.3, the method of predictive models of spatial distribution, the visual interpretation of these combined with Google Earth images and the field evaluations using control points, it has been determined that The surface of the forests is of 12 893.85 hectares distributed in the mountains, slopes and plains between 4225 to 5175 m asl. The analysis of the variables translates into a new image. It is a classification system. frequency of frosts, once high precipitations and steep slopes are required, observing the optimum conditions for their development, are the values calculated in where the largest forest surface is distributed, such as: Precipitation with values greater than 600 mm, the optimum climate is the sub humid and frigid, 54% of the relative humidity in most of the surface, geomorphologically better adapted to the media on the right side of the surface of the surface, geographically, emplaced and moderately steep and mainly in soils of the Inceptisol type. These are the characteristics of the ability to use.

Keywords: Polylepis, SIG, Moquegua, Characterization, Spatial distribution.

Resumen

El propósito de este estudio es identificar y calcular el área de distribución espacial más precisa concebible para las especies de Polylepis en el departamento de Moquegua. A pesar de la importancia de los bosques de Polylepis en la prestación de servicios relacionados con el bienestar humano, estos se ven principalmente amenazados por la falta de conocimiento existente sobre ellos, ya que no existen estudios disponibles sobre la distribución espacial, las variables superficiales y ambientales que requieren para su desarrollo normal, para los cuales utilizan el software ArcGIS 10.3. el método de modelos predictivos de distribución espacial, la interpretación visual de estos combinada con imágenes de Google Earth y las evaluaciones de campo usando puntos de control, ha determinado que la superficie de los bosques es de 12.893,85 hectáreas, distribuidas en las montañas, laderas y llanuras entre 4225 y 5.175 m sobre el nivel del mar. El análisis de las variables se traduce en una nueva imagen. Es un sistema de clasificación. frecuencia de heladas, una vez que se requieren altas precipitaciones y pendientes pronunciadas, observando las condiciones óptimas para su desarrollo, son los valores calculados donde se distribuye la mayor superficie forestal, tales como: precipitaciones con valores superiores a 600 mm, el clima óptimo es subhúmedo y gélido, 54% de la humedad relativa en la mayor parte de la superficie, geomorfológicamente mejor adaptado al medio en el lado derecho de la superficie, geográficamente, desplazado y moderadamente empinado, y principalmente en suelos del tipo Inceptisol. Estas son las características de la capacidad de usar.

Palabras clave: Polilepis, SIG, Moquegua, Caracterización, Distribución espacial.

INTRODUCTION

The Polylepis forests represent one of the most vulnerable ecosystems of the high Andes, due to the increasing human pressure from economic, social, and cultural factors (Servat et al., 2002). However, these ecosystems play a central role in Andean ecology, serving as habitats for many species of plants and animals, as an important source of resources for local inhabitants, as atmospheric CO2 absorbers, soil formers, associated medicinal plants, and regulators of the water cycle (Fjeldsa & Kessler, 1996; Venero & De Macedo, 1983; Arévalo & Recharte, 2003; Kessler, 2006; León, 2009, Castro & Flores, 2015).

Increasingly vulnerable, Polylepis (Rosaceae) forests are an important Andean ecosystem for the protection of biodiversity and the mitigation of local climate change effects (Zutta B., 2012). There is great ecological, systematic, and biogeographical interest in the genus Polylepis because it represents a unique biological system in the Andes, characterized by its restricted distribution (Koepcke 1961, Servat et al. 2002). The genus Polylepis includes approximately 27 species (Mendoza & Cano 2011, Kessler & Schmidt-Lebuhn 2006) that form evergreen forests with highly fragmented populations throughout the highlands of the tropical and subtropical Andes. It is estimated that less than 10% of their original extent remains in the high regions of Bolivia and Peru (Fjeldså & Kessler 1996) and fourteen species are listed as vulnerable (IUCN 2011). However, these forests contain a variety of endemic and endangered species (Servat et al. 2002) and perform important hydrological functions in fog interception. (Zutta B. 2012).

For Peru, 19 species are reported (more than 70% of the 27 registered for the entire Andean area), making Peru the country with the greatest diversity of Polylepis, compared to Bolivia (13), Ecuador (7), Argentina (4), Colombia (3), Chile (2), and Venezuela (1) (Mendoza & Cano 2011); Polylepis sp. are distributed across 19 departments, with the largest numbers found in Cusco (10) and Ayacucho (8). The highest diversity of species (15) was recorded in the southern Andes, with this region being considered the probable center of diversification for the genus Polylepis. Regarding the altitudinal distribution, the highest species diversity (18) is found between 3000 and 4000 meters in altitude. For the Moquegua department in Peru, the distribution of two species is considered: Polylepis subtusalbida and P. rugulosa. (Mendoza & Cano, 2011). In all the countries where Polylepis forests exist, efforts are being made for their conservation and restoration, from the creation of protected areas, research, to numerous reforestation projects. Even so, there is still much to be done. As an example, in almost all species of Polylepis, their complete distribution remains to be mapped. It is also unknown what the extent, structure, and biological diversity of Polylepis forests would be without strong human intervention. This information is important as it could be used to design reference areas to consider when making management decisions (Renison R., 2013). The ecological conditions (biotic and abiotic) of Polylepis forests can be characterized mainly in relation to temperature, humidity, and soil conditions. The fluctuations of these variables represent enormous stress for the plants, especially at altitudes above 4,000 m, demonstrating that most species show adaptations to low temperatures. These can be morphological, such as the thick bark of Polylepis and the cushion growth of Azorella, or physiological, such as freeze resistance, which is also observed in Polylepis (Goldstein et al. 1994, Körner 1999; Hoch & Körner 2005). The existing information on the area of Polylepis forests in Peru was generated thru various studies by the Ministry of the Environment at a national scale of 1:100,000, such as the National Vegetation Coverage Map of 2015 or the recent Ecosystems Map of Peru. However, the spatial distribution is generic and does not allow for the identification of the specific spatial distribution and area of Polylepis, much less its ecology based on environmental variables such as geology, geomorphology, climatology, and edaphology, which are directly related to the development and growth of the species. In this research work, two objectives were set: i) To determine and calculate the most precise possible spatial distribution area of the Polylepis species in the Moquegua department, and ii) To characterize the environmental variables of the Polylepis forests in the southernmost part of Peru.

MATERIALS AND METHODS

The studied area is located at the southernmost tip of Peru, in the Moquegua department, bordering Tacna, Arequipa, and Puno (Figure 1). To determine the spatial distribution area of Polylepis, 3 spatial distribution models (SDMs) were conducted, using "train" points and the BIOCLIM algorithms from ArcGIS 10.3. Based on them, the predictive analysis was carried out along with high-resolution images from Google Earth and above the reference altitude of 4000 meters above sea level at a scale of 1:10,000, with greater precision in the digitization of the Polylepis relict forests through visual interpretation and verification in field outings with 100 control points. To determine the species Polylepis, the key by Mendoza & Cano (2012) was used, whose analysis of the morphological characteristics of the species was carried out in the field (without collection). For the characterization of environmental variables, the vector information generated during the Ecological and Economic Zoning process of Moquegua (El Peruano, 2018) was used; for this, the vector polygons in shape format of: Climate Classification, Maximum, Average, Minimum Temperature, Precipitation, Relative Humidity, Soils, Physiography, Slope, Geology, Geomorphology, among others, and the cut was made using the Clip tool in ArcGIS 10.3, taking as a reference the polygon of the forest surface determined in the previous process.

Figure 1 – Study area of the spatial distribution and environmental characterization of relict Polylepis forests in the southernmost part of Peru, Moquegua department

RESULTS

The area of relict high Andean forests of the species Polylepis that are spatially distributed in the southernmost part of Peru is 12,893.85 hectares and is located at altitudes between 4,225 and 5,175 meters above sea level (Figure 2). Regarding the evaluated environmental variables, it has been determined that 77.6% of the forest area is distributed in zones with average annual precipitation greater than 600 mm (Figure 3), while in zones with average annual precipitation less than 200 mm (Figure 4), its distribution is limited to 0.7% of the forest area. Regarding the climatic classification, 68% of the surface is in subhumid and frigid zones, while 32% is in subhumid and semifrigid zones (Figure 5). The evaporation level ranges from 1535 to 1600 mm/day, occurring in 8% of the forest area, while it is from 1600 to 1665 mm/day in 70% of the area, reaching its highest level (1665-1730 mm/day) in 22% of the forest area (Figure 6). At the level of evapotranspiration (ETP), 54% of the forest area is at levels of 1421 to 1440 mm/day, followed by 43% of the area at levels of 1401 - 1420 mm/day. The minimum ETP level is between 1381 to 1400 mm/day and occurs in only 1% of the forest area, while the maximum ETP level is between 1441-1460 mm/day and occurs in 3% of the area. (Figure 7). Regarding relative humidity, 96% of the total surface area is distributed in zones with values between 48 and 54% relative humidity (Figure 8). Regarding temperatures (Figures 9, 10, and 11), 60% of the forest area has a maximum temperature ranging from 11.9 to 13.3°C with a tendency toward lower values (8.9 to 11.8°C). Regarding the average temperature, the largest percentage of the surface has values between 4.1 to 6°C with a tendency toward higher values. The minimum temperature for the distribution of Polylepis is in the range of -11.4 to -5.03.

Regarding precipitation (Figure 12), it has been determined that 10% of the Polylepis area can develop with values between 300 and 400 mm of precipitation, with values greater than 400 mm being adequate. The Major Use Capacity (MUC) allows for the characterization of soil potential and indicates that Polylepis forests are mainly distributed in protective lands, but they are also associated with grazing areas (Figure 13). Regarding the physiography, they are mainly distributed in glacial mountain areas with steep, moderately steep, and very steep slopes. (Figure 14). Geologically, the Polylepis forests are primarily on the sandy group, fluvioglacial deposit, and morainic deposit, with more than 90% of the surface distributed among the three types. (Figure 15). At the geomorphological level, Polylepis forests are found in mountains and to a lesser extent in plains (Figure 16). According to the hydrogeological classification, 42.8% is unconsolidated porous and 17.9% volcanic fissured, with 37.1% being undetermined (Figure 17).

At the slope level, the largest area of Polylepis forests is found on moderately steep, strongly inclined, moderately inclined, and strongly steep slopes. (Figure 18). According to the type of soils (Figure 19), they are mainly located in the Inceptisol and Entisol types (with more than 98%), while 1.2% are found in miscellaneous rock types and 0.1% in histosol. Regarding frost, 86% of the forest area is located in zones where this phenomenon occurs for more than 95 days a year, while 13.95% of the area experiences it between 90 to 95 days, and only 0.5% between 80 to 90 days. (Figure 20). Regarding solar radiation, the only value given across the entire forest area is 5.5-6.0. (Figure 21).

Figure 2 – Spatial distribution of Polylepis, covering an area of 23,081.76 ha

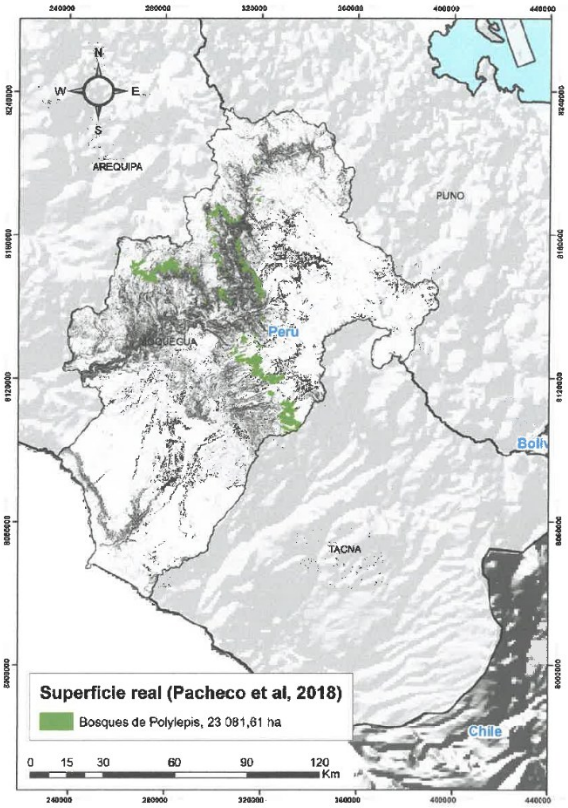


Figure 3 – Wet year. Forest area according to precipitation levels

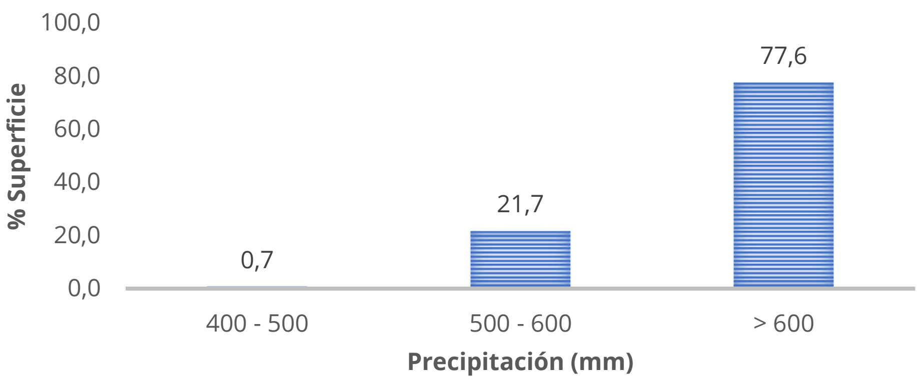


Figure 4 – Dry year. Forest area according to precipitation levels

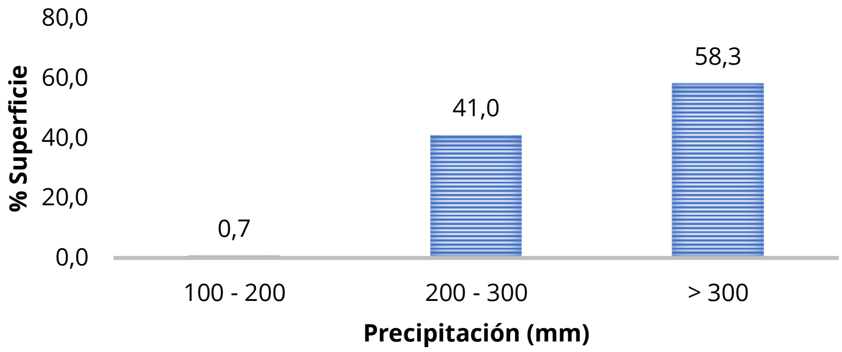


Figure 5 – Area of Polypesis forests according to climate type

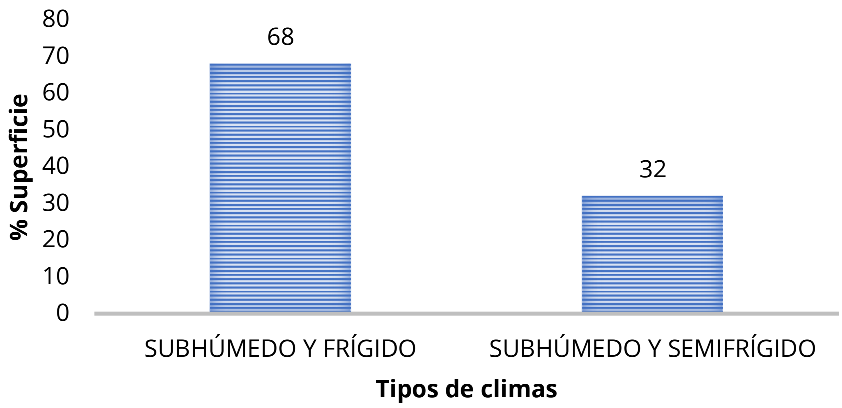
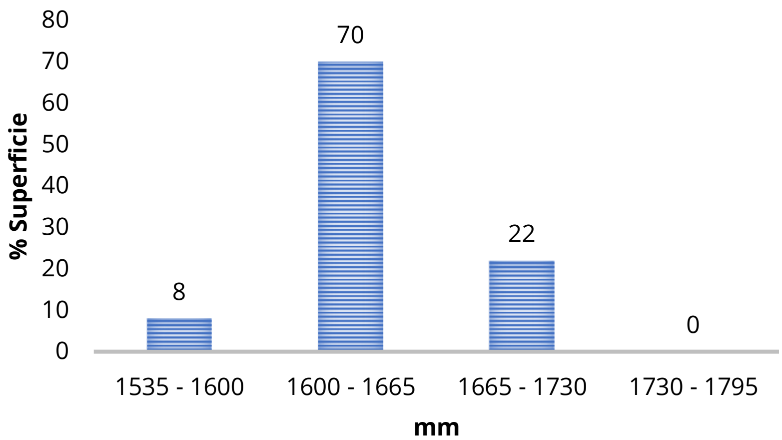


Figure 6 – Surface area of forests according to the level of evaporation



Revista de Economia, Empresas e Empreendedores na CPLP
Journal of Economics, Business and Entrepreneurship in the CPLP
ISSN 2183-7201 | V12 | Special Issue, Vol, 1 | 2026

Figure 7 – Forest area according to the level of evapotranspiration

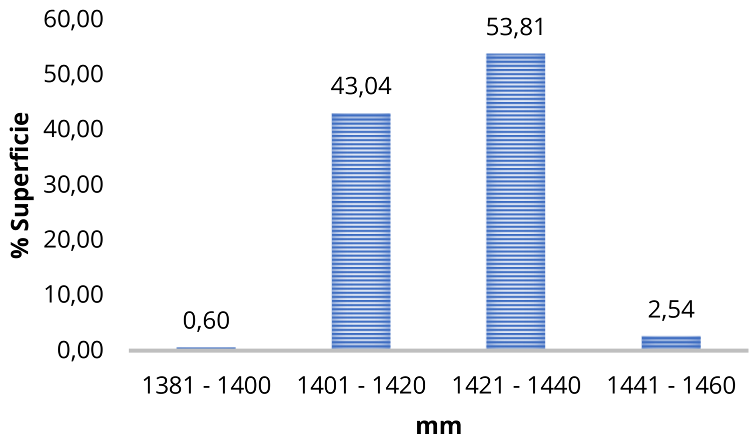


Figure 8 – Forest area according to the level of relative humidity

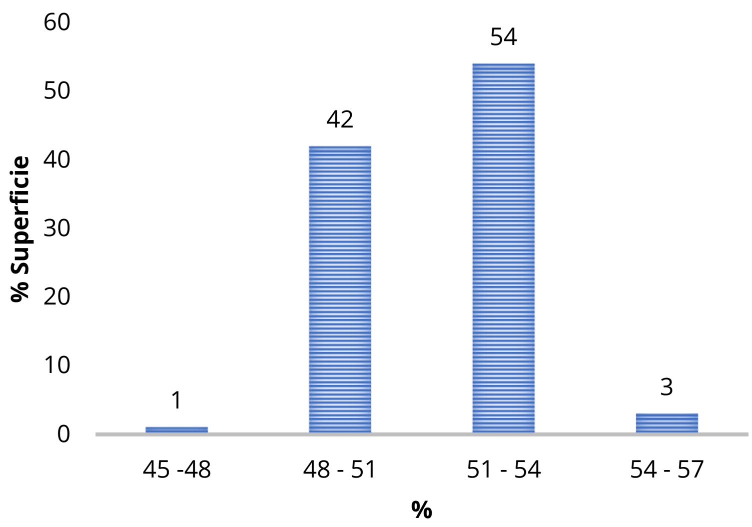


Figure 9 – Forest area according to maximum temperature

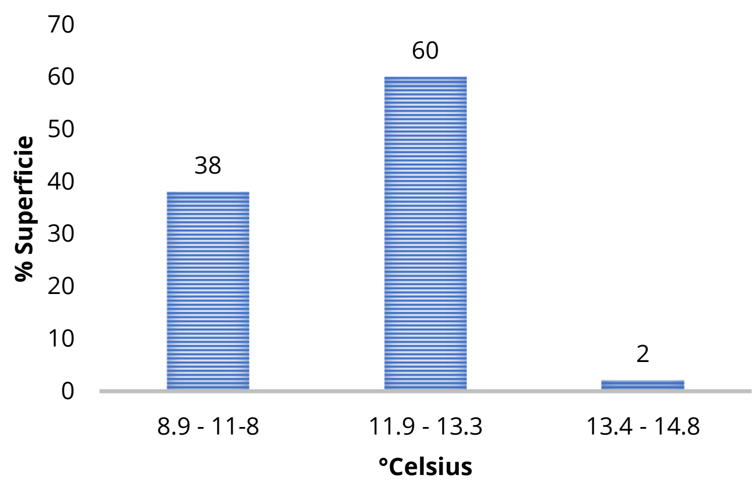


Figure 10 – Forest area according to average temperatures

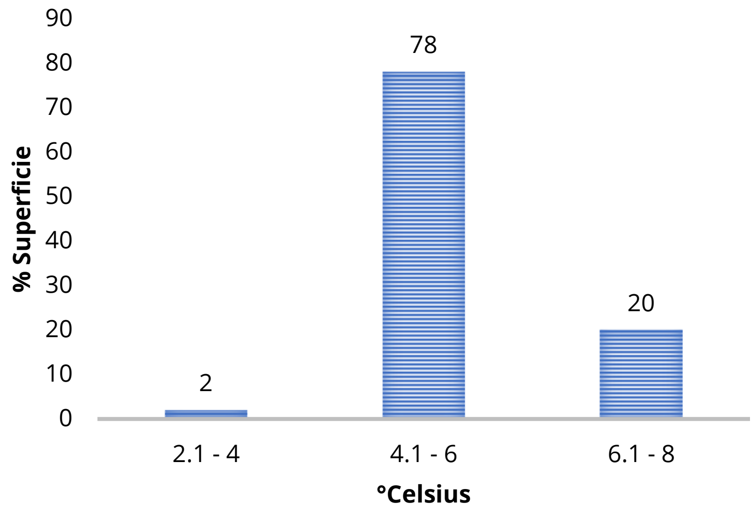


Figure 11 – Forest area according to minimum temperatures

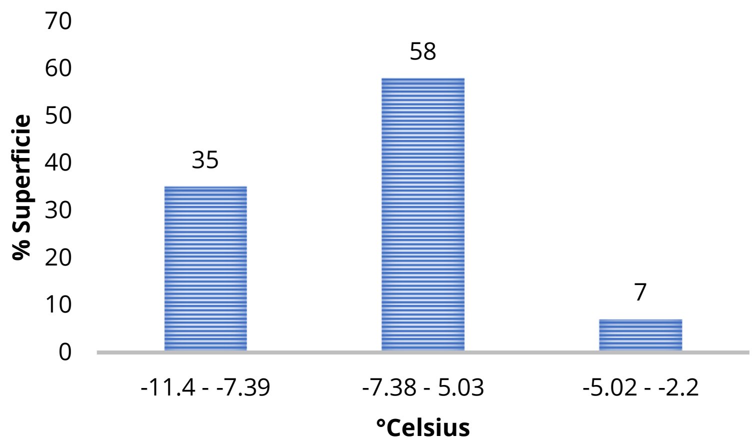


Figure 12 – Forest area according to precipitation levels

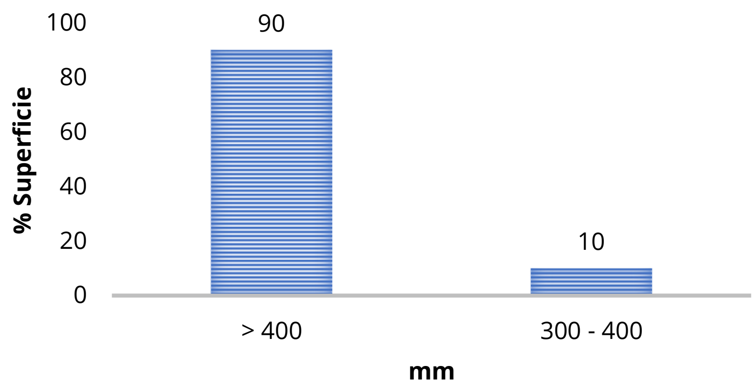


Figure 13 – Forest area according to the highest land use capability

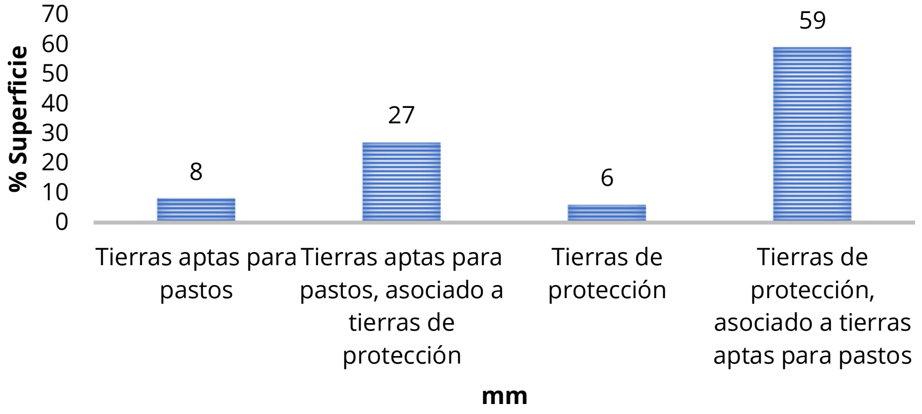


Figure 14 – Forest area according to the type of physiography

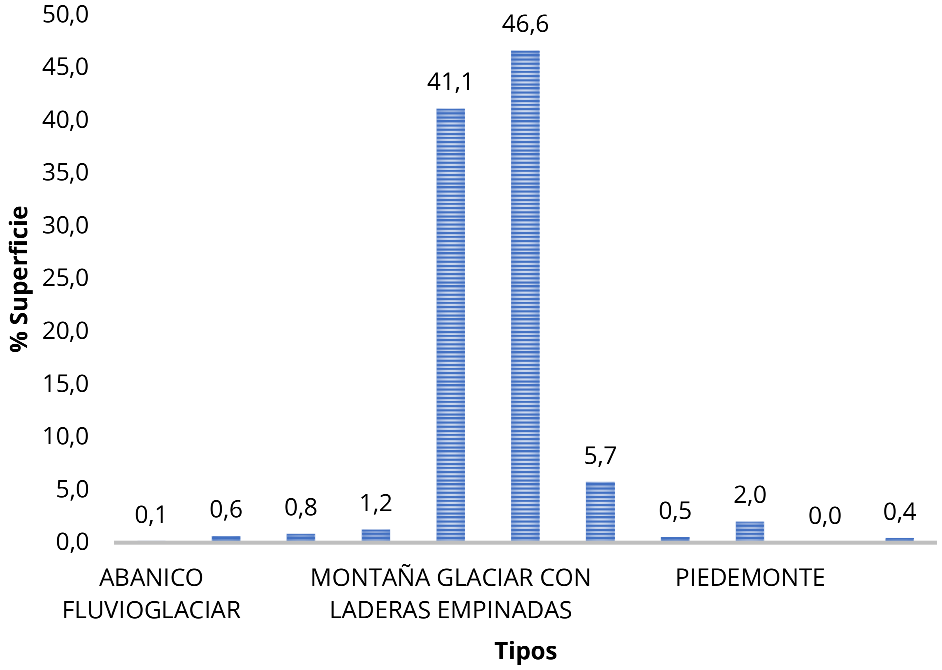


Figure 15 – Surface area of forests according to geological units

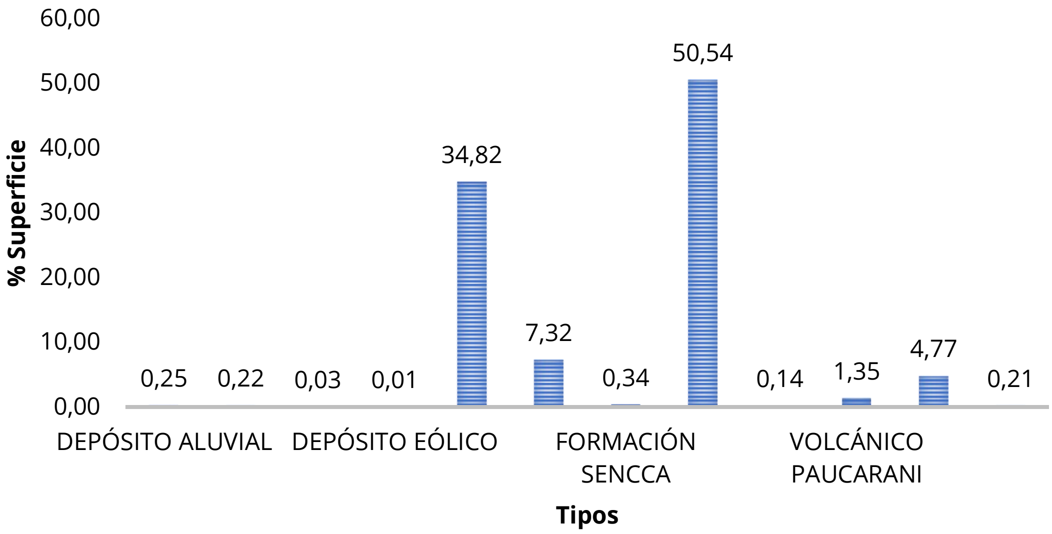


Figure 16 – Forest area according to geomorphological units

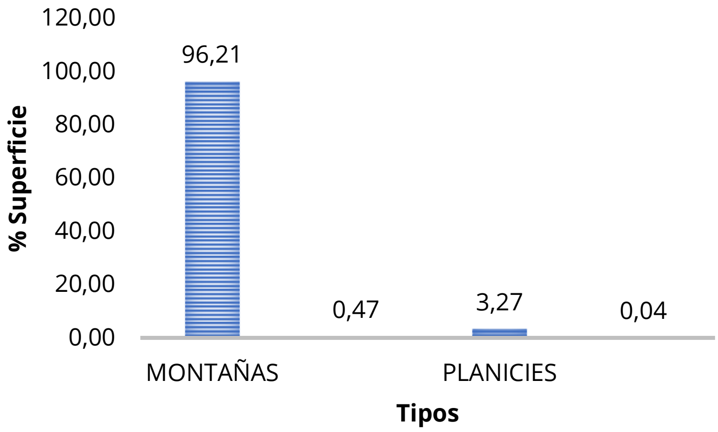


Figure 17 – Forest area according to hydrogeological units

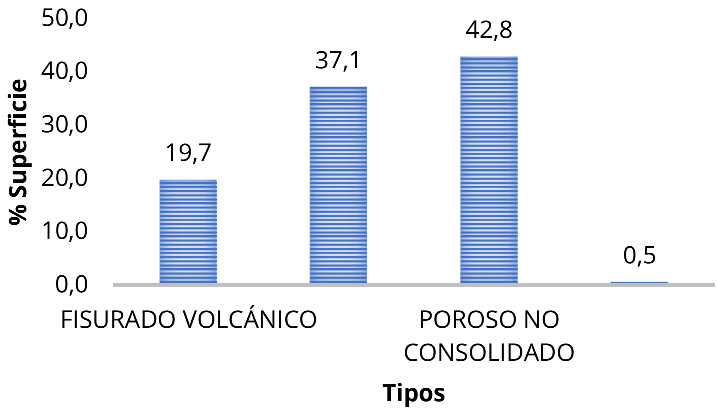


Figure 18 – Forest area according to slope level

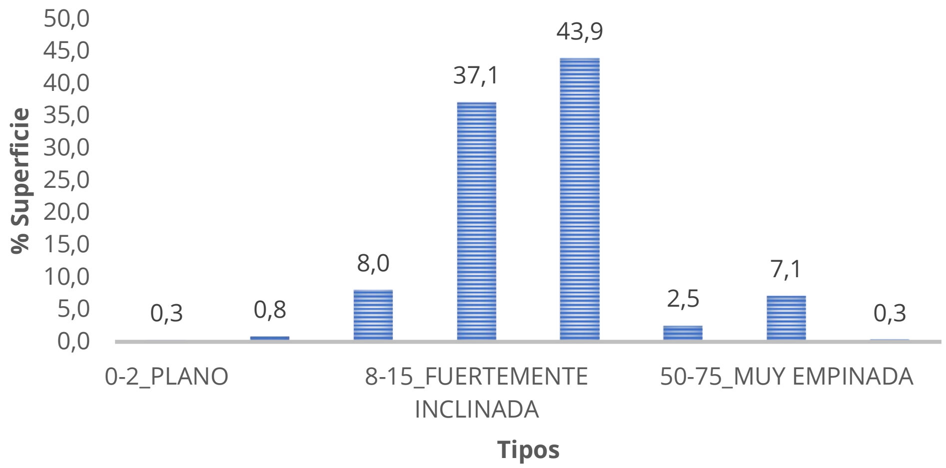


Figure 19 – Forest area according to soil type

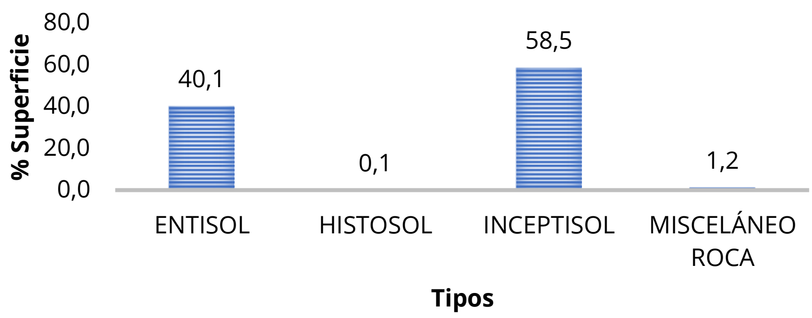


Figure 20 – Forest area according to frost frequency

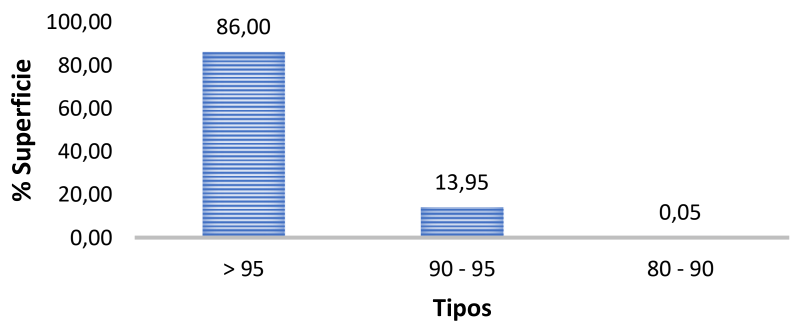
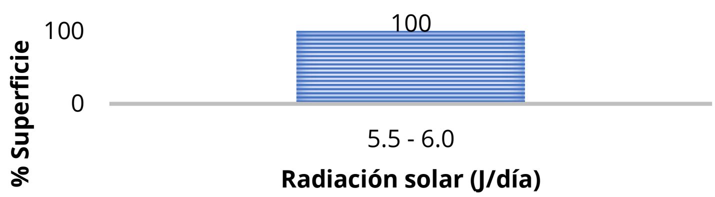


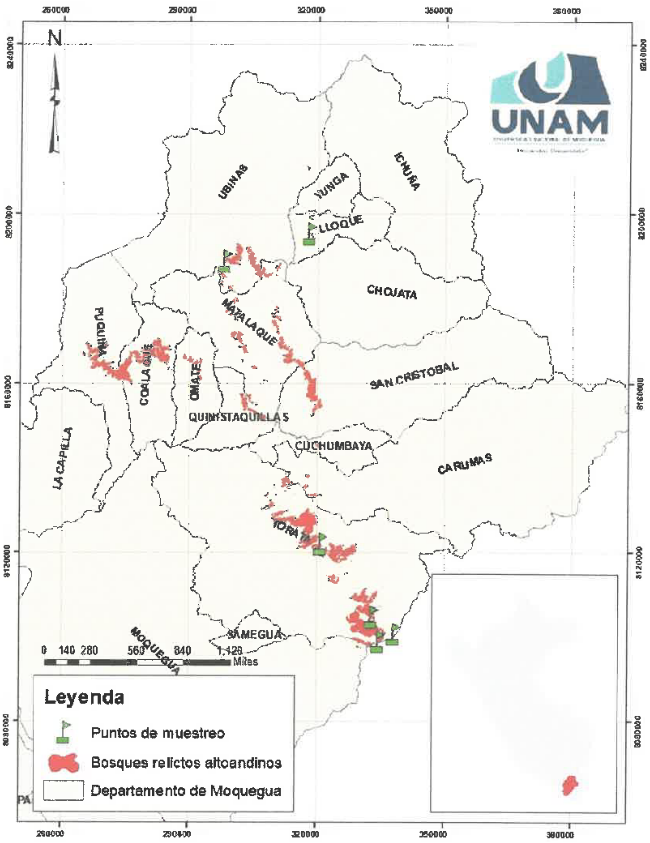
Figure 21 – Solar radiation in the Polylesis forests



DISCUSSION

According to the new National Ecosystem Map of Peru (Ministry of the Environment, 2018), the spatial distribution of the high Andean relic Polylepis forests in Moquegua covers an area of 16,345.17 hectares, which does not differentiate between the species of the genus Polylepis (P. subtusalbida, P. rugulosa, and Polylepis) reported for Moquegua, according to Cano & Mendoza (2012). Using the shape of the area obtained of 12,893.85 hectares, exclusively for Polylepis, and intersecting it with that of MYNAM (2018), there is a level of overlap of 7,305.56 hectares, so our research has contributed to the identification of 5,588.29 hectares. (Figure 22). It is assumed that the difference between the obtained surfaces is due to the work scale, as MYNAM (2018) conducted it at a scale of 1:100,000 and the present research is at a scale of 1:10,000.

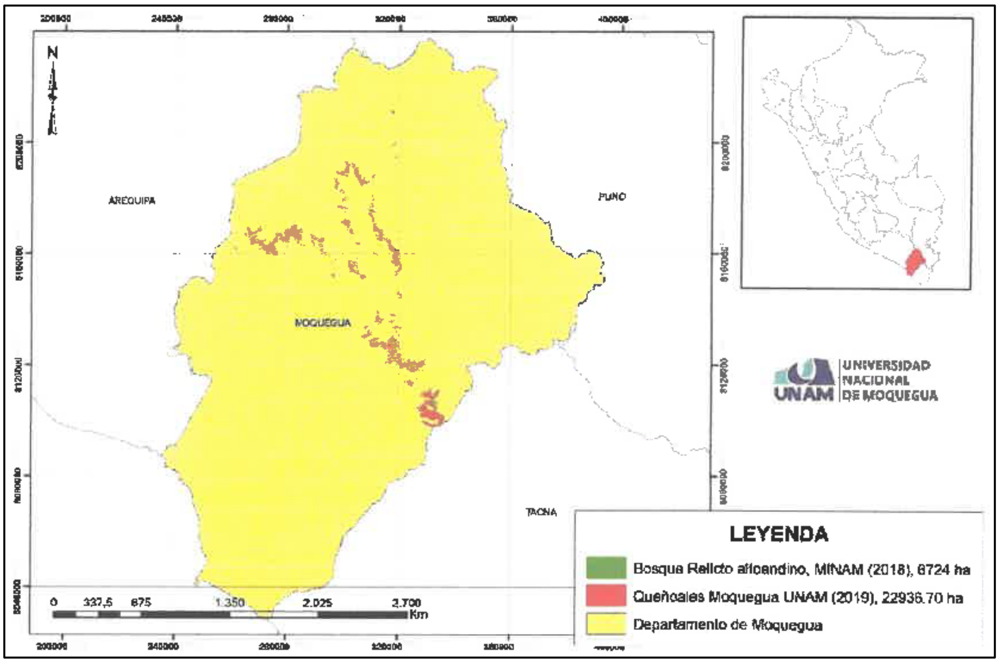
Figure 22 – The amount of 5,588.29 hectares of Polylepis Forest area (light green) that do not overlap with the high Andean relict forest polygons of the Ecosystem Map of Peru - MINAM, 2018



Similarly, the National Vegetation Coverage Map of Peru indicates that the extent of the high Andean relic forests of Polylepis in Moquegua is 8,336.76 hectares (Ministry of the Environment, 2015). Similarly to the previous case, in that extension there is no reference to the specific distribution of Polylepis or any other species; therefore, upon intercepting it, it is evident that there is no match between them, meaning that due to the scale of work, no hectare of Polylepis determined in the present research has been considered in the national vegetation cover map. (Figure 23).

Figure 23 – There is no match between the polygons determined at different scales in the present study and those in the National Vegetation Coverage Map - MINAM, 2015

HIGH ANDES RELICT FORESTS BECAUSE OF THE RATIONAL ECOSYSTEM MAP (2018) OF THE MOQUEGUA



REGION

In South America, Polylepis forests extend approximately up to 4800 meters above sea level in Chile and up to 5200 meters above sea level in the biogeographic floor of the Puna in Peru, Bolivia, and Chile, being the forest formations found at the highest altitude in the world. Forests of the genus that meet this condition and are found above the continuous forest line or treelines would be more susceptible to climate change (Macek et al. 2009, Kessler 1995, Fjeldså & Kessler 1996, Braun 1997). In Moquegua, Polylepis has an altitudinal range that varies between 4225 to 5175 meters above sea level. The highest altitude record is found in Bolivia, in the locality of Sajama above 5200 meters above sea level, and it has a wide ecological tolerance, ranging from very humid areas (yungas) to xerophytic areas (dry puna). (Mendoza & Cano 2011). For Peru, according to Brako & Zarucchi (1993), Polylepis has an altitudinal range between 4200 - 4800 meters above sea level. One of the most notable adaptations is the high tolerance to freezing, with resistances documented in the field at temperatures close to -13 °C for the dry and cold season and -6 °C for the wet and warm season. The minimum estimated temperatures to cause permanent damage would range between -20 and -21 °C (Azocar et al. 2007). Polylepis is a freeze-tolerant species, between -3 to -6 °C for the dry-cold season and between -7 to -9°C for the wet-warm season. Leaf damage temperatures range between -18 and -23°C during both seasons, respectively (Rada et al. 2001). In the case of Moquegua, in the Polylepis forests, they have a maximum temperature of 14.8 and a minimum of -11.4°C. According to Kessler (2006), the ecological conditions of the Polylepis forests can be characterized mainly in relation to temperature, humidity, and soil conditions. Due to their location at high elevations in the Andes, the Polylepis forests are subject to wide daily temperature fluctuations, commonly with differences of 20-30°C between the daytime maximum temperatures and the nighttime frosts. Vegetative growth mainly occurs during the humid and relatively warm season, while flowering primarily takes place during the dry and cold season. In Moquegua, in the Polylepis forests, there is a temperature difference between the maximum and minimum of 26.2°C. Likewise, they develop within a range of 45 to 57% relative humidity, with optimal values of 48 to 54% that occupy 96% of the forest area. In the case of soil, the most common types are Entisol and Inceptisol, while Histosol and miscellaneous rock are less frequent. Precipitation in the western Altiplano begins to be significant as altitude increases due to the greater moisture supply from the northeast. Precipitation is concentrated 80% during the summer months (November-March), with a climatic peak in January (Moya and Lara, 2011). In Moquegua, the optimal precipitation level in Polylepis forests is greater than 400 mm and occurs in 90% of the area, while only 10% develops between 300 - 400 mm. In a wet year, 77.6% of the area is subject to a precipitation level of more than 600 mm, while in a dry year, 0.7% of the area experiences precipitation between 100 to 200 mm. The Polylepis forests are located on the slopes of extinct volcanoes and in the intra-highland hills. They develop alongside the characteristic vegetation of the dry Puna (tussock grasslands, yaretales). These forests contribute to increasing the soil's water retention capacity, reduce erosion by regulating water runoff, and aid in the storage of sediments and nutrients. They also provide refuge and a food source for many animal species and facilitate the establishment of numerous plants (Fjeldså & Kessler 1996).

Moya and Lara (2011) point out that the soils of the Altiplano of Arica and Parinacota (Chile), where Polylepis forests are distributed, are shaped by the conditions of the cold climate and the xeromorphic characteristics of the environment. These are shallow, relatively young soils, composed of particulate material such as sand and coarse gravel, formed from the cryogenic decomposition of the parent rock, and in the flatter areas or intermediate depressions, soils formed from organic matter in various stages of decomposition (bofedales) are found. In Moquegua, these forests are mainly located in mountains, with 96% of their area, and only 3% are found in plains. Geologically, the forests are mainly distributed in the fluvioglacial deposit and the sandy group. Physiographically, the largest area of the forests is found in glacial mountains with steep and moderately steep slopes. The Secretariat of the Convention on Biological Diversity (2004) states that the driving forces of ecosystems, including those due to human activities, vary in space and time, which requires management at more than one scale to achieve their objectives. Therefore, it is necessary to conduct research at scales that allow for greater specificity of the biological and ecological characteristics of Polylepis forests if the successful conservation of these important high Andean ecosystems is truly desired.

CONCLUSIONS

The spatial distribution of Polylepis forests in Moquegua, at the southernmost tip of Peru, has been calculated to be 12,893.85 hectares, contributing to the identification of 5,588.29 hectares not considered in national studies. A minimum altitude of the Polylepis species of 4225 meters above sea level and a maximum of 5175 meters above sea level in Moquegua is reported, within the range of other national and international studies. The environmental characteristics discussed in this research are important inputs for restoration, afforestation, or reforestation programs, whose values could be adjusted to a better scale of measurement and instrumentation.

REFERENCES

Arévalo, R., & Recharte, J. (2003). Bosques de montaña: Ecosistemas relictos. In J. Recharte, R. Arévalo, & M. Glave (Eds.), *Islas del cielo* (pp. 11–19). Ancash, Peru.

Braun, G. (1997). The use of digital methods in assessing forest patterns in an Andean environment: The *Polylepis* example. *Mountain Research and Development, 17*(3), 253–262.

Brako, L., & Zarucchi, J. (1993). *Catalogue of the flowering plants and gymnosperms of Peru*. Missouri Botanical Garden.

Castro, A., & Flores, M. (2015). Caracterización de un bosque de queñual (*Polylepis* spp.) ubicado en el distrito de Huasta, provincia de Bolognesi (Áncash, Perú). *Ecología Aplicada, 14*(1).

Fjeldså, J., & Kessler, M. (1996). *Conserving the biological diversity of Polylepis forests of the highlands of Peru and Bolivia*. Nordic Foundation for Development and Ecology (NORDECO).

Goldstein, G., Meinzer, F., & Rada, F. (1994). Environmental biology of a tropical treeline species, *Polylepis sericea*. In P. W. Rundel, A. P. Smith, & F. C. Meinzer (Eds.), *Tropical alpine environments: Plants form and function* (pp. 129–149).

Hoch, G., & Körner, C. (2005). Growth, demography and carbon relations of *Polylepis* trees at the world's highest treeline. *Functional Ecology, 19*, 941–951.

International Union for Conservation of Nature. (2011). *IUCN Red List of Threatened Species*. http://www.iucnredlist.org

Kessler, M., & Schmidt-Lebuhn, A. (2006). Taxonomical and distributional notes on *Polylepis*. *Organisms Diversity & Evolution, 6*.

Koepcke, M. (1961). Birds of the western slope of the Andes of Peru. *American Museum Novitates, 2028*, 1–31.

Körner, C. (1999). *Alpine plant life: Functional plant ecology of high mountain ecosystems*. Springer.

León, D. (2009). *Propagación de dos especies de yagual (Polylepis incana y Polylepis racemosa)* (Tesis de ingeniería agronómica). Escuela Superior Politécnica de Chimborazo.

Ministerio del Ambiente del Perú. (2015). *Mapa nacional de cobertura vegetal: Memoria descriptiva*.

Ministerio del Ambiente del Perú. (2018). *Mapa nacional de ecosistemas del Perú: Memoria descriptiva*.

Macek, P., Macková, J., & De Bello, F. (2009). Morphological and ecophysiological traits shaping altitudinal distribution of three *Polylepis* treeline species in the dry tropical Andes. *Acta Oecologica, 35*, 778–785.

Mendoza, W., & Cano, A. (2011). Diversity of the genus *Polylepis* (Rosaceae, Sanguisorbeae) in the Peruvian Andes. *Revista Peruana de Biología, 18*, 197–200.

Moya, J., & Lara, A. (2011). Cronologías de ancho de anillos de queñoa (*Polylepis tarapacana*) para los últimos 500 años en el Altiplano de la región de Arica y Parinacota, Chile. *Bosque, 32*(2), 165–173.

Ordenanza Regional N.° 016-2012-CR/GOB.REG.MOQUEGUA. (2013, enero 10). *Diario Oficial El Peruano*.

Renison, R., et al. (2013). Distribución y estado de conservación de las poblaciones de árboles y arbustos del género *Polylepis* (Rosaceae) en las montañas de Argentina. *Ecología Austral, 23*, 27–36.

Secretaría del Convenio sobre la Diversidad Biológica. (2004). *Enfoque por ecosistemas* (Directrices del CDB). https://www.cbd.int/doc/publications/ea-text-es.pdf

Servat, P. G., Mendoza, W., & Ochoa, J. A. (2002). Flora y fauna de cuatro bosques de *Polylepis* (Rosaceae) en la cordillera del Vilcanota (Cusco, Perú). *Ecología Aplicada, 1*(1), 25–35.

Venero, J., & De Macedo, H. (1983). Relictos de bosque en la puna del Perú. *Boletín de Lima, 30*, 19–26.

Zutta, B., et al. (2012). Prediciendo la distribución de *Polylepis*: Bosques andinos vulnerables y cada vez más importantes. *Revista Peruana de Biología, 19*(2), 205–212.

AUTHORS' CONTRIBUTIONS (CREDIT)

Conceptualization, JLTF, VYP, FDC; methodology, EMRS, MFCS, SCLQ, KMLDC; formal analysis, JLTF, EMRS, FDC, MFCS, SCLQ, KMLDC; investigation, JLTF, FDC, KMLDC; data curation, JLTF, EMRS, VYP, FDC, MFCS, SCLQ, KMLDC; writing—original draft preparation, EMRS, VYP, MFCS, SCLQ, KMLDC; writing—review and editing, JLTF, VYP, FDC, MFCS, SCLQ; project administration, JLTF, EMRS, FDC, SCLQ, KMLDC; supervision, VYP.

All authors have read and agreed to the published version of the manuscript.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data supporting the findings of this study are available upon reasonable request.

ETHICS STATEMENT

This study did not involve human participants or animals and therefore did not require ethical approval.

ACKNOWLEDGEMENTS

The authors declare no acknowledgements.