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Artigos

Impact of the specific fire load on the performance of power transmission lines

O impacto da carga de incêndio específica no desempenho de linhas de transmissão de energia

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ABSTRACT

Transmission line outages caused by fires are frequent and affect the electric power supply to the population. Studying the factors that may aid in the understanding of this problem is fundamental to improve performance and guide future projects involving this type of installation. This study analyzed the forest inventories of vegetation adjacent to three Brazilian transmission line trunks and calculated their specific fire loads. The results were compared with the performance of these installations and revealed a high correlation (R^2=0.9877) between the fire load and the number of transmission line outages, demonstrating the influence of vegetation on the operation of these installations.

Keywords: Forest inventory; Fires; Electricity

RESUMO

Os desligamentos de linhas de transmissão provocados por queimadas são frequentes e afetam o fornecimento de energia elétrica à população. O estudo de fatores que ajudem a compreender esse problema é fundamental para melhorar o desempenho e orientar futuros projetos desse tipo de instalação. O presente trabalho analisou os inventários florestais da vegetação adjacente a três troncos de linhas de transmissão brasileiros e calculou suas cargas de incêndio específicas. Os resultados foram comparados com o desempenho dessas instalações e demonstraram uma elevada correlação (R^2=0,9877) entre a carga de incêndio e o número de desligamentos das linhas de transmissão analisadas, evidenciando a influência da vegetação na operação dessas instalações.

Palavras-chave: Inventário florestal; Queimadas; Eletricidade

1 INTRODUCTION

Transmission lines are essential installations as they connect power plants to load centers. Through these installations, large blocks of energy are transported to enable the operation of cities, industries and all the utilities of the modern world.

Transmission systems are designed to absorb simple contingencies, that is, the loss of an installation or equipment, without interrupting power supply to the final consumer (ONS, 2018). To meet this requirement, it is common to find situations where two electrical points (substations) are connected by two different transmission lines. In this situation, the set of lines that connect these electrical points are called trunks. These trunks can be understood more comprehensively as a set of transmission lines arranged in series (SANTIAGO; TAVARES, 2019) or in parallel.

The performance of the Brazilian transmission system is monitored through a specific system, owned by the national network operator. This system collects, classifies and consolidates the data on forced outages and disturbances for statistical purposes and the calculation of performance indicators (ONS, 2016).

According to Jian et al. (JIAN *et al.*, 2013), fires always cause the interruption of the operations of transmission lines. Studying the phenomenon is therefore of paramount importance. This occurs because the isolation of overhead power lines is significantly reduced by the presence of gases at high temperatures and particulate matter in suspension, which, when combined, may cause the flashover (Rupture of the dielectric strength of the air (LIU *et al.*, 2019)) of electrical circuits (YI-SHI YUE *et al.*, 2017).

In 2017, 21.3% of the transmission line outages in Brazil were caused by fires (ONS, 2018). By comparison, in South Africa, a country with a transmission system that is five times smaller (28 thousand km) than in Brazil, 22% of forced outages of its transmission system were caused by fires (MINNAAR; GAUNT; NICOLLS, 2012).

According to the Brazilian Electrical Energy Agency (*Agência Nacional de Energia Elétrica* – ANEEL) (ANEEL, 2018), the highest incidence of outages caused by fires occurs in the Northeast, Southeast and Center-West regions of Brazil, in the *Zona da Mata* areas dedicated to sugarcane cultivation and in areas with anthropized savannah biome (*Cerrado*).

Even within the same biome, there are significant differences in performance between the transmission lines of the Brazilian electrical system. This difference in performance may be associated with the specific fire load of the transmission lines. ABNT NBR 14432:2000, the Brazilian standard dealing with the subject, does not establish reference fire load values in forest environments, a factor that enhances the relevance of this work. The fire load can be defined as the total amount of energy that can be released by the complete combustion of all combustible materials in a certain area.

The fire load concept has already been used to model the risk of forest fires in areas affected by hurricanes in Mexico (RODRÍGUEZ-TREJO *et al.*, 2011); for predictive studies of forest fire intensity in South Korea (PARK; LEE; OHGA, 2018); for resource optimization in forest fire fighting in California (LEE *et al.*, 2013); and it also served as parameter for the calibration of a fire severity classification system using satellite images in operation in western Malaysia and Indonesia (DYMOND *et al.*, 2005).

The parameters needed to calculate the specific fire load are the heating value and the mass of the material at the same humidity, and the area under consideration.

Forest inventories provide estimates of the green volume to be cut (COUTINHO MENEGUZZI *et al.*, 2020) for the construction and operation of transmission lines. By knowing the green volume and the basic density, one can therefore estimate dry mass.

The use of forest inventories is recommended due to their level of detail and the accuracy of available data. Even so, forest inventories usually focus on wood stem information and do not take into account other tree components, i.e.: branches, twigs, foliage, bark and the unmarketable tree crowns (BOUCHARD; LANDRY; GAGNON, 2013).

The higher heating value of wood is defined as the amount of heat generated by the complete combustion of one unit of mass, including the vaporization heat of the constituent water. Basic density is defined by the ratio between the wood's dry mass at 0% of humidity and its volume obtained above the saturation point of the fibers.

After establishing the necessary parameters, the objective of this work is to calculate the fire load of three transmission line trunks based on the forest inventory study, and to check if the calculated fire loads are of influence on the performance of these installations.

2 MATERIAL AND METHOD

Employing the access to information law (*Lei de Acesso à Informação* – LAI) (BRASIL, 2011), the forestry inventory studies of three Transmission Line (TL) trunks with an operating voltage of 500 kV were obtained from the licensing executive agency:

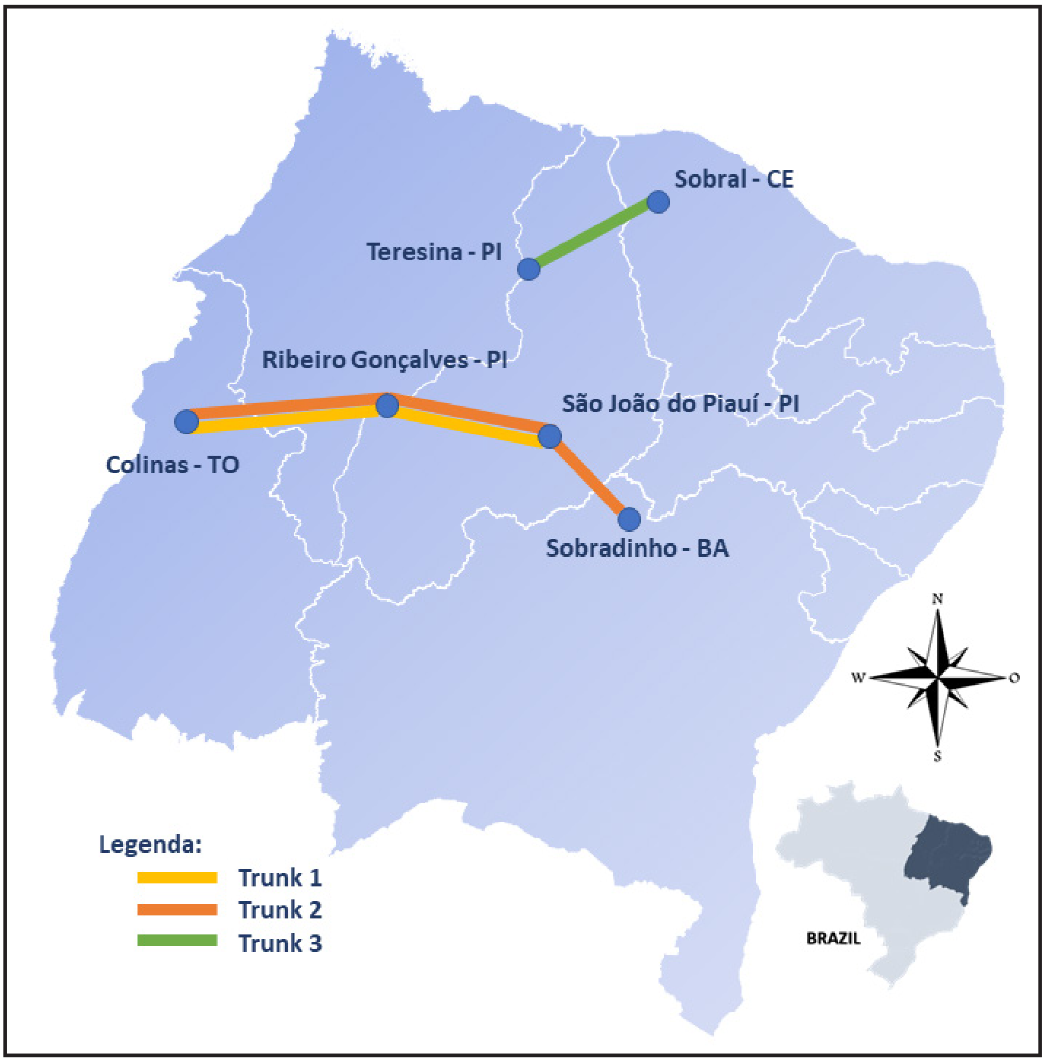
– Trunk 1: TL 500 kV Colinas - Ribeiro Gonçalves - São João do Piauí C2, built in 2009 by the utility IENNE (PEREIRA; TAVARES, 2009);

– Trunk 2: TL 500 kV Colinas - Ribeiro Gonçalves - São João do Piauí C1 - Sobradinho, built in 2005 by the utility ATE III (ROCHA *et al.*, 2005);

– Trunk 3: TL 500 kV Teresina II - Sobral III C2, built in 2000 by the utility STN, but with a forest inventory for the stretch between the cities of Teresina-PI and Piripiri-PI, revised in 2019 (ROCHA *et al.*, 2019).

The selection of these transmission lines (Figure 1) for analysis was based on the location of the installations. TLs which were predominantly located in the *cerrado* biome were prioritized. In addition, another preponderant factor was the availability of forest inventory studies in the archives of the licensing executive agency.

Figure 1 – Schematic of the analyzed transmission lines

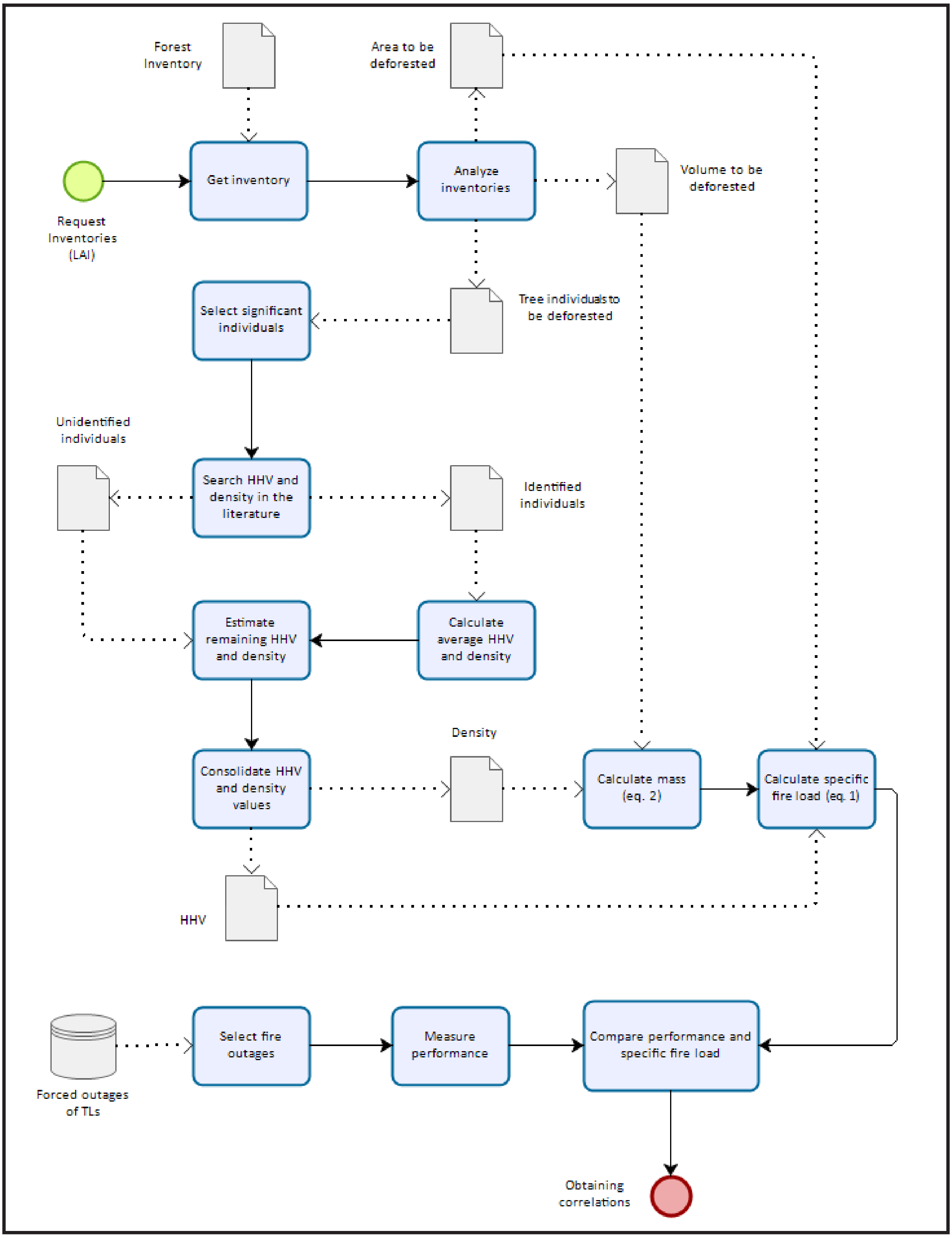


Source: Authors (2021)

The inventory data were obtained from different studies. These studies used similar methodologies. In the three cases, corresponding plots of land were selected along the paths of the transmission lines and the forest inventory was conducted inside these plots.

Figure 2 summarizes the methodology applied in the study.

Figure 2 – Summary of the methodology



Source: Authors (2021)

The volume of woody material to be cut, the areas to be deforested and the cataloged individual tree species were identified through the inventory for each of these TLs. Using a Pareto analysis (HARDY, 2010), the species with the highest representation were identified among the inventoried individuals. For this subset of species, a literature study was carried out to identify the Higher Heating Value (HHV) and the corresponding Basic Density (ρ_b).

Based on the ρ_b and volume data, the dry masses corresponding to each tree species were calculated using Equation (1). Once the dry wood mass and its HVV were known, the fire load corresponding to each species for each transmission line trunk could be calculated. The sum of the individual fire loads per species divided by the area to be deforested corresponds to the ratio of Equation (2), providing as a result the specific fire loads of the TL trunks. In those cases where it was not possible to identify the HVV and ρ_b, the means of the data found were used.

$$\rho_b = \frac{M_s}{V_{sat}} \tag{1}$$

Where: M_s - Dry wood mass (0% humidity); V_{sat} - Saturated volume.

$$q_i = \frac{\sum M_i HHV_i PCS_i}{A_i} \tag{2}$$

Where: q_i - specific fire load value, in MJ/m^2; M_i - total dry mass of each component i of the fuel material, in kg; $HHV_i PCS_i$ - higher heating value of each i-component of the fuel material, in MJ/kg; A_i - area of the space considered, in m^2.

3 RESULTS AND DISCUSSION

In the forest inventories under analysis, 111 species were identified, totaling 4502 distinct arboreal individuals. Three species could not be identified, corresponding to 245 arboreal individuals.

The 108 species identified were divided into 28 botanical families, totaling 4257 arboreal individuals inventoried. The literature was searched regarding the Higher Heating Value (HVV) and basic density (ρ_b) of each species. The heating value of 64 species and the basic density of 67 species could be identified. The species with an identified HVV and ρ_b can be seen in Table 1. The species for which these parameters were not identified are listed in the Table 2.

Table 1 – Species with Higher Heating Value (HVV) or Basic Density (ρ_b) identified in the literature

Family	Species	Arboreal individuals (units)	Basic Density ρ_b (g/cm³)	Higher Heating Value HHV (MJ/kg)
Anacardiaceae	*Anacardiaceae* 1	21	-	17.40[a]
	Anacardium humile St. Hilaire	9	0.42[b]	18.46[b]
	Anacardium sp	17	0.52[c]	18.64[c]
	Astronium fraxinifolium	18	1.13[d]	-
	Myracrodruom urundeuva	25	0.86[cc]	19.50[e]
Annonaceae	*Annonaceae* 1	15	0.60[d]	19.17[d]
	Xylopia aromatica	32	0.59[f]	19.17[f]
	Rollinia sp.	80	0.52[g]	-
Apocynaceae	*Aspidosperma pyhfolium* Mart.	59	-	20.31[h]
	Aspidosperma sp.	36	-	19.17[h]
Arecaceae	*Syagrus* sp.	81	0.92[i]	18.33[i]
Bignoniaceae	*Bignoniaceae* 1	13	1.05[d]	20.74[d]
	Jacaranda sp.2	27	0.35[b]	19.65[b]
	Tabebuia	14	1.05[c]	20.74[c]
	Tabebuia impetiginosa	18	0.84[dd]	20.19[j]
Burseraceae	*Protium* sp.2	16	0.55[k]	19.75[k]
Caryocaraceae	*Caryocar coriaceum* Wittm.	21	0.61[c]	20.25[c]
	Caryocar villosum	18	0.61[c]	20.25[c]
Chrysobalanaceae	*Hirtella* sp 1	14	0.52[jj]	-
Combretaceae	*Buchenavia capitata* (Vahl.) Mart.	9	-	16.03[l]
	Combretaceae 1	27	1.05[m]	18.65[m]
	Combretum leprosum Mart.	321	1.05[m]	18.65[m]
	Thiloa glaucocarpa (Mart.) Eichler	136	1.05[m]	18.65[m]
Dilleniaceae	*Curatella americana L.*	93	0.67[jj]	-
Ebenaceae	*Diospyros* sp1	11	0.64[n]	19.15[o]
Erythroxylaceae	*Erythroxylum* sp.	60	0.54[p]	20.63[p]

To be continued ...

Table 1 – Continuation

Family	Species	Arboreal individuals (units)	Basic Density ρ_b (g/cm³)	Higher Heating Value HHV (MJ/kg)
Euphorbiaceae	*Croton sonderianus* MCII. Arg.	18	-	19.28[h]
	Croton sp	38	-	19.28[h]
	Croton zehntneri pax. & K. Hoffm.	42	-	19.28[h]
Fabaceae	*Acacia* sp	35	0.52[gg]	19.92[h]
	Anadenanthera sp.6	21	-	18.76[q]
	Andira fraxinifolia Benth.	31	0.92[d]	20.34[r]
	Andira humilis Mart. ex Benth.	12	0.42[jj]	-
	Bauhinia sp	99	0.71[s]	18.83[s]
	Bowdichia virgilioides H, B & K.	16	0.69[jj]	19.97[q]
	Caesalpinia aff. pyramida'is Tul.	22	0.98[ee]	17.53[t]
	Caesalpinia ferrea	24	-	20.68[h]
	Caesalpinia microphyila Mart.	24	-	17.53[t]
	Cenostigma gardnerianum Tul.	157	0.80[ii]	19.49[u]
	Cenostigma macrophyllum	203	1.20[v]	20.27[v]
	Cenostigma pyramidale	136	-	17.53[t]
	Copaifera langsdorffii Desf.	27	0.65[ii]	18.89[h]
	Dalbergia sp	157	0.77[p]	20.48[p]
	Dimorphandra mollis	18	0.70[p]	20.67[p]
	Hymenaea courbaril L.	62	0.88[b]	20.05[b]
	Hymenaea stigonocarpa	63	0.78[p]	20.30[p]
	Luetzelburgia auriculata	22	0.37[m]	40.33[m]
	Machaerium sp.3	36	0.99[d]	-
	Mimosa acutistipula genth.	14	0.86[d]	19.46[d]
	Mimosa caesalpiniifolia Benth.	21	0.86[d]	19.46[d]
	Mimosa tenuiflora (Willd.) poiret	63	0.86[m]	19.46[t]
	Piptadenia moniliformis Benth.	387	0.65[ii]	19.59 [h]
	Platypodium elegans Vogel	42	0.82[d]	-
	Sclerolobium aureum	91	0.61[ff]	18.79[m]
	Sclerolobium paniculatum Vogel	105	0.72[m]	22.70[m]
Flacourtiaceae	*Casearia decandra*	31	0.63[w]	-
Liyhraceae	*Lafoensia pacari*	27	0.74[p]	20.03[p]
Malpighiaceae	*Byrsonima verbascifolia*	10	0.48[p]	19.96[p]
	Byrsonima sp.	62	0.58[p]	20.14[p]

To be continued ...

Table 1 – Conclusion

Family	Species	Arboreal individuals (units)	Basic Density ρ_b (g/cm^3)	Higher Heating Value HHV (MJ/kg)
Malvaceae	*Guazuma ulmifolia* Lam.	12	0.55[w]	-
	Apeiba tibourbou	12	0.32[jj]	-
	Luehea candicans	24	0.49[jj]	-
Moraceae	*Brosimum gaudichaudii*	19	0.65[hh]	19.64[x]
Myrtaceae	*Campomanesia xanthocarpa*	37	0.86[d]	-
	Eugenia sp	83	-	19.02[h]
	Eugenia dysenterica	15	0.66[jj]	-
	Myrcia sp	31	0.68[f]	19.13[f]
	Myrcia sp.5	13	0.68[f]	19.13[f]
	Psidium sp.1	21	0.20[p]	20.01[p]
	Myrtaceae sp.	76	0.45[y]	18.39[z]
Opiliaceae	*Agonandra brasiliensis*	11	0.67[jj]	-
Polygonaceae	*Coccoloba* sp	11	0.71[aa]	-
Rubiaceae	*Posoqueria* sp	18	0.71[jj]	-
	Rubiaceae sp.	39	-	21.32[bb]
Sapotaceae	*Pouteria ramiflora* (Mart) Radlk.	18	0.70[p]	20.00[p]
	Pouteria sp.3	12	0.90[p]	20.41[p]
Verbenaceae	*Aloysia virgata*	15	0.60[ii]	-
Vochysiaceae	*Qualea grandiflora* Mart.	113	0.69[m]	20.48[m]
	Qualea parviflora Mart.	78	0.69[p]	19.71[p]
	Salvertia covallariaeodora	22	0.59[jj]	-
	Simarouba amara	30	0.35[b]	19.36[b]

Source: Authors (2021)

In where: [a](PONTE *et al.*, 2019) *apud* (COSTA, 2021); [b](QUIRINO *et al.*, 2005) *apud* (COSTA, 2021); [c](QUIRINO *et al.*, 2005) *apud* (COSTA, 2021); [d](FILHO; SARTORELLI, 2015) *apud* (COSTA, 2021); [e](SILVA *et al.*, 2017) *apud* (COSTA, 2021); [f](SILVA, 2014) *apud* (COSTA, 2021); [g](ARAUJO, 2002) *apud* (COSTA, 2021); [h](QUIRINO *et al.*, 2005) *apud* (COSTA, 2021); [i](OLIVEIRA, 2013) *apud* (COSTA, 2021); [j](VALE; FELFILI, 2005) *apud* (COSTA, 2021); [k](INGA; CASTILLO, 1984) *apud* (COSTA, 2021); [l](QUIRINO *et al.*, 2005) *apud* (COSTA, 2021); [m](MACHADO NETO, 2013) *apud* (COSTA, 2021); [n](CUNHA, 2019) *apud* (COSTA, 2021); [o](CLINE-COLE; LAST; RICHARDS, 1945) *apud* (COSTA, 2021); [p](VALE; BRASIL; LEÃO, 2002) *apud* (COSTA, 2021); [q](QUIRINO *et al.*, 2005) *apud* (COSTA, 2021); [r](MORI *et al.*, 2003) *apud* (COSTA, 2021); [s](KUMAR JAIN, 1992) *apud* (COSTA, 2021); [t](JÚNIOR *et al.*, 2015) *apud* (COSTA, 2021); [u](BRAND *et al.*, 2016) *apud* (COSTA, 2021); [v](ARAÚJO *et al.*, 2018) *apud* (COSTA, 2021); [w](COSTA *et al.*, 2014) *apud* (COSTA, 2021); [x](MARABOTO *et al.*, 1989) *apud* (COSTA, 2021); [y](HSING; PAULA; PAULA, 2016) *apud* (COSTA, 2021); [z](HABITZREITER *et al.*, 2020) *apud* (COSTA, 2021); [aa](MARQUEZ-REYNOSO *et al.*, 2017) *apud* (COSTA, 2021); [bb](VALE; FIEDLER; SILVA, 2005) *apud* (COSTA, 2021); [cc](SIQUEIRA *et al.*, 2013) *apud* (COSTA, 2021); [dd](IPT, 1989) *apud* (COSTA, 2021); [ee](SILVA *et al.*, 2009) *apud* (COSTA, 2021); [ff](MACHADO NETO *et al.*, 2015) *apud* (COSTA, 2021); [gg](VALE; BRASIL; MARTINS, 1999) *apud* (COSTA, 2021); [hh](NOGUEIRA, 2008) *apud* (COSTA, 2021); [ii](HENNE *et al.*, 2017) *apud* (COSTA, 2021); e [jj](OLIVEIRA, 2014) *apud* (COSTA, 2021).

In Table 1 there are 4017 tree individuals which had their respective HVV or ρ_b identified, but it was not possible to identify the HVV and ρ_b of 240 individuals of 11 species, that is, 5.6%, as can be seen in Table 2.

Table 2 – Species with no identification of the Higher Heating Value (HVV) and Basic Density (ρ_b) in the literature

Family	Species	Arboreal individuals (units)
Indeterminate	Indeterminate 00	135
	Indeterminate 01	88
	Indeterminate 06	22
Arecaceae	*Bactris setosa*	74
Chrysobalanaceae	*Hirtella ciliata* Mart. & Zucc.	16
Fabaceae	Fabaceae sp.04	17
	Parkia platycephala Benth.	8
	Swartzia flaemingii Raddi	12
	Vouacapoua sp.1	12
Lamiaceae	*Vitex* sp	77
Melastomataceae	*Mouriri elliptica* Mart.	24

Source: Authors (2021)

Based on the data in Table 1, the mean HVV and ρ_b values of the species found in each of the transmission line trunks under analysis were calculated. The results obtained can be seen in Table 3.

Table 3 – Means of the Higher Heating Value (HVV) and Basic Density (ρ_b) per transmission line trunk

Trunks	Stretches	Average Basic Density - r_b (kg/m³)	Average Higher Heating Value - HHV (MJ/kg)
1	Colinas - São João	680	19.68
2	Colinas - Sobradinho	710	19.72
3	Teresina II - Sobral III	740	20.40

Source: Authors (2021)

An analysis of variance (ANOVA) was carried out of the basic density and higher heating value means found for the three trunks in Table 3. For the basic density, an F-statistic of 0.78 was found for a critical value of 3.11; that is, there was no significant difference ($p<0.05$) between the means. As for the Higher Heating Value, an F-statistic of 0.51 was found, lower than the critical value of 3.11; that is, no significant difference ($p<0.05$) was found between the means.

The HVV and ρ_b means were used as reference for the species of Table 2 with no values identified in the literature search.

The forest inventories analyzed provide information on the average volume per individual tree cataloged. With the ρ_b and volume information, it is possible to calculate wood mass per species using Equation (1). Using Equation (2), it is possible to obtain the specific fire load of each transmission line trunk under analysis, as shown in Table 4.

Table 4 – Specific fire load per transmission line trunk

Trunks	**Stretches**	**Mass (ton)**	**Heating Value (MJ/kg)**	**Area (km^2)**	**Specific fire load (MJ/m^2)**
1	Colinas – São João	16,173.86	19.68	3.58	88.94
2	Colinas – Sobradinho	21,853.17	19.72	12.81	33.65
3	Teresina II – Sobral III	16,671.70	20.40	1.98	171.78

Source: Authors (2021)

There is clearly a big difference between the specific fire load values of the analyzed transmission line trunks. In order to assess whether this difference is related to the electrical performance of the line, the forced outages were analyzed that occurred in the three line stretches in 2018 and 2019. Table 5 shows the performance results per trunk.

Different lines in a trunk had to be grouped for the analysis of performance due to the way in which the forest inventories under analysis were obtained. Trunk 1 comprised of two 500 kV transmission lines in the stretch between Colinas-TO and São

João do Piauí-PI. Trunk 2 corresponds to three 500 kV transmission lines in the stretch between Colinas-TO and Sobradinho-BA. Trunk 3 corresponds to a 152 km stretch of the 500 kV Teresina II - Sobral III, between the cities of Teresina-PI and Piripiri-PI. The forest inventory of trunk 3 was published in 2019, fifteen years after the line went into commercial operation, as the result of a request for review of the environmental licensing at the executive licensing agency. The utility responsible for the line took this step due to poor performance: This important power transmission line has suffered a high amount of outages due to forest fires that impact its administrative right-or-way range. In the last two years, we registered 36 outages, putting the electric power supply of our northeast region at risk. The Brazilian Electrical Energy Agency - ANEEL, which monitors the operating results of the national electrical system monthly, classified the TL Teresina II - Sobral II as the SIN - National Interconnected System line with the highest number of outages due to forest fires, and as such it is demanding measures from this Transmitter to reduce this rate. (ROCHA *et al.*, 2019).

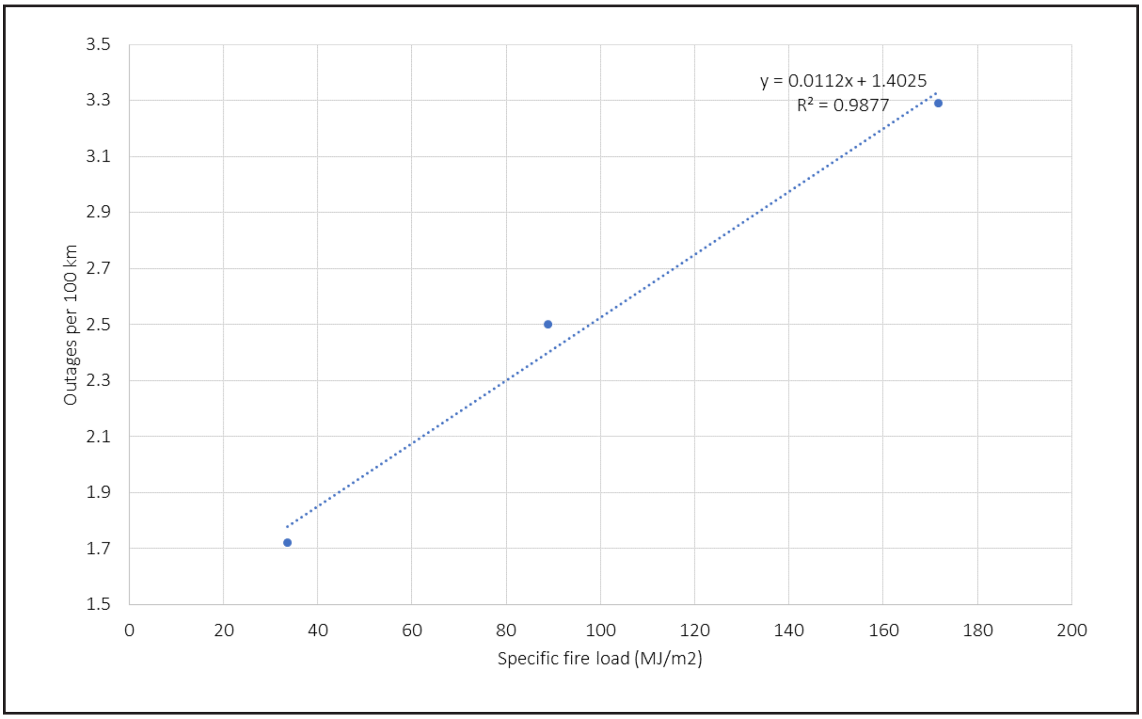
Table 5 – Relative quantity of forced outages in the analyzed transmission line trunks

Trunks	Transmission Lines at 500 kV	Outages	Line extension (Km)	Trunk outages	Trunk extension (km)	Outages/ 100 km
1	Colinas / Rib. Goncalves C2	4	367	17	720	2.50
	Rib. Goncalves / S. Joao Piaui C2	13	353			
2	Colinas / Rib. Goncalves C1	4	367	18	930	1.72
	Rib. Goncalves / S. Joao Piaui C1	14	353			
	S. Joao Piaui / Sobradinho C2	0	210			
3	Teresina II / Sobral III C1	5	152	5	152	3.29

Source: Authors (2021)

The poor performance observed by the regulatory agency was registered in periods prior to 2017. Nevertheless, in the period analyzed in this article, the TL 500 kV Teresina II - Sobral III was the transmission line with the highest number of outages per 100 km stretch. A correlation analysis between the fire load and the number of outages per 100 km was performed and is described in Figure 3.

Figure 3 – Transmission line outages per 100 km of line as a function of fire load



Source: Authors (2021)

Figure 3 reveals a high correlation (R^2=0.9877) between the specific fire load and the number of outages per 100 km on each transmission line trunk. The result shows that the characteristics of the arboreal species traversed by the transmission lines have a preponderant influence on the performance of these installations. This result makes it clear that stretches with dense forest should be avoided when selecting new transmission line paths, not only due to environmental factors, but also because of the better operational performance and lower maintenance costs of the transmission lines.

The means comparison test (ANOVA) of the basic density and Higher Heating Value of the timber species in the inventories revealed that there is no statistically significant difference between the transmission line trunks under study. Considering the data on the mass and areas available for deforesting in Table 3, one can see that there is a significant difference in the biomass density between the different trunks under study. The reason for this can be explained by the physiognomy of the vegetation existing in each trunk.

In trunk 1, the total deforested area was estimated at 3.58 km^2. Of this plot, 8.14% corresponded to the caatinga biome, 38.38% to forest and 53.48% to cerrado (PEREIRA; TAVARES, 2009). In trunk 2, the estimated deforested area was 12.81 km^2, with 20.00% corresponding to the caatinga area, 27.18% to a transitional area and 52.81% to cerrado (ROCHA *et al.*, 2005). Finally, trunk 3 had an estimated suppressed area of 1.98 km^2, containing 25.81% of cerrado, 34.67% of ecological tension zone and 39.50% of semideciduous seasonal forest (ROCHA *et al.*, 2019).

Trunk 3 is more vulnerable to outages caused by fires, and as can be seen it has the characteristic of possessing 74.17% of its area classified as semideciduous seasonal forest or ecological tension zone. In this trunk, the smallest proportion of cerrado (25.81%) was also found, which is the dominant physiognomy in more than half of the areas corresponding to trunks 1 and 2.

As they are less humid formations, semideciduous seasonal forests seem to be more exposed to the occurrence of fires (ARAÚJO FILHO, 2020).

According to Peixoto et al. (PEIXOTO *et al.*, 2012), semideciduous seasonal forests can increase the richness and diversity of species when exposed to fires. This behavior could be related to the opening of clearings that favor the establishment of pioneering and secondary species. Over time, this characteristic may explain the greater fire load observed in these areas.

Climatic factors can also influence the performance of the trunks regarding fires, but this information is not available in the forest inventories under analysis.

4 CONCLUSIONS

Based on the analysis of forest inventories and past scientific studies, it was possible to evaluate the energy quality of the vegetation present in the areas of influence of the transmission lines operating at a voltage of five hundred thousand volts. The calculated specific fire loads were compared with the performance of these lines. The results showed a high correlation (R^2=0.9877) between the fire load and the number of line outages, revealing the influence of vegetation on the operation of these installations. The analysis of the inventories also revealed that the lines with the highest outage rates crossed areas predominantly classified as semideciduous seasonal forest or ecological tension zone.

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