New York City's Young Street Tree Mortality Study
Results and Tools

New York City Department of Parks & Recreation
Forestry, Horticulture & Natural Resources

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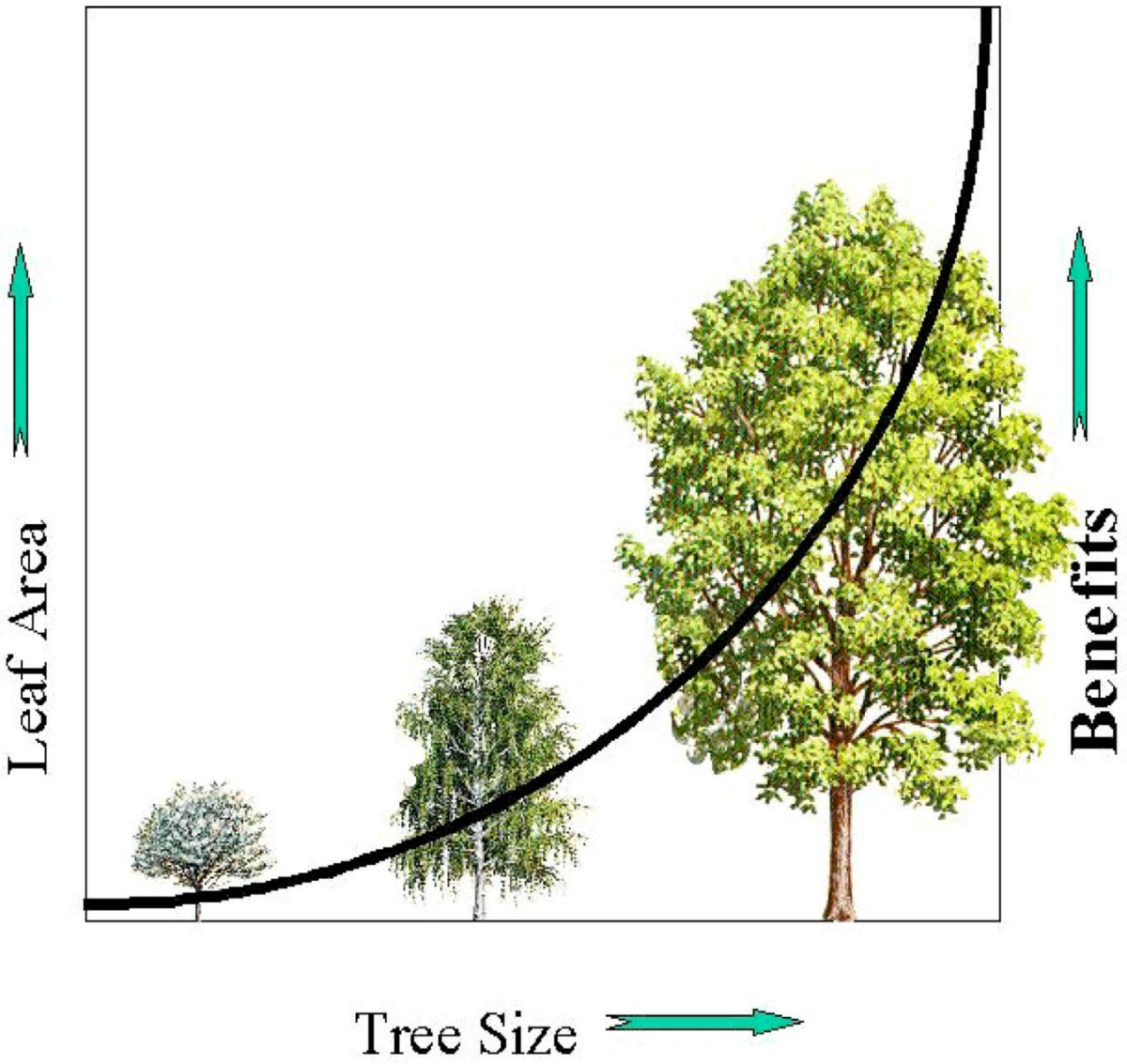
Partners in Community Forestry National Conference
Philadelphia, PA 2010

Urban Forest Benefits

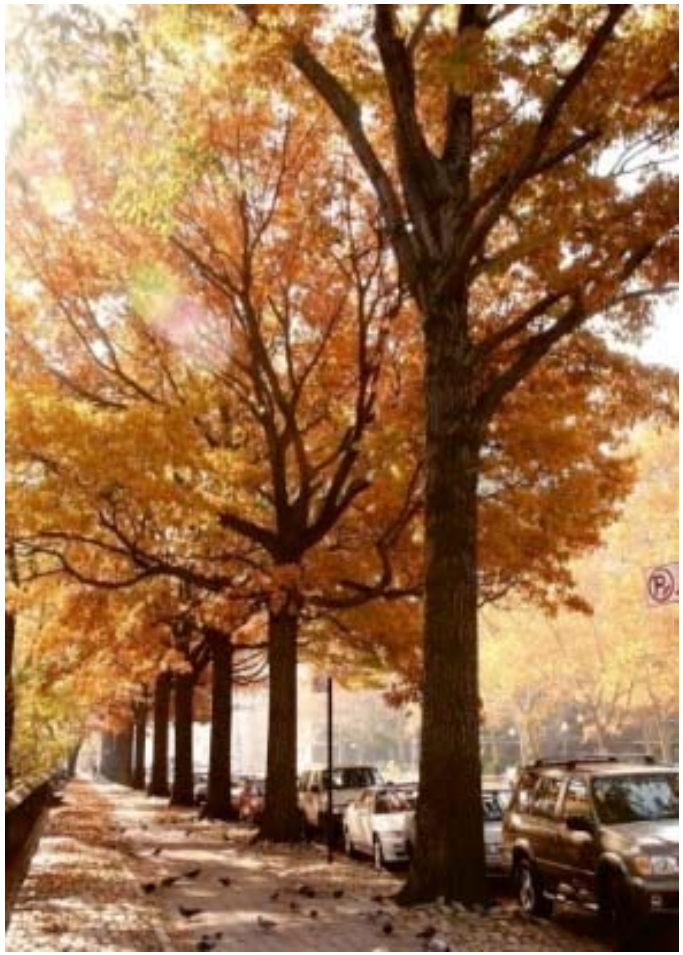
- Lowers air temperatures
- Reduces air pollution
- Captures and stores carbon
- Reduces energy consumption
- Captures stormwater runoff
- Improves human and community health

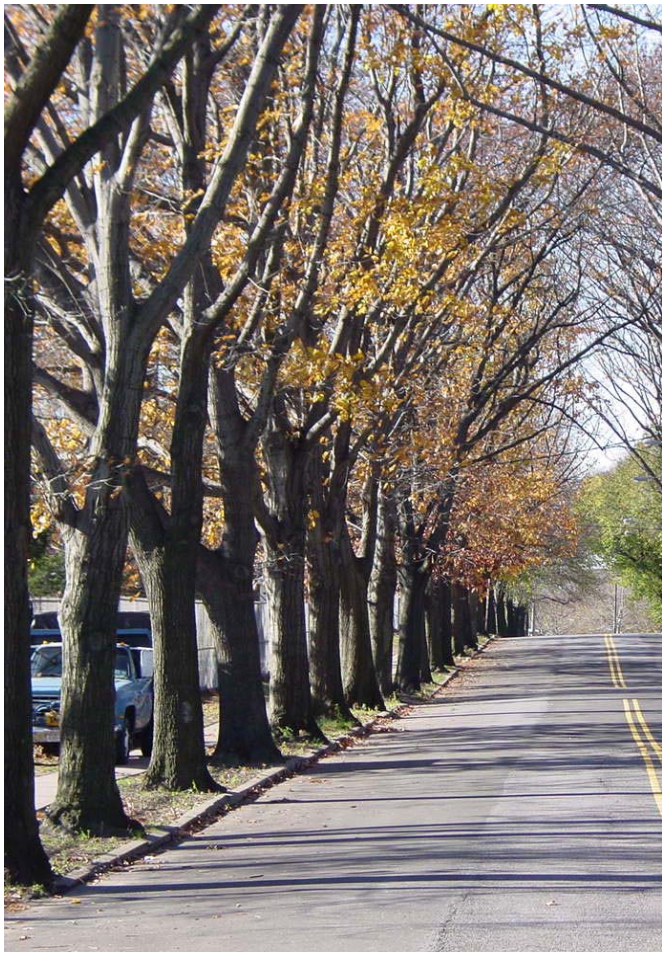


NYC's Street Trees

2006 Street Tree Census counted:

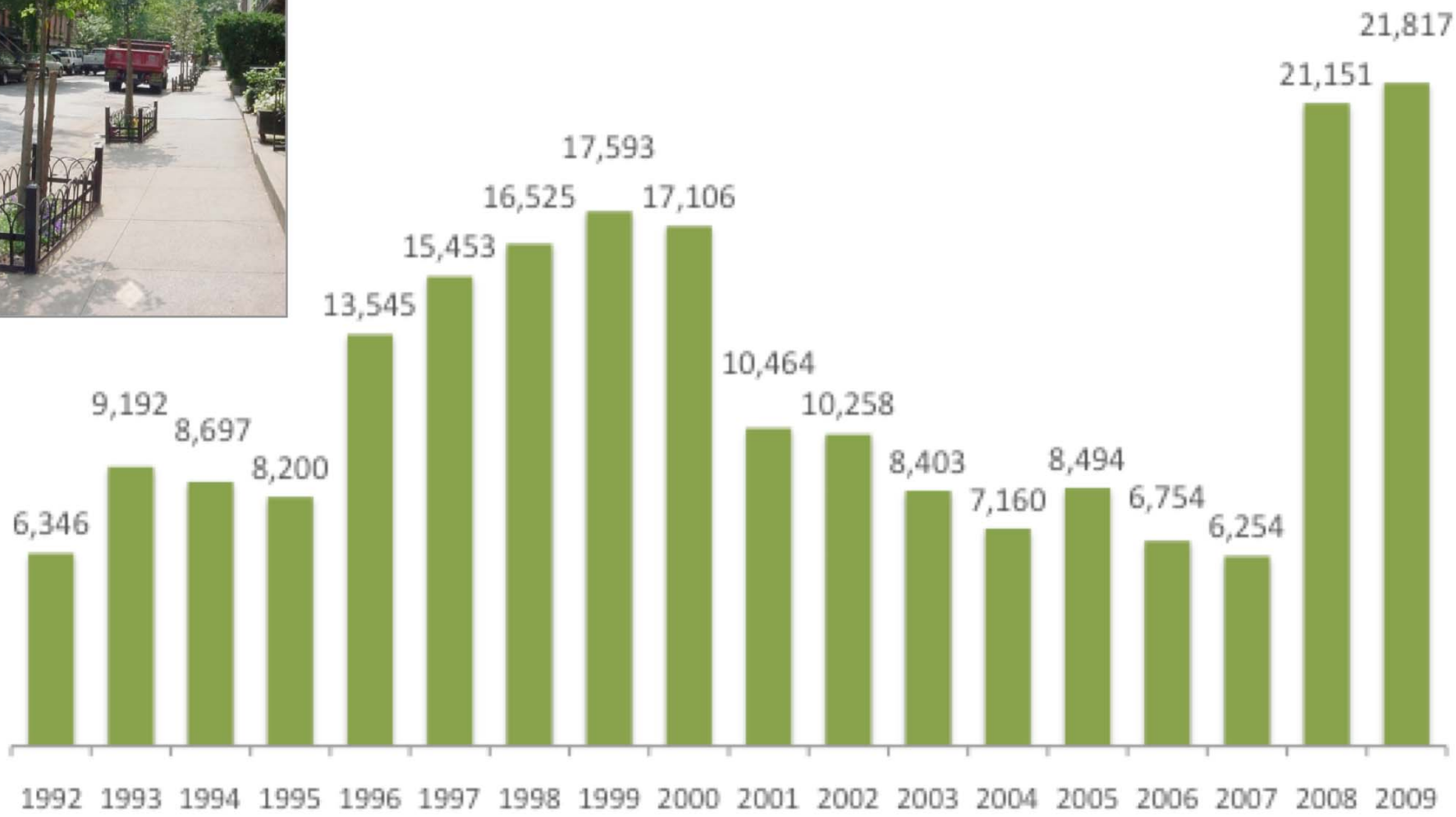
- 592,130 (19% increase since 1996)
- At least 150 species





Street Trees Planted

millionTreesNYC
A PLANYC INITIATIVE WITH NYC PARKS AND NEW YORK RESTORATION PROJECT



Life on the Streets

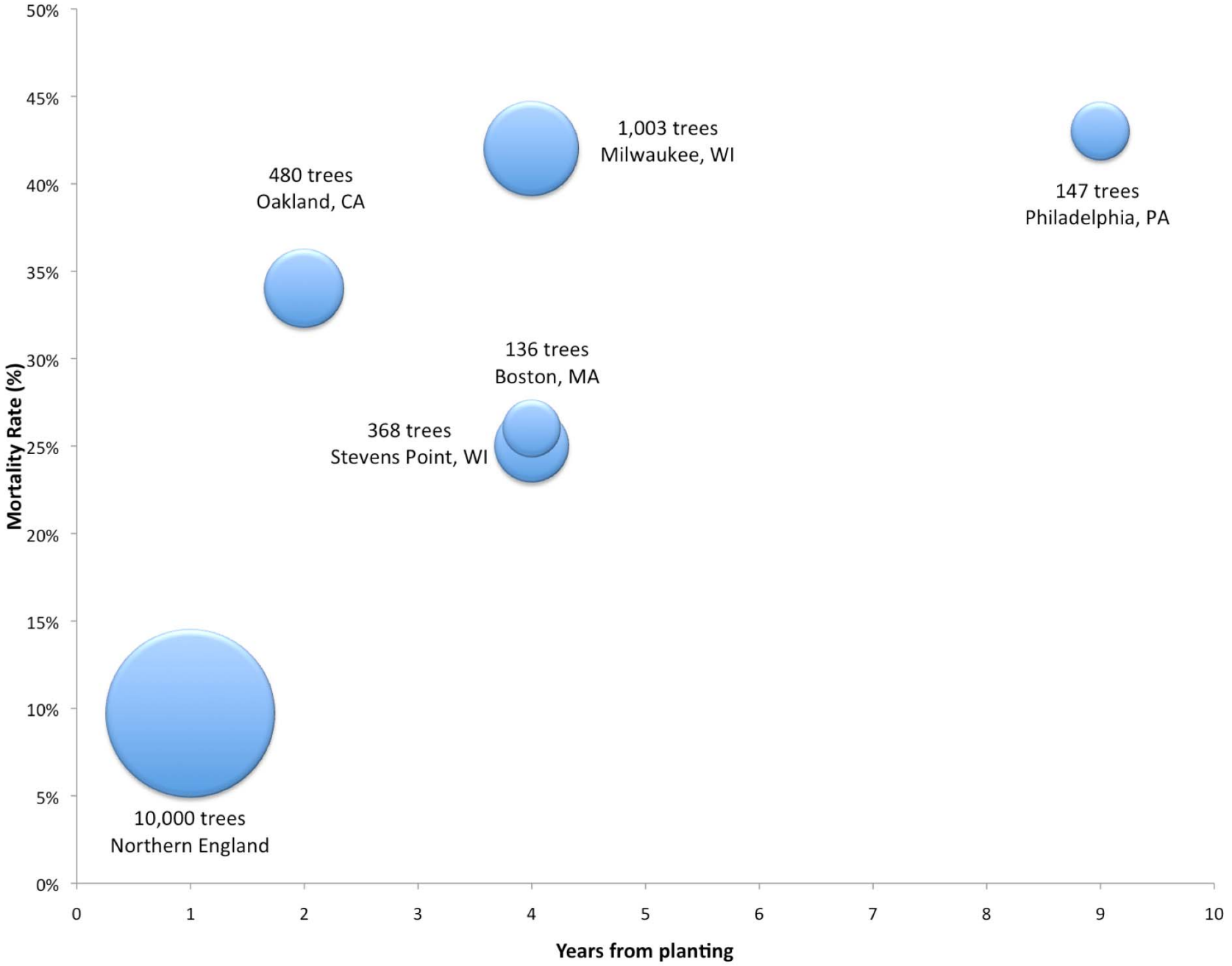
Life on the Streets

The average life of a downtown street tree is 13 years.

Skiera, B. and G. Moll. 1992. The sad state of city trees. *American Forests.* March/April.

Study based on a survey of urban forest managers in twenty U.S. cities.

Existing Studies



Aggregated from Roman (2006)

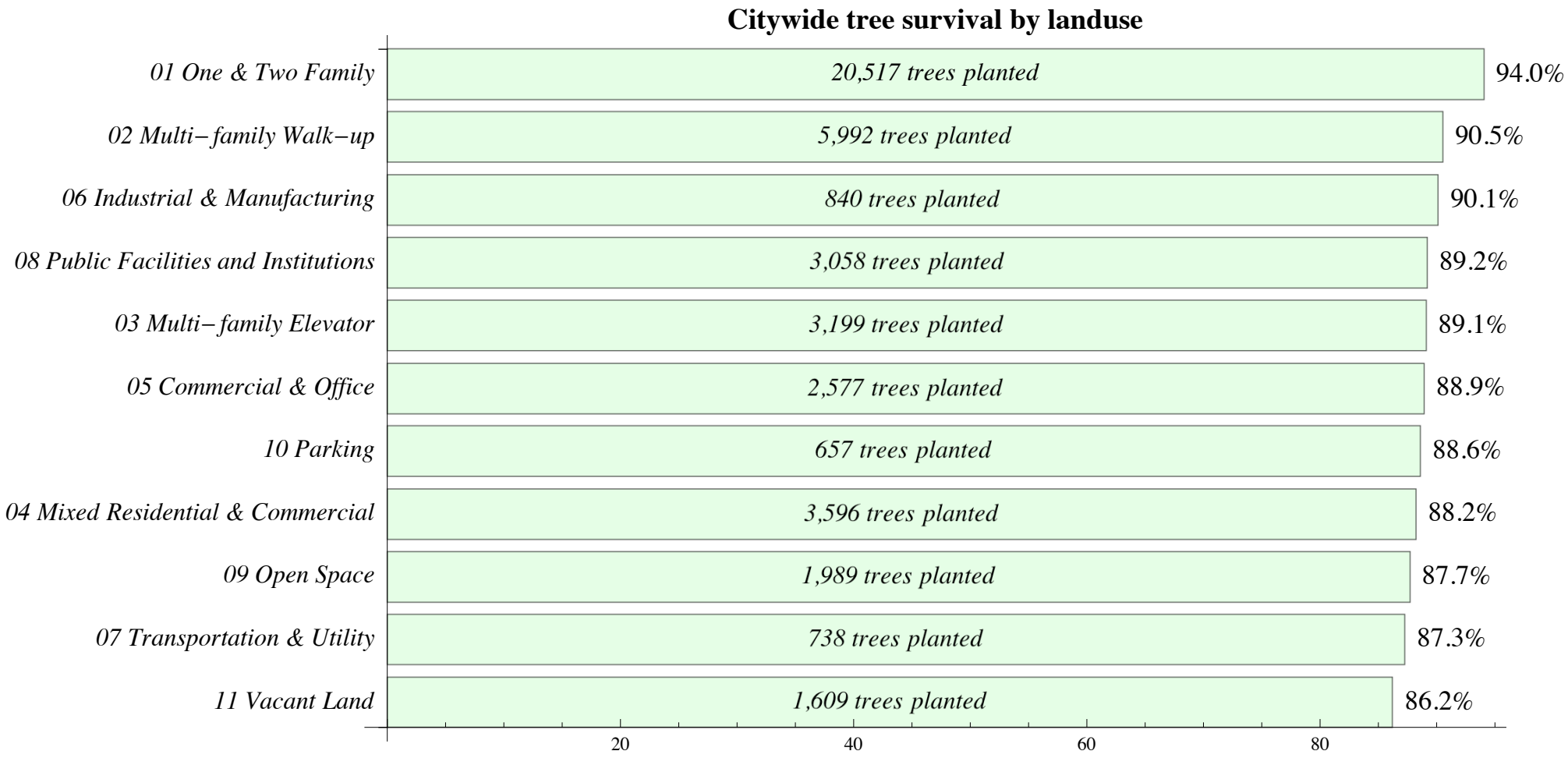
Our Project

- Funded by the National Urban and Community Forestry Advisory Council and the TREE Fund
- **Phase I**: Analyzed broad trends in 45,094 trees planted between 1999 and 2003 using contract inspection data
- **Phase II**: Resurveyed 14,667 trees over two summers, collecting 40+ categories of additional data
- Facilitate replication of study in other cities by creating **Site Assessment Tools** document

Phase I results

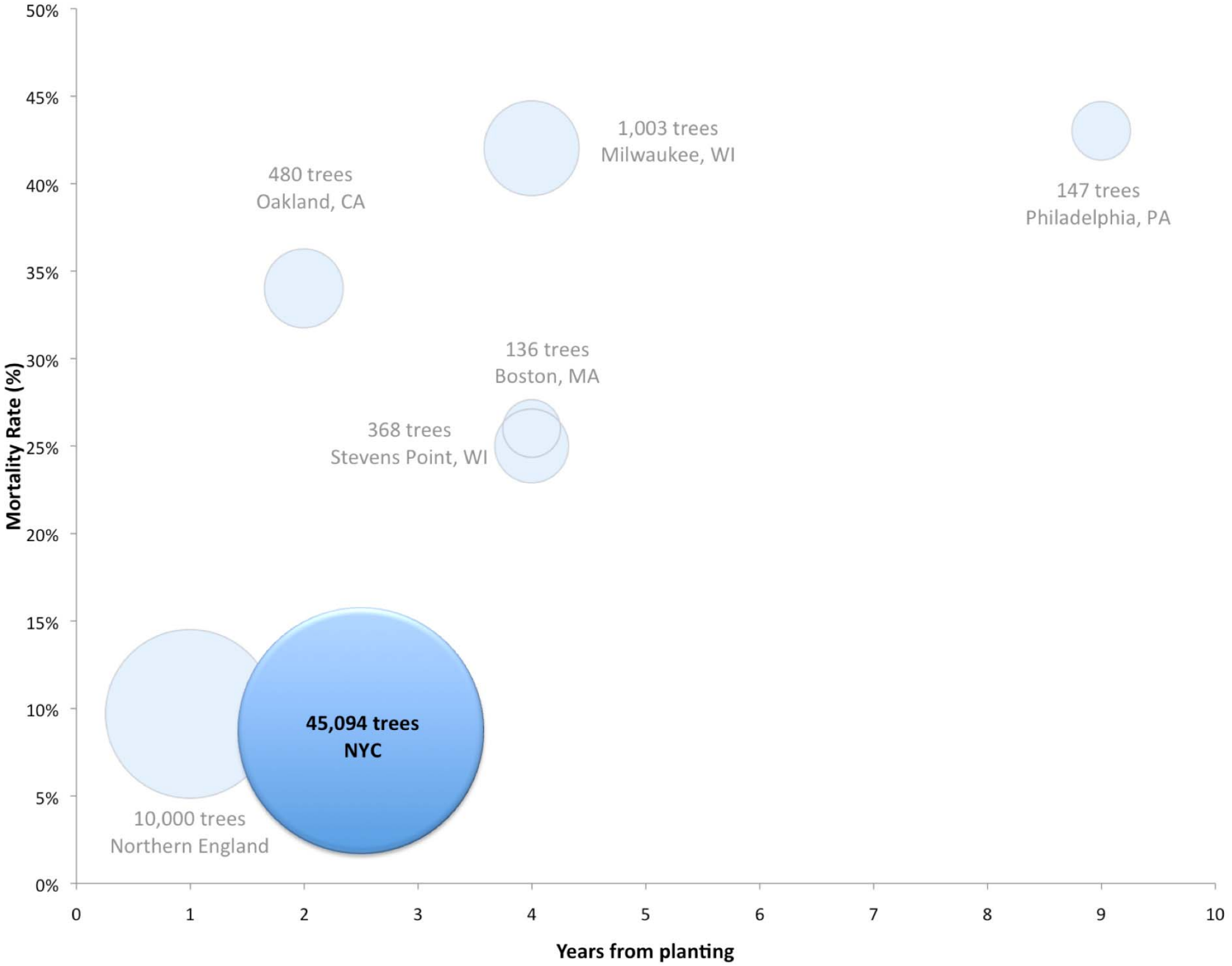
- *N* ~ 45,000 trees planted 1999- 2003
- Includes missing trees (where no tree was found at all)
- More trees were missing than dead at two year inspection
- 91.3% two year survival rate (8.7% mortality)

Phase I results



- Land use matters!
- Highest survival rates in residential areas
- Lowest rates near vacant land, transportation/ utility areas and open space
- Surprisingly high survival in industrial and manufacturing zoned areas

Existing Studies



Phase II: sampling plan

The sampling plan was developed after consulting Sun and Bassuk (1991).

A 14,000-tree sample – stratified by time in-ground and land use – selected randomly from the original data set.

Prior to pulling the sample for Phase II, dead, missing, and replaced trees were removed from the data set and the maximum number of trees per category was calculated.

SEASON_YEAR	01	02	03	04	05	06	07	08	09	10	11	Grand Total
FALL 1999	912	756	559	609	180	60	71	381	211	52	83	3874
FALL 2000	1545	525	368	350	203	115	59	203	211	70	115	3764
FALL 2001	1345	430	246	267	197	69	64	190	148	48	129	3133
FALL 2002	1098	368	216	272	146	52	60	225	154	42	112	2745
FALL 2003	120	46	24	12	17	9	1	35	12	2	15	293
FALL/SPRI 19992000	2007	329	62	86	122	11	45	99	50	13	190	3014
FALL/SPRI 2000	299	113	54	57	27	11		19	6	15	15	616
FALL/SPRI 20002001	96	122	92	57	77	29	3	61	6	29	14	586
FALL/SPRI 20012002	369	52	5	20	104	1	1	20	22		17	611
SPRING 1999	1296	433	239	308	172	24	18	131	85	57	129	2892
SPRING 2000	79	242	120	198	55	18	11	75	50	42	29	919
SPRING 2001	1614	545	202	345	251	79	60	271	234	44	259	3904
SPRING 2002	1997	437	336	312	311	120	89	303	212	58	152	4327
SPRING 2003	923	365	181	340	156	140	61	236	208	54	69	2733
SPRING&FA 19992000	240	126	105	37	36		1	86	17	21	20	689
SPRING/FA 1999	3114	543	191	194	198	58	87	302	146	19	124	4976
SPRING/FA 2000	3526	596	236	176	355	63	130	430	228	100	178	6018
Grand Total	20580	6028	3236	3640	2607	859	761	3067	2000	666	1650	45094
LANDUSE	1	2	3	4	5	6	7	8	9	10	11	

LANDUSE	01	02 / 03	04 / 05 / 08	06 / 07 / 10	09 / 11
1999 Spring to 2000 Spring	11473	4704	4333	927	1561
2000 Fall to 2002 Spring	6966	3360	3542	938	1519
2002 Fall to 2003 Spring	2141	1200	1439	421	570

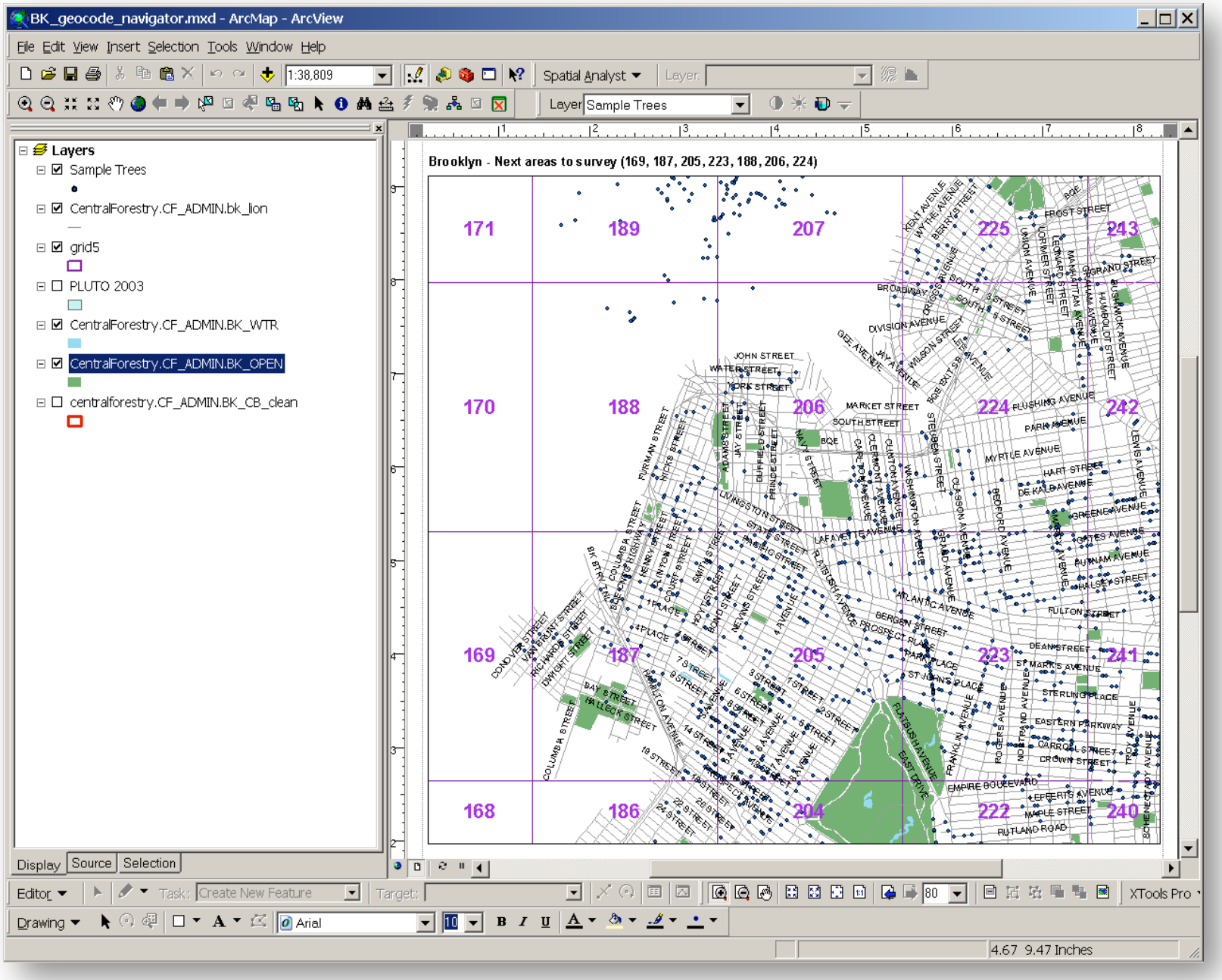
Population size	Sampling percentage required
<2,000	50%
2,000-5,000	35%
5,001-10,000	25%
>10,000	15%

1999 Spring to 2000 Spring		Sample Size			1999 Spring to 2000 Spring - INDIVIDUALS				
01	11473	0.15	1721		6	245	0.5	123	
02 / 03	4704	0.35	1646		7	363	0.5	182	
04 / 05 / 08	4333	0.35	1517		10	319	0.5	160	Total = 464
06 / 07 / 10	927	0.5	464		9	793	0.5	397	
09 / 11	1561	0.5	781		11	768	0.5	384	Total = 781
2000 Fall to 2002 Spring					2000 Fall to 2002 Spring - INDIVIDUALS				
01	6966	0.25	1742		6	413	0.5	207	
02 / 03	3360	0.35	1176		7	276	0.5	138	
04 / 05 / 08	3542	0.35	1240		10	249	0.5	124	Total = 938
06 / 07 / 10	938	0.5	469		9	833	0.5	417	
09 / 11	1519	0.5	760		11	686	0.5	343	Total = 1519
2002 Fall to 2003 Fall					2002 Fall to 2003 Spring = INDIVIDUALS				
01	2141	0.35	749		6	201	0.5	101	
02 / 03	1200	0.5	600		7	122	0.5	61	
04 / 05 / 08	1439	0.5	720		10	98	0.5	49	Total = 421
06 / 07 / 10	421	0.5	211		9	374	0.5	187	
09 / 11	570	0.5	285		11	196	0.5	98	Total = 570

LANDUSE
01 One & Two Family Buildings
02 Multi-Family Walk-up Buildings
03 Multi-Family Elevator Buildings
04 Mixed Residential and Commercia
05 Commercial and Office Buildings
06 Industrial and Manufacturing
07 Transportation and Utility
08 Public Facilities and Institutions
09 Open Space and Outdoor Recrea
10 Parking Facilities
11 Vacant Land

Phase II: map creation

All 14,000 trees were added to a Map Book series using a grid that displayed roughly 1:10,000 for 8.5 x 11” prints.

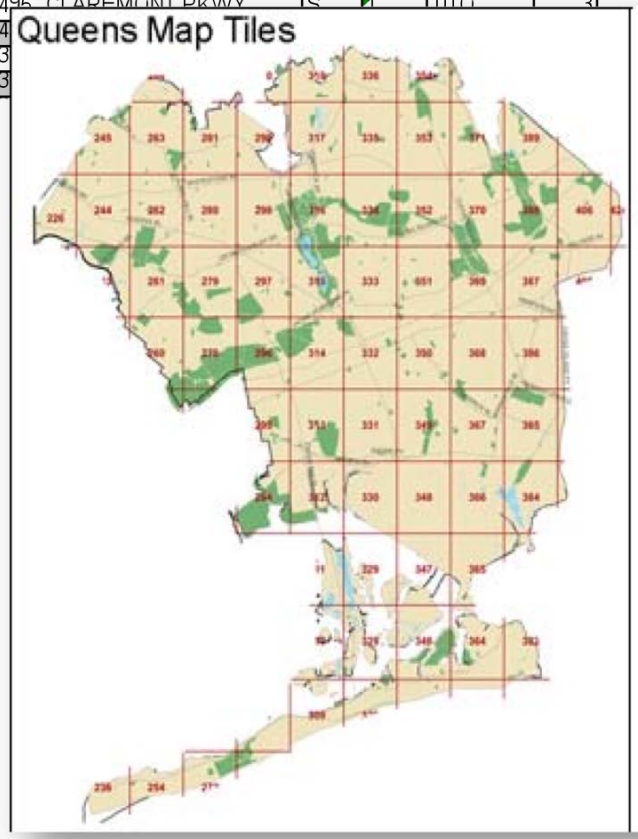


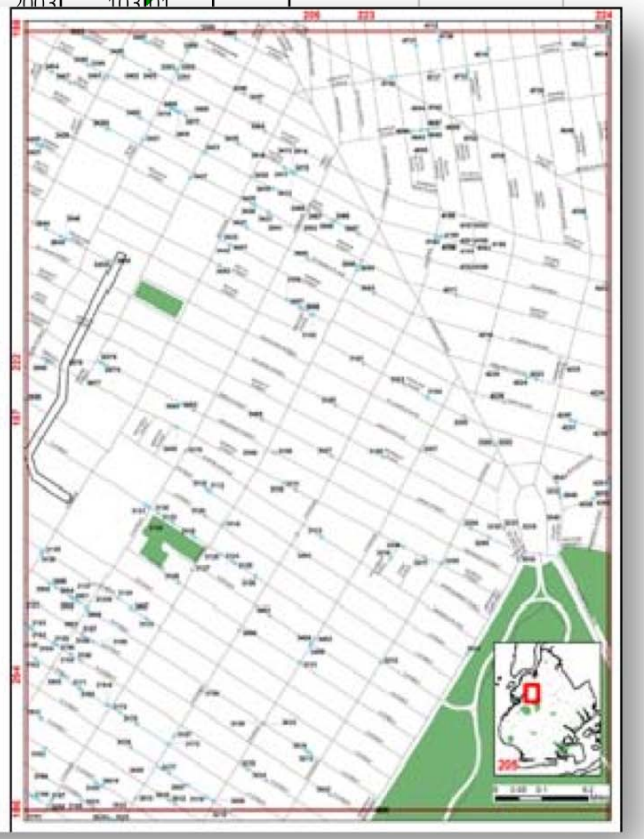
Phase II: field materials

- Road maps
- Palm handheld device using Pendragon Forms for data collection
- Maps and lists
- Screwdriver to measure soil compaction
- Caliper to measure DBH

Tree Sample Number	Address	Loc	No.	Tree Species	DBH	Year Planted	Comm. Board	Land Use	Tree Not Found
1	1710. WEBSTER AV	S	4	GIBI	3	2001	0	05	
2	498. CLAREMONT PKWY	S	0	TITO	3	1999	103	01	
3	1573. WASHINGTON AV	S	0	TITO	3	1999	103	06	
4	1573. WASHINGTON AV	S	0	TITO	3	1999	103	06	
5	1824. WASHINGTON AV	S	3.0A	ZESE	3	2001	106	02	
6	499. E 175 ST	S	2.0X	GLTR	3	2001	106	08	
7	410. E 173 ST	S	1	PYCA	3	2003	103	08	
8	4006. 3 AV	S	1	TICO	3	2001	103	06	
9	1745. BATHGATE AV	S	0	GLTR	3	2002	103	11	
10	1745. BATHGATE AV	S	0	GLTR	3	2002	103	11	
11	3805. 3 AV	S	1	GLTR	3	19992000	103	02	
12	3823. 3 AV	S	1	GLTR	3	19992000	103	02	
13	544. CLAREMONT PKWY	S	1	STJA1	3	1999	103	02	
14	495. CLAREMONT PKWY	S	0	TICO	3	1999	103	01	
15	495. CLAREMONT PKWY	S	1	TITO	3	2003	103	01	
16	4								
17	3								
18	3								

LANDUSE	
01	One & Two Family Buildings
02	Multi-Family Walk-up Buildings
03	Multi-Family Elevator Buildings
04	Mixed Residential and Commercia
05	Commercial and Offi ce Buildings
06	Industrial and Manufacturing
07	Transportation and Utility
08	Public Facilities and Institutions
09	Open Space and Outdoor Recrea
10	Parking Facilities
11	Vacant Land





Phase II: data collection

Biological Factors

- Species
- Size
- Condition

Phase II: data collection

Biological Factors

- Soil Compaction
- Soil Erosion
- Tree Damage

Phase II: data collection

Physical Factors

- Growing space
- Street width and slope
- Sidewalk width
- Building height
- Building type
- Land use

Phase II: data collection

Social Factors

- Garbage and graffiti present
- Building security
- Vacancy

Phase II: data collection

Social Factors

- Evidence of tree care
- Neighboring yard characteristics
- Murals

Phase II: data collection

Social Factors

- Presence and type of fence
- Visibility

Phase II: data collection

New York City's
Young Street Tree Mortality Study

Site Assessment Tools Description

16. Pit Observation

Check all that apply.

- ❑ **Pruned**- you can see one or more clean pruning cuts
- ❑ **Stakes, no wires**
- ❑ **Gator Bag**- an irrigation bag that wraps around the tree trunk
- ❑ **Bench**- bench may be part of walled tree guard or may be in pit
- ❑ **Bird Feeder**- stuck in ground or attached to tree
- ❑ **Bike Rack**- This includes a bike rack in a tree pit as well as a bike resting or locked to a tree.
- ❑ **Walled Tree Wall**- (typo: should be "Walled Tree Well") solid wall around the perimeter of tree pit; could be brick railroad ties or other solid material.
- ❑ **Tree Grate**- flat metal grate lying at sidewalk grade directly covering the tree pit.
- ❑ **Plantings**- intentionally planted in tree pit
- ❑ **Mulched**- wood chips intentionally placed in tree pit; not natural debris.
- ❑ **Weeded**- note when there is evidence that someone has recently weeded the tree pit, this should not be checked if there is merely an absence of weeds.
- ❑ **Gravel**- intentionally added, not just natural debris
- ❑ **Animal Scat**- animal feces in or within 5 feet of tree pit
- ❑ **Suckers**- shoots coming from base of tree trunk


Pruned


Stakes, no wires


Gator bag


Bird feeder


Bike rack


Bench


Mulched


Plantings


Walled tree well


Tree grate


Walled tree well


Weeded


Gravel


Suckers


Animal scat

22


Concrete block

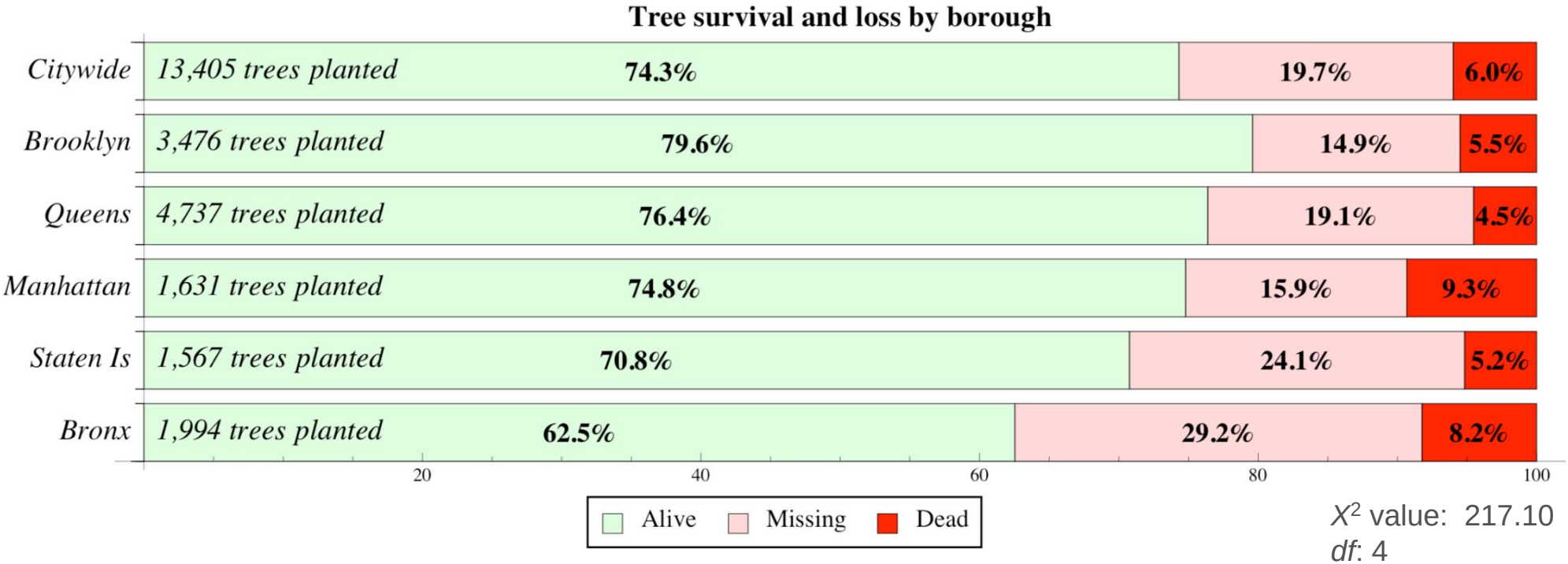

Missing block pav-


Sunken block


Tall, narrow

23

Phase II: results



X^2 value: 217.10
df: 4
$p < 0.001$

- **20% of surveyed trees were missing, only 6% were standing dead**
- **Original assumption was that missing trees likely had been vandalized and standing dead trees died from biological causes**

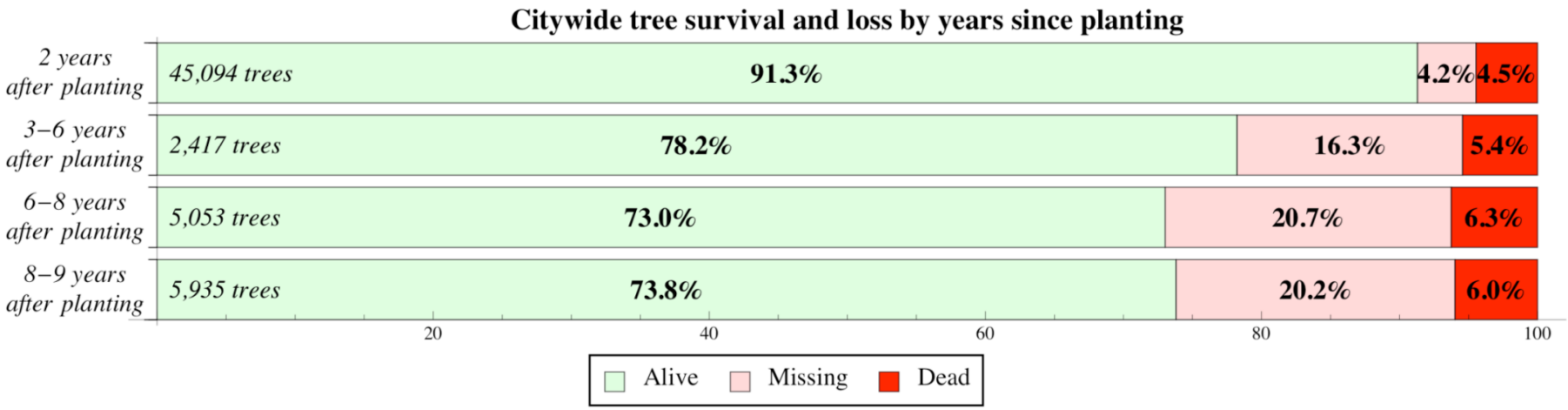
Are missing trees important?

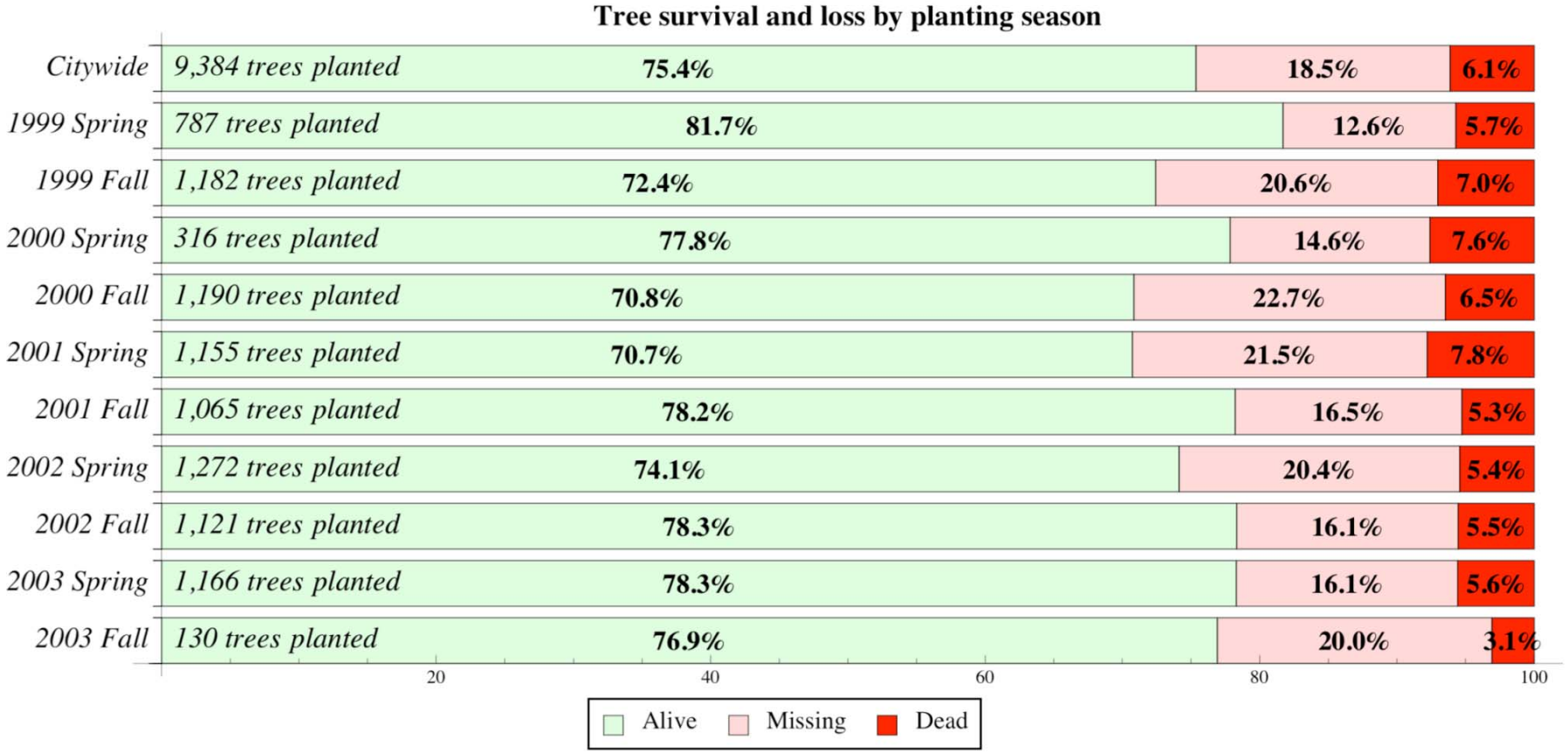
Tested key variables for significant differences between dead and missing trees (N. Falxa-Raymond)

- Trash in the tree pit is more common with dead trees than missing trees
- Missing trees are more likely to be on a road with a median present, or on sidewalks <5 feet wide
- Trees more likely to be missing than standing dead when planted in a lawn strip
- Missing trees are not statistically linked to the following:
  - Street slope
  - Presence of on-street parking
  - Sidewalk condition
  - Traffic volume
  - Number of years since planting

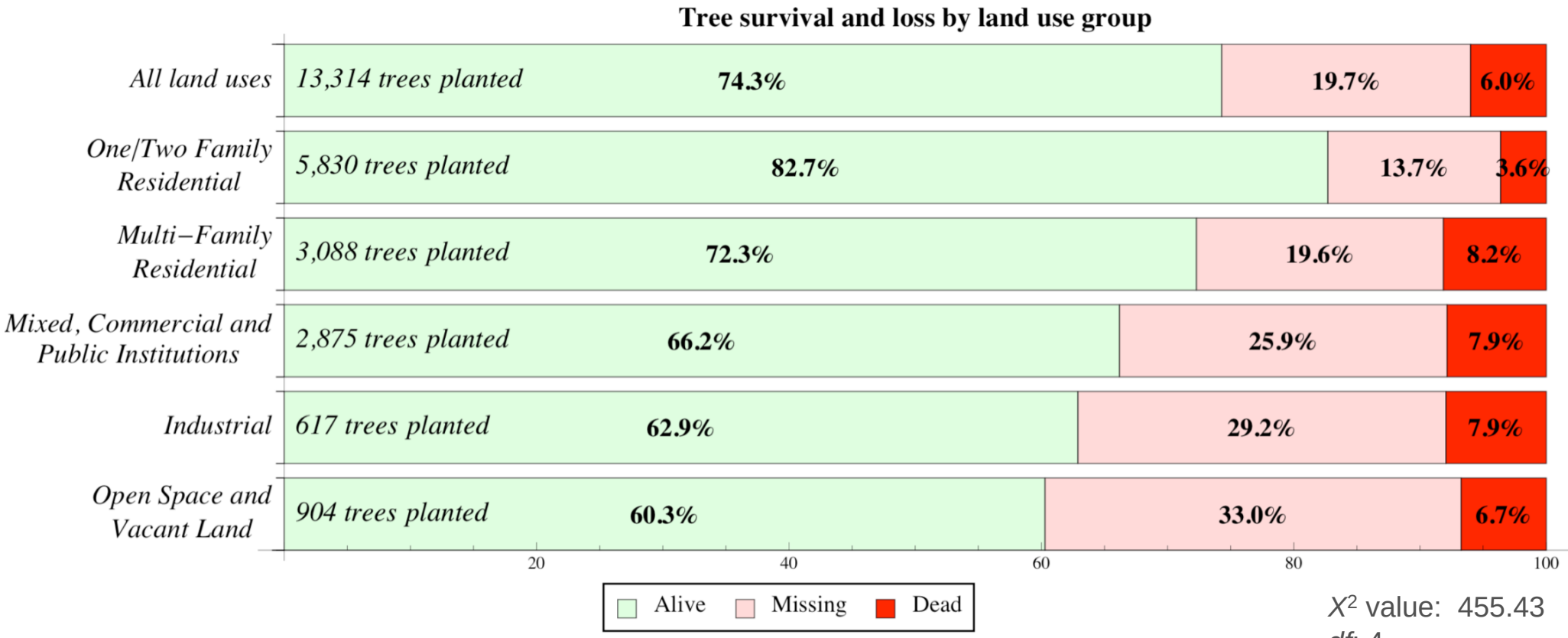
Missing trees are not clearly different from dead trees, and does not indicate mortality due to vandalism

Phase II: results





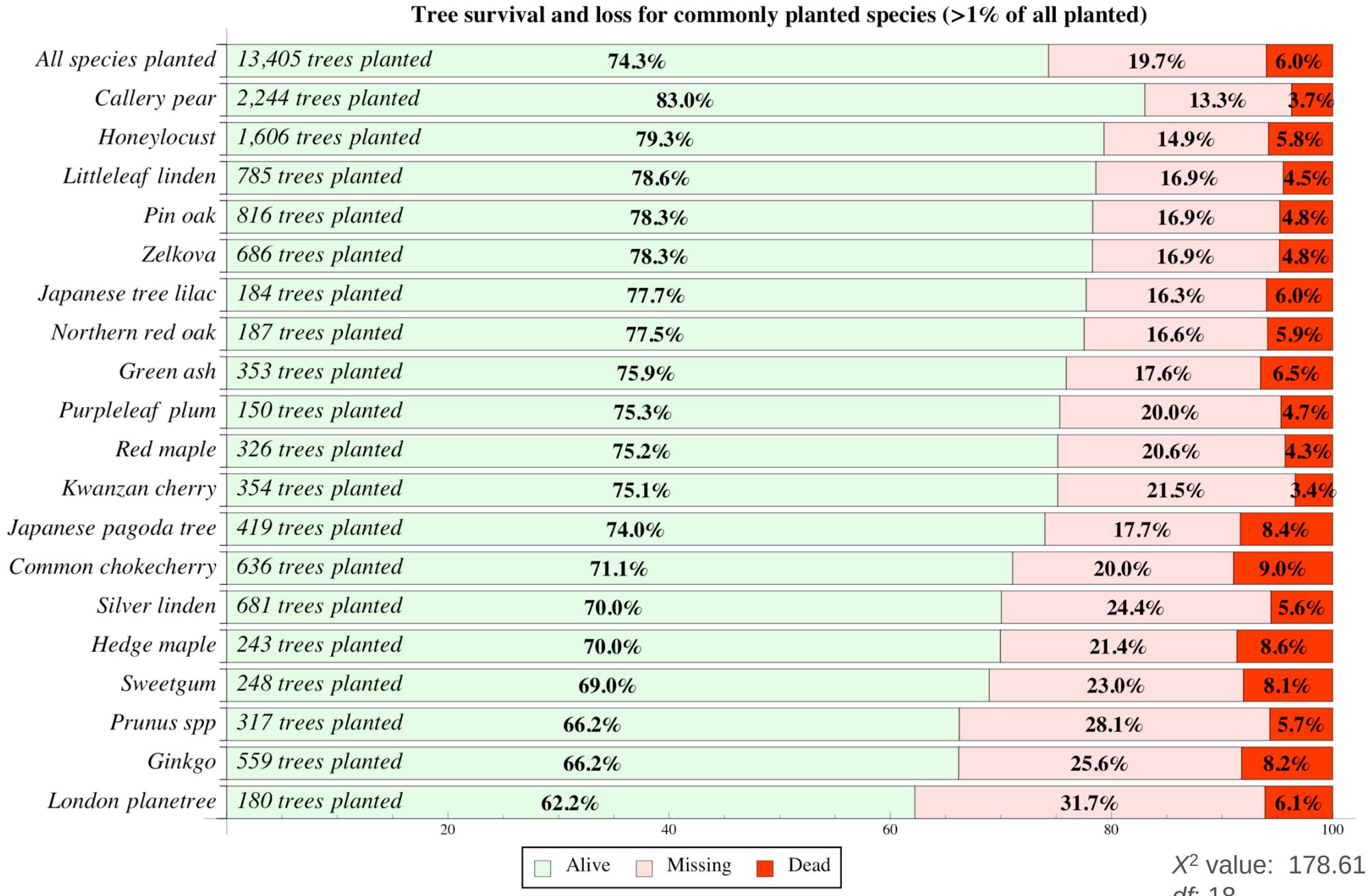
Phase II results: land use



X^2 value: 455.43
df: 4
$p < 0.001$

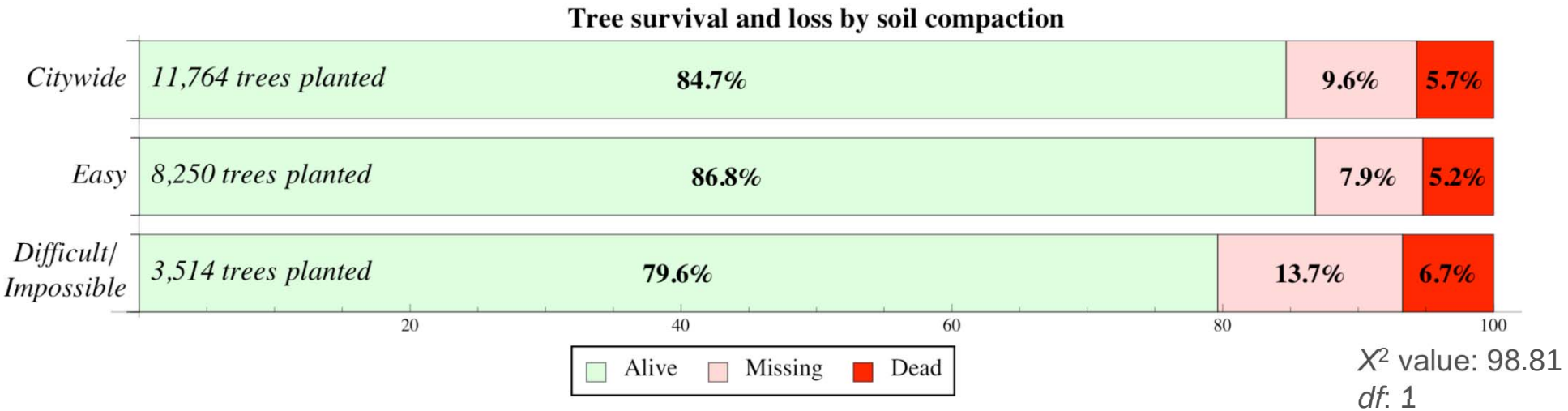
- **Land use matters! Reinforces our results from Phase I data**
- **Low density residential areas had highest street tree survival rates**
- **Industrial, open space and vacant land uses had the lowest survival rates**

Phase II results: biological factors

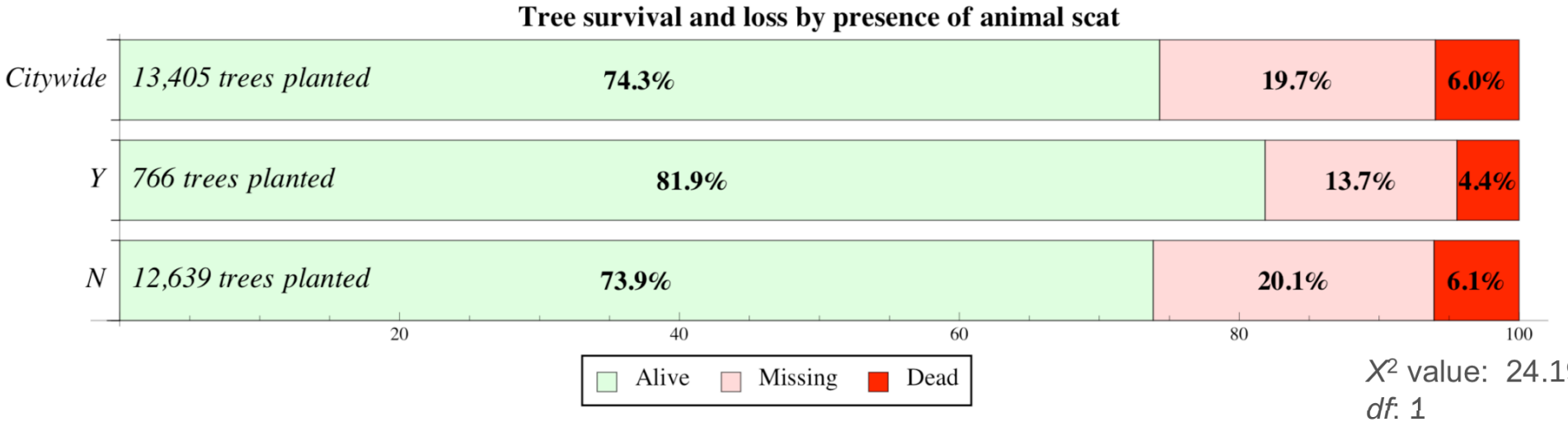


X^2 value: 178.61
df: 18
$p < 0.001$

Phase II results: biological factors



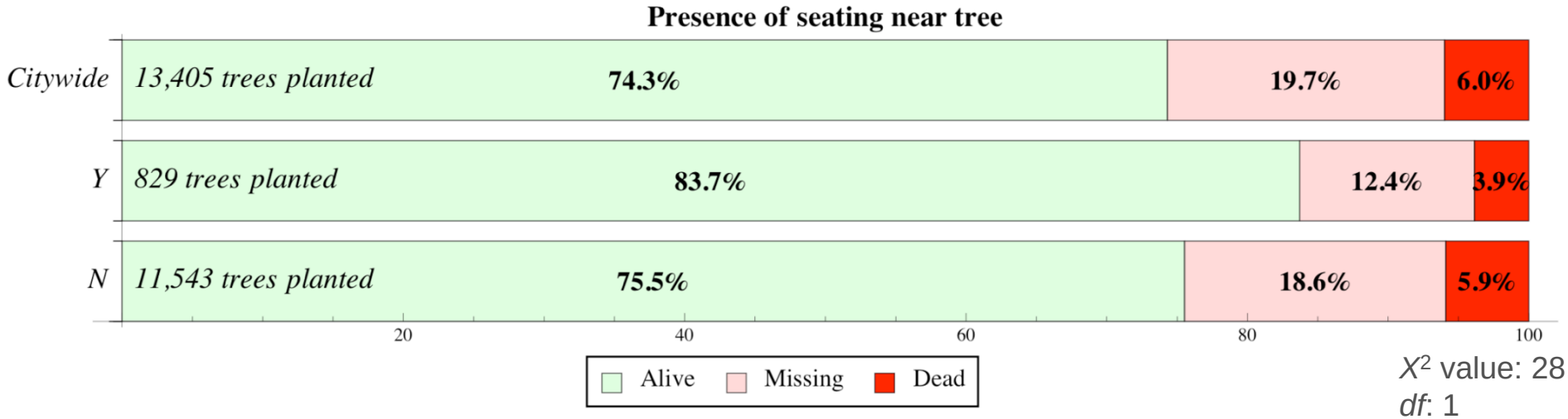
X^2 value: 98.81
df: 1
p< 0.001



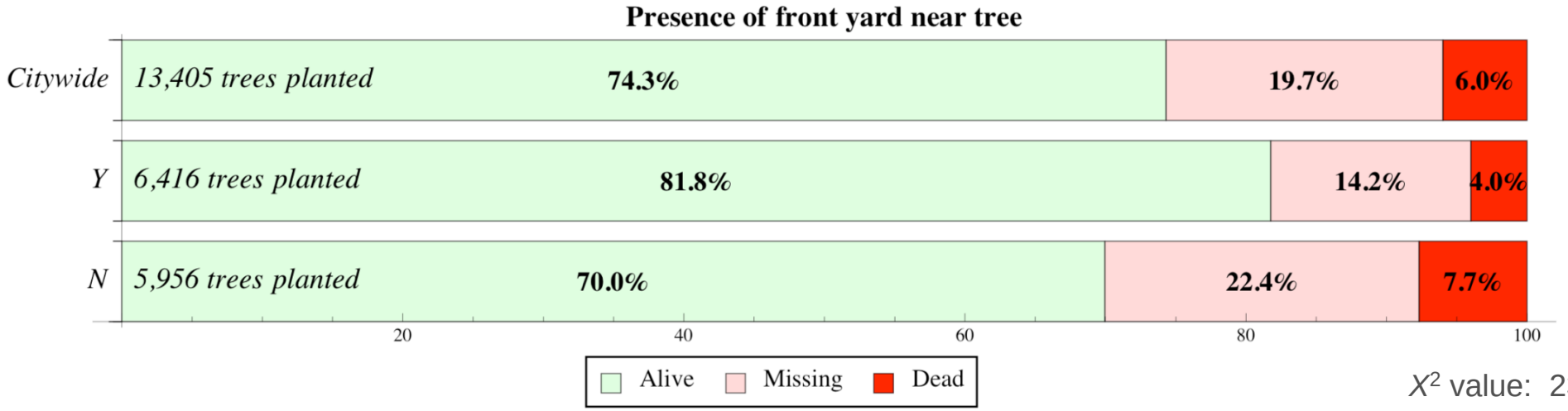
X^2 value: 24.19
df: 1
p< 0.001

- **Compacted soil significantly contributes to lower street tree survival**
- **Unexpected lower survival of trees *without* signs of animal scat nearby or in the tree pit**

Phase II results: sociability/stewardship



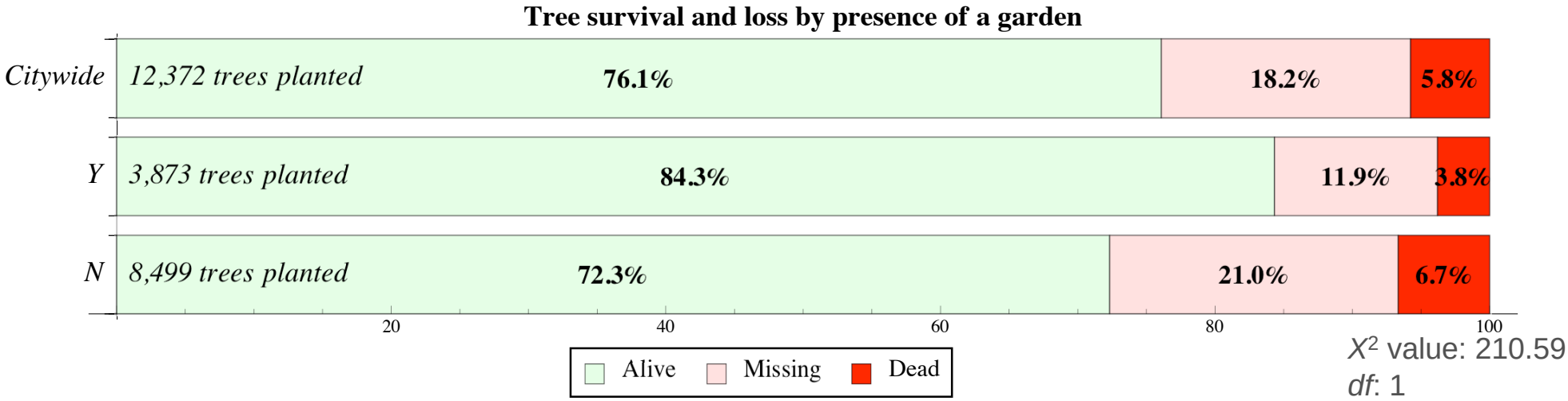
X^2 value: 28.44
df: 1
p< 0.001



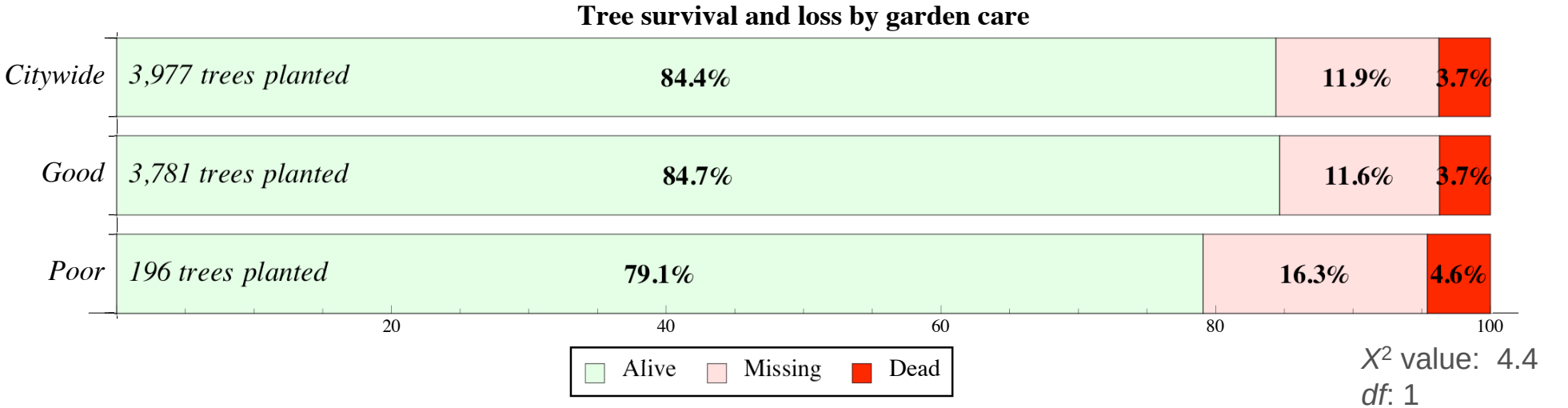
X^2 value: 236.39
df: 1
p< 0.001

- **Both the presence of seating and the presence of a front yard significantly contribute to street tree success in New York City**

Phase II results: sociability/stewardship



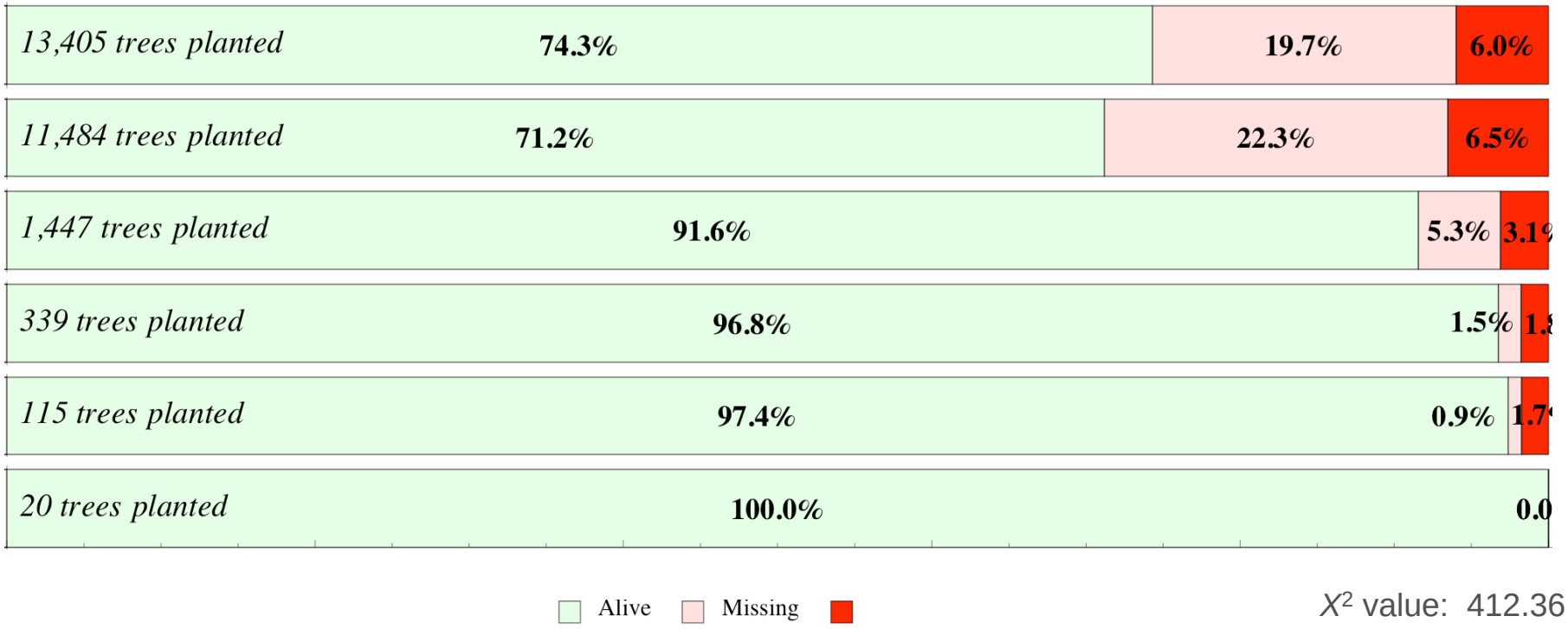
X^2 value: 210.59
df: 1
$p < 0.001$



X^2 value: 4.4
df: 1
$p = 0.036$

- **Presence of window box planters or a garden were associated with lower mortality**
- **Street tree survival was higher at garden sites that were well maintained**

Phase II results: sociability/stewardship

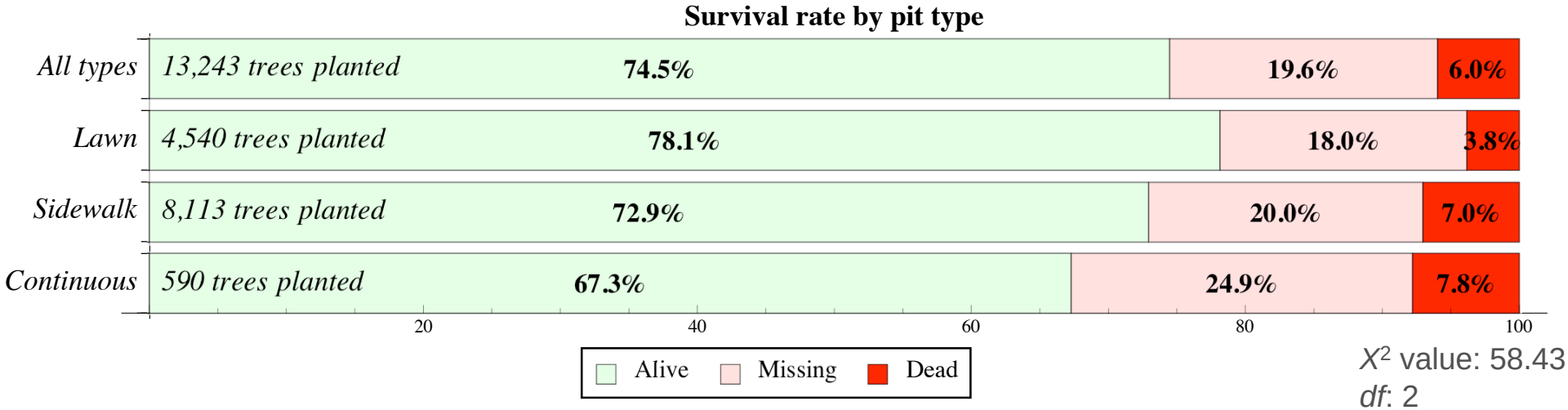


X^2 value: 412.36
df: 4
p< 0.001

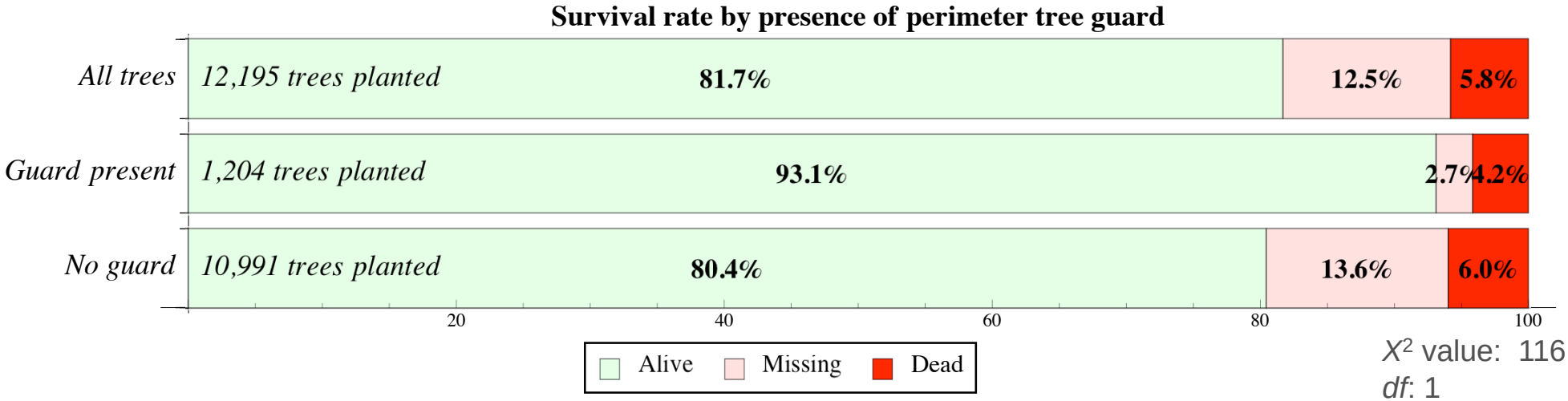
Signs of stewardship include:

- presence of signage on or around the tree
- plantings in street tree pits
- mulch placed in pit
- evidence of weeding

Phase II results: physical neighborhood factors



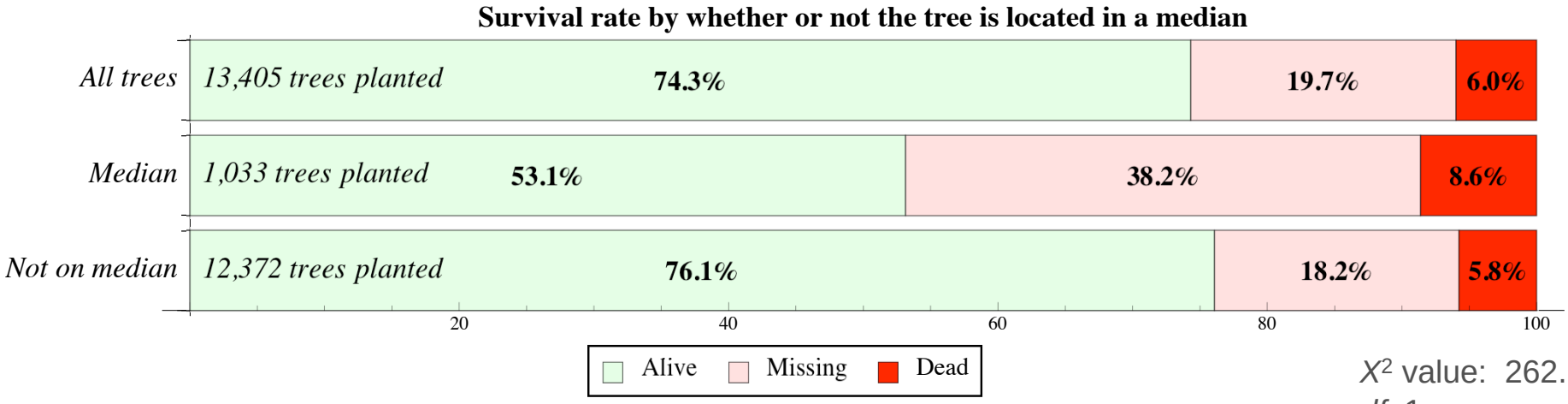
X^2 value: 58.43
df: 2
p< 0.001



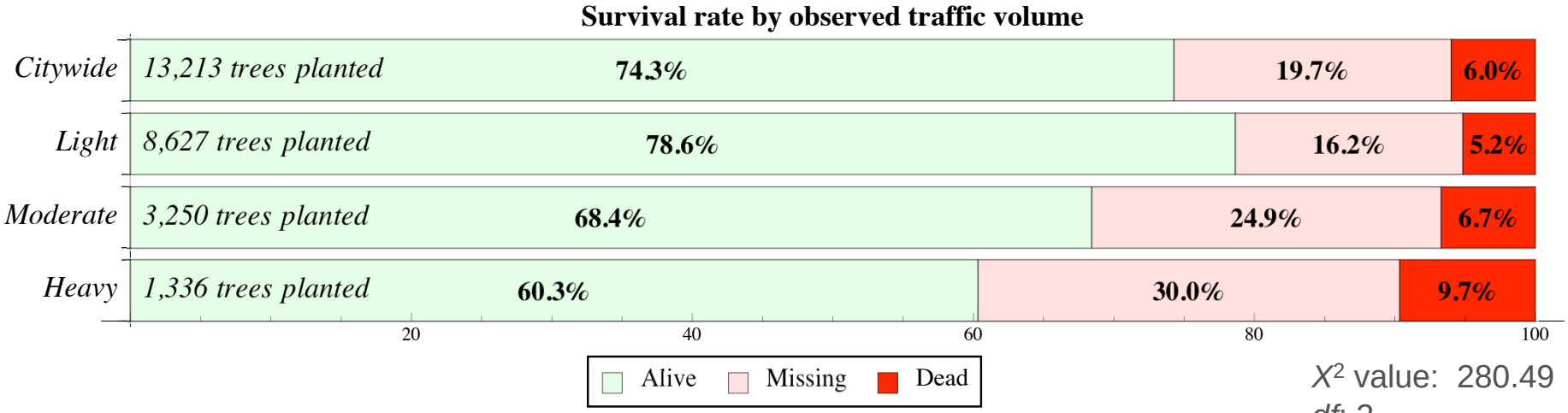
X^2 value: 116.42
df: 1
p < 0.001

- **Trees in lawn pits had highest survival rates**
- **Street tree survival was higher when a perimeter tree guard was present**

Phase II results: physical neighborhood factors



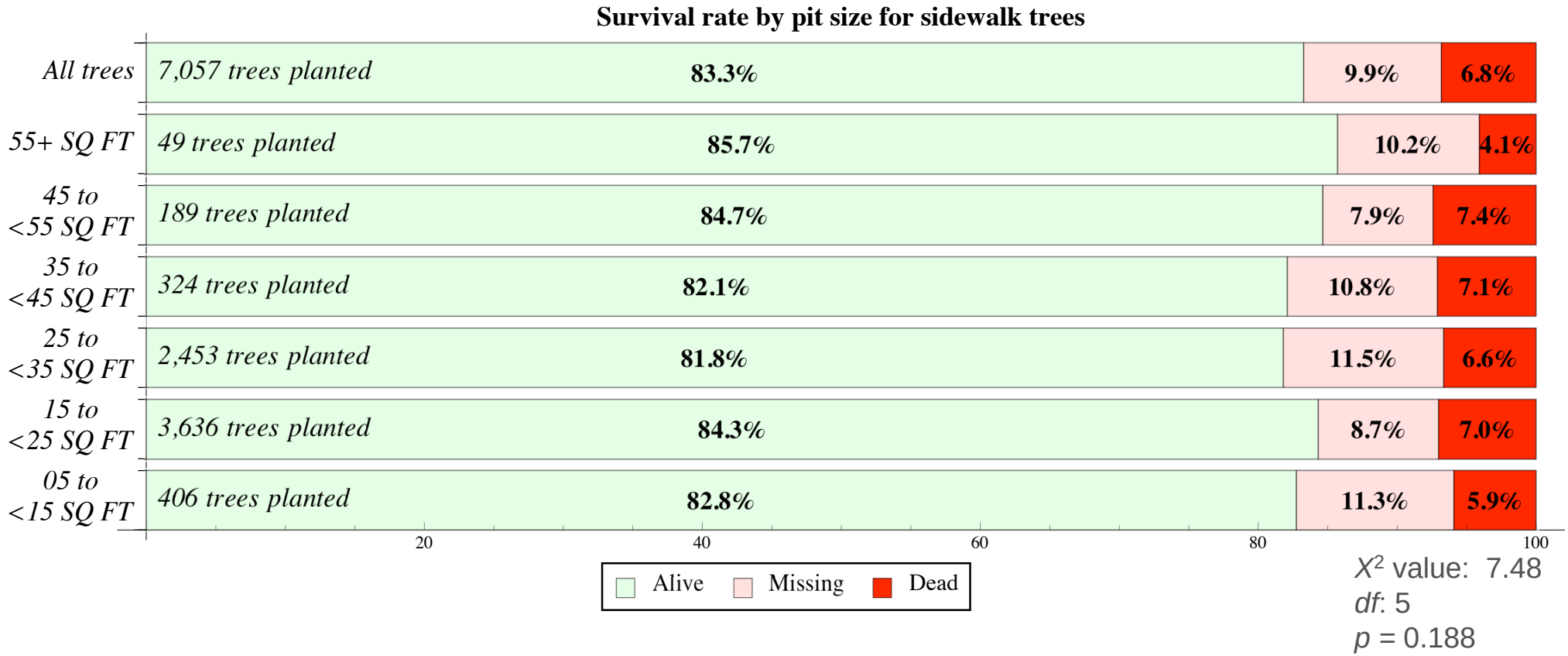
X^2 value: 262.78
df: 1
$p < 0.001$



X^2 value: 280.49
df: 2
$p < 0.001$

- **Trees located in road medians have significantly lower survival rates**
- **Street tree mortality rates increase with higher traffic volumes**

Phase II results: physical neighborhood factors



X^2 value: 7.48
df: 5
$p = 0.188$

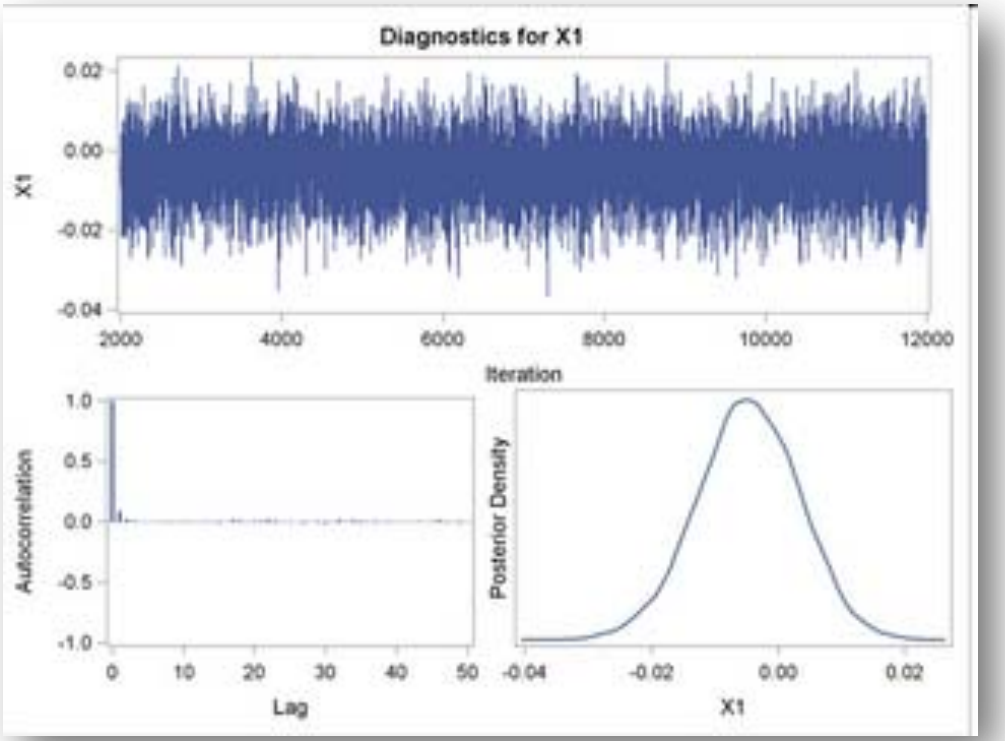
- **Pit size did not influence mortality rates for sidewalk trees**
- **Soil volume may not become a limiting factor until the tree "fills in" the initial available space**

Bayesian analysis

- Analysis conducted by Jessica Sanders and Jason Grabosky at Rutgers University

- Probability based analyses that uses prior datasets (Phase I data), to inform and allow for a better analysis of the Phase II data

- Over 55 questions were asked of the data



Key Results:

- Landuse affects survivorship of trees

- Tall tree guards have no effect on tree survival

- Infrastructure conflicts have a slight effect on survivorship

- Traffic volume alone was not conclusive but landuse is associated with traffic volume

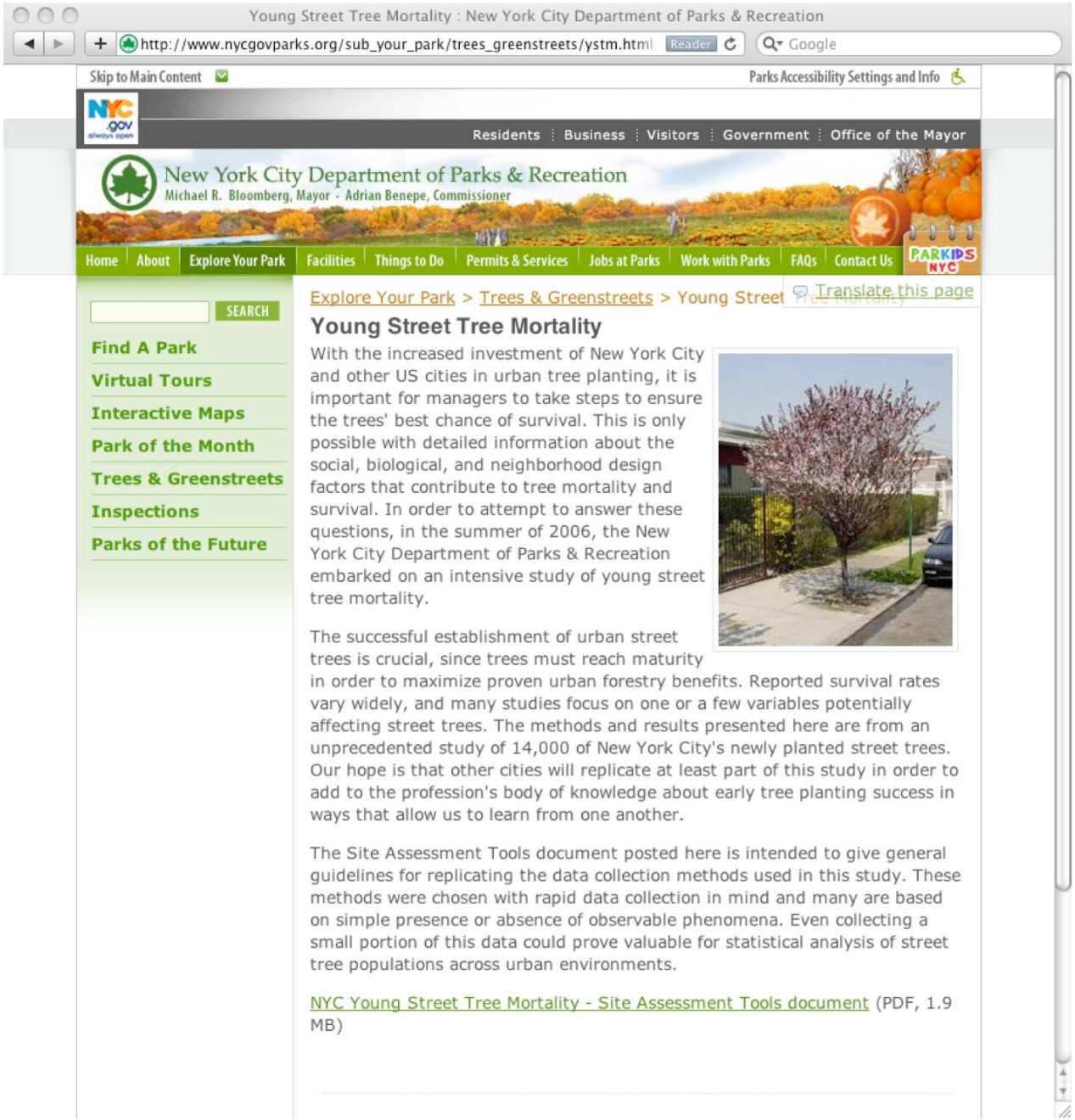
- Pit type affects survivorship – trees with more available soil tended to have a higher rate of survival

- Presence of stakes negatively impacted survivorship

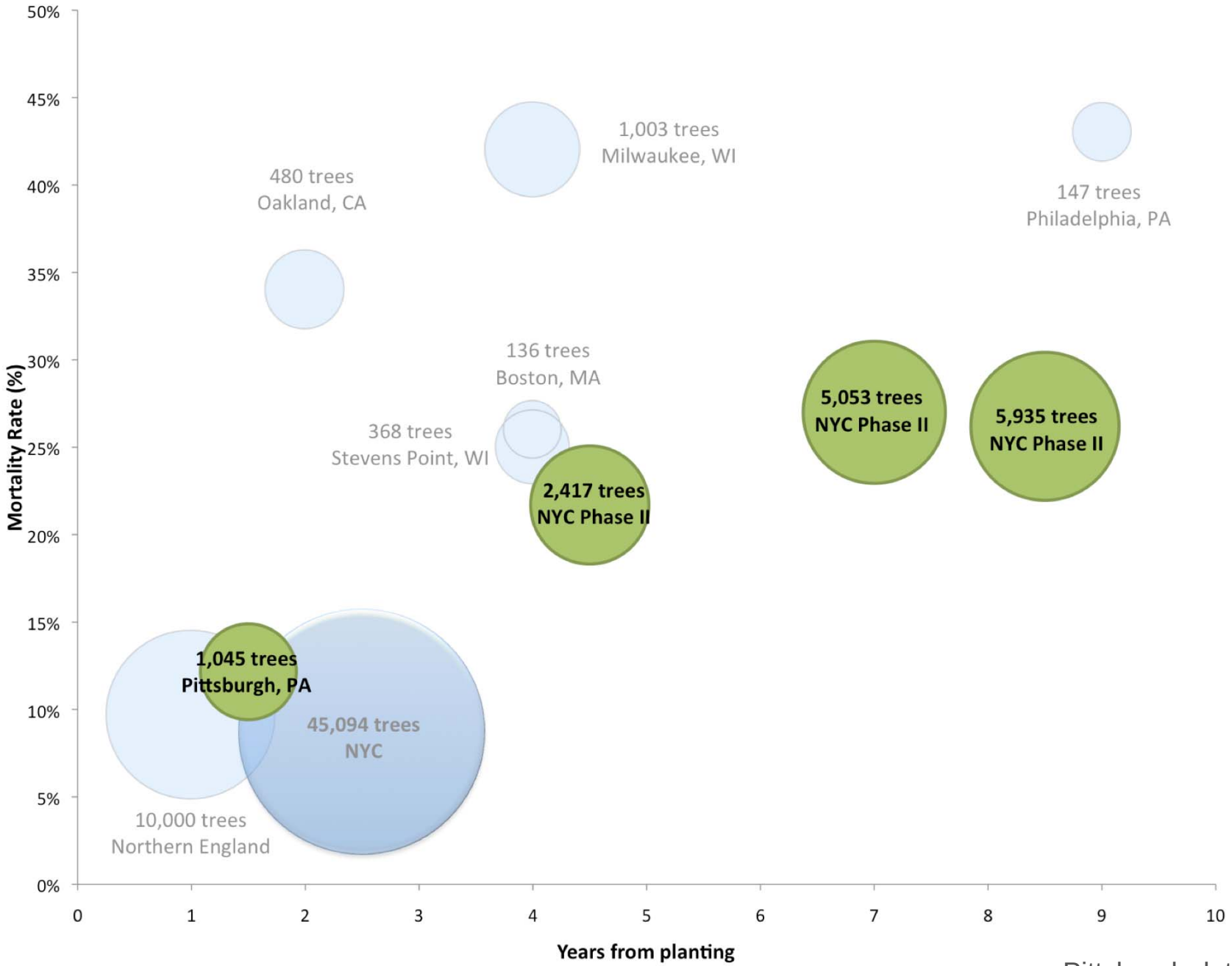
- Year planted had no effect on the overall survivorship of trees

Site Assessment Tools

- Step-by-step guide for city managers and researchers on how to assess street tree planting survival
- Detailed look at what data we collected and why
- Can be downloaded from NYC Parks & Recreation's website
- Used by Friends of the Pittsburgh Urban Forest summer of 2010



Cross-city comparisons



Pittsburgh data courtesy of
Friends of the Pittsburgh Urban Forest

Cross-city comparisons

Similarities

- Trees located on lawns had highest survival rates in both cities
- No clear relationship found between tree pit size and tree survival in both cities
- Soil compaction related to higher mortality rates in both cities
- Signs of stewardship are associated with higher survival rates
- Missing trees outnumber standing dead trees

Differences

- In Pittsburgh sidewalk trees had higher mortality rates than trees in continuous pits; in NYC trees in continuous pits had highest mortality rates
- In Pittsburgh both heavy and light traffic areas had higher mortality rates than areas with moderate levels of traffic; in NYC mortality rates increased with traffic

Next Steps

- Analysis of data for factors affecting tree condition, not just survival and mortality

  (N. Falxa-Raymond, Columbia University)

- Identify most informative data variables and continue monitoring these and more recently planted trees in summer 2011

  (N. Falxa-Raymond & NYC Parks & Recreation)

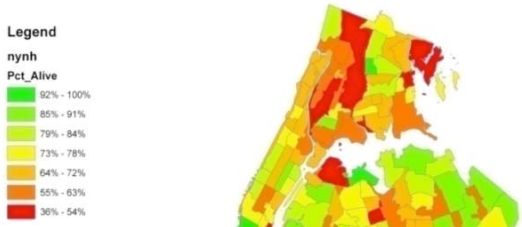
- Implement findings into management practices and planting policy

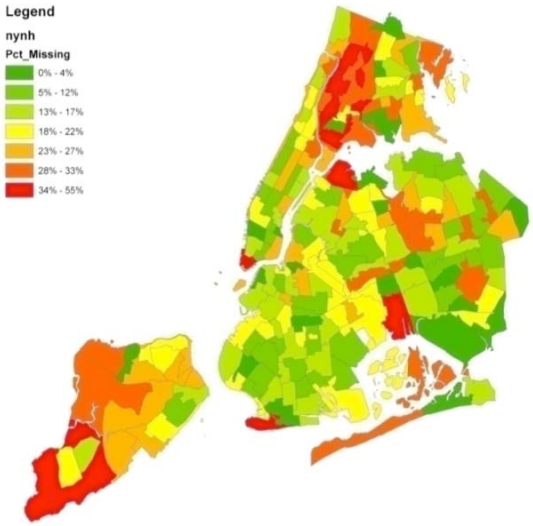
Crosstabs

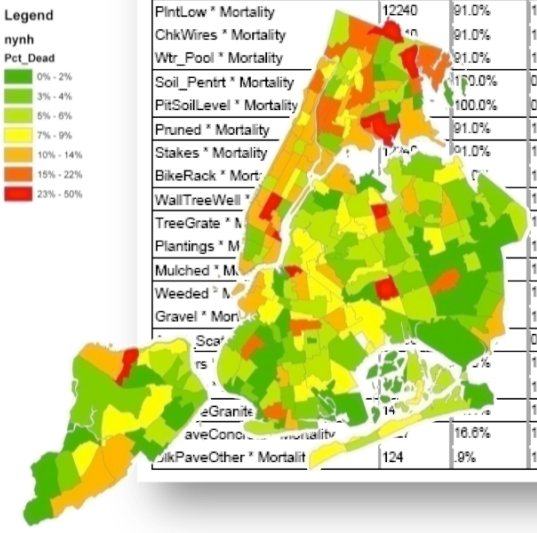
[DataSet1] /Users/mike/Documents/Freelance/DPR Tree Mortality/main_data_file.sav

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Year (1=2006 2=2007 * Mortality	13456	100.0%	0	.0%	13456	100.0%
Team * Mortality	13456	100.0%	0	.0%	13456	100.0%
Team2 * Mortality	13456	100.0%	0	.0%	13456	100.0%
Median is present? * Mortality	13456	100.0%	0	.0%	13456	100.0%
St_Prkng * Mortality	13456	100.0%	0	.0%	13456	100.0%
Prkng_Par * Mortality	13456	100.0%	0	.0%	13456	100.0%
Sidewalk Width (feet) * Mortality	13456	100.0%	0	.0%	13456	100.0%
Pit Type * Mortality	13456	100.0%	0	.0%	13456	100.0%
Slope * Mortality	13456	100.0%	0	.0%	13456	100.0%
SlopeDeg * Mortality	13456	100.0%	0	.0%	13456	100.0%
Sloplc * Mortality	13456	100.0%	0	.0%	13456	100.0%
Sdwlk_Cond_Good * Mortality	11769	87.5%	1687	12.5%	13456	100.0%
Sdwlk_Cond_Crkd * Mortality	11769	87.5%	1687	12.5%	13456	100.0%
Sdwlk_Cond_Rsd * Mortality	11769	87.5%	1687	12.5%	13456	100.0%
CurbIntct * Mortality	12240	91.0%	1216	9.0%	13456	100.0%
Fiveft_Drvwy * Mortality	13456	100.0%	0	.0%	13456	100.0%
Fiveft_Bus_stop * Mortality	13456	100.0%	0	.0%	13456	100.0%
Sgnage_Pres * Mortality	12240	91.0%	1216	9.0%	13456	100.0%
SgnTree * Mortality	12240	91.0%	1216	9.0%	13456	100.0%
SgnTrePitPole * Mortality	12240	91.0%	1216	9.0%	13456	100.0%
SgnTreeGrd * Mortality	12240	91.0%	1216	9.0%	13456	100.0%
SgnParkng * Mortality	12240	91.0%	1216	9.0%	13456	100.0%
PlntHigh * Mortality	12240	91.0%	1216	9.0%	13456	100.0%
PlntLow * Mortality	12240	91.0%	1216	9.0%	13456	100.0%
ChkWires * Mortality	[illegible]	91.0%	1216	9.0%	13456	100.0%
Wtr_Pool * Mortality	[illegible]	91.0%	1216	9.0%	13456	100.0%
Soil_Pentrt * Mortality	[illegible]	100.0%	0	.0%	13456	100.0%
PitSoilLevel * Mortality	[illegible]	100.0%	0	.0%	13456	100.0%
Pruned * Mortality	[illegible]	91.0%	1216	9.0%	13456	100.0%
Stakes * Mortality	[illegible]	91.0%	1216	9.0%	13456	100.0%
BikeRack * Mort[illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
WallTreeWell * [illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
TreeGrate * M[illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
Plantings * M[illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
Mulched * M[illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
Weeded * M[illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
Gravel * Mort[illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
[illegible] Scat[illegible]	[illegible]	[illegible]	0	.0%	13456	100.0%
[illegible] rs [illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
[illegible]	[illegible]	[illegible]	1216	9.0%	13456	100.0%
[illegible] eGranite[illegible]	14[illegible]	[illegible]	11967	88.9%	13456	100.0%
[illegible] aveConc[illegible] Mortality	[illegible]	16.6%	11229	83.4%	13456	100.0%
[illegible] lkPaveOther * Mortalit[illegible]	124	.9%	13332	99.1%	13456	100.0%







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Site Assessment Tools

http://www.nyc.gov/parks/trees

New York City's
Young Street Tree Mortality Study

Site Assessment Tools Description