# DO MATURE STREET TREES POSE A GREATER HAZARD RISK ACROSS SOCIOECONOMIC LINES?

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***ABSTRACT:*** *Damage from recent wind storms has heightened awareness of tree hazards in the northern New Jersey area. The purpose of this study is to determine if mature street trees pose a greater hazard across socioeconomic lines in suburban areas. Mature street trees were indentified, evaluated and measured in three northern New Jersey suburban neighborhoods: Montclair, Teaneck, and Englewood. A hazard index was created that consists of hazards (based on tree defects) and potential hazards (based on targets). Assessed property values and median incomes were obtained to determine socioeconomics for each neighborhood. Statistical analysis, ANOVA and regression/correlation, was conducted to prove or disprove the hypothesis. Results indicate a statistically significant difference in some tree hazards by town (number of potential targets, size of tree), and a significant negative correlation between property values and number of potential targets. There was little if any significant difference relating to the health of trees. The results point to a need for greater attention and care of urban trees, particularly in vulnerable neighborhoods.*

***Keywords***: *Urban hazards, Trees, Wind storms, Environmental equity*

## INTRODUCTION

The purpose of this study is to determine if mature street trees pose a greater hazard across socioeconomic lines in suburban areas. This study was inspired by a north eastern storm on March 13, 2010 which blew across northern New Jersey and the neighboring tri-state area. The storm left grounds saturated, with flood prone areas under water accompanied by wind gusts as high as 78 mph in some areas according to the National Weather Service, in New York (National Weather Service 2010). The storm caused mature trees to fail, both on public and private property. In one northern New Jersey town there were at least 200 felled mature trees after the storm according to the town's department of public works, leaving downed overhead utility lines, utility poles, property damage and fatalities (National Weather Service 2010). The storm had a paralyzing effect in northern New Jersey.

A number of research studies concluded the likelihood of damage from severe storms is strongly and positively correlated with average tree diameter (e.g.: Slater et al. 1995, DeGayner et al. 2005, Duryea et al. 1996, Greenberg and McNab 1998). Additional studies suggested that tree age may be positively correlated with damage to forests (Windham 2005, Kupfer et al. 2008), as well as height (Touliatos and Roth 1971). Literature concerning the onset of physical damage for specific species is lacking (Merry, Bettinger, and Hepinstall 2009) given deviations in wind speed, wind duration, topography, soil and forest characteristics related to specific storms. Therefore species specific damage during severe storms is difficult to characterize (Bettinger, Merry, and Grebner 2010).

Appleton (2006) states two trees, Red maple (*Acer rubrum)* and London planetree (*Plantanus x acerfolia)*, should not be planted in or near utility easements, due to maturation heights in excess of 40 feet. Appleton (2006) discusses the success of the Municipal Tree Restoration Program (MTRP) which was started in Virginia in 2000. The MTRP program is supported by state agencies, educational institutions, and utility companies, was designed to assist municipalities with conflicts between over head utility lines and inappropriately tall trees planted near line easements. The intended goals of Virginia's MTRP were as follows (Gerhold 1999: 81):

- To increase the general public's awareness of potential tree/utility conflicts.
- To increase recognition of tree/utility problems by municipal tree managers.
- To increase removal of utility-unfriendly trees by municipalities.
- To identify utility-appropriate tree species by research and field trials.
- To increase availability of utility-appropriate tree species in the nursery trade.
- To increase awareness of potential tree/utility conflicts in new plantings by developers, city planners and site plan reviewers.

A utility line arboretum will benefit all towns and would be useful in northern New Jersey. It would increase public awareness and social acceptance of an overlooked issue that after March 2010 became an obvious concern. Acceptance proceeds through knowledge, persuasion, implementation, and confirmation and can be traced to a number of factors such as relative advantage, complexity and triability (Mallett, 2007). Neighborhood municipalities should consider keeping records of felled trees after severe weather storms. This will accurately track species type and performance during severe weather storms during the hot and cold months and create a way to further track different species over time. This will decrease the risk of potential hazards, and hazards posed by mature residential street trees.

Minnesota Department of Natural Resources and USDA Forest Service (1996) identified seven types of tree defects. This paper considers five of these, summarized in Table 1. Two defects were omitted; cankers and root problems; the latter was observed and included in this study and (Figure 1), cankers were not observed therefore not included. Figure 1 identifies the actual and potential tree hazards from trees in the suburban area. Potential hazards are targets that would be impacted by falling trees and branches. Actual hazards are based on weaknesses in trees.

Table 1. Tree Defects Identified by Minnesota Department of Natural Resources and USDA Forest Service (1996)

| **Tree defect** | **Description** |
|---|---|
| Deadwood | Dry and brittle, cannot bend in the wind like living tree or branch. Can break off at any time and must be removed immediately. |
| Cracks | Deep splits through the tree bark that extend into the wood of the tree. Very dangerous and indicate a failing tree. |
| Weak branch unions | Two or more usually upright branches grow so closely together that bark grows between the branches, inside the union. Ingrown bark does not have structural strength of wood. Included bark may act as a wedge, force the branch union to split. Elm and maple tree have the tendency to form upright branches that produce weak branch unions. Weak branch unions can form after a branch is tipped or topped |
| Decay | Can lead to tree failure, but decay alone does not indicate tree hazard. Presence of advanced decay (soft wood, punky, crumbly, cavity where wood is missing) can create serious hazard. |
| Fungus | Includes mushrooms, conks, and brackets growing on root flares, stems or branches; indicate advanced decay. |

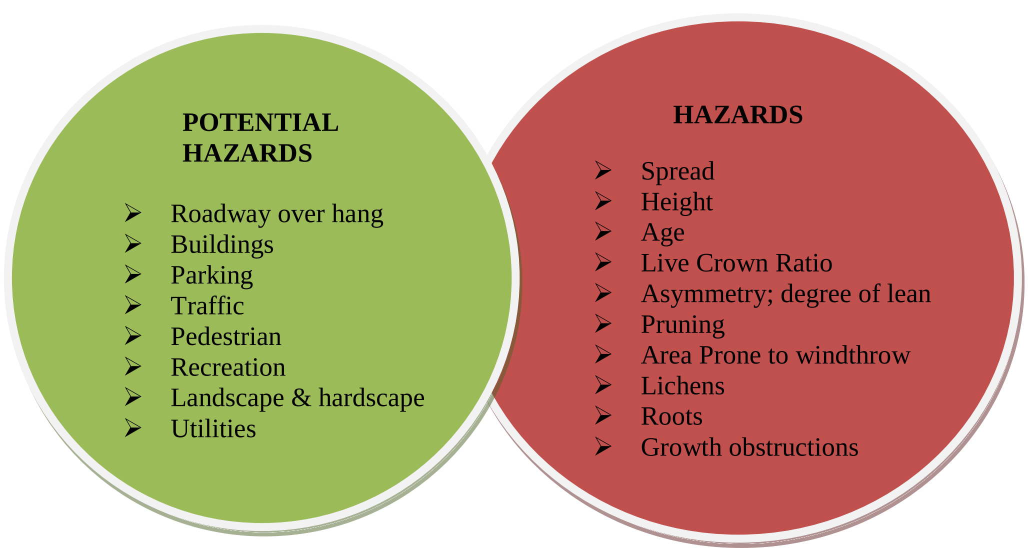


Figure 1. Tree hazards.

## MATERIALS & METHODS

In order to determine if mature street trees pose a greater hazard across different socioeconomic neighborhoods, this study used field data collected in early Spring 2010, utilized US Census and property tax assessment data available to the public. Mature street trees were indentified and evaluated in three New Jersey suburban neighborhoods. United States Census data and property values obtained from 2010 tax records were used to determine socioeconomic conditions for each neighborhood evaluated. The following outlines the methodological procedure.

### Study Area

Three towns in northern New Jersey were selected for this study, based on potential tree hazards and socioeconomics. Teaneck and Englewood street trees were chosen for evaluation due to the large number of mature felled trees after the March 2010 storm, and because both towns have dense mature tree populations. Montclair street trees were chosen for socioeconomic comparison and potential street tree failure from the March storm. The residential blocks were determined using a statistical random integer locator. A random number generator uses a computer algorithm to establish a random sequence of numbers. Numerous examples are available through the Internet, this study used www.random.org (Haahr, 2011). Two of the towns are located in Bergen County and the third is located in Essex County, New Jersey (Figure 2).

Teaneck and Englewood (both in Bergen County) are moderate middle class townships. Englewood has a total population of 26,203 (2000 census) and median household income of $58,379 (1999 dollars) with a slightly higher median family income of $67,194 (1999 dollars) (US Census, 2000). Teaneck has a total population of 39,260 (2000 census) and median household income of $74,903 (1999 dollars) also with a slightly higher median family income of $84,791 (1999 dollars). Teaneck and Englewood are neighboring towns and geographically located close to New York City with moderate sized homes and lot sizes. The third town, located in Essex County, New Jersey is Montclair which is an upper middle class township with larger homes and lot sizes. Montclair has a total population of 11,915 (2000 census) and median household income of $115,498 (1999 dollars) with a higher median family income of $140,377 (1999 dollars) (2000 census). Montclair is located about 12 miles southwest of New York City.

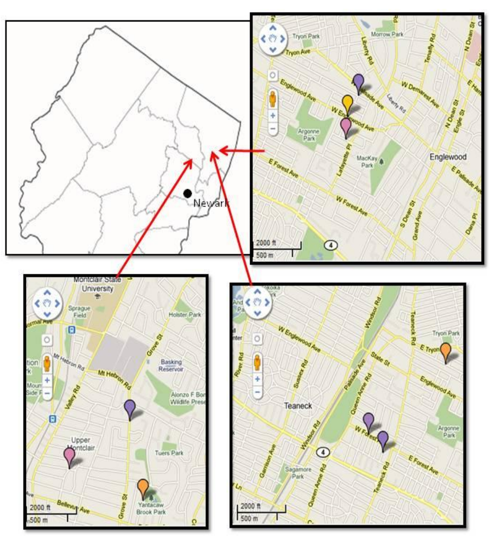


Figure 2. Study areas in Englewood, Teaneck, and Montclair, in northern New Jersey. (Base maps source: Google Maps, and New Jersey Dept. of Transportation)

#### *Teaneck street locations*

Location 1 - Washington Place is a quiet residential block with two way traffic; the street runs east and west and ends in an adjacent town on the eastern end of the street. The street trees evaluated on this street were situated on the western side of the street. Location 2 - Alicia Avenue is located in the southern region of Teaneck situated close to the local highway with easy access to New York City. Alicia Avenue is not as dense with homes but it has more diversity in home types and lot sizes, compared to street location 1. This street is located in an area of Teaneck that is densely populated with tall, mature trees. Location 3 - Katherine Street is located in the southern region of Teaneck. It is located close to the local highway that provides easy access to New York City. Like street location 2, this street location is dense with large mature street trees.

***Englewood street locations***

Location 1 - Palisade Place runs north and south. Street trees are located only at the southern end of the block that empties onto a main street with no street trees at the northern end. Street location 1 is a quiet residential block with moderate sized homes on small lots. The southern end of Palisade Place has numerous tall mature street trees with upper branches reaching over the roadway and into overhead utility lines. Location 2 - Orange Street and Reade Street (location 3) are adjacent to one another, both in the southern region of Englewood. Orange Street is a quiet residential block. Street tree evaluations were conducted at the southern end of this street, within the last block. Homes located on this portion of the block were moderate in size, close in proximity on small lots. Reade Street runs north and south and is adjacent to location two. Street trees on the southern end of the block were evaluated for this project**.**

***Montclair street locations***

Location 1 - Grove Street is located in the eastern region of town. It is a busy residential block, with moderately sized homes and lot sizes. Location 2 -Inwood Avenue is located in the western region of town. It is a quiet residential block with significantly larger homes and land lots compared to Grove Street. Inwood Avenue has fewer residential homes than locations one and three, due to the larger home and lot sizes. Location 3 - Greenview Way, is located in the eastern region of town. It is a quiet residential block. Along Greenview Way, home and lot sizes are moderate, consistent with street location one but smaller than location two.

**Field Methods**

Street trees were chosen for the evaluation process because they are public and situated on public property for easy accessibility. Ten street trees on each street were evaluated (resulting in 30 trees per town, 90 for the entire study). Species identification consisted of matching tree leaves to identified species leaf photographs using the National Audubon Society Field Guide to Trees Eastern Region North America (Little, 1980). A Tree Hazard Evaluation Form was used to catalogue each tree for this study (International Society of Arboriculture, June 6, 2010. City of Osewgo, Oregon, Planning Office, June 6, 2010), to assess tree hazards and targets. Tree characteristics included live crown ratio, wind throw potential, tree defects, root characteristics, and growth obstructions. Tree measurements included tree height (using a clinometer), crown ratio, spread (including spread over roadway), and diameter at breast height (DBH). Age is assessed in a categorical ranking of young, semi mature, mature, over mature, and senescent. Live crown ratio was assessed by visually determining the proportion of branches of a tree displaying leaves and assigning percentage of live branches.

**Socioeconomics**

Broad socioeconomic status was determined by zip code according the US Census (2000), using population, median household income, and median family income. Detailed socioeconomic proxy information relied on property value records, accessed from the NJ Property Search-Monmouth County-tax office search (2010). Property block, lot, and value amounts were used from 2010 tax records. Property value amounts were matched to street addresses where evaluated street trees were located in each town. In some instances property value amounts were unavailable, this occurred when searching property values for two streets in Englewood. To adjust for this discrepancy, property value amounts were used from a comparable street one block over from the evaluated block. Property values from the comparable street were used and matched to the initial evaluated street where no property value data was available. Addresses were confirmed in the field or via a real estate listing service (Zillow.com, 2010).

# RESULTS

The results suggest that some of the tree hazard and hazard potential do vary based on socioeconomic conditions in the three towns evaluated. The results here will show a.) a distinct difference in socioeconomics among the towns; b.) differences in some tree hazard parameters between towns; c.) correlation between property values and tree hazard attributes.

### Socioeconomics between Towns

Census data (Table 2) shows a clear difference in median household income and median family income. Although the difference in property values between Englewood and Teaneck is not significant, there is significant difference between Montclair and both Teaneck and Englewood (*ANOVA F= 58.2, p=0.000)* (Table 2).

Table 2. Socioeconomic Measurements for the Three Towns*

| Town | Median family income | Median household income | Mean property value |
|---|---|---|---|
| Montclair | $140,377 | $115,498 | $797,933 |
| Teaneck | $84,791 | $74,903 | $364,363 |
| Englewood | $67,194 | $58,379 | $377,157 |

*Median family and household incomes are based on aggregate US Census data per zip code; mean property values are from tax assessment, averaged from the locations samples for this project.

### Tree Species and Age

Different species were assessed; the most prevalent species among the three towns is the Norway maple (Figure 3). The Norway maple has an expected height of 18 meters at maturity and DBH of 0.6 meters. At these height potentials the Norway maple becomes more hazardous because of size and ability to impact targets in suburban neighborhoods, such as, pedestrians, vehicles, buildings overhead utilities. While the Norway maple tree is widely planted across the United States (Little, 1980), it will no longer be the popular species planted in suburban towns. Montclair arborist, S. Shuckman says, "the Norway maple are riddled with stress diseases and decay" (2010). Norway maple trees become brittle as they become older making them more hazardous, and surface roots decay from salting that occurs on roadways during the winter months.

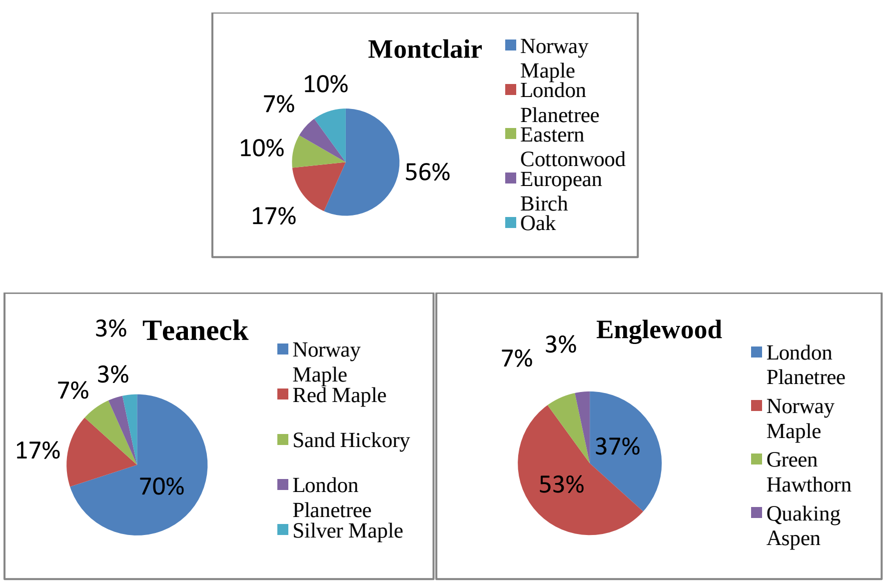


Figure 3. Street trees evaluated by town.

The London plane tree is second most common in the neighborhoods surveyed (Figure 3). The London plane tree species showed to be a popular choice in Englewood at 37%, compared to the other two towns. It is a reliable tree, able to withstand storms and offers wide open crowns (Shuckman, 2010). The London plane tree has height expectancy at maturity of 21 meters and a DBH of 0.6 meters. Most trees surveyed here were mature, which suggests that London plane trees evaluated in Englewood for this study pose a hazard.

Age is important to the health of the tree. Trees do not live forever. With age they become taller with wider trunk circumference (DBH) and canopy spread. A mature tree may appear healthy on the outside yet compromised internally by disease, insect and or environment (i.e., pavement), making it more susceptible to fall. Maturity can undermine structural integrity creating a greater hazard. Diameter at breast height is related to age as the circumference grows. Compared to the categorical field assessment (young, semi-mature, mature, over mature, and senescent), DBH proved to be an adequate proxy for age (ANOVA $F = 10.65$, $p = .000$) (Figure 4). Likewise, height of the tree and length of branch over roadway were differentiated by relative age ($F = 3.03$, $p = 0.053$ for height, $F=8.11$, $p=0.001$ for branch over roadway). There was no significant difference in tree age between towns. Similarly, there was no difference in tree age based on property values.

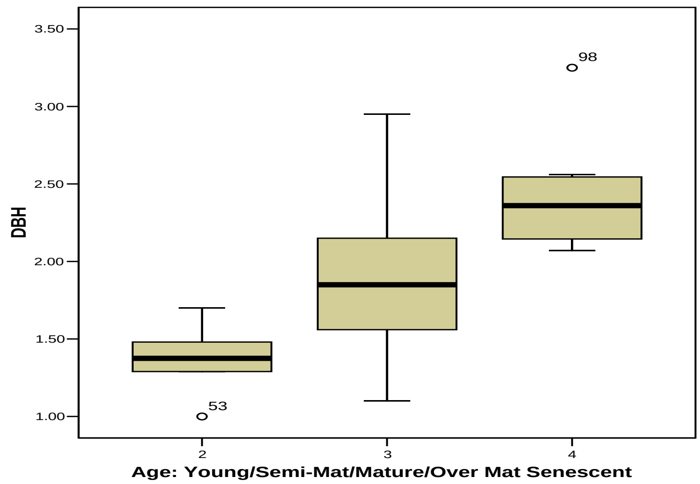


Figure 4. Categorical age indicated as follows: 2= semi mature, 3= mature, 4= over mature compared to (DBH) diameter at breast height. The box-whisker plots show the statistical spread of the data; the top and bottom of the box represent the 75th and 25th percentile, respectively, the middle line is the 50th percentile, whiskers represent the extremes, and dots are outliers.

**Potential Target Varying by Town and Property**

In this study targets are classified as any object a street tree could impact if it were to fall. Older, more mature and therefore larger trees pose a greater hazard potential if they were to fall onto property (i.e., buildings, vehicles, pedestrians, utility lines). Landscape is a target—it includes lawn shrubs and flowers. Hardscape targets include brick or stone flower beds, retaining walls, railings, mailboxes, fences and small feature targets such as lawn decoration (i.e., lawn furniture, garden gnomes and windmills). The larger the street tree, the greater number of targets. Number of targets represents the number of objects a tree will impact if it should fail. It was shown that tree size (age) does not differ between towns or property values. However, it is interesting that the number of targets varied significantly between towns. Neighborhoods with higher property value (and higher median incomes) had fewer targets than those with lower property value and lower median income. The housing density in Teaneck and Englewood is higher, therefore possibly concentrating the number of potential targets per tree. As indicated in Figure 5, Montclair has the least number of targets a street tree can impact upon failure. Teaneck street trees have more targets to impact upon failure than Montclair yet slightly more than Englewood. Analysis of variance confirms these differences ($F= 3.61$, $p = .031$).

There is a significant negative correlation between the number of targets and property value (n=90, $p=0.000$, $r=0.413$). Figure 6 shows that as property values increase the number of targets decrease. Therefore, in

Montclair, with higher property values, street trees will impact a lesser number of targets. Again, this may be due to higher housing density.

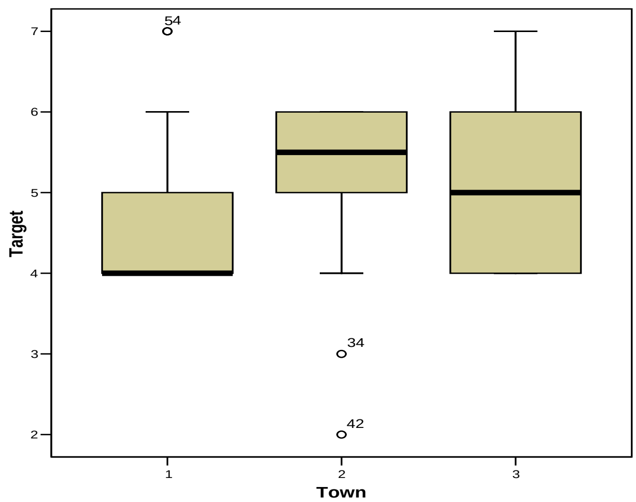


Figure 5. Number of targets vary by town. Montclair =1, Teaneck =2, Englewood = 3; box whisker plots are as described in Figure 4.

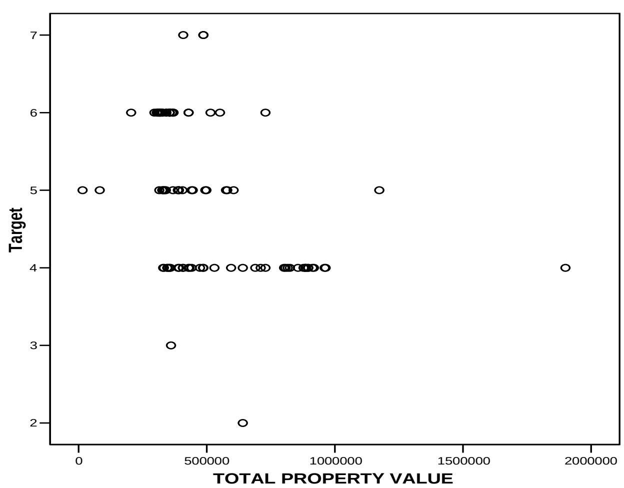


Figure 6. Scatterplot for property value (in 2010 dollars [New Jersey Tax Record Search]) compared to number of targets per tree.

**Tree Attributes against Targets**

There is a difference in size by species of tree; once mature certain species reach taller heights and greater canopy spread than others. At least 90% of the trees surveyed in this study were species that reach large size (such as maple, oak, hickory, London plane tree), so there is no anticipated variation in hazard, due to size, for this study.

Even street trees with small canopy spreads can have roadway overhang similar to those of trees with a large spread. Generally, older trees will have larger crown spread, and therefore larger overhang over roadways. Length of branch over roadway is a potential hazard. There is a significant correlation between length of branch over roadway and tree age. A comparison between DBH (proxy for age) and length of branch over roadway shows a positive and significant correlation (*F=40.04, p = .000, r= 0.572*). Mature trees have roadway overhang branches that extend as far as 14 meters. This indicates that the larger a street tree, the longer the extension of branch over the roadway, which indicates a greater hazard. There was no significant difference between towns in length of branch over roads and canopy spread. This is expected given the similarity in tree age among towns. Norway maple and London plane tree, two of the most prevalent species evaluated in this study, have a roadway over hang length of up to 13 and 14 meters, respectively. The majority of street trees with roadway over hang ranged from 5.5 meters to 21.5 meters.

The taller the street tree the greater number of potential targets if the tree fails. Tree height does vary by town (ANOVA $F = 3.44$, $p = 0.036$), where street trees in Montclair are the tallest when compared to Teaneck and Englewood. Englewood and Teaneck have similar street tree heights. This is an unexpected relationship. There are numerous factors that may account for the difference in tree height (soil, microclimate, care and maintenance).

Live crown ratio is the amount of green canopy in a tree, and should relate to age (via DBH). However, there is a poor correlation between these variables ($p=0.736$, $r= 0.0316$). The majority of street trees surveyed have high live crown percentages, with little variation. It is possible that dead branches were previously trimmed, or felled by the earlier windstorm. Live crown ratio did not correlate with crown spread or height.

## CONCLUSIONS

The purpose of this project was to evaluate the hazards associated with large mature street trees in suburban neighborhoods and to determine if socioeconomics plays a role. The intention was not to point out any wrong doing towards the three New Jersey towns evaluated in this study or suggest lack of concern regarding this topic. This study does point out that different town compositions, a function of suburban socioeconomics, do present a relevant concern regarding street tree hazards.

This study assessed street tree attributes and hazards across a verified socioeconomic cross section in suburban northern New Jersey. The key findings of this study are:

- Age of trees, using a tree diameter proxy measurement, did not vary among towns surveyed for this study.
- Tree heights did differ among towns, due to unspecified factors.
- The number of potential tree failure targets did vary between towns, possibly a function of housing density.
- The number of potential tree failure targets decreased with increasing property values, also possibly a function of housing density.
- Length of branch overhang on roads correlated with tree age, but did not vary between towns.
- Live crown ratio did not vary significantly within the surveyed population, and therefore did not differ by town or property value, a possible result of previous pruning or storm damage.

Street trees are currently a strong topic in Bergen county New Jersey due to property damage and cleanup costs. Mature street trees are desirable, yet potentially hazardous. During the evaluation process for this study, a local newspaper, *The Bergen Record*, discussed issues residents now have regarding street trees (Yellin, 2010). The article stated that towns want smaller street trees that will not extend into utility wires, or are planting trees further away from power lines, or halting tree plantings altogether on public thoroughfares. Also during this project, Route 4 in Teaneck and the Henry Hudson Parkway in Manhattan were cleared of roadway overhang branches. Recent storm events, particularly the severe March 13, 2010 wind storm, seemed to bring about an increased awareness of tree hazards.

What can be concluded from this study is that suburban towns should consider perhaps smarter species type trees, with maturation heights less than 6 meters when planting on residential streets. In this study species of tree is crucial in decreasing the risk of hazards associated with mature street trees. Utilizing a smaller species along residential streets will eliminate overhead utility contact, decrease branch overhang on roadways and canopy spread. Moderate property value neighborhoods might consider the number of street trees planted compared to property lot sizes. This could assist municipalities regarding the amount of street tree planted in the future.

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