

US Consumers' Awareness and Opinion of Boxwood Shrubs and Boxwood Blight

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Abstract. Boxwood blight is a significant threat to nurseries, garden centers, landscaping businesses, and homeowners, causing both financial and ecological damage. This fungal disease is primarily caused by two species, with *Calonectria pseudonaviculata* being the only reported casual species in the United States. The pathogen is spread by wind-driven rain, water splash, and contaminated plants, emphasizing the need for exclusion, sanitation protocols, cultural practices, and fungicides to manage its spread. Recently, efforts have shifted from containment to disease management, focusing on fungicide efficacy, diagnostic assays, and boxwood production analysis. Agricultural extension programs promote best practices to prevent disease introduction into nursery and landscape environments. Understanding consumer awareness and perceived risk regarding infestations is crucial as control measures evolve. In our Jul 2020 survey, which had 2795 completed responses from across the United States, we assessed consumer knowledge and opinions regarding boxwood shrubs and Boxwood light. The findings revealed demographic variations in awareness and opinions. Suburban residents were more aware of boxwood blight, whereas urban residents had a higher opinion of boxwood shrubs. From the tobit model, men were more likely to purchase boxwood compared with women despite knowing about blight, and Caucasians compared with non-Caucasians exhibited decreased liking for boxwood after seeing pictures of blight-infected plants. These insights can inform targeted communication strategies and assist consumers, vendors, and related industries in addressing the challenges posed by Boxwood blight. Further research into alternative plant preferences among consumers is also warranted for better development of boxwood blight management strategies.

Boxwood blight is a major source of concern for nurseries, garden centers, landscape gardening business, and homeowners. In the past, apart from the financial damage (Henricot et al. 2008; LaMondia 2014), boxwood blight has led to incalculable losses to historic gardens in Europe and America (Groen and Zielemann 2012) as well as devastating impacts on natural ecosystems of boxwood in Europe and Asia (Akilli et al. 2012; Di Domenico et al. 2012; Henricot et al. 2000; Mirabolfathy et al. 2013; Mitchell et al. 2018; LeBlanc et al. 2019). As noted by Hall et al. (2021), boxwood blight exacerbated supply chain issues by increasing production costs of boxwood and limiting production regions for growing boxwood.

There are only two fungal species known to cause boxwood blight, *Calonectria pseudonaviculata* (Syn. *Cylindrocladium pseudonaviculatum*, *C. buxicola*) and *Calonectria*

henricotiae. Of these two species, *C. pseudonaviculata* is the only known cause of cases of boxwood blight in the United States (Baysal-Gurel and Liyanapathirana 2017). Water splash provides the pathogen means for short distance pathogen dispersal. On the other hand, longer distance dispersal may be via the movement of contaminated plants and cuttings used in decorations for winter holiday greenery (Matheny 2018). Consequently, it is important to exercise exclusion (restricting the occurrence of infected plants in nursery or landscapes) and strict sanitation protocols in managing the spread of boxwood blight (Douglas 2013). Additionally, cultural practices and the application of fungicides can be employed to suppress disease development (Gauthier and Dockery 2018).

Given the ongoing spread of boxwood blight, there has been a paradigm shift in recent years from containment to management of the disease. There is a major focus on testing the efficacy and residual activity of fungicides and biocontrol agents as well as developing efficient, simplified diagnostic assays, and analyzing surveys of boxwood blight movement within boxwood production (Brand 2006; Henricot et al. 2008; Henricot and Wedgwood 2013; Hong 2019; Ivors et al. 2013).

As boxwood blight has spread, there have been efforts from agricultural extension

programs to generate community-level best management practices that can prevent the introduction of the disease into nursery and landscape environments (Bush et al. 2016; Baysal-Gurel and Liyanapathirana 2017; Gauthier and Dockery 2018; Gauthier and Sears 2013). As boxwood blight controls are developed, it is crucial to understand consumer awareness and the perceived risk associated with infestations. Through this exploration, researchers and producers can better understand the amount of effort they need to devote to controlling boxwood blight. Therefore, this study aims to assess US consumers' knowledge and awareness of boxwood shrubs and boxwood blight, overall opinion of boxwood and boxwood blight, and determine the impact boxwood blight information has on consumer opinions of boxwood shrubs.

Methods

During Jul 2020, an online survey was administered using the online national consumer database of Toluna, Inc (Dallas, TX, USA). The survey was approved by the University of Georgia Institutional Review Board (#00004215). Toluna was contracted to provide sample for the survey. Panelists within the Toluna database were contacted by Toluna via e-mail and asked if they wanted to participate in the survey. Panelist agreeing to participate were directed to the survey. Approximately 3000 consumers aged 18 years of age and older were sampled from across the United States, with 2795 respondents completing all questions. The sample was generally representative of the population of the US Median age of the sample was 43 (Table 1), whereas the US Census estimates the median to be 38 years of age (US Census Bureau 2020). The slightly higher median age is due to the US Census estimates containing respondents under 18 years of age, whereas this survey only included respondents 18 years of age and older. The sample largely comprised baby boomers (37%) and was predominantly Caucasian (71%). Most respondents lived in suburban (46%) areas, followed by urban (28%) and rural (26%) areas. The sample's median household income was \$54,999, which is lower than the median national income of \$64,999 (US Census Bureau 2022).

Respondents were directed to the survey and after agreeing to participate, they entered the survey. Upon entering the survey, respondents were shown pictures of boxwood and were asked whether they had seen boxwood in their own landscape, neighbors' landscape, city-maintained area, or business/commercial property. Respondents were provided the following choices "yes," "no," or "not sure" for each location. A χ^2 analysis was performed to measure the level of significance. Notably, a χ^2 analysis was used to compare responses across urban, suburban, and rural respondents.

Next, respondents were asked about their overall opinion of boxwood shrubs in a landscape on a scale of 0 to 100 where 0 =

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Table 1. Descriptive statistics for the sample collected in an online survey of US consumers about their opinions and awareness of boxwood shrubs and boxwood blight.¹

Variable	Mean	SD	Census estimates ⁱⁱ
Age (median years)	43.0		38.4
Baby Boomers ⁱⁱⁱ	36.9%	48.3%	
Gen X	19.6%	39.7%	
Millennial	29.4%	45.6%	
Gen Z	14.1%	34.8%	
Caucasian	70.8%	45.5%	75.8%
Male	45.0%	49.8%	49.5%
Education			
High school degree or less	25.0%	43.3%	
Some college/2-year degree	31.5%	46.7%	
Bachelor's degree	22.4%	41.7%	
Graduate degree	21.1%	40.1%	
No. of adults per household	2.42	1.42	
No. of kids per household (<18 years)	1.80	1.36	
Urban	27.8%	44.8%	
Suburban	46.4%	49.9%	
Rural	25.8%	43.7%	
Household income (median \$)	\$54,999		\$64,994
Political party			
Republican	38.6%	48.7%	
Democrat	26.1%	43.9%	
Independent	28.1%	44.9%	

¹ Data are from an online survey conducted in late Jul 2020, on consumers across the United States.ⁱⁱ US Census Bureau (2020, 2022).ⁱⁱⁱ Baby Boomers were born from 1964 or earlier, Generation X were born from 1965 to 1980, Millennials were born from 1981 to 1996, and Generation Z were born from 1997 to 2012 (Pew Research Center 2019).

“extremely dislike,” 50 = “neither dislike/like,” and 100 = “extremely like.” A two-sample *t* test was conducted to compare the responses against the area where the respondents resided (i.e., urban, rural, or suburban).

After completing the boxwood section, respondents were shown pictures of boxwood infected with boxwood blight and given a description of what causes the blight and its symptoms (“Boxwood blight is a fungal disease that affects the above ground portions of boxwood shrubs. The symptoms may include brown blotches on leaves, white spores on the underside of leaves, and defoliation of the shrub”). After seeing the pictures and description of boxwood blight, respondents were asked whether they had seen boxwood blight at varying locations: own landscape, neighbors’ landscape, city-maintained area, or business/commercial property. Finally, respondents were asked their overall opinion about boxwood shrubs given that they may suffer from boxwood blight on a 0 to 100 scale where 0 = “extremely dislike,” 50 = “neither dislike/like,” and 100 = “extremely like.” As with the boxwood shrub analyses, a χ^2 analysis and *t* test were used to compare boxwood blight responses across urban, rural, and suburban households.

The main objective of this research was to determine which consumer characteristics were more impacted by boxwood blight information and thereby which consumers would be more likely to purchase boxwood shrubs post-blight information. To test this objective, we calculated the difference between post- and pre-blight information ratings. This difference represents the impact of the information treatment on a respondent’s

opinion of boxwood. Given the construction of the difference dependent variable (post-minus pre-rating), the bounds of the differences would range between –100 and 100. In the difference variable, values ranged from –100 to 80, which implies there is a lower, but not upper bound to the dependent variable. Therefore, a tobit model was then used to understand how demographics and socioeconomic variables impact a respondent’s overall opinion of boxwood shrubs given that they may suffer from boxwood blight.

The tobit model was initially developed by Tobin (1958) and accounts for censoring within the data. We focus on the conditional on being uncensored marginal effects as described by McDonald and Moffit (1980). The unconditional marginal effects and the probabilities of being uncensored are not discussed but can be obtained from the authors. The tobit model can be formulated as follows:

$$y_i^* = \beta x_i + \varepsilon_i (i=1, \dots, n)$$

$$y_i = 0 \text{ if } y_i^* \leq -100$$

$$y_i = y_i^* \text{ if } y_i^* > -100 (i=1, \dots, n), \quad [1]$$

where y_i^* is a latent variable that is not observed for values below –100, x is a matrix of explanatory variables, β is a vector of coefficients, and ε is an independently and normally distributed error term with zero mean and variance σ^2 (Rosett and Nelson 1975).

Results and Discussion

Pre- and post-boxwood blight information treatment. The results on responses to pre- and post-treatment information provided some unique insights. Figure 1 shows that the boxwood blight information treatment did

have an impact on ratings, as the post-information cumulative distribution function (cdf) line is lagging behind the pre-information cdf line. For instance, at the halfway point of the 100-point line (i.e., 50 on the line, which represents neither like nor dislike boxwood shrubs), ~20% of the sample was below the halfway point pre-information. However, post-blight information, ~40% were below the halfway point, which implies 20% more respondents had a neutral or negative opinion of boxwood. From a retailer perspective, it will be important to know that as consumers become more aware of boxwood blight via firsthand observation, media, information from retailers, third parties, and so on, their preferences will shift to a less favorable opinion of this plant.

Awareness and opinion of boxwood shrubs. Compared with respondents living in either rural or urban areas (Table 2), a significantly higher percentage of respondents living in suburban areas answered “yes” to having seen boxwood in the locations, such as own landscape, neighbor’s landscape, city-maintained area, or business/commercial property. Respondents in suburban areas were more likely to have seen boxwood in either city-maintained areas (31.2%) or at a business/commercial property (28.7%) and in neighbor’s landscape (23.5%) than in their own landscape (19.1%). Based on χ^2 analysis, there was a statistical significance at 95% interval for responses pertaining to own landscape ($\chi^2 = 33.7, P = 0.00$) and neighbor’s landscape ($\chi^2 = 8.2, P = 0.00$). However, no statistical significance was found for responses pertaining to the other locations such as city-maintained area ($\chi^2 = 0.7, P = 0.074$) and business/commercial property ($\chi^2 = 0.1, P = 0.174$).

When respondents’ overall opinion of boxwood shrubs was assessed on a scale of 0 (“extremely dislike”) to 100 (“extremely like”), those who lived in urban areas were more likely to have a higher opinion of boxwood shrubs ($\bar{X} = 70.79$) than those who lived in either suburban ($\bar{X} = 65.05$) or rural ($\bar{X} = 63.26$) areas (Table 3). The results were statistically significant at a 95% confidence interval in the case of suburban vs. urban and rural vs. urban.

Awareness and opinion of boxwood blight. When respondents were asked whether they had seen boxwood infected with blight in their own landscape, neighbors’ landscape, city-maintained area, or business/commercial property, those living in suburban areas were more likely to have seen boxwood infected with blight primarily in either city-maintained areas (13.1%) or business/commercial property (12%) compared with respondents from urban or rural areas (Table 4). According to the χ^2 analysis, there was statistical significance in the responses among the respondents from rural, suburban, and urban areas for four locations—namely, own landscape ($\chi^2 = 43.2, P = 0.00$), neighbor’s landscape ($\chi^2 = 23.5, P = 0.00$), city-maintained area ($\chi^2 = 28.7, P = 0.00$), and business/commercial property ($\chi^2 = 22.5, P = 0.00$). However, the proportion

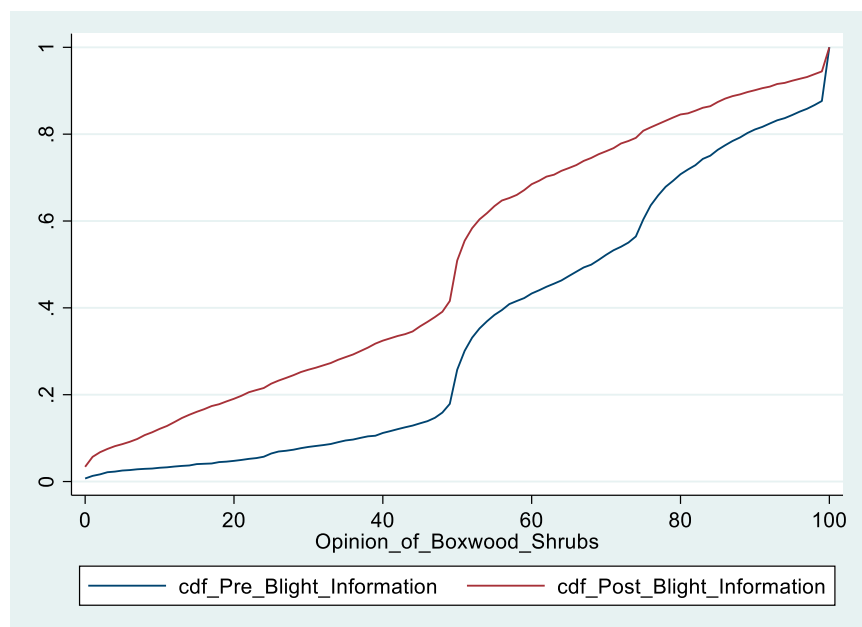


Fig. 1. Cumulative density function associated with ratings pre- and post-boxwood blight information treatment.

Table 2. Chi-square analysis from data collected via an online survey of US consumers examining whether they had seen boxwood shrubs at the following locations.

Location ⁱ	Urban	Suburban	Rural	χ^2 (4)	P value
Respondents that responded “yes”					
Own landscape	15.1%	19.1%	9.2%	33.7	0.000
Neighbors’ landscape	14.9%	23.5%	11.2%	8.2	0.000
City maintained area	19.1%	31.2%	16.7%	0.7	0.074
Business/Commercial property	17.5%	28.7%	15.9%	0.1	0.174
Respondents that responded “no”					
Own landscape	10.6%	24.4%	15.1%	34.8	0.000
Neighbors’ landscape	10.1%	18.4%	12.1%	11.7	0.000
City maintained area	5.9%	9.6%	6.4%	4.5	0.074
Business/Commercial property	6.4%	10.5%	6.5%	2.0	0.174
Respondents that responded “not sure”					
Own landscape	1.9%	2.9%	1.3%	2.2	0.000
Neighbors’ landscape	2.6%	4.4%	2.2%	0.3	0.000
City maintained area	2.8%	5.6%	2.4%	3.3	0.074
Business/Commercial property	3.8%	7.3%	3%	4.2	0.174

ⁱ χ^2 tests were performed on the actual data. Percentages shown are for yes, no, not sure for urban, rural, and suburban. For instance, to calculate 15.1% for urban own landscape, the calculation is the number of respondents that marked yes for own landscape living in an urban setting, divided by all respondents that marked yes for own landscape across urban, rural, suburban.

of respondents having said “yes” to seeing infected boxwood shrubs at the chosen locations was less than those who said “no.” The reason for more saying “no” could be due to several factors. First, there are better management and treatment practices to curb the issue of boxwood blight at places where these respondents are located. Two, there exists a gap in the understanding and identification of the disease among the participants primarily because a lower percentage

of people possess boxwood, and most have identified the shrubs in commercial settings.

After seeing pictures and information about boxwood blight, respondents were asked again about their overall opinion on boxwood shrubs which was assessed on a scale of 0 (“extremely dislike”) to 100 (“extremely like”). Respondents living in urban areas were more likely to have a higher opinion of boxwood shrubs (\bar{X} = 56.41) compared with individuals living

in either rural (\bar{X} = 46.6) or suburban (\bar{X} = 47.50) areas (Table 5). The results were statistically significant at a 95% confidence interval (P = 0.00, t test) in the case of suburban vs. urban and rural vs. urban area. However, it is evident that there was a notable decline in opinions among respondents living in urban areas, comparing their opinion before they were shown pictures of infected boxwood shrubs (\bar{X} = 70.79) and after (\bar{X} = 56.41). A similar trend was seen in the case of respondents from rural (\bar{X} = 63.26 vs. 46.6) and suburban areas (\bar{X} = 65.05 vs. 47.50), respectively.

Tobit regression: Overall opinion of boxwood before and after seeing pictures of boxwood blight. Understanding which consumers are more receptive to boxwood blight information is one way to target boxwood shrubs to consumers that would be less likely to have their perceptions shifted by boxwood blight information. On the basis of the results from the tobit regression model (Table 6), Gen X, Millennials, and Gen Z had scores 3.5%, 6.7%, and 8.7% higher than Baby Boomers. However, ratings post-boxwood blight information decreased across all age generations (Table 7). Thus, pictures of boxwood plants infected with blight impacted the overall opinion of boxwood shrubs across all generations, although to varying degrees. Similarly, Caucasian respondents’ overall opinions of boxwood decreased by 4.8% after they were shown pictures of infected boxwood shrubs compared with non-Caucasian respondents.

The overall opinion of boxwood of males was 3.9% higher than that of females (Table 6), although male ratings decreased by 15% post-blight pictures (Table 7). Similarly, respondents with a graduate degree had a 3.2% higher rating than respondents with a bachelor’s degree, whereas respondents with some college had a 3.2% lower rating. No significant results were found for respondents living in suburban and rural regions. However, as household income increased by \$1000, the rating decreased by 0.001%.

Conclusion

In this study, we find that demographics played an important role in the overall awareness and opinions regarding boxwood shrubs and boxwood blight. Respondents living in suburban areas are more aware of boxwood shrubs and boxwood blight than those living in either rural or urban areas. It is likely that more boxwood shrubs are grown in city-maintained and commercial settings in suburban areas, leading to awareness of boxwood shrubs and inquiry into the cause of symptoms of boxwood blight. However, we did not find any statistical significance in suburbanites’ overall opinion of boxwood shrubs after having been shown pictures of blight compared with respondents from urban areas. We also found that men might be more willing to buy boxwood, despite their knowledge of

Table 3. T-test results comparing overall opinion of boxwood shrubs among respondents in urban, rural and suburban areas using data from an online study of US consumers.

Comparison	Mean	SD	t	df	P
Rural vs. suburban	63.26 vs. 65.05	24.18 vs. 23.41	-1.63	2043	0.050*
Suburban vs. urban	65.05 vs. 70.79	23.41 vs. 24.46	-5.35	2101	0.000*
Suburban vs. urban	63.26 vs. 70.79	24.18 vs. 24.46	-6.02	1516	0.000*

* Statistically significant results at the 0.05 level or less.

Table 4. χ^2 analysis from data collected via an online survey of US consumers examining whether they had seen boxwood blight on boxwood shrubs at the following locations.

Location ¹	Urban	Suburban	Rural	χ^2 (4)	P value
Those who responded “yes”					
Own landscape	9.1%	9.2%	5%	43.2	0.000
Neighbors’ landscape	8.7%	10.2%	5.4%	23.5	0.000
City maintained area	11.3%	13.1%	7.3%	28.7	0.000
Business/commercial property	10.2%	12%	6.8%	22.5	0.000
Those who responded “no”					
Own landscape	15.3%	32.6%	18.4%	19.7	0.000
Neighbors’ landscape	15.1%	29%	17.1%	8.9	0.000
City maintained area	11.1%	23.3%	13.8%	16.2	0.000
Business/commercial property	11.9%	23%	13.7%	8.8	0.000
Those who responded “not sure”					
Own landscape	3.1%	4.6%	2.2%	2.3	0.000
Neighbors’ landscape	3.7%	7.3%	3.1%	4.5	0.000
City maintained area	5.5%	10.1%	4.4%	5.0	0.000
Business/commercial property	5.5%	11.5%	5%	7.2	0.000

¹ χ^2 tests were performed on the actual data. Percentages shown are for yes, no, not sure for urban, rural, and suburban. For instance, to calculate 15.1% for urban own landscape, the calculation is the number of respondents that marked yes for own landscape living in an urban setting, divided by all respondents that marked yes for own landscape across urban, rural, and suburban.

Table 5. *t* test results comparing overall opinion of boxwood given that they may suffer from boxwood blight, among respondents in urban, rural and suburban areas using data from an online survey of US consumers.

Comparison	Mean	SD	<i>t</i>	df	P
Rural vs. suburban	46.6 vs. 47.5	27.78 vs. 26.62	−0.71	(2017)	0.23
Suburban vs. urban	47.5 vs. 56.41	26.62 vs. 29.43	−7.11	(2082)	0.00*
Rural vs. urban	46.6 vs. 56.41	27.78 vs. 29.43	−6.63	(1499)	0.00*

* Statistically significant results.

blight, compared with women. This could be because men generally are more engaged in landscape maintenance than women (Bureau of Labor Statistics 2023a, 2023b) and might have prior experience of successfully dealing with similar infestations. Overall, Caucasians displayed comparatively less liking for boxwood after having been shown pictures of blight infestations. It is possible that Caucasians purchase boxwood more frequently than other ethnic groups for their landscaping and, therefore, pictures of blight infected boxwood induced

a greater response in Caucasians than in other races.

We believe that the implications of the present study are broad. The emerging problem of widespread boxwood infestation can be associated with consumer knowledge gaps as well as the insufficient communication between the experts such as ag extension agents and consumers. Often, inadequate awareness and knowledge of boxwood blight can affect consumers’ ability to make prompt decisions and take suitable actions toward prevention/containment/mitigation of the disease on their

Table 6. Marginal effects of the tobit model individual-level explanatory variables on the overall opinion of boxwood shrubs after knowledge of boxwood blight using data from an online survey of US consumers.

Variable	Conditional on being uncensored	
	Marginal effect	P value
Gen X	3.514	0.014
Millennial	6.734	0.000
Gen Z	8.699	0.000
Caucasian	−4.873	0.000
Male	3.880	0.000
High school or less	1.969	0.195
Some college	−3.231	0.024
Graduate degree	3.207	0.038
No. of children in household (aged ≤18)	0.472	0.284
No. of adults in household (aged ≥18)	0.802	0.058
Suburban	−0.916	0.476
Rural	−0.020	0.989
Household income ¹	−0.001	0.031
No. of observations	2795	
Log pseudolikelihood	−13,095.525	
<i>F</i> (13, 2785)	12.32	
Prob > <i>F</i>	0.000	
Pseudo <i>R</i> ²	0.005	

¹ Multiplied by a factor of 1000 (units in \$).

Bold indicates significance at the 0.1 level or less.

Table 7. Overall opinion of boxwood shrubs before and after being provided information about boxwood blight by demographics using data from an online survey of US consumers.

Variable	Overall opinion of boxwood	
	Before pictures of blight (\bar{X})	After pictures of blight (\bar{X})
Baby Boomers	65.161	42.477
Gen X	64.784	44.567
Millennial	69.056	56.163
Gen Z	60.020	50.215
Caucasian	67.557	48.876
Non-Caucasian	62.869	51.930
Male	66.636	51.465
Female	65.823	48.361
Some college	64.784	44.567
Graduate degree	72.175	58.777

premises of their landscape and beyond. Therefore, it is important to assess consumers’ existing awareness and knowledge of boxwood and boxwood blight. Such enquiry can assist in developing communication strategies relevant to the specific needs of the targeted group. This information will be beneficial not only to consumers, but also to the vendors and other ancillary industries associated with boxwood.

This study was restricted to consumers’ awareness of boxwood shrubs and boxwood blight and their overall opinion of boxwood after knowledge of boxwood blight. Further investigations to discern the alternatives consumers might prefer over boxwood are worth considering. As noted by Omolehin et al. (2023) boxwood producers did not abandon boxwood but rather saw increased sales in less-susceptible boxwood cultivars, such as ‘Winter Gem’, ‘Wintergreen’, ‘SB 300’ (Freedom), ‘SB 108’ (Independence), and ‘Little Missy’.

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