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SUSTAINABILITY OF PERMANENT PRESERVATION AREAS (PPAS): A MATHEMATIC APPROACH OF WHITE ANGICO (*Anadenanthera colubrina*)

SUSTENTABILIDADE DAS ÁREAS DE PRESERVAÇÃO PERMANENTE (APAS): UMA ABORDAGEM MATEMÁTICA DA ESPÉCIE ANGICO BRANCO (*anadenanthera colubrina*)

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ABSTRACT: Brazil has a high demand for wood for the most varied purposes, and almost 20% are wood from native species, especially Angico. Related to the vegetation of permanent preservation areas (PPAs), they have important ecological roles of protecting and maintaining water resources, conserving the diversity of plant and animal species, and controlling soil erosion and the consequent siltation and pollution of watercourses. Then, 74 portions were demarcated along of the permanent preservation areas (PPAs), 5 X 100 meters, totaling 500 m² each portion. The samples were collected in a permanent preservation area (PPA) of rural properties in the western of Paraná State (Brazil). The observed values of the frequency distribution were adjusted using the software called Statistics in order to analyze the Normal, Gamma, Log-Normal and Exponential probabilistic distributions and the Excel program was used to analyze the Weibull probability distribution with 2 and 3 parameters. In order to test the adherence of the functions to the data, the Kolmogorov-Smirnorv (KS) test was used. When the frequency distribution was analyzed, it was observed that the samples collected and distributed in classes of the Angico species have native forest behavior, in other words, the inverted curve in "J", and that most individuals are in the first two classes of samples.

Keywords: Forest Products; Adherence test; Native forest; Environmental preservation.

RESUMO: O Brasil apresenta grande demanda por madeira para os mais variados fins, sendo que quase 20% correspondem a madeiras de espécies nativas, especialmente o Angico. No que se refere a vegetação das áreas de preservação permanente (APPs), as mesmas desempenham importantes papéis ecológicos de proteger e manter os recursos hídricos, de conservar a diversidade de espécies de plantas e animais, e de controlar a erosão do solo e os consequentes assoreamento e poluição dos cursos d'água. Foram demarcadas 74 parcelas ao longo das áreas de preservação permanente (APPs) de 5 X 100 metros totalizando 500 m² cada parcela. A coleta das amostras foi realizada em área de preservação permanente (APP) de propriedades rurais na região Oeste do Paraná. Os valores observados da distribuição de frequência foram ajustados por meio do software denominado Estatística para analisar as distribuições probabilísticas Normal, Gama, Log-normal e Exponencial e o programa Excel para analisar a distribuição probabilística Weibull com 2 e 3 parâmetros. Para testar a aderência das funções aos dados, utilizou-se o teste Kolmogorov-Smirnorv (KS). Quando analisado a distribuição de frequência observou-se que as amostras coletadas e distribuídas em classes da espécie Angico têm o comportamento de matas nativas, ou seja, a curva invertida em "J", e que a maioria dos indivíduos estão contida nas duas primeiras classes amostrais.

Palavras-chave: Produtos Florestais; Teste de aderência; Mata nativa; Preservação ambiental.

INTRODUCTION

Angico species is a native tree of American tropical regions. In Brazil, Angico occurs in Maranhão, Ceará, Piauí, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia, Tocantins, Goiás, Distrito Federal, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo and Paraná. They also appear in Argentina, Bolivia, Paraguay and Peru. Its scientific name is *Anadenanthera colubrina* from the *Leguminosae-mimosoideae* family. Angico is an evergreen to semi-deciduous tree, 10 to 20 meters high and 30 to 60 cm in diameter at chest height (PAD), reaching up to 35 meters in height and 100 cm PAD in adulthood.

The species is suitable for rural, naval and civil construction, woodwork and carpentry. It is used for the manufacture of sleepers, furniture, boards, bodywork, rafters, clapboards, frames, floorboards, ceilings, jambs, props, timbers, crosspieces, supports, floors, fences, stakes, poles, wagons, mill wheels and hydraulic works. It also produces good quality firewood and charcoal.

Wood with very high lignin content, being considered excellent for the production of alcohol and bituminous coal. It shows rapid growth and it can be successfully used for reforestation of degraded areas and permanent preservation. It is considered an apiculture plant, providing pollen and nectar (33% of sugar), and the honey produced by the bees that feed on its flowers is clear and with superior quality. The bark and fruit contain about 15 to 20% of tannin, an indispensable product in the tanning industry.

Brazil has a high demand for wood for several purposes and it can be used for the production of coal, paper and pulp, furniture and besides light and heavy construction and the demand that has been growing in the recent years, and almost 20% corresponds to woods of native species, especially Angico. As it can be seen, there are several economic benefits that the species in question can provide to farmers, especially those who develop commercial crops.

Observing with an ecological or preservation bias, in addition to preserving water resources, native species forests also work as corridors for animals and plants, linking the various fragments of natural vegetation. Related to the vegetation of permanent preservation areas (PPAs), they have important ecological roles in protecting and maintaining water resources, conserving the diversity of plant and animal species, and controlling soil erosion and the consequent siltation and pollution of watercourses, and then the angico species may be a viable alternative for the development of these areas.

Although significant changes have been taking place in recent decades in rural areas, the predominant view of producers is still that preserving nature is synonymous of economic loss. In this context, environmental preservation is only taken seriously with the imposition of punitive laws, since most farmers do not realize the real benefit from the preservation process. As it can be observed, there are income alternatives for the rural producer using Angico species for the economic and environmental development of their properties.

Given these economic and preservation perspectives, this study aimed to evaluate the distribution of stem diameter and height of White Angico and Cassia fistula trees in permanent preservation areas (PPAs).

THEORETICAL REVIEW

The prediction of diameter distribution in forest stands is very important for planning, allowing to make the prognosis of wood multi-products (RENNOLLS *et al.*, 1985).

For Catalunha *et al.* (2002), the use of probability density functions is directly linked to the nature of the data to which they are related. Some have good estimation capabilities for little data, others require large series of observations. Since it is respected the representativeness aspect of the data, the estimates of its parameters for a given region may be established as general use, without prejudice to the accuracy of the probability estimation.

The probability density function of normal distribution with average μ and variance σ^2 (equivalent form, standard deviation σ) is defined as follows:

$$f(x,\mu,\sigma) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)}, -\infty < x < \infty, \sigma > 0.$$

If the random variable X follows this distribution, it is written: $X \sim N(\mu, \sigma^2)$. If $\mu = 0$ and $\sigma = 1$, the distribution is called the standard normal distribution and the probability density function reduces to:

$$f(x) = \frac{1}{\sqrt{2\pi}} e^{\left(-\frac{x^2}{2}\right)}.$$

Being a and b are known constants, the normal distribution shows some properties:

- If X follows a normal distribution, $X \sim N(\mu,\sigma^2)$, then $aX + b \sim N(a\mu + b, b,a^2\sigma^2)$.
- If X and Y are independent random variables that follow normal distribution, then the sum U = X + Y, the difference V = X - Y or any linear combination W = a X + b Y are also random variables with normal distribution.
- The sum of a large number of random variables (with some restrictions) tends to a normal distribution, and the most precise meaning of this is the Central Limit Theorem.
- The normal distribution is infinitely divisible in the following sense: if X is a random variable that follows a normal distribution and n is a natural number, then there are n random variables $X_1, X_2, \ldots X_n$, independent and identically distributed, such as: $X = X_1 + X_2 + \ldots + X_n$

In statistics, the Kolmogorov-Smirnov test (KS test) is a nonparametric test on the equality of continuous and one-dimensional probability distributions which can be used to compare a sample with a probability distribution of reference or two samples with one another. The Kolmogorov-Smirnov statistic quantifies the distance between the empirical distribution function of the sample and the cumulative distribution function of the reference distribution or between the empirical distribution functions of two samples (DANIEL, 2000).

According to the author, the Kolmogorov-Smirnov (KS) test is a test of adherence. That is, it evaluates the degree of agreement between the distribution of a set of sample values (observed values) and a given specific theoretical distribution. This tests whether the sample values can probably be considered as coming from a population with a supposed theoretical distribution. The test uses the cumulative distributions, in other words, it compares the cumulative frequency distribution that should occur under the supposed distribution with the cumulative frequency distribution of the observed values. The statistical test is the point of greatest difference (in absolute value) between the two distributions.

In probability and statistics, a random variable X has the distribution log-normal when its logarithm $Y = log(X)$ has the normal distribution. Therefore, its density function is:

$$f(x;\mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left[-\frac{(\ln(x)-\mu)^2}{2\sigma^2}\right]$$

The importance of the log-normal distribution is due to a result analogous to the Central Limit Theorem: just as a normal distribution appears when several independent distributions are summed. The log-normal distribution naturally appears as the product of several independent (always positive) distributions.

The exponential distribution is a kind of continuous probability distribution, represented by a parameter λ (lambda parameter). This is a distribution that has a constant failure rate function. The exponential distribution is the only one with this property. It is considered one of the simplest in mathematical terms. The random variable X has Exponential distribution of parameter λ, λ> 0, if it has density given by:

$$f(x) = \begin{cases} \lambda e^{-\lambda x} \text{ se } x \geq 0 \\ 0 \text{ se } x < 0 \end{cases}$$

The cumulative distribution function F (x) is given by:

$$F(x) = \int_0^x f(s)ds = \begin{cases} 1 - e^{-\lambda x} \text{ se } x \geq 0 \\ 0 \text{ se } x < 0 \end{cases}$$

The probability that the random variable X assumes any nonnegative value in the infinitesimal range [x *, x * + dx] is $\lambda e^{-\lambda x}$. The probability that the random variable X assumes a negative value is zero.

In statistics, a Gamma distribution is a continuous probability distribution, with two parameters r (shape parameter) and α (scale parameter), which it is required r > 0 and α > 0; which density function for values x > 0 is:

$$f(x) = \frac{\alpha}{\Gamma(r)}(\alpha x)^{r-1}e^{-\alpha x}$$

for x ≤ 0, there is:
f(x) = 0.

Here, Γ is the gamma function, which is given by:

$$\Gamma(z) = \int_0^\infty t^{z-1}e^{-t}\,dt$$

The Weibull probability density function is currently the most widely used in the forest sector. This generates a configuration that coincides with the ideal conditions for the adjustment of this function (GUIMARÃES, 1994). According to Bailey and Dell (1973), it can be expressed as follows:

$$f(X) = \left\{ \frac{\gamma}{\beta}\left(\frac{(x-\alpha)}{\beta}\right)^{(\gamma-1)} e^{-\left(\frac{(X-\alpha)}{\beta}\right)^{\gamma}} \right.$$

For a < x <∞ where α is the location parameter, β is the scale parameter (β> 0), γ the shape parameter (β> 0) and γ is the class center of the diameter (x> 0).

The use of probability distribution functions requires the use of tests in order to prove the adaptation of data or data series to the functions. These tests are known as adherence tests and their real function is to verify the form of a distribution by analyzing the adequacy of the data to the curve of a hypothetical distribution model.

According to Assis *et al.* (1996), the Kolmogorov-Smirnov adherence test, serves to compare the empirical probabilities of a variable with the theoretical probabilities estimated by the distribution function in test, verifying if the sample values can come from a population with that theoretical distribution.

METHODOLOGY

Initially 74 portions were demarcated along of permanent preservation areas (PPAs), the 5 X 100 meter, totaling 500 m² each portion. The samples were collected in permanent preservation areas (PPAs) of rural properties in the western region of Paraná State (Brazil), in the riparian forests of the respective properties. The rectangular units are generally used with large dimensions, where there is greater variability in plant formation or to capture greater variability in the forest, but they may be of various sizes (SANQUETTA *et al.*, 2006).

In the sample unit of 100 meters long and 5 meters wide, it was measured the individuals with chest height diameters greater than or equal to 10 cm. The sampling process was simple randomized, where all individuals have the same chance of being selected. According to Sanquetta *et al.* (2006), the simple random sampling process is the fundamental process from which all other processes derive. The selection of the sample units assumes that all possible combinations of sample units have an equal chance of being selected.

It was collected height and circumference at the chest height (HCC) from 708 samples of Angico (trees). The respective HCCs were transformed into chest height diameters (CHDs). The respective CHDs were distributed in 12 diametric classes, being observed that the lower limit was 4.77 (CHD) and the upper limit was 81.81 (CHD) of the set of observations. The classes range is 6.42 cm.

The observed values of the frequency distribution were adjusted using the software called “Estatística” in order to analyze the Normal, Gamma, Log-Normal and Exponential probabilistic distributions and the Excel program to analyze the Weibull probability distribution with 2 and 3 parameters.

In order to test the adherence of functions to the data, the Kolmogorov-Smirnorv (KS) test (SOKAL; ROHLF, 1981; GIBBONS; SUBHABRATA, 1992) was used. This test compares the estimated cumulative frequency with that observed, being the class with greater statistical divergence of the KS test.

Where S (X) is the observed cumulative frequency, and F(X) is the frequency estimated by the density-function probability. The test was applied at each adjustment, at 1% of significance for the Normal, Gamma, Log-Normal and Exponential probability distributions and 5% of significance for the Weibull probability distribution (2 and 3 parameters).

When it is adjusted a probability distribution to a data set, it is hypothesized that the distribution can adequately represent that set of information. One way to prove this hypothesis is using some non-parametric tests, such as the Adhesion Test of Kolmogorov-Smirnov: This test was introduced by Kolmogorov and Smirnov (1933), cited by Assis (1996), as a methodology for its application, considering F(x) the proportion of expected values less than or equal to a x S(x) the proportion of observed values less than or equal to x, where D calculated is modulus of the maximum observed deviation:

$$D \text{ calculated} = MAX\,[F(X) - S(X)]$$

For this it is compared D calculated with D tabulated (D tabulated is the maximum tabulated deviation found in appropriate tables); if D calculated was lower, there is agreement between observed and expected frequencies, the sample comes from a population that follows the probability distribution under test.

The Kolmogorov-Smirnov test can be used for both grouped and individual data. In grouped data there is no restriction on the number or value of classes. It is based on the modulus of the largest difference between the probability of observed and estimated values, which is compared to a tabulated value, according to the number of observations in the series under test.

In order to obtain the D tabulated, the standard formula was used, observing the critical values of the KS statistical distribution developed by Kolmogorov-Smirnov, being for adherence level $p > 0.05$, as calculated (1.36 / ROOT 708), obtaining the result of D tabulated of 0.05111.

RESULTS AND DISCUSSIONS

It was observed 708 samples of Angico species, being the lowest CHD observed 4.77 and the highest 81.81, divided into 12 classes with a class interval of 6.42. The average observed in the set of values was 12.9049, with a variance of 127.0948 and the standard deviation was 11.27363.

When it was analyzed the frequency distribution, it was observed that the samples collected and distributed in classes of Angico species have the behavior of native forests, in other words, the inverted curve in “J”, and that biggest part of the samples (individuals) are contained in the first two sample classes representing 81.49%.

TABLE 01: Summary probabilistic distributions adjustments.

PROBABILISTIC DISTRIBUTIONS	***Kolmogorov Smirnov Calculated***	***Kolmogorov Smirnov Tabulated (5%)***	***p***
NORMAL	0.23540	0.05111	0.000
GAMA	0.14267	0.05111	0.000
LOG-NORMAL	0.10865	0.05111	0.000
EXPONENTIAL	0.30926	0.05111	0.00153
WEIBULL (3 P)	0.08315	0.05111	0.05
WEIBULL (2 P)	0.17671	0.05111	0.05

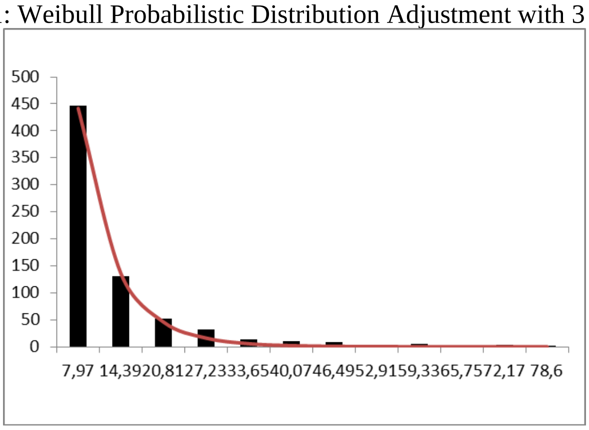
Source: Developed by the authors

Related to the sensitivity of the Kolmogorov-Smirnov (KS) adherence test of the probability distributions, the results of D tabulated with a probability of 5%, according to the calculation method presented above, it showed index of 0.05111. The results of D calculated for the various probabilistic distributions are summarized according to Table 01.

Among the probabilistic distributions analyzed, observing the sensitivity of the Kolmogorov-Smirnorv (KS) adherence test, the exponential probabilistic distribution (0.30926) presented the lowest adherence level, in order words, the largest difference between D calculated and D tabulated. Normal probabilistic distribution showed D calculated of 0.23540.

The Weibull probabilistic distribution with 2 parameters obtained D calculated of 0.177671, Gamma probabilistic distribution (0.144627) and the log-normal probabilistic distribution (0.10865). The one that showed the best performance, that is, the smallest difference between D calculated and D tabulated, was the Weibull probabilistic distribution with 3 parameters and it presented D calculated of 0.08315.

CHART 01: Weibull Probabilistic Distribution Adjustment with 3 parameters.



Source: Developed by the authors

The Weibull probabilistic distribution with 3 parameters presented the best index in the Kolmogorov-Smirnorv (KS) adherence test, but its adherence is not significant at a probability level of 5%, since it showed D calculated (0.08315) greater than D tabulated (0.05111).

Among the analyzed adjustments of the probabilistic distributions, it was observed that none of them provided adherence, in other words, they are not significant by the Kolmogorov-Smirnorv (KS) test ($p > 0.05$), because D tabulated (5%) presented the index of 0.05111.

FINAL CONSIDERATIONS

For all probabilistic models analyzed, the Kolmogorov-Smirnov (KS) test showed that there is no significant difference at a probability level of 5% among the observed values and the estimated values of each one of the probabilistic distributions analyzed.

When it was analyzed the frequency distribution, it was observed that the samples collected and distributed in classes of Angico species have native forest behavior, that is, the inverted curve in “J”, and that the biggest part of the individuals is contained in the first two classes of samples.

Angico species can be fully used for the re-composition of the permanent preservation areas (PPAs), providing economic and ecological gains in these special areas and due to the importance of the species. It is suggested to continue studies in order to determine what distribution provides adherence using the Kolmogorov-Smirnov (KS) test observing other probabilistic distributions or another adherence test for non-normal data, such as the Shapiro-Wilk test.

REFERENCES

ASSIS, F.N.; ARRUDA, H.V.; PEREIRA, A.R. **Aplicações de estatística à climatologia: teoria e prática**. Pelotas: Ed. Universitária/UFPel, 1996. 161p.

ASSIS, J. P. et al. Ajuste de séries históricas de temperatura e radiação solar global diária às funções densidade de probabilidade normal e log-normal, em Piracicaba, SP. **Revista Brasileira de Agrometeorologia**, v. 12, n. 01, p. 113-121, 2004.

BAILEY, R.; DELL, T. Quantifying diameter distributions with the Weibull function. **Forest Science**. v.19, n.2. p.97-104, 1973.

CATALUNHA, M. J. et al. Aplicação de cinco funções densidade de probabilidade a séries de precipitação pluvial no Estado de Minas Gerais. **Revista Brasileira de Agrometeorologia**, v. 10, n. 01, p. 153-162, 2002.

DANIEL, W. W. Applied Nonparametric Statistics. Duxbury Press. 2.d. Revisada. New York, 2000.

GIBBONS, J. D.; SUBHABRATA, C. **Nonparametric statistical inference**. 3.ed. New York: Marcel Dekker, 1992. 544p. (Statistics: textbook and monograph, v.31).

GUIMARÃES, D. P. **Desenvolvimento de um modelo de distribuição diamétrica de passo invariante para prognose e projeção da estrutura de povoamentos de eucalipto.** 1994. 178f. Tese (Doutorado em Ciência Florestal) - Universidade Federal de Viçosa, Viçosa, MG, 1994.

RENNOLLS, K.; GEARY, D. N.; ROLLINSON, T. J. D. **Characterizing diameter distributions by the use of the Weibull distribution. Forestry**, v.58, n.1, p.57-66, 1985.

SANQUETTA, C.R. et al. **Inventários Florestais**: planejamento e execução. Curitiba, 2006.

SOKAL, R. R.; ROHLF, F. J. **Biometry**. San Francisco: Freeman, 1981. 859p.

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