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ANALYSIS OF SPECTRAL SIGNATURE OF THE SPECIES POLYLEPIS RETICULATA USING GEOSPATIAL TECHNOLOGIES IN A HIGH ANDEAN COSYSTEM OF THE PROVINCE OF TUNGURAHUA

Julia Desiree Velastegui Cáceres (1) *
jdvelastegui@espe.edu.ec, https://orcid.org/0000-0002-6825-0853,

Susana Monserrat Zurita Polo (2)
susana.zurita@espoch.edu.ec, https://orcid.org/0000-0002-5325-486X

Vicente Javier Parra León (3)
vicente.parra@espoch.edu.ec, https://orcid.org/0000-0002-7632-2474

Edmundo Danilo Guilcapi Pacheco (4)
eguilcapi@espoch.edu.ec, http://orcid.org/0000-0001-5072-1437

Geraldo Ariolfo Cuadrado Barreto (5)
20201332@lamolina.edu.pe , https://orcid.org/0000-0002-5728-1953

(1) Universidad de las Fuerzas Armadas ESPE. Departamento de Ciencias de la Tierra y la Construcción. Pichincha, Ecuador
(2) (3) (4) Escuela Superior Politécnica de Chimborazo (ESPOCH). Facultad de Recursos Naturales. Chimborazo, Ecuador.
(5) Universidad Nacional Agraria La Molina, Doctorando en Ingeniería y Ciencias Ambientales
(1) Sangolquí, Pichincha, Ecuador
(2) (3) (4) Riobamba, Chimborazo, Ecuador
(5) Distrito de la Molina, Lima, Perú
*Correspondence: * jdvelastegui@espe.edu.ec

SUMMARY

The reflective energy measured in each living being, part of the principle that bodies absorb specific wavelengths and reflect others in certain proportions, this captured energy is obtained information about matter and its interaction. The objective of this research was to perform an analysis of the spectral signature in the species Polylepis reticulata with Sentinel 2 images in the Sachafilo forest, Tungurahua-Ecuador. For which the forest was georeferenced, the data obtained entered the ArcGis 10.8 software; Two satellite scenes corresponding to the wet and dry seasons were taken, performing a stratified random sampling and then validating data through the confusion matrix to assess this classification model; With the sampling the reflectance values were acquired and with it obtain the representative signature of the species, as well as of the other cover that inhabit the forest in the two seasons of the year; in addition, the coverage of the species was visually determined using the SAVI index. The signatures obtained from the species at both times of the year did not show high variation in the wavelength trend, but the dry season signature

showed a small decrease in reflectance; Regarding the signature of the herbaceous cover compared to the signature of the species, there was a similar trend, but with a high variation in reflectivity; Regarding the coverage of the species, a vegetation of medium density was obtained. The variation of reflectance in the species may be due to factors such as angles of the sun, shadows and atmospheric conditions while the variation of the reflectance presented by the herbaceous cover may be due to the presence of pests, ambient temperature, phenological state and even activities such as flowering and germination.
Keywords: Spectral signature, geospatial technologies, Polylepis reticulata, environmental management, tree species.

1. INTRODUCTION

Information on tree species and forest types is essential for solving the extensive ecological problems of forests, sustainable management and conservation (Karppinen, 1998; Majumdar et al., 2008; Urquhart et al., 2012; Häyrinen et al., 2015, Häyrinen et al., 2016). Therefore,mapping the composition of a forest is essential to monitor the state and condition of this ecosystem being important from the ecological, forest conservation and socioeconomic point of view (Wiser & De Cáceres, 2018).

The advancement of technology that is currently going through allows us to have knowledge about any surface of the earth through images from sensors on board satellite platforms (Chuvieco et al., 2002). Satellitephotographs have allowed a combination and interpretation of forest maps that allow to evaluate the types of forests, the distribution of forests from the relationships between geolocatedplots, terrain characteristics, climatic conditions and aerial and spatial images (Horvath et al., 2019). In order to analyze and interpret these satellite images it is necessary to have the help of a particular science, radiometry that with the help of remote sensing provides tools for the study of vegetation and one of these are spectral signatures (Carrillo, 2016). These satellite photographs are also used directly to differentiate between vegetation types through spectral and structural analysis (Colstoun et al., 2003, Amarnath et al., 2003, Ihse, 2007). These spectral signatures present the relationship between the energy coming from solar radiation and the incident energy of a body on the earth's surface as a function of wavelength (Aguirre, 2015) which makes it possible to identify different objects in satellite images, making their signature their own, that is, similar to a fingerprint because each type of surface reacts differently to radiation (Ávila, 2019).

Due to this concept, remote sensing-based forest mapping is used with different techniques and types of sensors, including optical systems (multispectral and hyperspectral). In 2015, the European Space Agency (ESA) launched the Sentinel-2 mission to continue the global coverage of the Earth previously provided by the Landsat and SPOT satellites (Gascon et al., 2017). In orbit are two Sentinel-2 A+B satellites with a wide swath of 290 km, with a review time of 5 days (with two satellites) and observe the Earth with 13 spectral bands specifically chosen to capture surface and vegetation properties (Drusch et al., 2012). The recording of multitemporal, multispectral satellite images and the high dimensionality of algorithms provides opportunities to map forests in greater detail to classify tree species and forest types with high levels of accuracy (Pasquarella et al., 2018).

Forest areas contain a wide variety of species whose amount of reflective energy measured in each individual depends on the nature of the same, leaf area, cell structure, water content and atmospheric conditions (Chuvieco, 2008) all these factors make the spectral signatures unique for each species and because of this the appropriate methodological processes must be used taking into consideration the atmospheric conditions, adequate equipment and good resolution in satellite images (Corrales & Ochoa, 2014). Due to this, the spectral behavior of vegetation cover in a forest is quite complex taking into account that this reflectivity can be altered in two periods of the year such as the dry and wet season as an external factor.

Native forests constitute a unique ecosystem that has taken many years to form (Arriaza, 2018), which is why entities responsible for their protection and conservation have been established. The native forests at the level of Ecuador are ecosystems of great importance since they provide a vital space for numerous populations of living beings (Arriaza, 2018) and their spectral behavior varies depending on certain external factors such as weather conditions, seasons and even lighting conditions (Carrillo, 2016) . The advancement and application of technology has facilitated studies in which they have allowed an analysis regarding the variation of the reflectance of species such as Gynoxys sp, Pinus radiata, Alnus acuminata and Eucalyptus globulus (Carrillo, 2016; Carrera & Cruz, 2019) obtaining quite representative benefits. Due to this, the use of geotechnologies was taken into consideration in this study, analyzing the behavior of the species that inhabit native Sachafilo forest, especially the species Polylepis reticulata as the predominant species with the help of satellite images to verify with the help of the spectral signature if its spectral behavior varies depending on the times of the year (dry and wet) that Ecuador presents.

Because the species that predominates is Polylepis reticulata and being in a vulnerable state it is necessary to carry out studies where the possible affectations that arise for this species can be analyzed either by its structure or by external factors and with the information obtained the risks can be reduced in an implementation of the same or help the species with an adequate management, Likewise, the behavior of the other species living in the forest in the two seasons of the year will be analyzed.

Given this situation and theobjective of this research is to analyze the spectral signature of the species Polylepis reticulata with Sentinel 2 images in the Sachafilo forest, Pasa Parish, Ambato Canton, Tungurahua Province-Ecuador, as well as the signature of the herbaceous cover (other species living in the forest) being an important tool to study the variation of spectral behavior that is It occurs in species in the dry and wet season.

2. MATERIALS AND METHODS

2.1. Experimental design

The present research had as its first point the survey of the place to be studied through basic cartography and an in situ visit to perform the geolocation with the help of GPS data, which allowed to delimit the Sachafilo forest. Subsequently, satellite images were obtained at different study times (wet season and dry season) of the Copernicus Open Access Hub managed by ESA, with the lowest percentage of cloudiness in the scene and especially in the study area, with an atmospheric correction with the QGIS software through the Semi-Automatic Classification plugin (SCP). For the survey of the reflectance values, the composition of bands was carried out using the Composite bands tool in the ArcGis program, medant the Extract Multi Values to Points tool of ArcToolbox all the reflectance values of the thirteen bands were extracted with the 100 sampling points of each stratum, said Procedure was performed for two satellite scenes. The coverage of Polylepis reticulata was determined using the SAVI index (0.5). Theclassification of the species was considered the plant profile proposed by Alencar et al. , (2019) being a tree or shrub species. To obtain the spectral signature of the stratum of the other species, the same methodology was carried out to obtain the spectral signature of the species Polylepis reticulata in the dry and wet season. The comparison was made through an analysis in which it was verified if there is a variation of the spectral signatures of the component of the species Polylepis reticulata with the herbaceous component in the two seasons of the year.

2.2. Place of study

The native Sachafilo forest is located in Ecuador, province of Tungurahua in the Parish of San Antonio de Pasa is geographically limited: North by the Quisapincha Parish, South by the Juan Benigno Vela and Pilahuín Parishes, West the San Fernando Parish, East the Quisapincha Parish. Its extreme cardinal points are: in the North 01º18'04" W, in the South: 01°24'15" S, 78°36'40" W, in the East 01°18'20" S, 78°40'26" W and in the West 01º22'25" S, 78°43'40" and the Sachafilo Native Forest is geographically located in Zone 17S, DatumWGS84, Projected UTM coordinates 748914 X; 9865417 Y, altitude 3556 masl. At 3556 meters above sea level, with an average annual temperature ranging from 13.3 ° C, varying between 4 and 26.3 ° C and a rainfall of 500 to 1000 mm in the lower part and up to 2000 mm in the high zone and in moors, as shown in Figure 1.

2.3. The research parameters/sample are as follows:

Population and sample

A stratified random sampling was carried out using the methodology of Congalton, (1988 and 1991) and Camacho et al., (2015) in which at least 50 points per category were verified, but for this study 100 points per category were taken for greater precision. This scoop was applied in the two satellite images taking into consideration that the sampling points are the same for the two satellite scenes.

Methodological development

For the development of the research, an on-site visit was planned for the collection of geolocation data with GPS and with basic cartography extracted by theMilitary Geographic Institute (IGM), from this the Sachafilo forest was delimited. Later se obtained two satellite images at different times wet season and dry season of Copernicus Open Access Hub managed by ESA in compressed format, observing the lowest percentage of cloudiness in the scene and especially in the study area, after the discharge the atmospheric correction was made with the help of the QGIS program through the Semi-Automatic Classification plugin (SCP). The delimitation of the strata was

carried out in two categories, the first of the forest of Polylepis reticulata and the second category the herbaceous stratum. This definition of the strata was carried out with a previous field visit and then through the ArcGIS 10.8 program. Carry out its delimitation. To obtain the reflectance values for each of the bands that make up the satellite image, band composition was performed using the Composite bands tool in the ArcGis program. Using the Extract Multi Values to Points tool in ArcToolbox, all the reflectance values of the thirteen bands with the 100 sampling points of each stratum were extracted, this procedure was performed for the two satellite scenes. All the determined values were obtained the relative values of reflectance of each of the bands that were obtained in ArcGis 10.8 in order to have a representative value for each band and obtain the spectral signature. The coverage of the species Polylepis reticulata was determined by the SAVI index following the methodology proposed by Contreras (2019) where, L depends on the density of the vegetation, in this case it determined a density of 0.5 identifying itself as very dense vegetation (0.406-0.688).
Posterior was classified using the plant profile proposed by Alencar et al (2019) in three categories: Category 1: Low density tree and shrub, Category 2: Medium density tree and shrub and Category 3: High density tree and shrub. The highest values of the SAVI index were obtained where the highest values range between 0.307 and 0.498 representing a high density coverage. On the other hand, the lowest values range between 0.194 and 0.217 representing a low density coverage. To obtain the spectral signature of the stratum of the other species living in the Sachafilo forest, the same methodology was carried out to obtain the spectral signature of the species Polylepis reticulata in the dry and wet season. Finally, se made the comparison through an analysis in which it was verified if there is a variation in the spectral signatures of the component of the species Polylepis reticulata with the herbaceous component in the two seasons of the year.

2.4. Data validation

Data validation was performed on the two satellite scenes using the confusion matrix. This matrix is two-dimensional and is comprised between rows representing the true terrain (samples) and columns representing the map, deduced from the interpretation of satellite images (Camacho et al., 2015 p.98). For the confusion matrix, it was verified that the percentage of global accuracy is greater than 90%, being within a range of acceptability.

3. RESULTS

3.1. Validation of summer (dry season) and winter (wet season) data of the species Polylepis reticulata.

Through the Copernicus Open Access Hub platform, the satellite scenes were obtained and the atmospheric correction was made using the QGIS program. With the points obtained from the GPS, the strata were delimited through the ArcGis 10.8 program as can be seen in Figure 1.
A sampling was carried out verifying that 100 points were established per category as can be seen in figure 2. The points were taken based on the site where there was greater coverage in the case of the species Polylepis reticulata and in the same way for the herbaceous cover
Data validation was performed using the confusion matrix where it was obtained for the dry and wet season as shown in Table 1, 810 pixels of the herbaceous cover that have been classified

while 396 pixels have been classified in the coverage of the species Polylepis reticulata and for the coverage of Polylepis reticulata 4710 pixels have been correctly classified while 112 have been classified in herbaceous cover. Where an overall accuracy is observed on the map of 92% with an error rate of 8% and the Kappa index (k) 0.71 was determined with a substantial agreement for the dry season.

The wet season data validation determined that 907 pixels of the herbaceous cover have been correctly classified while 259 pixels of this cover have been classified in the coverage of Polylepis reticulata and for the coverage of Polylepis reticulata 4847 pixels have been classified perfectly, while 15 pixels have been classified in the herbaceous cover.

The wet season ratio between the number of correctly assigned points and the total manifests an overall accuracy on the map of 95% with an error rate of 5%. On the other hand, by means of the confusion matrix it was possible to determine the Kappa index (k) 0.84 , that is, an almost perfect agreement, as presented in Table 1.

Table 1. Results of confusion matrix of summer season and winter season.

Summer season (dry season)				
Coverage	**Class**	**Herbaceous cover (pixels)**	**Polylepis coverage (pixels)**	**Total**
Herbaceous cover	1	810	396	1206
Polylepis Coverage	2	112	4710	4822
Total		922	5106	6028
Global Accuracy	92%	**Error rate** 8%	**Kappa** 0,71	
Wet season (wet season)				
Herbaceous cover	1	907	259	1166
Polylepis Coverage	2	15	4847	4862
Total		922	5106	6028
Global Accuracy	95%	**Error rate** 5%	**Kappa** 0,84	

3.2. Determination of the visual shape of the cover of Polylepis reticulata in the Sachafilo forest

In figure 3 it can be seen that the minimum values are between a range of 0.217 to 0.348, these values represent a coverage with lower density while the maximum values are in a range of 0.407 to 0.521 that represent a coverage of Very dense vegetation. The results obtained present a higher SAVI index in the range of 0.348 to 0.407 this means that the species in the summer season presents a coverage of medium density. In Figure 4, it is observed that the minimum values are in a range of 0.194 and 0.336 that represent a lower density coverage while the maximum values are between a range of 0.379 and 0.498 that represent a vegetation cover very dense. According to the results obtained, this species presents higher SAVI index in the range of 0.336 and 0.379

this means a coverage with average density in the winter season and finally it can be verified that in the summer season the values are higher than in the winter season.

3.3. Obtaining the spectral signature of the species Polylepis reticulata in summer season (dry season) and winter season (wet season)

Table 2 presents the reflectance values in summer season for each band with an intermediate range of 0.08 (8%), where band 13 is the one with the highest reflectance with a value of 0.264 (26.2%) while the band that presented lower reflectance is band 10 with a value of 0.012 (1.2%). On the other hand, the reflectance values for the winter season for each band with an intermediate range of 0.072 (7.2%), where band 13 is the one with the highest reflectance with a value of 0.262 (26.2%) while the band that presented lower Reflectance is band 10 with a value of 0.012 (1.2%).

Table 2. Reflectance values of Polylepis reticulata in the summer and winter season

Polylepis reticulata coverage		
Bands	**Reflectance values Summer season**	**Reflectance values Winter season**
Band 1	0,023	0,028
Band 2	0,071	0,072
Band 3	0,066	0,067
Band 4	0,048	0,049
Band 5	0,08	0,067
Band 6	0,196	0,202
Band 7	0,235	0,244
Band 8	0,246	0,235
Band 9	0,174	0,151
Band 10	0,012	0,012
Band 11	0,145	0,144
Band 12	0,07	0,071
Band 13	0,264	0,262

3.4. Representation of the spectral signature of the species Polylepis reticulata in summer season (dry season) and winter season (wet season)

After the process can be seen in figure5, the spectral signature representative of the species Polylepis reticulata in the summer season and winter season. As you can see the trend of the wavelength remains similar in the two seasons of the year, however, from band 9 there is no change while from band 1 to 8 They have minimal variations in reflectance. On the other hand, in the winter season this reflectance presents a peak for band 8 but mostly in band 13 and the lowest value is in band 10 for the two seasons.

3.5. Obtaining the spectral signature of the herbaceous stratum in the summer season (dry season) and winter season (wet season)

Table 3 presents the reflectance values in the summer season and winter season, for the summer season with each band with an intermediate range of 0.107 (10.7%), where band 13 is the one with the highest reflectance with a value of 0.304 (30.4%) while the band that presented the lowest reflectance is band 10 with a value of 0.012 (1.2%). For the winter season the reflectance values for each band with an intermediate range of 0.092 (9.2%), where band 13 is the one with the highest reflectance with a value of 0.306 (30.6%) while the band that presented the lowest reflectance is the band 10 with a value of 0.012 (1.2%).

Table 3. Reflectance values of herbaceous cover in the summer and winter season

Herbaceous cover		
Bands	**Reflectance values Summer season**	**Reflectance values Winter season**
Band 1	0,025	0,029
Band 2	0,076	0,077
Band 3	0,079	0,081
Band 4	0,062	0,061
Band 5	0,107	0,092
Band 6	0,222	0,231
Band 7	0,263	0,277
Band 8	0,281	0,278
Band 9	0,161	0,166
Band 10	0,012	0,012
Band 11	0,180	0,180
Band 12	0,092	0,092
Band 13	0,304	0,306

3.6. Representation of the spectral signature of the species Polylepis reticulata with the spectral signature of the herbaceous cover in the summer season (dry season)

As can be seen in Figure 6, both the spectral signature of the coverage of the species Polylepis reticulata and the signature of the herbaceous cover have a wavelength with a fairly similar trend, however, if they are presented Differences in reflectance values in 11 bands while in 2 bands the same values are maintained in the two signatures.

3.7. Representation of the spectral signature of the species Polylepis reticulata with the spectral signature of the herbaceous cover in the winter season (wet season)

Figure 7 shows the spectral signatures of the species Polylepis reticulata and herbaceous cover continue to maintain the same trend, however, there are changes in the values of 11 bands while in band 1 and 10 do not change.

3.8. Representation of the spectral signature of the herbaceous cover in the summer season (dry season) and winter season (wet season)

As can be seen in Figure 8, the signature of the herbaceous cover does not present variability in wavelength, but like the species Polylepis reticulata, small variations in reflectance are manifested for some bands. On the other hand, the reflectance shows a peak for band 8 but mostly in band 13 in the wet season , in the dry season there is a peak in band 7 but mostly in band 13 and the lowest reflectance value is in band 10 for the two stations.

4. DISCUSSION

The results derived from the process of obtaining the spectral signature of Polylepis reticulata show that the species does not present a prominent change in the wavelength trend at both times of the year, however, there are small variations in reflectance being almost minimal. In the summer season a small decrease in reflectance can be observed, this means that the species absorbs more solar energy while in the winter season the species slightly lowers its photosynthetic activity, confirming with (Martínez, 2014; Mejía et al., 2014) when mentioning that when the photosynthetic activity is weak, carotenes are generally the ones that capture the light creating defense mechanisms due to the stress suffered by the plant when the atmospheric conditions are altered, however, when there is a lower Reflectance There is a greater presence of chlorophyll to capture solar radiation and the species maintains its biological processes. On the other hand (Carrillo, 2016) mentions that the variability of the reflectance may be due mostly to cloudiness in the study area, but (Paz et al., 2006; Liang et al., 2001; Palacios et al., 2018) mention that the variability of reflectance in the bands could be in addition to cloudiness due to shadows and atmospheric conditions as in this case it was studied at two times of the year. On the other hand (Sobrino, 2000; López, 2014) mentions that this variability can be affected by mineral deficiencies that affect chlorophyll tenure and even by stress conditions.

For the determination of the coverage of the species Polylepis reticulata by means of the SAVI index, a cover with a vegetation with medium density was presented. The forest, having a fairly irregular topography, means that the species does not receive the same adequate light conditions for its development, corroborating with (Fernández, 2011) when mentioning that this density is directly related to the lack of light towards the interior and lower part of the forest since the vegetation does not resist the conditions of shade and Die. He also mentions that in this species the crowns overlap, joining with other contiguous branches and forming a dense layer, causing a limitation for new individuals to develop. According to (Pacheco, 2015) this species presents an imbalance in terms of photosynthesis and respiration, so the survival of individuals of the species Polylepis reticulata can be affected by climatic conditions and therefore does not present greater density.

As for the spectral signature of the herbaceous cover compared to the signature of the species Polylepis reticulata both in the summer and winter season have a different behavior. According to (Ritchie, 2003) chlorophyll is mainly responsible for reflectance, this explains the different behavior of the signature of the herbaceous cover because it has a higher reflectance , that is, this coverage has a chlorophyll with a low absorption, due to the low presence of photosynthetic pigments, while the species Polylepis reticulata It possibly has a higher concentration of photosynthetic pigments controlled by chlorophyll. This is generally given by the internal composition of the leaf, so (Chuvieco, 2008) highlights that it is necessary to know the internal morphological structure of the leaves since the structure of the leaf is very different in several species.
Both the signature of the species Polylepis reticulata and the signature of the herbaceous cover present a certain vitality since (Martínez, 2014) mentions that the more contrast is present in the reflectance values in the bands, the better the physiological state of the plant. It can also be seen in graphs 5-3 and 6-3 that in the mid-infrared the reflectivity increases considerably and its humidity decreases this means that the water found in the vegetation has a low absorption.

A comparison of the spectral signature of the herbaceous cover in the two seasons was additionally carried out and this coverage presented a similar spectral behavior, but in the same way that in the species Polylepis reticulata the signature that presents the wet season presents a small increase in reflectance that is to say that the photosynthetic activity decreases that, for this (Vergara, 2006; Hoyos, 2019) states that the reductions in photosynthetic activity is due to the attack of insect pests with sucking habits that with the field visit this factor could be evidenced but on the other hand (Sierra, 2005; Hoyos, 2019) mentions that the photosynthetic rate can be affected by ambient temperature, mineral imbalances in the soil and the phenological state of herbaceous vegetation, while in the dry season this cover absorbs more solar energy where (Martínez, 2014) mentions that possibly most of this energy absorbed It will be used for flowering or germination of seeds that usually occurs in the month of March and August taking into consideration that the satellite scene in the dry season is the month of August.

5. CONCLUSIONS

The spectral signature of Polylepis reticulata was determined in the summer season and the winter season, revealing that the spectral behavior of this species varies according to the time of year in minimal amounts, that is, that the reflectance changes according to the atmospheric conditions of the place, all this due to angles of the sun and shadows. This species has a low reflectance and high light absorption in the visible spectrum.

The coverage of Polylepis reticulata was visually determined by means of the SAVI index, obtaining as a result a vegetation cover of medium density. For the realization of this objective, the SAVI index was chosen because it is focused on reducing the influence of soil brightness through the correction factor, taking into consideration that the forest is located in the páramo where the vegetation that predominates is low and little leafy, therefore this index is consistent with the characteristics of the study area.

The spectral signature of Polylepis reticulata was compared with the spectral signature of the other species living in the forest in which it was shown that the reflectance they present is different; the herbaceous cover has a higher reflectivity and lower absorption of sunlight than the species of Polylepis reticulata in both seasons of the year due to the internal morphological structure of the leaves, although the wavelength of the two signatures presents the same trend.

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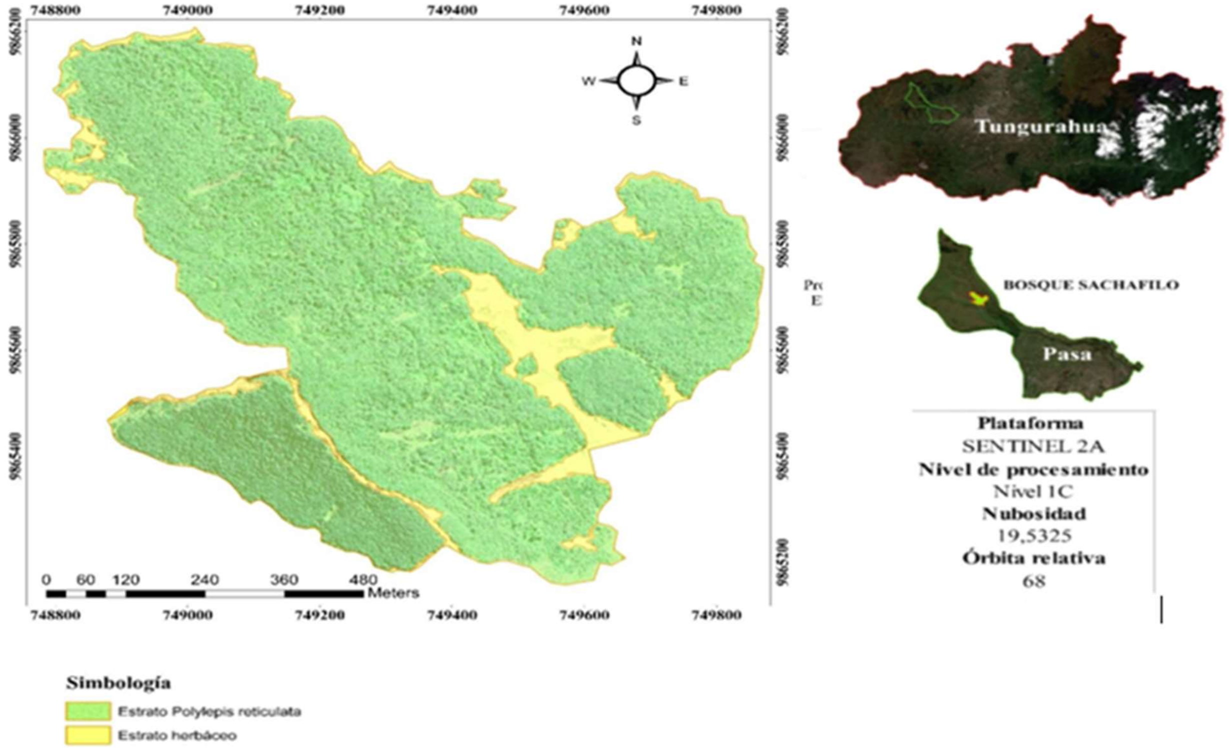

Figure 1 Location of Sachafilo forest and definition of strata

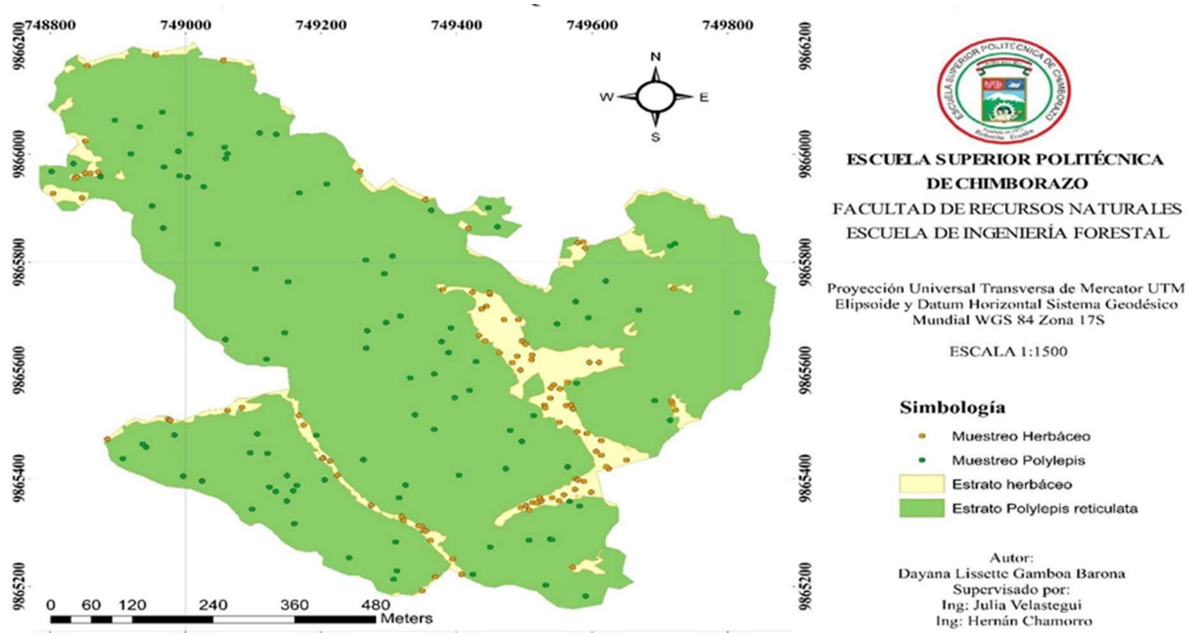

Figure 2. Sampling of Sachafilo forest by strata

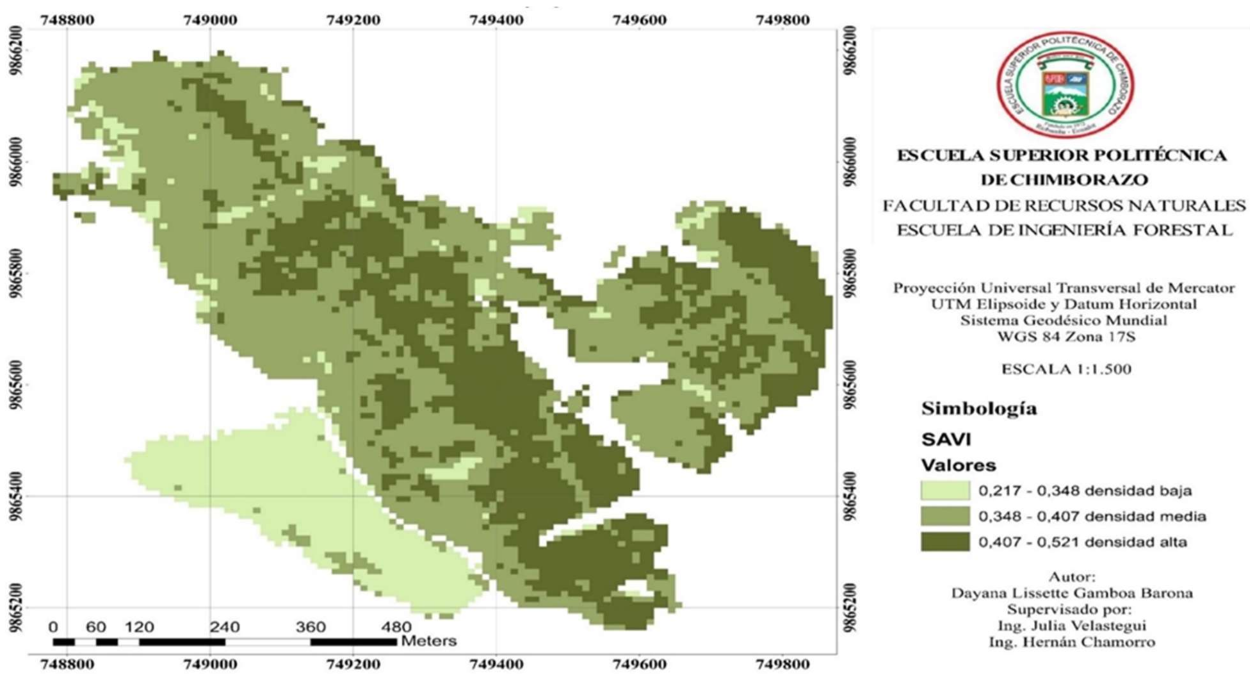

Figure 1. Coverage of the species Polylepis reticulata in the summer season

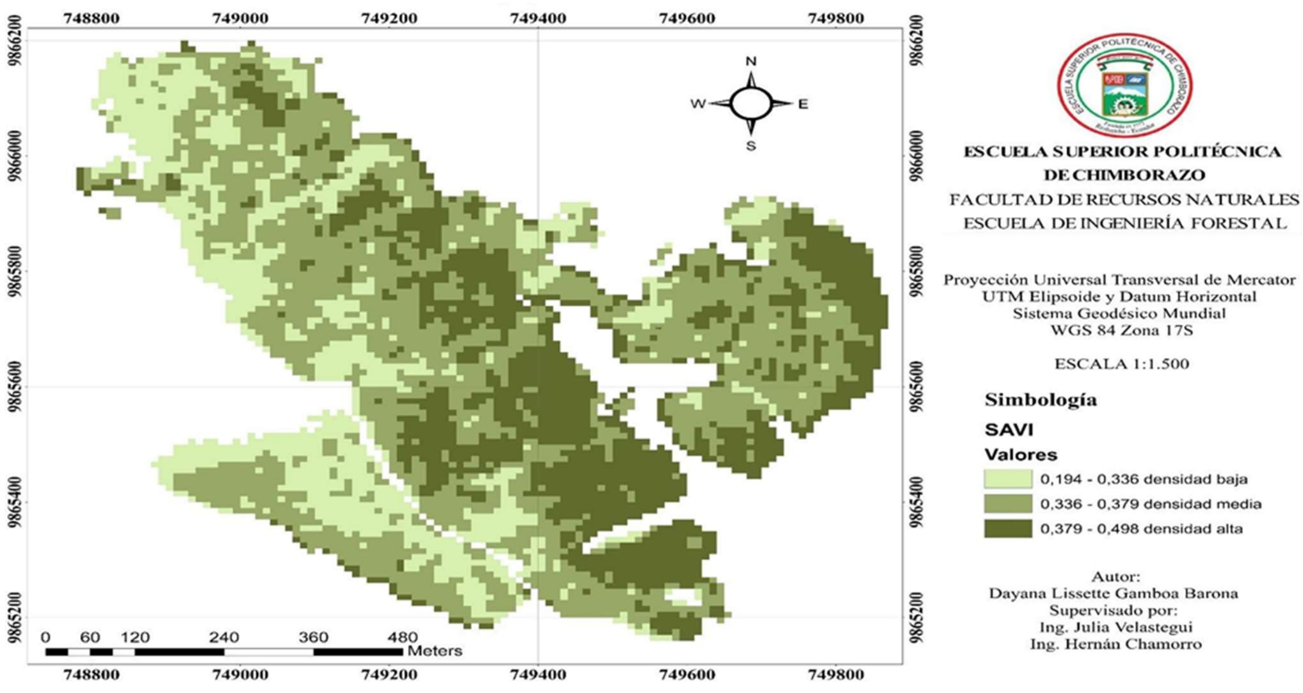

Figure 2. Coverage of the species Polylepis reticulata in the winter season

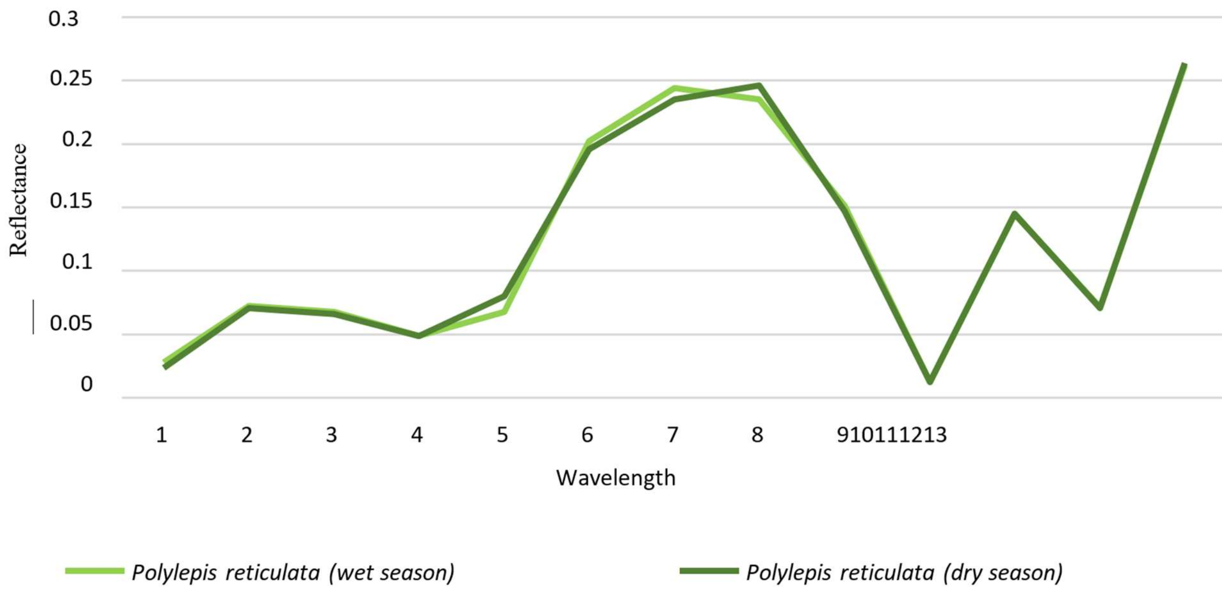

Figure 5. Comparison of the spectral signature of *Polylepis reticulata* in the wet season and dry season

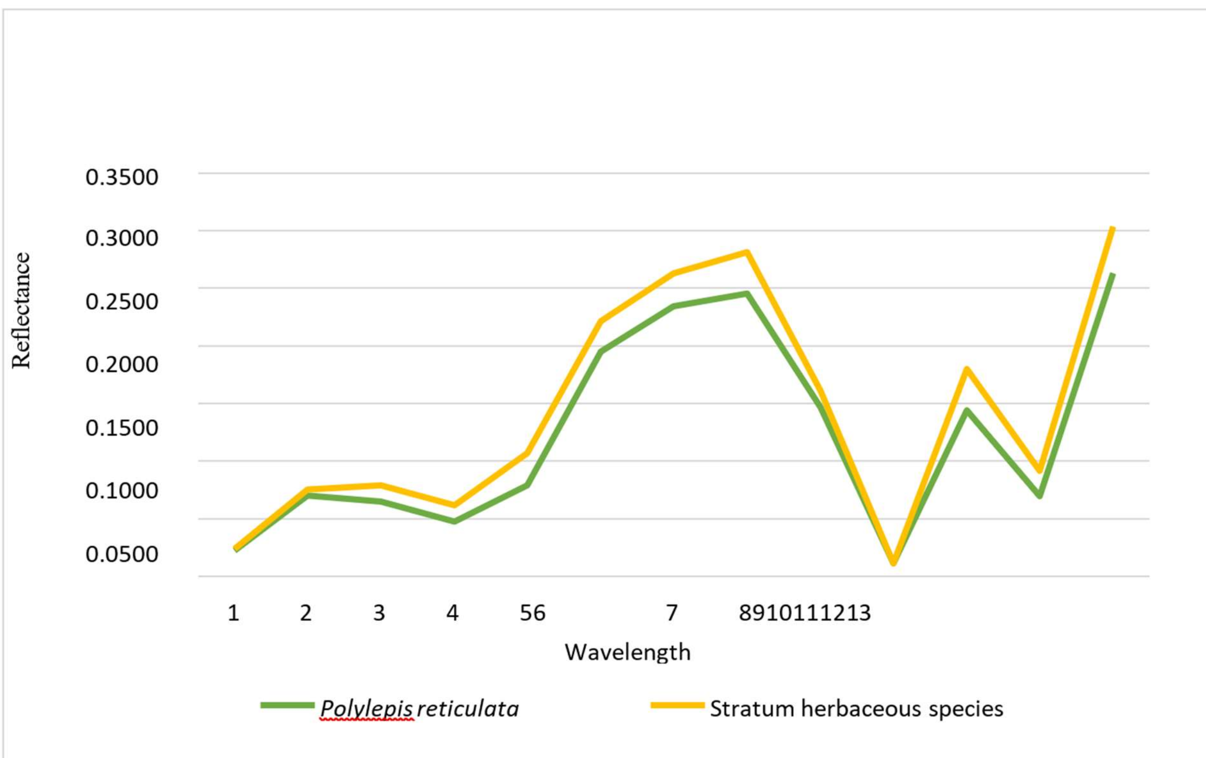

Figure 6. Comparison *of the spectral signature of Polylepis reticulata* and the spectral signature of the herbaceous cover in the summer season

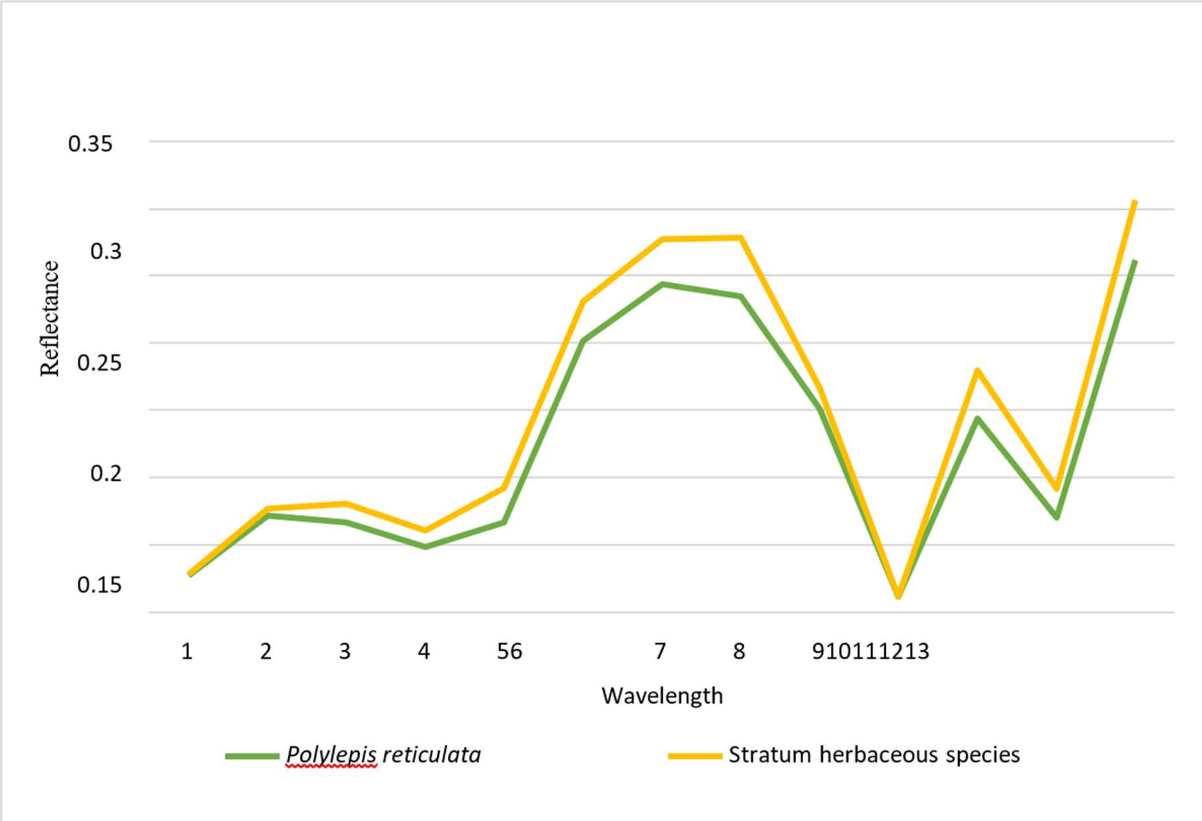

Figure 7. Comparison *of the spectral signature of* *Polylepis reticulata* and the spectral signature of the herbaceous cover in the winter season

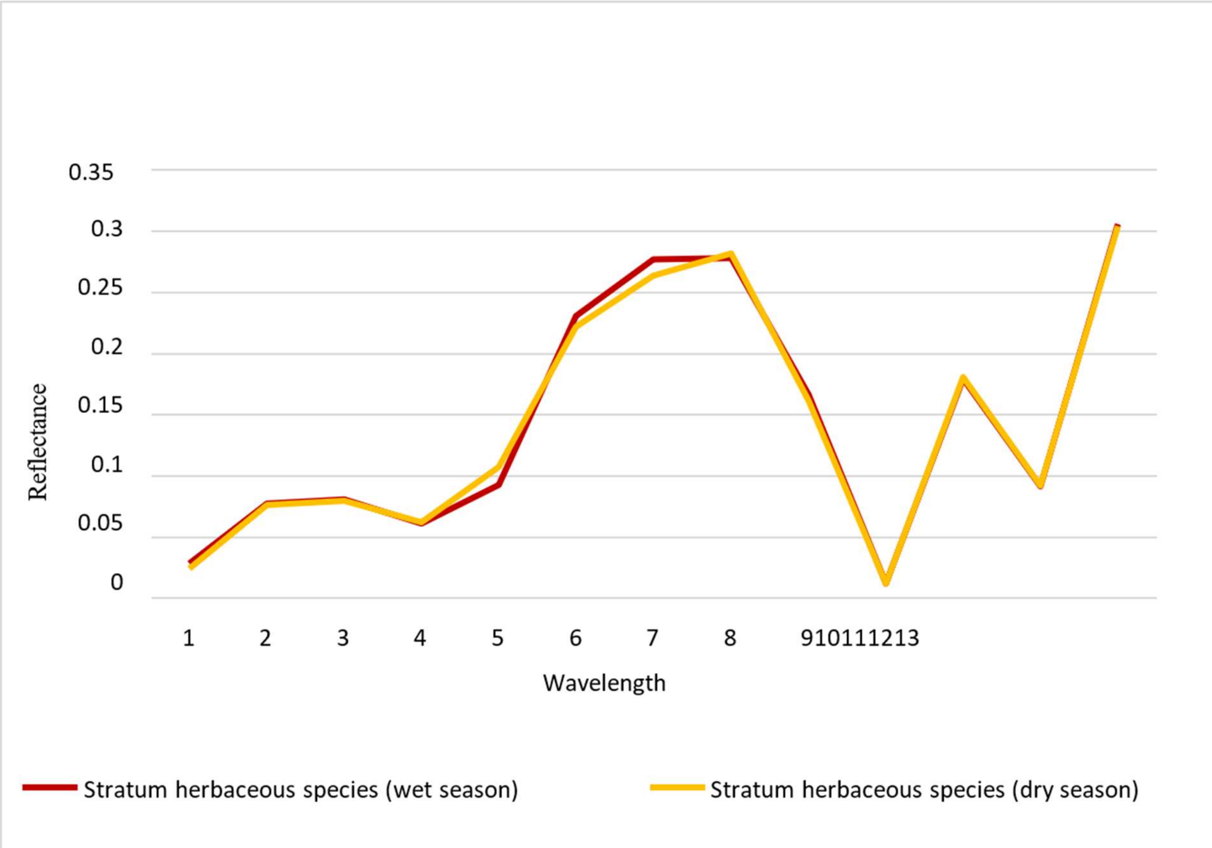

Figure 8. Comparison of the spectral signature of the coverage of herbaceous species in the wet and dry season