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The flammability of ornamental species with potential for use in highways and wildland urban interface (WUI) in southern Brazil

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Abstract

The areas of wildland urban interface (WUI) are sites that have mixed characteristics, from the influence of rural and urban areas. With the increase in urban population in national and global level, the areas are losing this characteristic transition with diversity of functions. One of the most common problems due to this rural/urban proximity are forest fires that cause damage to many homes in urban areas. The highway is a transportation infrastructure located in the area of the wildland urban interface that can serve as a barrier or mitigation of forest fires that threaten urban areas, through its landscaping. For the highway integrate with the local landscape is necessary that this landscaping provide conservation or ecological, cultural and aesthetic function. The objective of this study was to evaluate the flammability of native ornamental species with potential for use in the prevention of forest fires in the vicinity of highways. The selected species are native from southern Brazil due the presence of interesting aesthetic features. They are: *Aspilia montevidensis* (Spreng.) Kuntze - the family Asteraceae species with ornamental potential both by the beauty of the flowers of bright yellow color, like the long flowering period that occurs almost all year round and can be used in landscaping as ground cover, is indicated for public areas by not requiring maintenance and also for treatment of degraded areas; *Peltodon rugosus* Tolm. - herbaceous species of the family Lamiaceae, native to southern Brazil, on “Estepe Gramíneo-lenhosa” presents both its ornamental inflorescence globose form and by its leaves with visible vein, can be used in degraded areas due to its hardiness; and *Verbena rigida* Spreng - the Verbenaceae family, is a little branched herbaceous perennial, rhizomatous, erect, popularly known as “grass-wire”, native of the fields of the plateau in southern Brazil, can reach 20-30 cm in height with decorative flowering, stiff and rough leaves, inflorescences with small flowers blue-purple color formed in spring-summer. For each species were performed 50 burnings in epiradiator of 1 g of material freshly harvested. During the experiments burning in the epiradiator, the following variables were collected: Frequency of ignition (FI), time to ignition (TI), duration of combustion (DC), flame height (AC) and combustion index (IC). Statistical analysis was done by SNK test at 95 % probability. The results of the species flammability show that *Aspilia montevidensis* and *Peltodon rugosus* differ statistically of the *Verbena rigida* for FI and TI, indicating to be less flammable, although all species show low flammability. Given the results, it is concluded that the analyzed species exhibit excellent characteristics for landscape composition on highways both due its aesthetic appearance and functional, and can also serve as a barrier against forest fires in areas of wildland urban interface in southern Brazil.

Keywords: *in forest fuels, epiradiator, native ornamental species.*

1. Introduction

The Wildland Urban Interface areas, otherwise known as WUI, are places that have mixed features, with influence of rural and urban areas (BIONDI, 2013). Are multifunctional spaces where there are fragmented presence of land use and the absence of urban structure, with deep economic, social and physical transformations and that still feature a dynamic closely linked to the presence of a nucleus around (MIRANDA, 2009).

Radeloff *et al.* (2005) complements the concept of WUI stating that this area is a zone of conflict between humans and the environment, where there is destruction of houses by forest fires, fragmentation of natural habitats, introduction of exotic species and the loss of biodiversity.

According to Biondi (2013), with the increase of urban population, these areas are losing that characteristic of transition and acquiring a rural or urban physiognomy, moreover, to be removed shall

become the boundary between urban and rural zone. With that, one of the most common problems that occur are the forest fires that eventually reach the homes of the urban areas. Thus, since the highway is a transportation infrastructure in urban and rural transition area, could serve as a barrier and mitigation or forest fires that threaten urban areas

The assessment of forest fires risk on the landscape planning of roads should be an essential element to reduce the damage caused by the fire in the wildland urban interface areas of Paraná-Brazil (BIONDI *et al.*, 2013). According to the same authors, from the characterization of the degree of risk of fire it is possible to perform the selection and planning of less flammable species composition in order to impede the spread of fire.

The knowledge of how the species differ in their flammability characteristics it is necessary to develop more reliable lists of plants recommended for residential landscaping in wildland - urban interface (WHITE and ZIPPERER, 2010).

According Ganteaume *et al.* (2013) currently, there is no research on the evaluation of flammability of ornamental species.

Flammability can be defined as how easy it is for a material to catch fire, both spontaneously and through exposure to certain conditions (ZHANG *et al.*, 2011). According to Anderson (1970) flammability initially was defined based on three components: the potential of ignition, which is the time needed for the fuel reaches the ignition after being exposed to a source of heat; sustainability, refers to the ability to maintain combustion after ignition; and combustibility, which is the rate of burn after ignition.

The plant species that provide the fuel for the fires have specific flammabilities (CURT *et al.*, 2011), which varies according to the species and with moisture content (VÉLEZ, 2000). In addition, the volatile organic compounds, such as monoterpenes, constitute other possible factors contributing to the increased flammability vegetation (ALESSIO *et al.*, 2008).

The aim of this study was to evaluate the flammability of native ornamental species with potential for use in the prevention of forest fires in the surrounding highways.

2. Methods

The experiment was conducted in the laboratory of forest fires at the Campus III of the “Universidade Federal Paraná” (UFPR), in Curitiba, Brazil. The original vegetation of the city, before the anthropic action, consisted of “Estepe Gramíneo-Lenhosa” (fields), intermingled of arboreal groupings (with the presence of *Araucaria angustifolia*), next the downloaded and streams (RODERJAN *et al.*, 2002)

The climate of Curitiba, according to Köppen classification, is Cfb, humid subtropical, humid, without dry season, with cool summers and winters with frequent frosts and occasional snow precipitation. Has average temperatures of 19.7° C in summer and 13.4° C in winter, with average annual precipitation of 1419.9 mm (IPPUC, 2011).

The species selected for the experiment are native from southern Brazil, on the “Estepe Gramíneo-Lenhosa”, and present interesting aesthetic characteristics for use in landscaping. They are: *Aspilia montevidensis* (Spreng.) Kuntze, *Peltodon rugosus* Tolm and *Verbena rígida* Spreng.

Aspilia montevidensis is a species of the Asteraceae family that boasts great potential both for ornamental beauty of flowers of bright yellow color, as for the long flowering period that occurs almost the whole year. In landscaping, can be used as lining plant in flower beds to homogeneous full sun, being indicated for public areas and also in degraded areas, not requiring great care in maintenance.

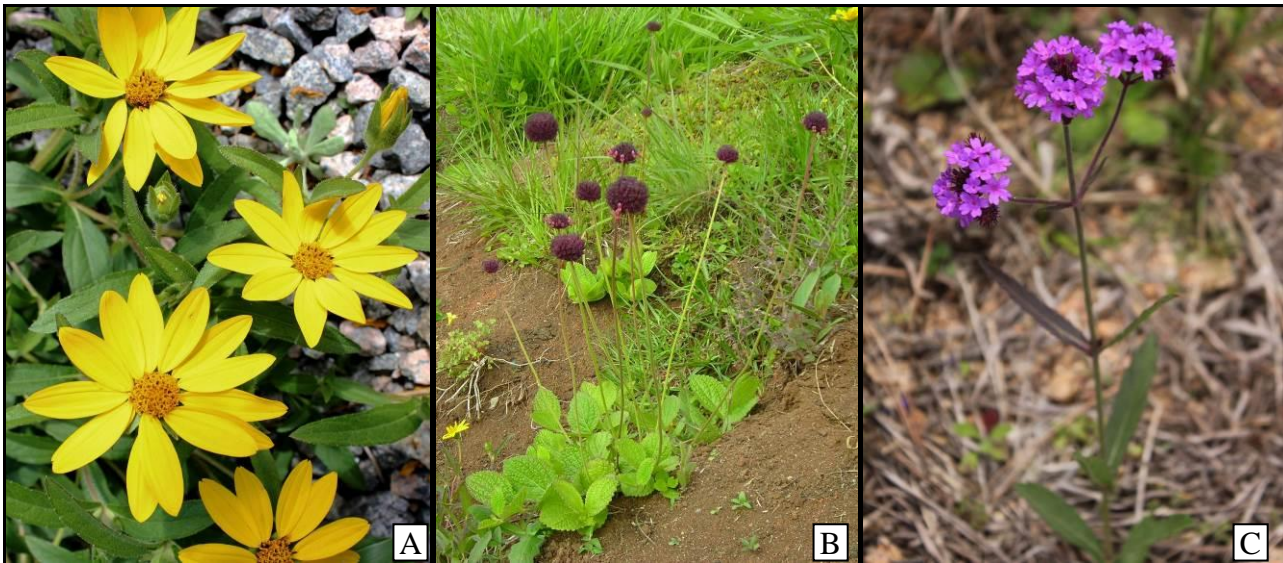


Figure 1. The selected species: A) *Aspilium montevidensis*; B) *Peltodon rugosus*, C) *Verbena rigida*

Peltodon rugosus, of the family Lamiaceae, is a herbaceous plant which features ornamental potential both for its inflorescence shape globe, as by their apparent ribbed leaves. Due to its hardiness can be used in recovery of degraded areas.

Verbena rigida, family Verbenaceae, is a little branched herbaceous perennial, rhizomatous, erect, popularly known as wire weed. Can reach of 20 to 30 cm tall, with decorative flourish, stiff and rough leaves, inflorescences with small flowers-blue color formed in spring-summer.

The concept of flammability can be reduced to distinct aspects of combustion, according to the type of metric used in its assessment (WHITE and ZIPPERER, 2010). Thus, it can be experimentally evaluated by fuel burning in the laboratory, whether in the form of discrete elements (such as a leaf or branch), or as a fuel bed and a heterogeneous set of individual units (FERNANDES and CRUZ, 2012). In this research the flammability was analyzed from the combustion experiments, performed in a chapel (a draught-free location), with an epiradiator of 500 W nominal power constant, kept in a controlled temperature range of 250 °C. The material used in the experiment consists only of leaves of selected species, which were collected in the vicinity of the building of Forestry and Wood of the UFPR, moments before the beginning of the experiment, which was carried out within a maximum of 2 hours after collecting.

Flammability tests were conducted according to the methodology proposed by Petriccione *et al.* (2006) and Petriccione (2006). For each species were performed 50 repetitions, each with 1 g of green fuel material, determined with the aid of a precision balance. The forests fuel was exposed to epiradiator for 60 seconds. In all the steps performed were taken the care required to be no direct contact with the material, so as to avoid interference in their properties.

During the experiment, conducted in the epiradiator, were collected the following variables: ignition frequency (FI), ignition time (TI), duration of combustion (DC) and height of the flame (AC). Flammability values were obtained from the potential of ignition (PI) and the average combustion time (TC) based on table 1 (VALETTE, 1990). This index is calculated based on the values of frequency ignition (FI), which refers to the number of positive ignitions (less than 60 seconds) of a total of 50 repetitions and the combustion time (time that the flame remains visible). Statistical analysis of the data was made by SNK test the 95% probability.

Table 1. Flammability Values (Valette, 1990)

PI	< 25	25-38	39-48	42-44	45-47	48-50
TC - s						
>32,5	0	0	0	1	1	2
27,5 – 32,5	0	0	1	1	2	2
22,5 – 27,5	0	0	1	2	2	2
17,5 – 22,5	1	1	2	2	3	3
12,5 - 17,5	1	1	2	3	3	4
< 12,5	1	2	3	3	4	5

Note:

PI – potential of ignition (positive number of ignitions a total of 50 trials); TC – combustion time in seconds.

0 = very low flammability; 1 = low flammability; 2 = flammable; 3 = moderately flammable; 4 = very flammable; 5 = extremely flammable.

3. Results

The variables of flammability were analyzed separately, which has shown the difference in behavior between the species studied. The ignition timing in each repetition performed for the species can be observed in Figure 2.

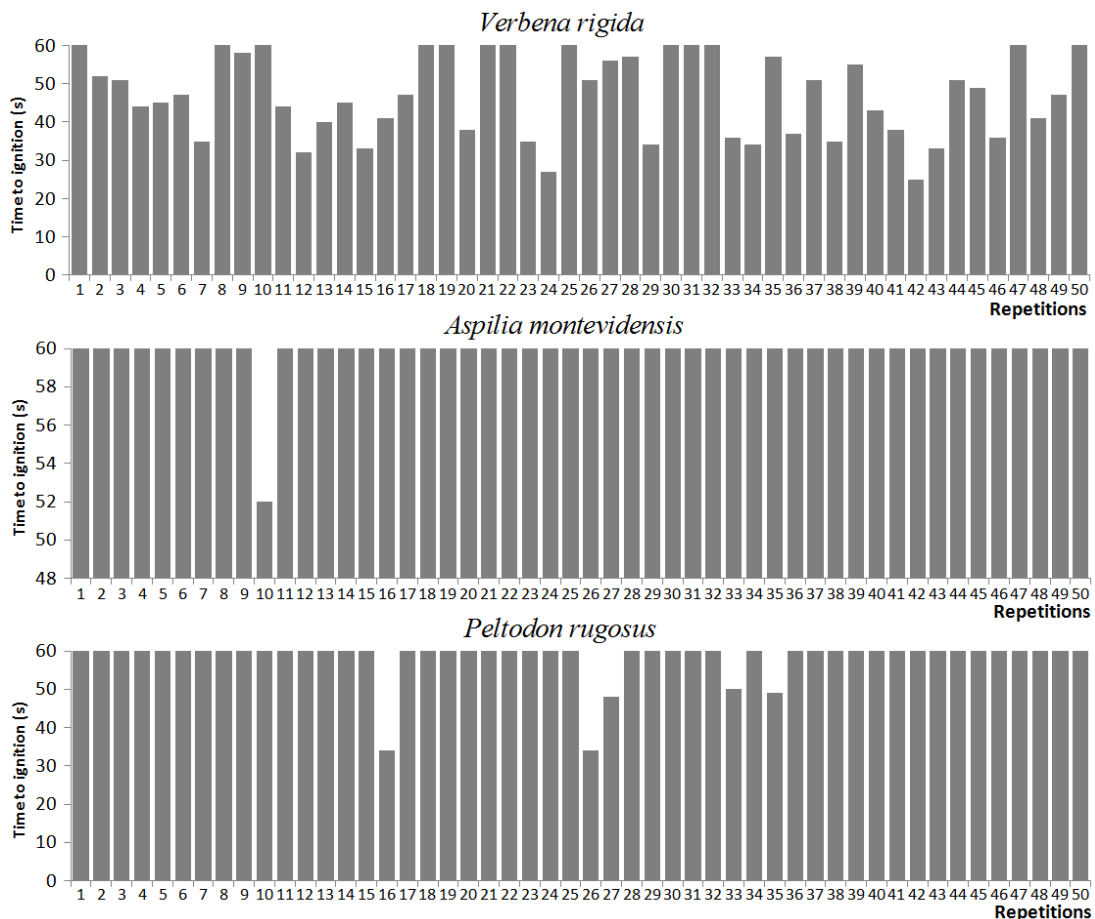


Figure 2. TI of the species in each repetition

It is observed that *Verbena rigida* was the species that presented greater variation in TI, being that most of the repetitions performed less than 60 s, corresponding to positive ignitions.

Aspilia montevidensis presented only one positive ignition, while *Peltodon rugosus* presented five positive ignitions. These results support the use of *Aspilia montevidensis* and *Peltodon rugosus* as barriers to the ignition of the forest fires in the edges of the WUI.

DC and AC variables were only possible to analyze in detail the species *Verbena rigida* (Figure 3 and 4). This is because the other species present in the vast majority of the repetitions, TI greater than 60 seconds, indicating negative ignition, and if “no ignition, no combustion”.

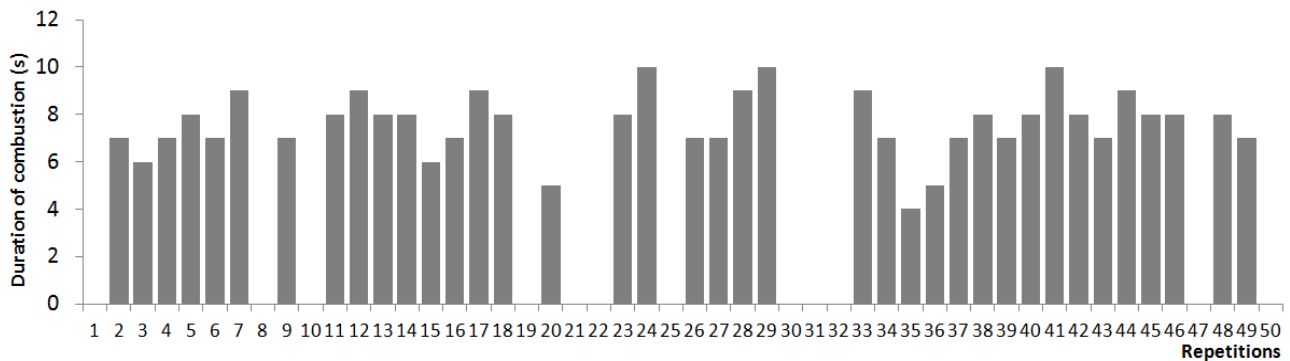


Figure 3. DC of *Verbena rigida* in each repetition.

It can be observed that there was wide variation in the DC of species in the repetitions performed. The average DC of *Verbena rigida* lasted 7.6 seconds, varying between 4 and 10 seconds.

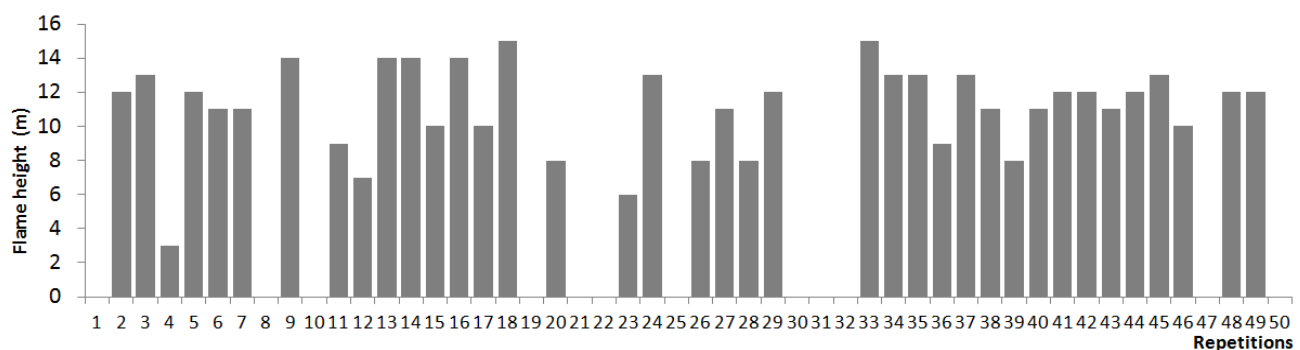


Figure 4. AC of *Verbena rigida* in each repetition

The flame height of *Verbena rigida* also showed wide variation, with an average of 11.1 cm, ranging from 3.0 to 15.0 cm.

After the analysis of the variables held separately, was assessed the flammability of the species, which allows to obtain a more accurate result regarding its use as a fuelbreak (table 1).

Table 1. Avaliação da inflamabilidade de espécies ornamentais

Species	FI (%)	TI (s)	DC (s)	AC (cm)	Combustion Index (IC)
<i>Aspilia montevidensis</i>	2 (a)	> 60 (a)	13	9	1 - Low flammability
<i>Peltodon rugosus</i>	10 (a)	> 60 (a)	9,2	14	1 - Low flammability
<i>Verbena rigida</i>	76 (b)	43,9 (b)	7,6	11,1	2 - Moderately flammable

Note:

FI -ignition frequency; TI - ignition time; DC duration of combustion; AC - height of the flame.

For FI and TI variables, means followed by the same letter in the column do not differ at 5% significance level by SNK test.

It is observed that *Aspilia montevidensis* and *Peltodon rugosus* differ statistically from *Verbena rigida* for variables FI and TI, indicating they are of low flammability although all species demonstrate weak flammability.

4. Conclusion

By the results, it is concluded that the analyzed species exhibit excellent characteristic to landscape composition on highways both for its aesthetic aspect as functional, and may also serve as a barrier against forest fires in WUI areas in southern Brazil.

In relative terms of flammability can be concluded that the species analyzed presented the following behavior: *Aspilia montevidensis* < *Peltodon rugosus* < *Verbena rígida*.

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