

# Impact of ecological disturbance on awareness of urban nature and sense of environmental stewardship in residential neighborhoods

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## ABSTRACT

Experience with nature contributes to human wellbeing and environmental stewardship. Both may be affected when people experience local environmental disturbances. I test the hypothesis that relatively gradual ecological disturbance in urban areas increases awareness and appreciation of urban nature and environmental stewardship. In recent years the Emerald Ash Borer killed 10,000 street trees in Ann Arbor, Michigan. Information on residents' attitudes and behavior regarding urban nature and street trees was collected from a mailed survey returned by 594 homeowners. Residential properties in the sample were distributed across the city as 24 pairs of nearest neighbor streets, including a "treatment street" (>70% street trees lost) and a "control street" (<30% street trees lost).

Findings indicate that those experiencing tree loss were significantly more engaged with nature and more willing to participate in stewardship. The degree of increased engagement was directly related to the individual's proximity to the disturbance. Proximity to the loss was also a significant contributor to respondents' appreciation of urban nature and the feeling that street trees enhance sense of wellbeing. However, regardless of proximity to tree loss, responses to items concerning appreciation of urban nature and the feeling that street trees enhance sense of wellbeing were extremely high. The results of this study suggest that recovery from ecological disturbance may be best supported by stewardship activities that engage citizens in what they care about, in ways that foster wellbeing of both the self and the urban ecosystem.

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## 1. Introduction

Experience of nature contributes to human wellbeing when assessed in terms of physical and psycho-social benefits (Pretty, 2004). In urban areas worldwide, the experience of nature within the city restores attention fatigue (Kaplan, 2004), improves wellbeing (Chiesura, 2004), supports health (Abraham et al., 2010), and facilitates social cohesion (Maas et al., 2009). The effect of loss or degradation of urban nature on human wellbeing is less studied except as relates to catastrophic change (e.g., Chamlee-Wright and Storr, 2009), yet losing nature more subtly is a common experience. This research offers a quantitative look at the way people value urban nature as experienced in daily life in light of an ecological disturbance that threatened and destroyed nature in small increments over a 5-year period. The relationship between loss of urban nature and subsequent care behavior at home and in the neighborhood is also evaluated to better understand the basis of environmental stewardship for the individual and the community.

The ecological disturbance occurred when the Emerald Ash Borer (*Agilus planipennis*) caused extensive loss of ash trees (*Fraxinus* spp.) in southeastern Michigan beginning in 2002 (Poland et al., 2006). By the end of 2007 in Ann Arbor, Michigan, over 10,000 ash trees, 17% of the city's total street tree population, had died and been removed from easement areas, the public land adjacent to all streets. Where the density of ash trees was high, the ecological and aesthetic integrity of neighborhoods was dramatically changed, often in a single season, along with the restorative benefits provided by these trees.

Street tree loss brings overt aesthetic change. The disturbance also impacts urban ecosystem processes by altering sun/shade patterns, temperature and humidity, and by reducing rainwater infiltration and complexity of the habitat structure for urban wildlife (McPherson et al., 2005). It is important to remember that the easement area is owned by government but usually managed by the property owner. Consequently, many people think of this area as personal space. Sense of control in the face of street tree loss and associated disturbances may be limited as street trees reside in public space.

This research investigates the impact of ecological disturbance on a community's awareness and appreciation of urban nature and the likelihood that such disturbance will increase environ-

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mental stewardship. It offers insight on the role of street trees, a critical component of the urban forest, in the relational feedback between human wellbeing and healthy urban ecosystem function. The results also contribute to a growing body of knowledge about people's perceived relationship with nature and the role of these perceptions on stewardship and sustainable lifestyles.

### 1.1. *Precedents and experimental goals*

*Appreciation and wellbeing:* The association between neighborhood greenness and mental and physical health (Sugiyama et al., 2008) has been shown even when nature is experienced from inside (Kaplan, 2001). Jackson's (2003) review of the literature concluded that access to visible greenery, especially within a neighborhood setting, is critical to human health and supports social cohesion. Based on their review of the empirical evidence Matsuoka and Kaplan (2008) concluded that nearby natural environments play an important role in the wellbeing of urban residents across diverse cultures and political systems.

Street trees make a significant contribution to the perception of greenness in urban areas owing to their size and presence along commonly used city corridors. In Chicago, for example, street trees alone account for 24% of the total leaf area (Nowak, 1994). As a component of the urban forest, street trees usually bring aesthetic satisfaction, although studies occasionally uncover negative reactions stemming from cultural (Schroeder et al., 2006) and demographic factors (Hitchmough and Bonugli, 1997). Street trees promote neighborhood satisfaction (Lee et al., 2008), influence people's choice of residence (Zhang et al., 2007), and are associated with greater use of outdoor space by both children and adults (Coley et al., 1997). In the context of the present study, it is hypothesized (H1) that the experience of street trees in particular and urban nature in general elicits positive emotional and aesthetic reactions and (H2) that this appreciation of urban nature/street trees contributes to a sense of wellbeing.

*Disturbance:* Natural ecological disturbance can adjust urban ecosystem structure (Bolund and Hunhammar, 1999) as well as human perception of place (Brown and Perkins, 1992; Hunter, 2008). Empirical work has shown that sensitivity to ecological disturbance can amplify personal valuation of nature (Burley et al., 2007; Chamlee-Wright and Storr, 2009). It is hypothesized (H3) that loss of street trees elicits an emotional reaction and (H4) that proximity to tree loss amplifies awareness of and emotional reaction to environmental disturbance.

*Stewardship:* The relationships among attitudes about nature, experience of nature, and protective behavior towards nature have been under investigation for some time. Results suggest that people who are more concerned about the environment are more likely to engage in stewardship behaviors, particularly when their own relationship with nature is at stake (Hartig et al., 2007; Kals et al., 1999). Loss or disturbance of nearby nature is known to galvanize communities to action whether the cause is anthropogenic or natural (Gist and Lubin, 1999). It is hypothesized (H5) that people who have lost a street tree in front of their homes are more likely to express environmental stewardship as measured by interest or engagement in supporting ecological recovery.

## 2. Methods

*Study area:* Ann Arbor is popularly called the City of Trees because of its 100 year history of abundant tree planting in public spaces including parks and street easement areas. While the diversity of publicly held trees is good, dominance of one species even to the point of monoculture occurs locally when developers overuse commercially popular species. In selecting households for the sur-

vey about street tree loss, it was necessary to assess the spatial citywide distribution of ash trees – all of which had been recently removed by the time of the survey. To do this, a map of tree loss density classes was created from an existing city GIS database that included a layer with the location of ash trees. This assessment led to a selection of likely residential neighborhoods that included adjacent or nearby streets that would permit pairings of a treatment street (>70% street trees lost) and a control street (<30% street trees lost) (Fig. 1). Field canvassing led to selection of street pairs based on tree loss criteria as well as streetscape characteristics including similarity of lot size, house style, and site layout. Subsequently, an online real estate database operated by the City of Ann Arbor was used to confirm field impressions of similarity by checking property size, house area, and time since construction to ensure similarity in the maturity of vegetation. The final selection of street pairs was based on intensity of tree loss, matching of physical and temporal criteria, avoidance of rental neighborhoods, and equal representation within Ann Arbor's five voting precincts to maximize coverage of homeowner neighborhoods. In total, 48 city blocks (24 paired streets) with 1350 residential properties were selected for the study (Fig. 2).

*Contact with study participants:* In the summer of 2007, 1350 households were contacted by mail 3–4 times from June through August in this sequence: introductory postcard, survey with accompanying invitation to participate, follow up reminder postcard, a second copy of the survey if one was not returned. This effort yielded a return survey from 594 households (44%) by the end of September. The identity of the participants was not known so there was no way to verify that there was only one response per household.

*Survey instrument:* A cover letter included with the mailed surveys explained that participation in a university research study would be used to evaluate the community's reaction to widespread street tree loss and the importance of nature in the home environment. They were also told that answers were confidential and were given contact information should questions arise. The 4-page survey included questions addressing each of the following: (1) awareness of loss, (2) emotional response to loss, (3) appreciation of and aesthetic response to trees and nearby nature, (4) wellbeing related to trees and outdoors, (5) perceived economic impact of trees, and (6) interest and engagement in stewardship. Multiple items were used to assess these topics. For example, stewardship was evaluated in terms of both action and intent as relates to physical participation in habitat creation (spending time, getting dirty), intellectual participation (using educational materials that may alter perception and action), economic participation (spending money on tree installation and habitat improvement) and community participation (local tree re-planting or habitat enhancement). Most questions required a response along a 5-point scale (e.g., "not at all" to "very much") and provided a "not applicable" option. The survey also asked about personal attributes including time lived at the address, age of respondent, presence of children under 15, presence of outdoor pets, and about property attributes such as age of the house, number of street trees lost and the number and year of replacement trees provided by the city. In addition, the survey included questions regarding the number of trees lost, when this occurred, and whether they had been replaced. Respondents were also invited to add additional comments.

### 2.1. *Data analysis*

Survey data were analyzed for descriptive statistics and measure of association statistics for ordinal response variables. To eliminate problems of low frequency for response categories, the 5-point scale was collapsed to 3-point ordinal scales. Consolidation of response categories was based on the frequency distribution for

treatment street



control street



Fig. 1. Images show the characteristic look of street loss in treatment group (loss >70%) and control group (loss <30%).

each item. The Cochran–Mantel–Haenszel test (SAS PROC FREQ) was used to evaluate the impact of proximity to tree loss. General linear models (SAS GLM) were used to compare responses by tree loss status. Spearman’s correlation test (SAS GLM) was used to measure association among variables. Cumulative logit models (SAS PROC LOGISTIC) produced least squares estimates and odds ratios that described the relationship among ordinal variables and offered likelihood predictions.

*Index variables:* Following the indicator variable coding method from Stokes and Davis (2009), four index variables were developed to summarize responses to questions that were thematically linked: *Awareness of disturbance* included tendency to notice street tree loss while (1) driving, (2) walking, (3) biking, (4) sitting outside, and (5) looking outdoors from inside house. *Emotional distress* included emotional response to street tree loss in terms of (1) sadness, (2) irritation or anger, (3) concern, and (4) fear. *Interest in stewardship* included interest in: (1) receiving information on biodiversity in residential settings, (2) volunteering for street tree installation, (3) receiving tips on how to design yards for birds and pollinators and (4) how to create a rain garden. *Perceived economic impact* included sense that the presence of street trees influences (1) heating bills, (2) cooling bills, (3) water bills and (4) the value of the property.

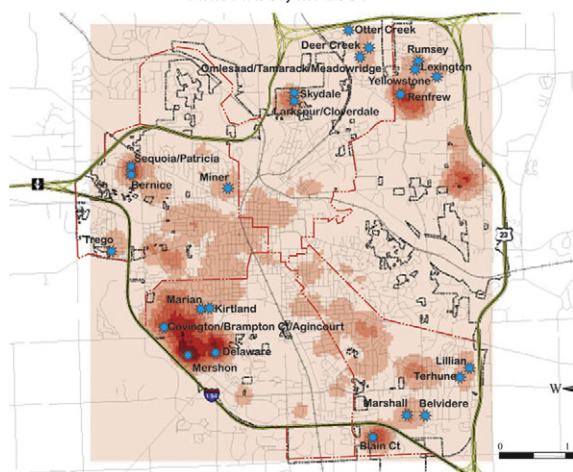
Cases with two or more missing responses relating to a specific theme were dropped for that index variable. Each index variable was tested for reliability with Cronbach’s alpha statistic (Table 1; SAS PROC CORR, alpha option). Where alpha was greater than or equal to 0.7, it was assumed that a single underlying factor was involved in the group of thematically tied responses (SAS Publishing, 2009).

3. Results

*Characteristics of homeowners and their property:* The age distribution ranged from 30 to over 70, with 41% of the sample under 50, and 30% ages 60 and higher. Twenty-seven percent lived in households with children under 15 and 41% had pets that use the outdoors. The majority of the respondents (57%) had lived on their property more than 10 years, including 18% who had 30 years or more in place. For more recent arrivals, 15% had 2–5 years and 13% were still unpacking (<2 years). The majority of respondents (71%) said their house was built between 1950 and 1969, meaning that it had been 40–50 years since the residential vegetation was first established. As would be expected, time lived at a house was strongly related to age ( $r=0.77, p<0.0001$ ). The shorter the time lived in the house, the more likely the residents had children under

Ash Tree Loss: Treatment Street Locations

Ann Arbor, MI 2007



Ash Tree Loss: Control Street Locations

Ann Arbor, MI 2007

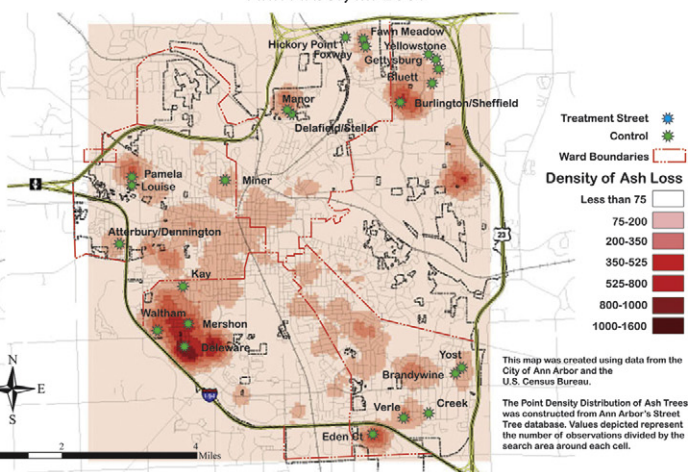


Fig. 2. Density pattern of ash tree loss across the city and location of treatment and control streets. GIS data on ash tree location was provided by the City of Ann Arbor.

**Table 1**  
Descriptive and analytical values for five index variables related to street tree loss; Cronbach alpha (*a*) measures internal consistency of the scale.

| Index variable and scale  | Mean | SD   | <i>n</i> | <i>a</i> |
|---|------|------|----------|----------|
| Awareness of disturbance 1 = not at all; 3 = very much  | 2.64 | 0.39 | 391      | 0.78     |
| Emotional distress 1 = not at all; 3 = very much  | 2.25 | 0.46 | 493      | 0.70     |
| Interest in Stewardship 1 = not at all; 3 = very likely   | 2.07 | 0.59 | 565      | 0.80     |
| Perceived economic impact of trees 1 = not at all; 3 = very much  | 2.22 | 0.52 | 517      | 0.77     |
| Aesthetic response to own property <sup>a</sup> 1 = looks much worse; 4 = looks much better much better | 1.75 | 0.42 | 298      | 0.78     |

<sup>a</sup> Only those losing a street tree in front of home.

15 ( $r = -0.39, p < 0.0001$ ) and pets that used the outdoors ( $r = -0.11, p = 0.007$ ), although the correlation between children and pets was low ( $r = 0.09, p = 0.03$ ). The younger the resident, the more likely the household was to have an outdoor pet ( $r = -0.21, p < 0.0001$ ).

Forty-three percent of respondents reported no street tree loss along the front of their property and 35% indicated loss of one tree. That leaves almost a quarter of the sample (22%) who indicated loss of 2 or more street trees. For those who recalled when dead or dying ash trees were lost (82% of the sample), most indicated 2006 or 2007 as the date. When street tree replacement occurred, it was done most often by the city of Ann Arbor (for 42% of reporting households). When the city did not make the replacement, 6% of respondents bought and installed a tree themselves, 13% plan to do this, and 34% have no plans to do so.

### 3.1. Sensitivity to ecological disturbance in urban settings

*Appreciation of urban nature and its relationship with wellbeing:* There was a positive association between respondents' appreciation of street trees and the sense that street trees enhance their wellbeing ( $r = 0.26, p < 0.0001$ , Spearman). Further, respondents' sense that street trees enhance wellbeing was also associated with a sense that urban nature brought stress relief ( $r = 0.34, p < 0.0001$ , Spearman). Although appreciation of street trees was extremely high (with 96% of respondents declaring the highest level of appreciation), respondents who had lost a tree in their own easement expressed significantly higher appreciation than when no loss occurred (97% versus 94%,  $p < 0.008$ ). The two groups did not differ in their high endorsement of enjoyment gained from looking at street trees (95%), from listening to the sounds of nature (90%), from walking in the neighborhood (80%), and from looking out at nature from inside the home (62%). For 81% of the participants street trees greatly enhanced their neighborhood pride.

In contrast to the previous item about appreciation, responses to the item about street trees enhancing sense of wellbeing were more differentiated, with 68% declaring the highest level of impact. The rating of wellbeing enhancement was significantly stronger ( $p < 0.028$ ) from those who had lost a street tree in front of their home (72%) compared to those who had not (62%). Simply being outdoors offered stress relief for 86% of the respondents, with the majority of the respondents (64%) declaring the highest level of impact; the two groups, however, did not differ in their endorsement of this item.

Respondents' sense that street trees enhance their wellbeing was strongly related to the thematic index variables. As shown in Table 2, those who gain a greater sense of wellbeing from street trees were 3.8 times more likely to be aware of the disturbance, 3.7 times more likely to have a distressing emotional response to it, 2.8 times more likely to think that street trees have an economic impact, and 2.6 times more likely to show interest in stewardship activities. The relationship with stewardship activities was also true for respondents reporting greater stress relief from being outdoors, with an Odds ratio of 2.0. In all instances the likelihood values related to wellbeing were higher for those who had lost a street tree in front of their home compared to those who had not (Table 2).

*Emotional impact of loss:* The emotional impact of street tree loss was high with respondents declaring the highest level of sadness (82%), concern (72%) and impact on neighborhood pride (81%). While there was no difference among respondents who did and did not lose a street tree for sadness and concern, those losing a street tree expressed significantly higher irritation or anger than those who did not experience the loss (38% versus 28% for the highest response level,  $p = 0.016$ ). Overall, greater sense of neighborhood pride was associated with greater emotional distress over tree loss ( $r = 0.40, p < 0.0001$ , Spearman). By contrast, people with outdoor pets were less likely to experience emotional distress from tree loss ( $r = -0.10, p = 0.036$ ); but what about the dogs?

*Awareness of ecological disturbance:* Awareness of street tree loss was greater for respondents who lost a street tree than those who did not (index variable values  $-2.71$  versus  $2.57, p = 0.0006$ , GLM). Despite this effect, there was only a small impact on behaviors involving interface with urban nature among respondents who lost a tree: 13% used the front porch less (1% more), 17% closed the blinds/curtains more (4% less), 11% spent more time gardening (5% less), 8% looked outside through their windows less (5% more), and 8% walked less in their own neighborhood (5% walked more).

### 3.2. Basis of environmental stewardship for the individual and the community

Overall, most people exhibited attitudes and engaged in behaviors that are emblematic of stewardship. The majority of households (71%) indicated they have one or more wildlife support items on their property, with bird feeders the most prevalent item. Participants, regardless of whether or not they experienced tree loss, spent time and money on wildlife habitat enhancement by providing food and adding structural habitat that supports urban fauna, chiefly birds and butterflies. Evidence of stewardship was also assessed in terms of intentions, with the Interest in stewardship index variable incorporating willingness to volunteer for street tree planting in the neighborhood, interest in receiving information on neighborhood biodiversity and design information about how to support the presence of birds and pollinators at home. For the index variable, there was no significant difference as a function of street tree loss, although those who lost a tree were far more interested in volunteering to plant trees (40% versus 22%,  $p < 0.0004$ , Cochran–Mantel–Haenszel test). Interest in stewardship was positively associated with the presence of pets that use the outdoors ( $r = 0.12, p = 0.006$ ), time living in the house ( $r = 0.17, p = 0.0001$ , and age of the respondent ( $r = -0.17, p = 0.001$ ) based on Spearman's tests.

Interest in stewardship was amplified by proximity to disturbance of urban nature. People who lost a tree in front of their home disproportionately returned the mail-in survey (57%). This group also expressed the highest level of enthusiasm for joining in a community tree planting effort (40% versus 22%,  $p < 0.0004$ ).

Only those losing a street tree were asked questions about stewardship activities within the easement area itself. Of the 339 reporting households in this category, 205 (60%) indicated some form of stewardship manifested as either action taken or intended

**Table 2**

Relationships between 4 index variables for reactions to and attitudes about urban nature and 2 wellbeing variables – perception that (A) street trees enhance wellbeing and (B) being outdoors reduces stress. Multinomial logistic regression for models A and B:  $n = 317/319$ ;  $\chi^2$  for likelihood ratios = 101.73/23.33,  $df = 4/4$ ,  $p = < 0.0001$  for both; all interactions were non-significant; below, CI = 95% Wald confidence limits. Comparison of odds ratios for significant relationships between index variables and two wellbeing measures.

| Relationships between Index variable and . . .      | Maximum likelihood estimate | SE   | p-Value | Odds ratio | 95% CI  | No street tree loss: odds ratio | With street tree loss: odds ratio |
|---|-----------------------------|------|---------|------------|---------|---------------------------------|-----------------------------------|
| Awareness of disturbance and (A) enhanced wellbeing | 1.33                        | 0.37 | 0.0004  | 3.8        | 1.8 7.8 | 4.0; $p = 0.01$ ; CI = 1.4–11.3 | 4.3; $p = 0.01$ ; CI = 1.4–13.0   |
| Emotional distress and (A) enhanced wellbeing       | 1.31                        | 0.35 | 0.0002  | 3.7        | 1.9 7.3 | 3.0; $p = 0.04$ ; CI = 1.1–8.4  | 4.4; $p = 0.002$ ; CI = 1.7–11.6  |
| Economic impact of trees and (A) enhanced wellbeing | 1.02                        | 0.30 | 0.0008  | 2.8        | 1.5 5.0 | 2.2; $p = 0.05$ ; CI = 1.0–5.0  | 3.5; $p = 0.007$ ; CI = 1.4–8.6   |
| Interest in Stewardship and (A) enhanced wellbeing  | 0.96                        | 0.28 | 0.0006  | 2.6        | 1.5 4.5 | 2.4; $p = 0.04$ ; CI = 1.0–5.3  | 3.0; $p = 0.005$ ; CI = 1.4–6.6   |
| Interest in Stewardship and B) stress reduction     | 0.72                        | 0.24 | 0.002   | 2.0        | 1.3 3.2 | n/s                             | 2.3; $p = 0.01$ ; CI = 1.23–4.27  |

(147 and 58 households, respectively). The form of stewardship included these actions/intentions: planting grass seed (68%/57%), laying sod (9%/14%), planting flowers (37%/31%), planting shrubs or young trees (24%/12%), and other activities (8%/16%) including planting vegetables or groundcover, adding a raingarden and laying Astroturf (1 individual each).

Since stewardship often arises from need, it was important to find out how people felt about the impact of street trees on home economics. Respondents thought that street trees have a moderate influence on utility bills for heating, cooling, and outdoor water use; of these, cooling bills were thought to be most heavily impacted. The majority (70%) felt strongly that the presence of street trees affected the monetary value of their home (Table 3). The sense that street trees affect home economics increased as neighborhood pride increased ( $r = 0.37$ ,  $p < 0.0001$ , Spearman), based on the index variable for economic impact. None of these reactions were related to the loss of a street tree on one’s own property.

3.3. Other factors influencing response to urban nature

**Neighborhood canopy context:** The status of street tree loss in the immediate neighborhood was brought into the analysis to see if the context of nearby loss was influential. Comparisons were made between two groups – those with minimal experience of nearby street tree loss (not on their own property and <30% on their neighborhood street) and those with more intense experience of loss (on their own property and/or >70% on their neighborhood street) (Table 4). Differences were significant for awareness of loss when walking near home and when sitting outside, level of anger or irritation from tree loss, the sense that cooling costs were greater owing to tree loss, interest in volunteer replanting effort, and willingness to provide extra text comments on the survey (in equal measure, the comments concerned stewardship actions, complaints related to tree loss, and other topics).

**Outdoor activity:** Outdoor activity at or near the home influenced perception that street trees support wellbeing. People who experi-

ence moderate and high levels of wellbeing from gardening were 2.2 times and 6.5 times respectively, more likely to gain a sense of wellbeing in the presence of street trees than were those who experience no sense of wellbeing from gardening. This same group was 2.8 times and 7.4 times, respectively, more likely to find that simply being outdoors brings moderate and high levels of stress reduction (Table 5a). People who get moderate enjoyment from walking in the neighborhood were half as likely to gain a sense of wellbeing in the presence of street trees as were those who enjoy neighborhood walking a lot. There was no relationship between enjoyment from walking in the neighborhood and a sense of stress relief from simply being outdoors (Table 5a).

**Passive interface with urban nature:** Even passive interface with urban nature enhanced the perception of wellbeing. People who experience a moderate level of enjoyment from sitting in their backyard were half as likely to experience wellbeing in the presence of street trees compared to those who greatly enjoy sitting in their backyard. People who experience moderate and high levels of enjoyment from sitting in their backyard were 4 times and 10.5 times, respectively, more likely to experience a high level of stress reduction from simply being outdoors (Table 5b). People who enjoy listening to the sounds of nature ‘a lot’ were 36 times more likely to report greater wellbeing from street trees than were people who don’t enjoy the sounds of nature at all.

**Correlation among index variables:** There were significant correlations among the thematically grouped responses to tree loss. An increasing emotional response to tree loss was associated with (a) a greater sensitivity to environmental disturbance, (b) a higher probability of embracing stewardship, and (c) a greater sense that street trees positively influence household economics (Table 6).

**Table 3**

Perception of street tree influence on home utility bills and monetary value of the home, given as % of sample size.

| Perception of street tree influence on home utility bills and monetary value of the home | Not at all | Some | Very much | n   |
|--|------------|------|-----------|-----|
| Street trees affect heating  | 31         | 44   | 25        | 504 |
| Street trees affect cooling  | 14         | 42   | 44        | 528 |
| Street trees affect water use  | 28         | 51   | 21        | 451 |
| Street trees affect house value  | 2          | 28   | 70        | 554 |

**Table 4**

Impact of neighborhood canopy loss on residents with minimal versus intense experience of tree loss; responses shown are the percent claiming ‘very much’, the highest level of response although all response were included in analyses; p-value from Cochran–Mantel–Haenszel test (row mean score) for differences among groups. Not nearby means no loss on respondent’s property and 0–30% street tree removal along the block; Nearby means loss on respondent’s property and/or >70% loss along the block.

| Responses shown as % ‘very much’     | Not nearby | Nearby | p-Value |
|--------------------------------------|------------|--------|---------|
| Notice walking near home             | 87         | 94     | 0.019   |
| Noticed sitting outside              | 64         | 77     | 0.0006  |
| Affects enjoyment sitting out front  | 52         | 40     | 0.024   |
| Brought anger or irritation          | 25         | 37     | 0.018   |
| Perception that loss impacts cooling | 40         | 46     | 0.045   |
| Interest in volunteer planting       | 24         | 36     | 0.038   |
| Provided extra comment in survey     | 34         | 48     | 0.003   |

**Table 5**  
Relationship for 2 response variables – street trees enhance wellbeing and stress relief from being outdoors and 2 predictor variables (a) active and (b) passive interface with urban nature. Each logistic regression model has two predictors; highest response score used as reference. Odds ratios are adjusted for presence of paired predictor. Maximum likelihood estimate (ML), standard error (SE), *p*-value and confidence interval given for each adjusted odds ratio.

| Response                          | Predictors                        | Type 3 Wald $\chi^2$ | df | <i>p</i> -Value | ML    | SE   | <i>p</i> -Value | Adj. odds ratio | 95% CI |      |
|-----------------------------------|-----------------------------------|----------------------|----|-----------------|-------|------|-----------------|-----------------|--------|------|
| <b>(a) Active interface</b>       |                                   |                      |    |                 |       |      |                 |                 |        |      |
| Wellbeing from street trees       | Gain wellbeing from gardening     | 43.58                | 2  | <0.0001         | 0.77  | 0.38 | 0.046           | 2.2             | 1.0    | 4.6  |
|                                   | Some vs. not at all               |                      |    |                 |       |      |                 |                 |        |      |
|                                   | A lot vs. not at all              |                      |    |                 | 1.87  | 0.38 | <0.0001         | 6.51            | 3.1    | 13.8 |
| Stress relief from being outdoors | Enjoy walking in the neighborhood | 8.82                 | 2  | 0.012           | -0.69 | 0.23 | 0.003           | 0.5             | 0.3    | 0.8  |
|                                   | Gain wellbeing from gardening     |                      |    |                 |       |      |                 |                 |        |      |
|                                   | Some vs. a lot                    |                      |    |                 |       |      |                 |                 |        |      |
|                                   | Some vs. not at all               |                      |    |                 |       |      |                 |                 |        |      |
|                                   | A lot vs. not at all              |                      |    |                 | 1.02  | 0.37 | 0.006           | 2.8             | 1.3    | 5.8  |
|                                   | Enjoy walking in the neighborhood | 2.69                 | 2  | 0.26            | 2.00  | 0.37 | <0.0001         | 7.4             | 3.6    | 15.2 |
| <b>(b) Passive interface</b>      |                                   |                      |    |                 |       |      |                 |                 |        |      |
| Wellbeing from street trees       | Enjoy sitting in back yard        | 12.99                | 2  | 0.002           | -0.76 | 0.23 | 0.001           | 0.5             | 0.3    | 0.7  |
|                                   | Some vs. a lot                    |                      |    |                 |       |      |                 |                 |        |      |
|                                   | Enjoy sounds of nature            |                      |    |                 |       |      |                 |                 |        |      |
|                                   | A lot vs. not at all              | 21.02                | 2  | <0.0001         | 3.57  | 1.40 | 0.01            | 35.6            | 2.3    | 5.5  |
|                                   | Some vs. a lot                    |                      |    |                 | -1.10 | 0.28 | 0.0001          | 0.3             | 0.2    | 0.6  |
| Stress relief from being outdoors | Enjoy sitting in back yard        | 29.86                | 2  | <0.0001         | 1.39  | 0.63 | 0.03            | 4.0             | 1.2    | 14.0 |
|                                   | Some vs. not at all               |                      |    |                 |       |      |                 |                 |        |      |
|                                   | A lot vs. not at all              |                      |    |                 |       |      |                 |                 |        |      |
|                                   | Some vs. a lot                    |                      |    |                 |       |      |                 |                 |        |      |
|                                   | Enjoy sounds of nature            |                      |    |                 |       |      |                 |                 |        |      |
|                                   | Some vs. a lot                    | 9.98                 | 2  | 0.007           | -0.95 | 0.22 | <0.0001         | 0.4             | 0.2    | 0.6  |
|                                   | Some vs. a lot                    |                      |    |                 | -0.87 | 0.28 | 0.002           | 0.4             | 0.2    | 0.7  |

**Table 6**  
Spearman correlation matrix for index variables, correlation coefficient (*n*); *p*-value <0.0001 in all cases.

|            | Emotional  | Stewarding | Economics  |
|------------|------------|------------|------------|
| Awareness  | 0.34 (360) | 0.22 (377) | 0.32 (357) |
| Emotional  |            | 0.23 (478) | 0.39 (444) |
| Stewarding |            |            | 0.20 (487) |

#### 4. Discussion

Street tree loss in an urban residential setting is a small ecological disturbance by some standards. However, it produced a measurable impact on a community's response to urban nature. The results suggest that people become more engaged with nature, and more willing to participate in stewardship, after experiencing the effects of local environmental disturbance. Further, the degree of engagement with nature increases in relation to the individual's proximity to the disturbance event. Residents of Ann Arbor, Michigan who had lost ash trees from their easement areas reported a greater appreciation of street trees and were more likely to report that street trees enhance their wellbeing than did residents who had not lost trees. Negative emotional responses to street tree loss were stronger among those residents who had lost trees from their own easement area. Finally, participation and interest in stewardship increased greatly with proximity to areas of high tree loss, perhaps in part because residents who had lost trees were more likely to expect increases in their utility bills, particularly for cooling, and declines in their property values caused by tree loss. Beyond immediate residential boundaries, the degree of street tree loss in the nearby neighborhood amplified the response to environmental disturbance. Residents with personal loss and/or heavy loss on their own street were more sensitive to loss, more irritated about it, found less enjoyment from sitting outside, and were more interested in volunteer tree planting than those living in no to low impact areas. Taken together, these results support the hypotheses: (H4) that proximity to tree loss amplifies awareness of and emotional reaction to environmental disturbance, and (H5) that people who lose a street tree in front of

their homes are more likely to express environmental stewardship as measured by interest or engagement in supporting ecological recovery.

Although personal experience of tree loss heightened residents' valuation of urban nature, those values were already high in the community. The overall results support three general hypotheses: (H1) that street trees elicit positive emotional and aesthetic responses, (H2) that appreciation of urban nature/street trees contributes to a sense of wellbeing, and (H3) that loss of street trees elicits an emotional reaction. These statements were borne out regardless of street tree loss in the resident's easement area, although the experience of street tree loss at home amplified ratings about appreciation of street trees and their ability to enhance wellbeing. Ann Arbor residents are highly responsive to the presence and benefits of urban nature and are enthusiastic in their support of urban nature, with over two-thirds of those surveyed keeping one or more wildlife support items on their property. It is unknown whether Ann Arbor is representative in its highly positive valuation of urban nature. The city has a long history of expanding and supporting its urban forest, possibly making the community more liable to distress when a component of place is destroyed. Other communities may differ in response owing to nearby access and proximity to wild areas (de Vries et al., 2003), the cultural inclination to practice local land stewardship (Schroeder et al., 2006; Zhang et al., 2007), and the socioeconomic situation (Lorenzo et al., 2000).

The results presented here suggest that the experience of urban nature from the home plays a significant role in a person's affinity with the natural world and their willingness to support nature in the built environment. More particularly, this study shows that street trees are an important part of the nature experience. Street trees typically occur in ordered arrays and are most often accompanied by lawn or other low ground cover. This brings both depth and openness to the urban forest and offers a spatial configuration that is highly preferred in tests of aesthetic response to forests (Ulrich, 1986). Consequently, street trees offer a preferred version of nature while avoiding the security problems many urbanites associate with woods and thickets (Skar, 2010). It is not surprising that loss of such a preferred setting causes distress.

#### 4.1. Underpinnings of local land stewardship

In this study, a sense of greater wellbeing from the experience of street trees is positively associated with greater interest in stewardship. Other research shows that attachment to nature is reinforced when stewardship brings rewards beyond that of nature protection. For example, Moore et al. (2006) found that involvement in conservation behaviors contributes to wellbeing of the individual and the social capital of the local community. Consequently, willingness to participate in neighborhood tree planting in response to loss may itself have contributed to respondents' appreciation ratings for street trees. Beyond the interplay between wellbeing and care behavior, the results uncovered additional factors that may influence engagement with nature and interest in stewardship in urban areas: the effect of ecosystem service losses on home economics, and the contribution of street trees to sense of place.

*Sense of place and motivation to stewardship:* Research shows that sense of place can impact and be impacted by stewardship (Stedman, 2002; Measham and Barnett, 2008). Sense of place is an experiential process created by the setting, combined with what a person brings to it (Steele, 1981). One component of this phenomenon is place attachment, a positive cognitive and emotional bond between individuals and their environment, particularly for important settings such as the home (Altman and Low, 1992; Hunter, 1987). Place attachment in this study was manifested in the positive experience of urban nature from home – enjoyment in the yard, listening to the sounds of nature, gardening, and walking in the neighborhood, as well as the sense of wellbeing in response to street trees and stress relief from being outdoors.

Place attachments can be developed or nurtured in response to changes in the place itself (Manzo, 2003). Hull and others (1994) found that the extensive destruction in Charleston, South Carolina from Hurricane Hugo in 1989 left 30% of the community rating loss of natural features as the most distressing physical loss; natural features included street and yard trees (17%) and parks and gardens (13%). Chamlee-Wright and Storr (2009) report that place attachment motivated people to attempt to rebuild their hurricane-ravaged communities. Burley et al. (2007) found that continual experience of low level storm disturbance and associated erosion of coastal wetlands near the home heightened place attachment in Louisiana residents. The results presented here on street tree loss are congruent with these earlier studies. There was a positive association between awareness of the loss and motivation to stewardship among all respondents and, for those who experienced greater loss near home, the degree of awareness, emotional reaction, and motivation to stewardship was greater.

*Economic impact of tree loss:* Is economic impact a major motivation for stewardship? The findings support that there is a relationship. Most people felt strongly that street trees affect the monetary value of their home and have a moderate influence on utility bills for heating, cooling, and outdoor water use. These perceptions are corroborated by research showing that street trees increase property values (Orland et al., 1992; Treiman and Gartner, 2006), decrease time-on-market and provide an economic benefit that extends to neighboring houses (Donovan and Butry, 2010).

However, there is also reason to think that participants' stewardship interests and intentions are motivated by other factors. There are significant associations between perception of economic impact and awareness of loss, emotional distress due to loss, and stewardship. The simple fact that loss of a street tree means loss of the shading/cooling effect in summer may account for these correlations. The modification of the home environment, inside and out, when nearby street trees were lost may have made people more

aware of the contribution of trees to home economics and possibly, more grateful. This idea finds support in the amplified likelihood that people who report that their wellbeing is enhanced by street trees are 2.2 times more likely (no tree loss on easement) versus 3.5 times more likely (tree loss on own easement) to think that street trees have an economic impact.

#### 4.2. Conclusions and recommendations

The rapid and widespread loss of street trees, a critical component of the urban forest, left residents and local government searching for solutions more satisfying than tree-free easement areas. Even in the so-called City of Trees, mature trees do not grow overnight. Moreover, the cost of replanting 10,000 young street trees over a short time frame presents an economic challenge for any community. The results of this study suggest an alternative route for approaching manageability of the loss of street trees and the consequent impact on the urban ecosystem. By engaging the community in a variety of stewardship strategies, not only can recovery from environmental disturbance be addressed, but there can be simultaneous benefits to those who are involved and their neighborhoods as well. People are often emotionally engaged when they feel they can make a difference and when their wellbeing or place identity is at stake. With this in mind a focus on education about creating "place" that is both ecologically sound and aesthetically satisfying can lead to committed local efforts. This suggestion is supported by other research. Management strategies for urban vegetation are most successful if based on personal motivations to participate in stewardship activities (Grove et al., 2006). Place attachment can motivate cooperative efforts to improve one's community (Manzo and Perkins, 2006), and community stewardship action can increase resilience of urban ecosystems (Nisbet et al., 2009). Consequently, design and planning recommendations for stewardship may be particularly effective forms of education as they speak to people's attachment to place and desire for wellbeing, while promoting sustainable and healing behaviors.

This research also offers insight into how people respond to environmental perturbation, a topic of deep importance as global environmental change brings increasing disruption to typical ecological patterns. Compared to acute natural disturbances like hurricanes, the impacts of environmental change can be more subtle owing to the extended time frame of many small changes such as shifts in plant distributions (Parmesan, 2006) and the erratic weather fluctuations that accompany gradual global warming (IPCC, 2007). For most people, environmental change may appear to be a small disturbance as experienced from a chair on the front porch. That people are able to perceive and respond to relatively small environmental disturbances when they occur close to home suggests there is time for adaptation (e.g., Hunter, 2011). Action plans for adjusting environmental quality at the scale of the residence would offer people some sense of control and the ensuing psychological relief for an apparently massive problem (Hunter, 2008). Pickett et al. (2004) point out that when good design links urban ecosystem structure with ecological functions, the ecosystem is better able to maintain itself in the face of disturbance. Because humans are critical drivers of ecosystem processes, particularly in urban areas, a focus on resilience of human wellbeing in the face of landscape disturbance can be a useful vantage point for design and planning that protects ecosystem function. With guidance and support from committed designers, planners and community organizations, the additive impact of individual effort at the scale of the residence could make major contributions to urban quality of life, urban ecosystem function, and the ecological protection of wildlands both within and surrounding urban areas.

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