PROPOSAL FOR A SYSTEM OF TREES FALL POTENTIAL RISK ASSESSMENT IN URBAN PARKS[1]

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[1] Received on 02.01.2016 accepted for publication on 28.06.2017.
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ABSTRACT – This study aimed to create a system to assess the potential tree fall risk (SARPQA) and to assess all the trees in the Museum Paraense Emílio Goeldi Zoo (PZB/MPEG) and in the Rodrigues Alves Park/ Botanical Garden of Amazônia (BRA/JBA). We analyzed aspects, such as diameter at breast height (DBH), tree total heigh, surface biomass, apparent phytosanitary, stem inclination, canopy balance and presence of lianas. We assessed 1074 trees (DBH e" 20 cm) distributed in 229 species and 40 families. The average stem height, the total height and diameter at breast height were 10.9 m, 18.7 m and 41.9 cm respectively. The SARPQA showed that 23 trees had very high risk of fall, 142 had high risk, 750 individuals had medium and low risk and 159 had very low risk. Both parks have hundreds of large trees, which associated with the amount of people using these spaces, can increase the risk of accidents by tree fall. Trees with high risk of fall need immediate attention because they present risks to human life and/or property. The system proposed in this study proved to be practical and can be an effective tool for decision makers in the management of urban parks.

Keywords: Urban afforestation; Tree fall risk; Phytosanitary and risk descriptors.

PROPOSTA DE UM SISTEMA DE AVALIAÇÃO DO RISCO POTENCIAL DE QUEDA DE ÁRVORES EM PARQUES URBANOS

RESUMO – Este trabalho objetivou criar um sistema de avaliação do risco potencial de queda de árvores (SARPQA) e avaliar o risco queda de árvores no Parque Zoobotânico do Museu Paraense Emílio Goeldi e (PZB/MPEG) e no Bosque Rodrigues Alves/Jardim Botânico da Amazônia (BRA/JBA). Analisou-se aspectos relacionados ao diâmetro (DAP), altura total, biomassa aérea, fitossanidade aparente, inclinação do tronco, balanço da copa e incidência de cipós. Foram avaliados 1074 indivíduos (DAP e" 20 cm) distribuídos em 229 espécies e 40 famílias. A média da altura do fuste, da altura total e do diâmetro a altura do peito foram 10,9 m, 18,7 m e 41,9 cm respectivamente. O SARPQA mostrou que 23 árvores apresentaram risco de queda muito alto, 142 apresentaram risco alto, 750 indivíduos mostraram risco mediano e baixo e 159 têm risco muito baixo. Os dois parques apresentam centenas de árvores de grande porte, que associado à quantidade de pessoas que os utilizam, podem aumentar os riscos de acidentes com a queda de árvore. As árvores com elevado risco de queda precisam de atenção imediata, por apresentarem riscos à vida humana e/ou ao patrimônio. O sistema de avaliação proposto neste estudo mostrou-se prático e pode ser um instrumento eficiente para os tomadores de decisão no manejo de parques urbanos.

Palavras-chave: Arborização urbana; Risco de queda de árvores; Fitossanidade e Descritores de risco.

1. INTRODUCTION

Urban forests are a frequent topic in discussions about green spaces within urban environments. For Miller (1997) urban forests are the sum of all tree vegetation surrounding urban áreas, from small urban centers to large metropolitan areas, including streets, avenues, parks, squares, public and private areas and conservation areas.

Trees in urban environments provide numerous socio-environmental benefits of an ecological, biological and psychological nature, and also indirect economic benefits, becoming a determinant factor of mental health, directly influencing the people wellbeing (Milano and Dalcin, 2000; Melo et al., 2007; Schallenberger et al., 2010). However, trees in urban centers can cause a number of problems, such as the lifting of the sidewalks due to the growth of the roots, the fall of fruits, branches or the tree itself. These events may cause accidents and damage to people and property (Randrup et al., 2003).

According Gonçalves et al. (2007) the risk of accident due to the fall of a tree or part of it is potentialized according to what will be hit. The risk of tree fall is considered higher when human lives are involved, and smaller when it involves only material goods. Due to the possible damages that a tree fall can cause is relevant to know the phytosanitary conditions of trees in public places that concentrate a large flow of people. Among these places are parks, which are large areas for social interaction and important components of the local landscape formation (Pivetta and Silva Filho, 2002; Silva et al., 2007).

The risk assessment of urban trees has been a constant concern, because it is almost always associated with decisions that involve lives and patrimonies. Several methods have been created for local risk analysis, methods that generally use the establishment of ranks and weights in a objective way, according to the different modalities of risk that will be investigated (Seitz, 2005; Loboda et al., 2005; Gonçalves et al., 2007).

Quantitative parameters analyzed in isolation, and also broad qualitative characterizations, may erroneously express the reality of the urban afforestation. However, qualitative and quantitatively combined assessments make it possible to know the distribution of the vegetation in urban environment, and furthermore its qualitative characteristics (Silva et al., 2007).

To access a qualitative and quantitative combined assessment, it is necessary to know the set of trees presenting in the study area using tree inventories, which, depending on the area, can be done by partial or total sampling. Tree inventories may have previously defined objectives, inserted in different methodologies, and they may also present different results. These inventories also provide important information for tree assessment, and serve as a basis for the afforestation planning, and for define appropriate actions of monitoring and management of parks (Milano and Dalcin, 2000; Silva et al., 2007).

Taking into account the relevance of trees fall risk assessment for decision making on urban afforestation, this study aim to propose a tree fall potential risk assessment system and carry out a assessment of the trees from Museu Paraense Emílio Goeldi Zoo (PZB/MPEG) and from Bosque Rodrigues Alves Jardim Botânico da Amazônia (BRA/JBA) combining qualitative and quantitative aspects.

2. MATERIALS AND METHODS

2.1. Characterization of study area

The study was carried out in PZB/MPEG and BRA/JBA, located in central regions of the city of Belém, capital of the state of Pará, with a current population of 1,432,844 inhabitants, in an area of 1,059,458 km² (IBGE, 2014). The city has a hot and humid climate, defined as Afi according to Köppen classification (Amaral et al., 1993). According INMET (2015) Belém station presented in 2014 minimum monthly rainfall averaging 89.7 mm in the driest months, and maximum averaging 432.5 mm in the wettest months. Minimum and maximum monthly temperature averages are between 24° C and 32° C, while mean relative air humidity is between 75% and 87% in drier, and wetter months, respectively.

PZB/MPEG covers an area of 5.2 hectares and BRA/JBA 15 hectares. These spaces are the main parks of the capital of Pará, preserving part of the Amazonian biodiversity, and present an expressive number of visitors looking for leisure and contact with nature (Barreiros et al., 2005; Figueiredo et al., 2013).

According to IBGE (1992) PZB/MPEG phytogeographic was classified as dense hygrophilous lowland rainforest of the Amazonian region neotropical zone, hereinafter referred as ombrophilous forest. BRA/JBA phytogeographic according to Veloso et al., (1991) was classified as a non-alluvial dense ombrophilous forest fragment.

2.2. Data collection and fieldwork

The inventories were carried out in the total PZB/MPEG area and in one hectare of the BRA/JBA. This one hectare área from BRA/JBA covering the sides of the park corresponding to Perebebuí street and Almirante Barroso avenue, measuring, respectively, 12.5 m x 300 m and 12.5 m x 500 m. All trees with diameter at breast height (DBH, diameter of the stem at 1.30 meters from the ground) equal or greater than 20 cm were measured, and data were collected from May to July 2014.

Each tree had a registration number tagged on aluminum plates (8 x 2 cm), attached to the tree using nylon wire, with the number of the tree and its registration number recorded; For example, C2-32 (site 2, tree no. 32).

For each trees we assessed, measured, and properly registered in the field worksheet, the registration number of the tree; taxonomic classification of the species; diameter at breast height (DBH); stem and canopy height; apparent phytosanitary; stem inclination; canopy balance (canopy architecture); presence of lianas and presence of strangulating parasites ("apuí or mata-pau"); and potential risk of fall.

Species identification in the field was conducted by Nélson A. Rosa, parabotanical of the Museu Paraense Emilio Goeldi (MPEG). The taxonomic classification of the species was performed according to the APG III System (2009), and was confirmed by comparison with the collection of the MG herbarium and queries to the database of the Missouri Botanical Garden (2015) and to the List of Species of Flora of Brazil (2015).

2.3. Descriptors analyzed

Descriptors are variables used in the classification of the tree fall potential risk, we selected eight descriptors: (1) diameter (DBH), (2) total height, (3) aerial biomass, (4) apparent phytosanitary, stem inclination, (6) canopy balance, (7) presence of lianas and (8) canopy/stem ratio.

These descriptors were splitted in two groups: self-descriptors and risk descriptors. The self-descriptors are those inherent to the tree, independent of the species, such as: diameter, height, biomass and canopy/stem ratio. Risk descriptors are those related to the risk of tree fall, such as: apparent phytosanitary, stem inclination, canopy balance and the presence of lianas.

2.3.1. Self-descriptors

2.3.1.1. Diameter of the stem

The diameter of the stem was measured at 1.30 m from the ground, or above irregularities and sapopemas, using diametric tape (cm).

2.3.1.2. Stem Height and Total Height

The stem height and the total height were estimated using a 5 meters rod. The total height is the sum of the stem height and the canopy height.

2.3.1.3. Aerial Biomass

Biomass can be calculated through several allometric equations available in the literature. Generally, equations are chosen for each type of vegetation and, more specifically, the phytogeographic region studied.

The term biomass in this study refers to tree live aerial biomass (stem, branches and leaves) at a given time. Live aerial biomass estimates were calculated following Brown et al. (1989) allometric equation, which estimates the dry weight of the tree.

$$\mathbf{Y} = 38{,}4908 - 11{,}7883\ (D) + 1{,}1926\ D^2 \quad - \text{ Brown et al. (1989)}$$

Where: **Y** = aerial biomass, dry weight (kg*tree^{-1})

D = DBH (cm)

In this work we used green weight (with water), obtained by multiplying biomass by two, since it is generally assumed that water corresponds for half of the weight of a tree.

2.3.2. Risk Descriptors

2.3.2.1. Apparent Phytosanitary (AP)

To assess phytosanitary aspects we considered and registered the following in the worksheet:

- 1 = visible damage caused by fungi and insects;
- 2 = visible hollows and cracks in the stem.

In the weighting of this descriptor - P(AP) – we assigned weights (P):

• P = 1, apparent damage from insects/fungi or presence of visible hollows/cracks;

• P = 2, apparent damage from insects/fungi and presence of visible hollows/cracks.

2.3.2.2. Stem inclination (SI)

To assess stem inclination we considered and registered in the worksheet:

• 1 = slightly tortuous stem - (< 30 ° to the stem axis);

• 2 = strongly tortuous stem - (> 30 ° to the stem axis).

In the weighting of this descriptor - P (SI) – we assigned weights (P):

• P = 1, slightly tortuous stem (< 30 ° to the stem axis)

• P = 2 steeply tortuous (> 30 ° to the stem axis).

2.3.2.3. Canopy balance (CB)

To assess the balance of the canopy we considered and recorded in the worksheet:

• 1 = unbalanced canopy to one side;

• 2 = broken canopy

In the weighting of this descriptor - P(CB) - we assigned weights (P):

• P = 1, decompensated canopy to one side with risk of tree fall or break.

• P = 2, canopy broken and decompensated to one side with risk of tree fall.

2.3.2.4. Presence of lianas (PL)

To assess the presence of lianas we considered and recorded in the worksheet:

• 1 = presence of thin lianas (diameters less than 5 cm).

• 2 = presence of thick lianas (diameters greater than 5 cm).

In the weighting of this descriptor - P(PL) - we assigned weights (P):

• P = 1, presence of thin lianas in the canopy;

• P = 2, presence of thick lianas in the canopy.

2.3.2.5. Canopy/stem ratio (C/R)

To assess the ratio between canopy height and stem height (C/R), we considered the following:

• 0 = canopy height smaler than stem height (C/R <1.0);

• 1 = canopy height between one and two times bigger than stem height (C/R $\geq$ 1.0 and C/R <2.0);

• 2 = canopy height more than twice bigger than the stem height (C/R $\geq$ 2.0).

In the weighting of this descriptor - P(C/R) - we assigned weights (P):

• P = 0.1; C/R <1.0

• P = 1.0; C/R $\geq$ 1.0 and C/R <2.0

• P = 2.0; C/R $\geq$ 2.0.

2.4. Tree Fall Potential Risk Assessment System - SARPQA

We proposed a system to assess tree fall potential risk, which assess the risk of fall obtained by the risk descriptors, together with the analysis of the self-descriptors. The calculation of the tree fall risk (RQ) is obtained by the sum of the weights of the risk descriptors:

The higher the RQ value (ranging from 0 to 8), the greater the tree fall risk. To simplify the results, RQ values were grouped into five classes: very low, low, medium, high and very high. For each RQ class, subclasses were created (with signs - or +), except for the very low class (Table 1).

3. RESULTS

3.1. Floristic composition

A total of 1,074 trees were found in the study áreas, distributed in 40 families and 229 species. The families with the highest species richness were fabaceae and arecaceae, with 60 and 22 species respectively. A total of 11 families occurred with only one species.

In relation to abundance, fabaceae and arecaceae were the most representative, with 224 and 178 individuals respectively. In 34 families, 75 to 2 individuals were found. Four families occurred with only one individual, consequently, with a single species.

The most abundant species were *Simarouba amara* Aubl. (marupá), *Guarea trichilioides* L. (jataúba), *Platymiscium trinitatis* Benth. (macacauba), *Eschweilera coriacea* Mart.ex O.Berg (matamatá-branco), *Bentinckia nicobarica* (Kurz) Becc. (bentinkia), *Attalea speciosa*

Table 1 – Tree fall risk classes based on risk descriptors, in function of the tree fall risk value (RQ).
Tabela 1 *– Classes de risco de queda de árvores baseadas nos descritores de risco, em função do valor do risco de queda (RQ).*

VALUE OF THE TREE FALL RISK VARIABLE (RQ)	CLASSES AND SUBCLASSES OF THE TREE FALL RISK (RQ)		RANGE OF THE FALL PROBABILITY	
			Bottom Limit(%)	Up Limit (%)
0,1	1- Very Low		0,1	0,2
1	2- Low	Low (-)	0,3	12,7
2		Low (+)	12,8	25,3
3	3- Median	Median (-)	25,4	37,8
4		Median (+)	37,9	50,2
5	4- High	High (-)	50,3	62,7
6		High (+)	62,8	75,3
7	5- Very High	Very High (-)	75,4	87,7
8		Very High (+)	87,8	100

Mart. (babassu) and *Livistona rotundifolia* (Lam.) Mart. (palmeira-de-leque), presenting about a quarter of the total number of individuals. A total of 104 species occurred with only one individual.

3.2. Primary Descriptors

We found that 39.6% of the total trees were in first diametric class, DBH between 20 and 29 cm. Mean DBH of the total population was 41.9 cm, ranging from 20 to 238 cm. Most of the trees (97.3%) are well distributed in the diametric classes up to 100 cm. Only four trees had diameter greater than 200.0 cm, one apuí (*Ficus amazonica* (Miq.) Miq.) With 238.0, one guajará (*Chrysophyllum excelsum* Huber) 219,3 and two samaúmas (*Ceiba pentandra* (L.) Gaertn .), 210.0 and 212.0 cm (Table 2).

Stem height had a range two to thirty meters, with an average of 10.9 m. Stem height class, ranging from 5 to 9 m, had the highest number of trees, with 37% of the total. Only five trees occurred in the highest class of stem height (30-34 m), “palmeira-de-leque” (*Livistona rotundifolia* (Lam.) Mart.), a “ucuúba-da-mata” (*Virola michelii* Heckel), a “ucuúba” (*Osteophloeum platyspermum* (Spruce ex ADC) Warb) and two “bentinkia” (*Bentinckia nicobarica* (Kurz) Becc.) (Figure 1).

Total height ranged from 5 to 50 m, with a mean of 18.7 m. Two “paricás” (*Schizolobium parahyba var. amazonicum* (Huber ex Ducke) Barneby) and one “timborana” (*Pseudopiptadenia suaveolens* (Miq.) J.W.Grimes) were the highest trees with 42, 44 and 50 m respectively (Figure 1).

Table 2 – Distribution of the number of trees per diameter at breast height classes.
Tabela 2 *– Distribuição do número de árvores por classes de diâmetro à altura do peito.*

DBH Classes (cm)	N. of trees
20-29	425
30-39	245
40-49	134
50-59	96
60-69	50
70-79	45
80-89	31
90-99	19
100-109	9
110-119	4
120-129	3
130-139	1
140-149	3
150-159	1
160-169	2
180-189	1
190-199	1
210-219	3
230-239	1

Tree biomass, considering green weight, ranged from 0.56 to 129.6 tons with an average of 4.8 tons, with four trees with biomass above 100 tons: *Ficus amazônica* (Miq.) Miq. With (129.57 tons), *Chrysophyllum excelsum* Huber (109,62 tons) and two *Ceiba pentandra* (L.) Gaertn. (102.28 tons) and (100.31 tons). These species were also the ones that presented higher DBH, evidencing the high correlation between dominance and biomass.

3.3. Risk Descriptors

From the total 1074 analyzed trees, 263 (25%) had some apparent phytosanitary problems. The rest, 811

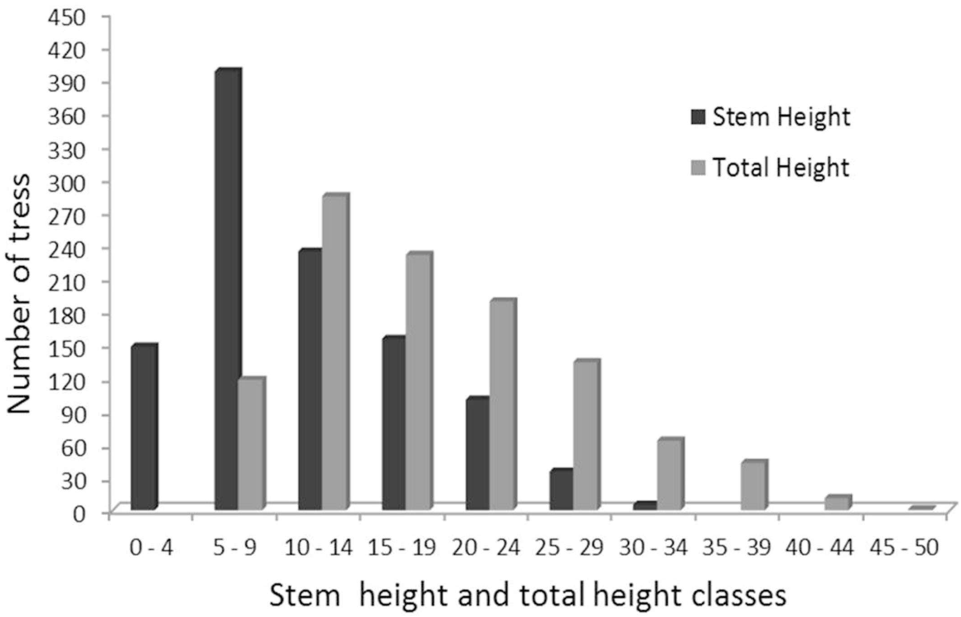

Figure 1 – Distribution of trees in classes of stem height and total height
***Figura 1** – Distribuição das árvores em classes de altura do fuste e altura total.*

(75%) trees had no apparent phytosanitary problems. Among the trees with phytosanitary problems 250 (95%) had visible damage caused by fungi and/or insects, and 44 (17%) had visible hollows and/or cracks in the stem. A total of 31 (12%) of these trees had both phytosanitary problems, presenting the higher scores in the potential tree fall risk analysis.

About 60% of the trees (647) had inclination on the stem, with 480 having a slight inclination (<30 ° to the axis of the stem) and 167 having a strong inclination (> 30 ° to the axis of the stem). The remaining 427 trees (40%) had no stem inclination.

From all inventoried trees, 78% (833) had unbalanced or broken canopy, dividing in 681 trees with decompensated canopy to one side and 152 with broken canopy. From this total of 833 trees, 135 had decompensated and broken canopy.

We observed that only 2.3% of the trees had presence of liana, 28 had thin lianas, and four had thick lianas and other four trees had both.

A total of 719 trees (67%) had canopy height smaller than stem height. In other 241 trees (22%) canopy height was in the range between stem height and twice stem height, and the others 114 trees (11%) had canopy height greater than twice the stem height.

3.4. Tree fall potential risk assessment system

The analysis of the self-descriptors and risk-descriptors presented that 23 trees in the RQ classes 8 and 7 had a very high potential risk of fall (probability greater than 75%). A total of 159 trees had a very low risk. Low risk class (0.3% to 25.3% probability) had the highest number of trees, with a total of 386 trees. Median risk class (25.4% to 50.2% probability) had 364 trees and high risk class (50.3% to 75.3% probability) concentrated the remaining 142 trees (Table 3).

4. DISCUSSION

We ranked tree fall risk by classes and subclasses to obtain an accurate assessment of which trees have the higher risk of fall, allowing the selection of trees for removal or management. Potential tree fall risk assessment system (SARPQA) showed that 14.8% of the trees surveyed were in excellent condition, presenting minimal risk of fall. In 69.8% of the cases trees were in the low and medium risk classes, with regular and good conditions, 13.2% presented bad conditions and 2.2% very bad conditions, with maximum potential risk of fall.

Table 3 – Number and percentage of trees per subclass and class of risk fall.
***Tabela 3** – Número e porcentagem de ávores por subclasse e classe de risco de queda.*

VALUE OF THE TREE FALL RISK VARIABLE (RQ)	CLASSES AND SUBCLASSES OF THE TREE FALL RISK (RQ)	TREE FALL RISK (RQ) N. OF TREES (%) BY SUBCLASSES	N. OF TREES (%) BY CLASSES
0,1	1- Very Low	159 (14,8%)	159 (14,8%)
1	2- Low (-)	170 (15,8%)	386 (35,9%)
2	2- Low (+)	216 (20,1%)	
3	3- Median (-)	215 (20,0%)	364 (33,9%)
4	3- Median (+)	149 (13,9%)	
5	4- High (-)	90 (8,4%)	142 (13,2%)
6	4- High (+)	52 (4,8%)	
7	5- Very High (-)	22 (2,1%)	23 (2,2%)
8	5- Very High (+)	1 (0,1%)	
TOTAL-	1074 (100%)	1074 (100%)	

Results very close to ours were found in a study carried out in parks and squares in Irati, city located in the state of Paraná, where Schallenberger et al. (2010), using similar variables, showed that from 615 trees cataloged, 19.4% had excellent conditions, 35.9% had good conditions, 32.4% were classified as regular; 11.1% bad conditions and 1.3% very bad conditions. Souza et al. (2013) assessing CBH (circunference at breast height, considering 1.30 m from the ground), height, phytopathogen presences and mechanical injuries, observed that trees in Altamira, city from the state of Pará, had 29% of the trees in good conditions, 69% in regular conditions and 9% in bad and/or very bad conditions.

The most abundant species were *Simarouba amara* Aubl. with 5.8% and *Guarea trichilioide*s L. with 4.4%, inside the range suggested by Milano and Dalcin (2000), where each species should not exceed the limit between 10 and 15% of total individuals of the tree population, minimizing the risks inherent in pests and diseases (Grey and Deneke, 1986).

Diameter distribution indicated an stable tree population, with participation of young and adult trees. About 3% of the analyzed trees had diameter greater than one meter. Trees with large diameters in urban areas are one of the cause for constant concern, as their fall can cause serious risks of accidents with people and property. However, it is emphasized that it is not the diameter of the tree that will induce it to fall, and alone has no capacity to raise the potential risk of fall.

Total height of a tree can also be a source of great concern, especially in urban areas, since height can increase the radius of destruction caused by its fall. The largest trees observed, with total height superior to 40 meters, were ranked in low and medium risk classes, with the exception of one, *Pseudopiptadenia suaveolens* Miq., with 40 meters height, ranked in high risk class, requiring immediate intervention, due to the imminence of an accident.

Taking into account the methodology used by Santos and Teixeira (2001), which classifies as large vegetable, the ones with height superior to 6 meters, we can assume that 99.8% of PZB/MPEG and BRA/JBA trees population is classified as large vegetable. It must be considered that very tall trees are more sensitive to strong winds. In Amazonia, where soils are usually poor in nutrients, plants usually develop a subsurface root system to cover more area and volume of soil, causing the non-development of the pivotal roots, which are the main responsible for the mechanical sustentation of the trees.

Among all trees sampled 23.3% had phytosanitary problems caused by fungi and/or insects, and 4.1% presented physical damages such as visible hollows and/or cracks in the stem. These results are lower than those found by Cunha and Paula (2013) Vitória da Conquista, a city from the states of Bahia, where 63.93% of the trees sampled had visible signs of phytopathogens attacks and 77.86% presented physical damages of all types.

Visible damage caused by fungi and/or insects were 23.3% lower than the results found by Raber and Rabelato (2010) in Colorado, in the state of Rio Grande do Sul, which observed that 49.16% of the individuals presented some form of attack by fungi and/or insects. Trees presenting damages caused by insects, fungi and bactéria, allied to the presence of hollows and cracks, have the highest scores in the risk assessment.

Stem inclination mostily occurs due to natural causes, such as competition for light, however, inclination can also happen because of structural problems of the root system. When it is caused by problems in the roots system, in long term, can represent danger to the visitors of the parks, and also to the passers-by of the surrounding roads, due to the risk of fall of trees presenting this condition. However, the great majority of tree individuals sampled (84.5%) had erect or slightly inclined stem.

Root system can also be a good descriptor for risk of fall. It provides mechanical support to the tree. According to Motter and Muller (2012) the analysis of the root system is important for good quality afforestation, because superficial roots can cause damage to the public patrimony and contribute to the occurrence of accidents. However, there is no way to assess the root system for studies of tree fall risks. Thus, this descriptor was not included in the analysis of this study.

Alterations in the tree canopy architecture can compromise its structural dynamics, which involves roots, stem and canopy, which when well distributed and balanced, give support to the development of the tree. Unbalanced canopies are more likely to fall, since the weight of the tree is more concentrated to one side. About 65% of the assessed trees had unbalanced or broken canopy.

Another very relevant descriptor is the internal hollows of the stem. However, it is expensive to do such analysis for many trees, as we had in this study, since tree assessments have high costs. Pereira et al. (2011), among other urban afforestation studies consider the presence of external hollows associated with the presence of phytopathogens.

5. CONCLUSION

Afforestation of the studied parks presented positive aspects, since the majority of the tree were in good conditions. However, a few individuals, with high diameters and heights had great risks of fall, and in these situations the potential of damages is higher. Tree Fall Potential Risk Assessment System (SARPQA) has reached the defined objectives, in addition, it is a practical system and can be an efficient tool in the management of urban green areas, preventing tree fall, especially for those trees with larger sizes. The data recorded in this work aim to contribute to more precise decision in relation to the afforestation of urban centers, especially for the studied parks.

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