Roadside Landscaping and Safety

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May 15, 2014

Today's Presentation

- **Introduction and housekeeping**
- **Audio issues?**
  Dial into the phone line instead of using "mic & speakers"
- **PBIC Trainings and Webinars**
  www.pedbikeinfo.org/training
- **Registration and Archives at**
  pedbikeinfo.org/webinars
- **PBIC News and updates on Facebook**
  www.facebook.com/pedbike
- **Questions at the end**

Trees and Safety in the Urban Environment

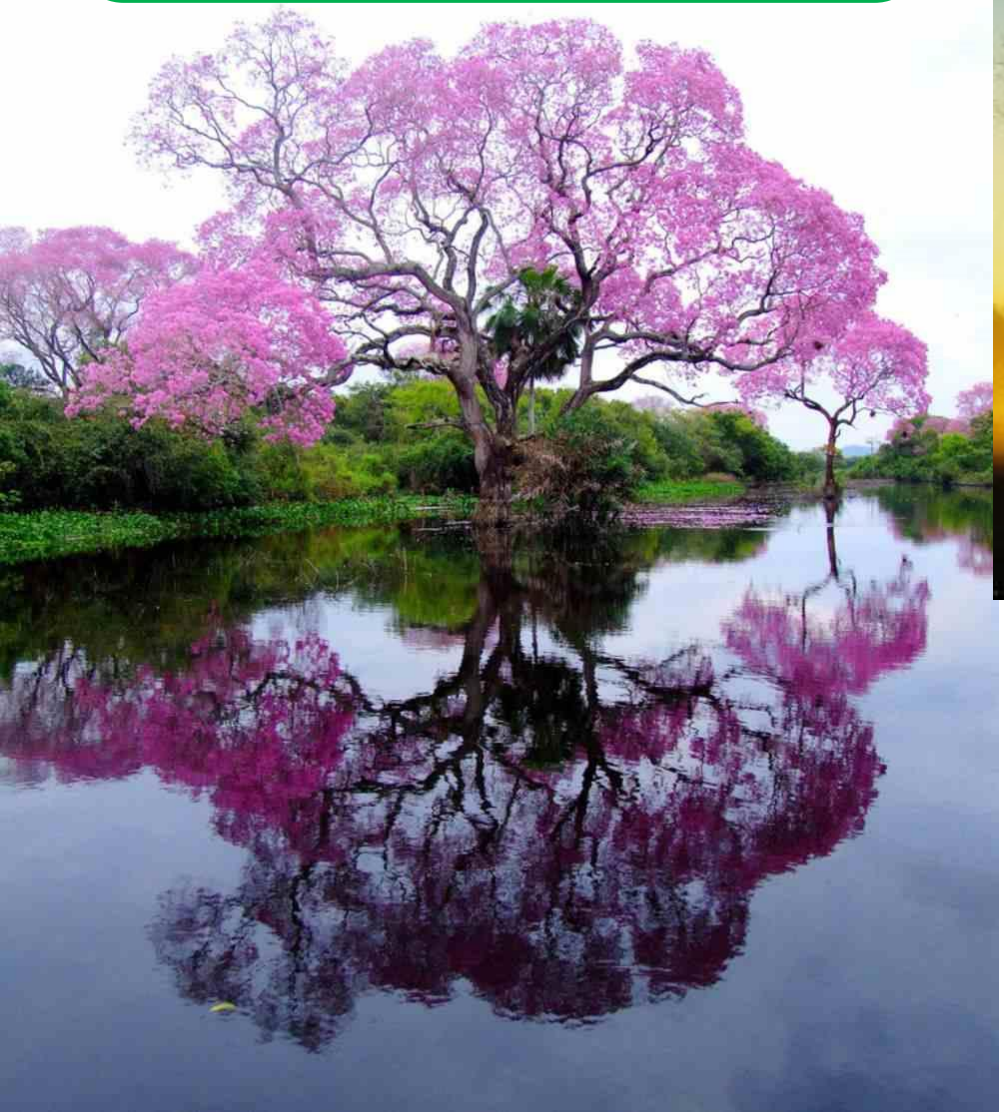
Dick Albin

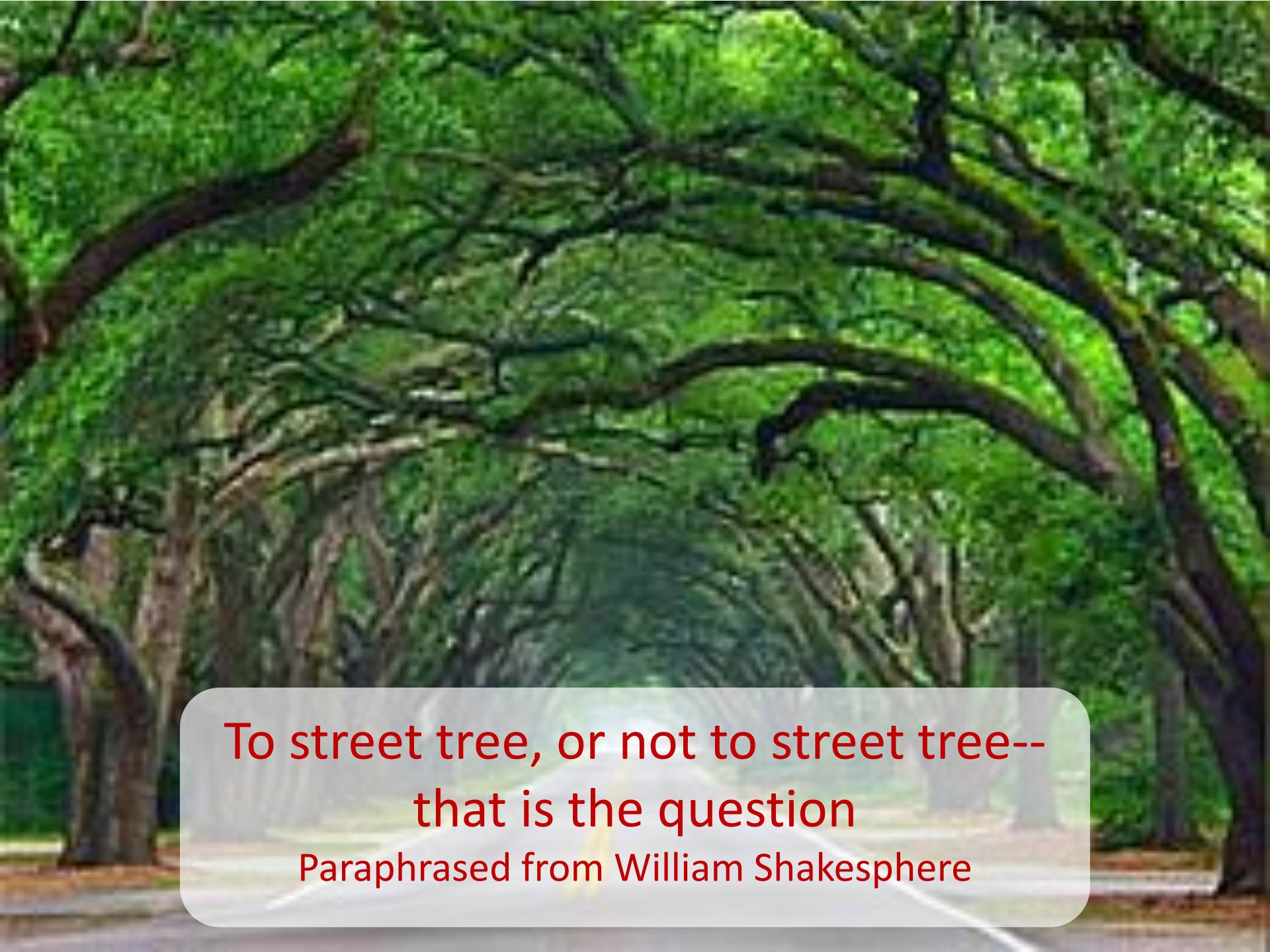
FHWA Resource Center

I THINK that I shall never see

A poem lovely as a tree.

Joyce Kilmer. 1886–1918




To street tree, or not to street tree--
that is the question
Paraphrased from William Shakesphere

Benefits of Street Trees

Benefits attributed to street trees include:

- Increase by 9-12% the amount people will pay for products and services
- Lessen stress of commuters
- Reduce aggressive driving
- Increase job satisfaction
- Reduce storm water runoff by 4-8%
- Calm traffic - 10% reduction in 85th % speed

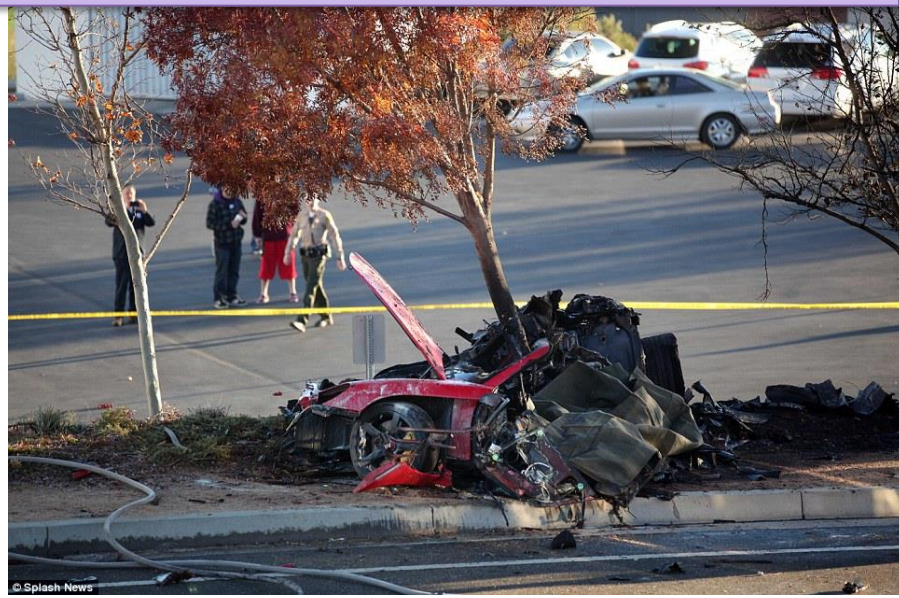
http://depts.washington.edu/hhwb/Thm_SafeStreets.html

Are fixed Object Crashes a concern in the Urban area?

There are some opinions that fixed objects aren't an issues in the urbanized area because speeds are lower.

Often, the impacts to motorist safety are minimized

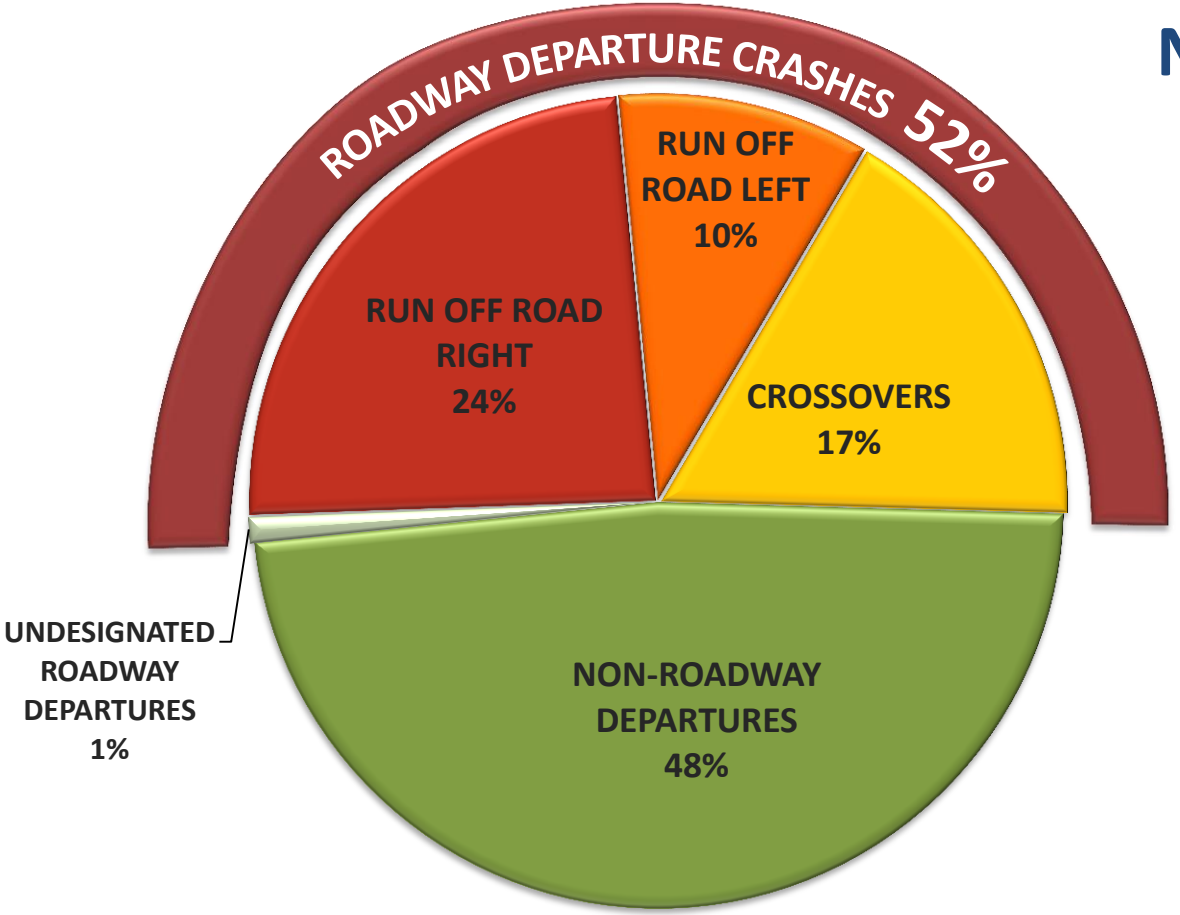
- "Far less than 1% of crashes involve a tree on an urban street"
- Fatal Pedestrian crashes are approximately 0.08% of all crashes



	U.S. Total	Tree Accidents	Urban Accidents	Urban Tree Accidents
All Accidents	*6,316,000 (100%)	1.9% *141,000 (2.2%)	37%	0.7%
Incapacitating Injury and Fatality	13%	0.9%	4.1%	0.04%
Fatality	1.2% *43,005 (0.6%)	0.1% *3,258 (< 0.001%)	0.4%	< 0.001%

* NHTSA (2004) - %s may differ due to sampling and analysis procedures

Roadway Departure Crashes



National Fatal Crashes

(Average 2009-2011)

30,305 Fatal Crashes/Year

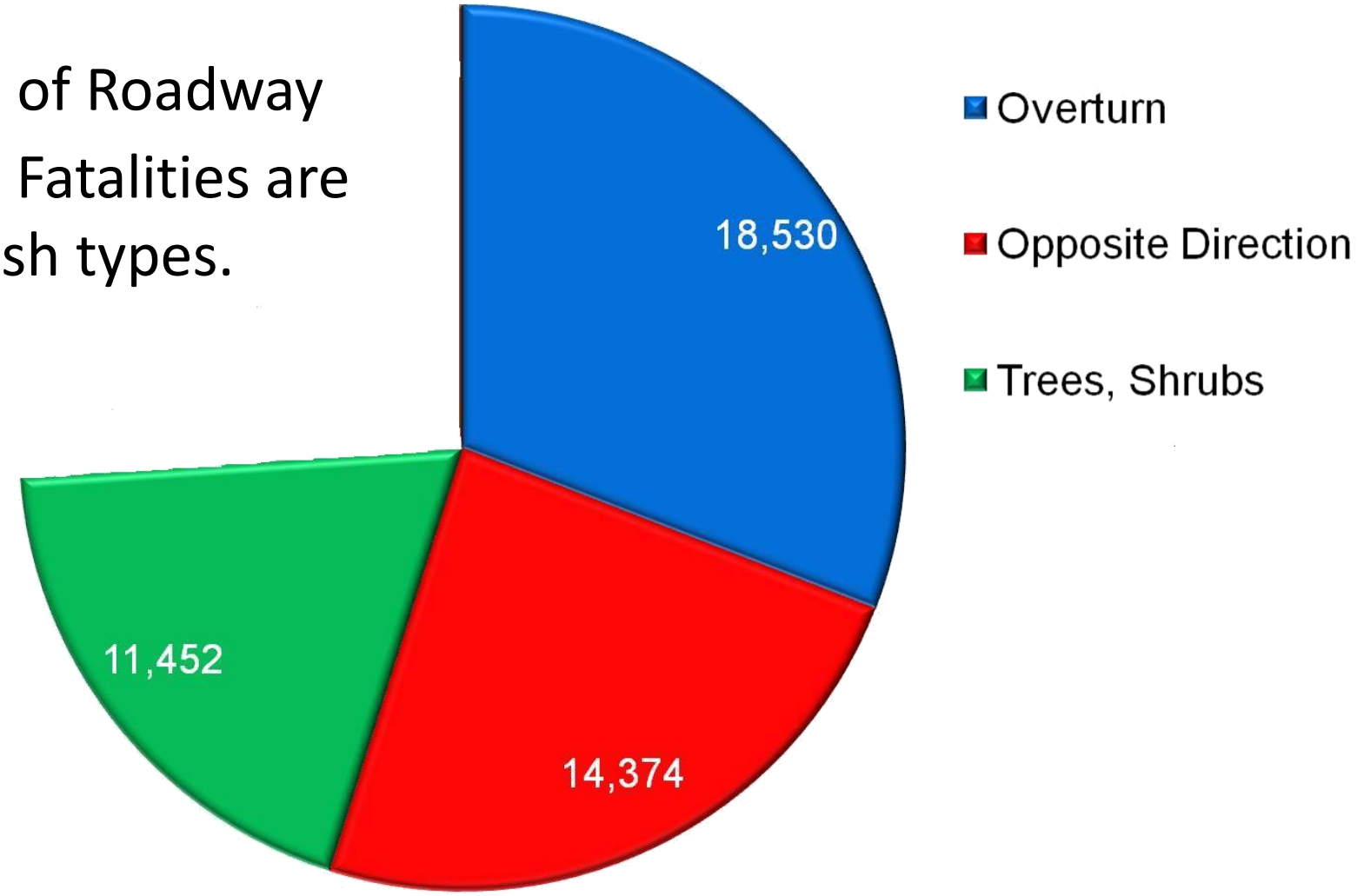
15,783 Fatal RwD Crashes/Year

Source: NHSTA FARS

Roadway Departure Crash - A non-intersection crash in which a vehicle crosses an edge line, a centerline, or otherwise leaves the traveled way.

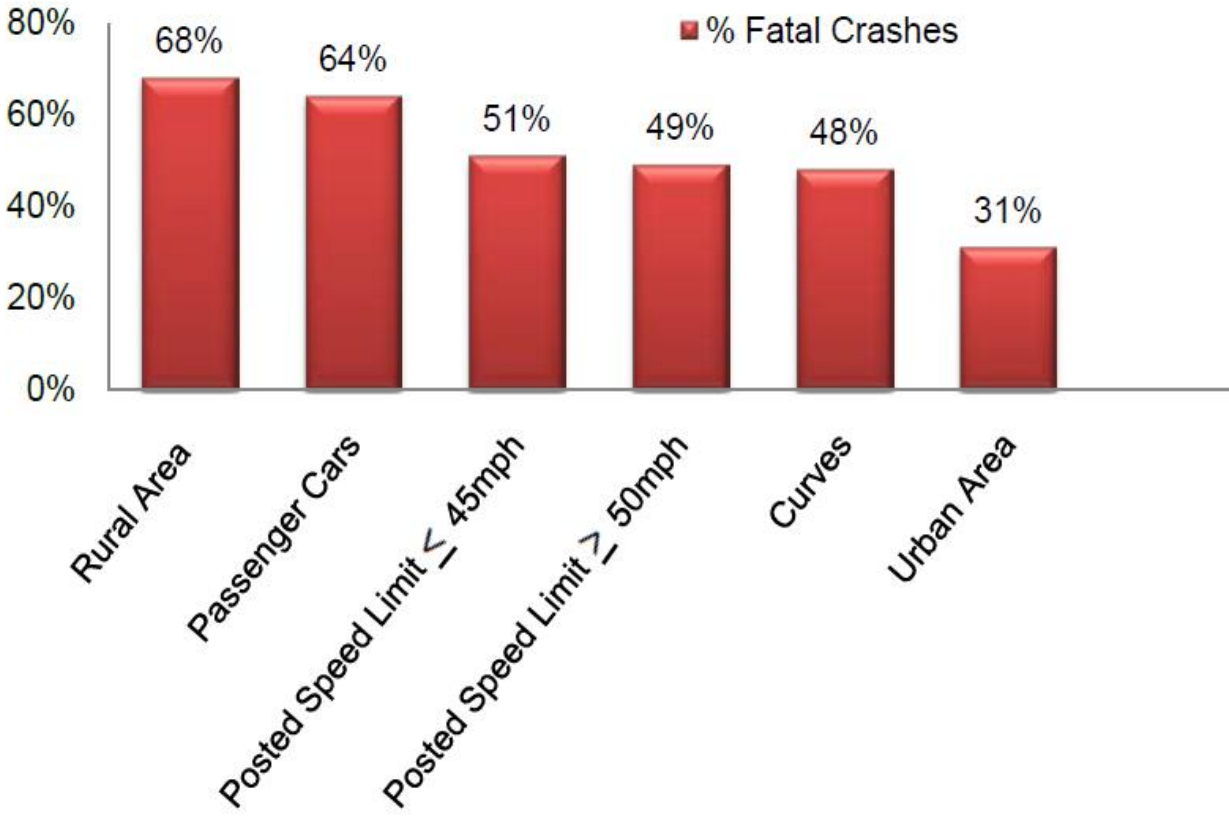
Roadway Departure Strategic Plan

Nearly ¾ of Roadway Departure Fatalities are from 3 crash types.



http://safety.fhwa.dot.gov/roadway_dept/

Fatal Tree Crashes (2007-2009)

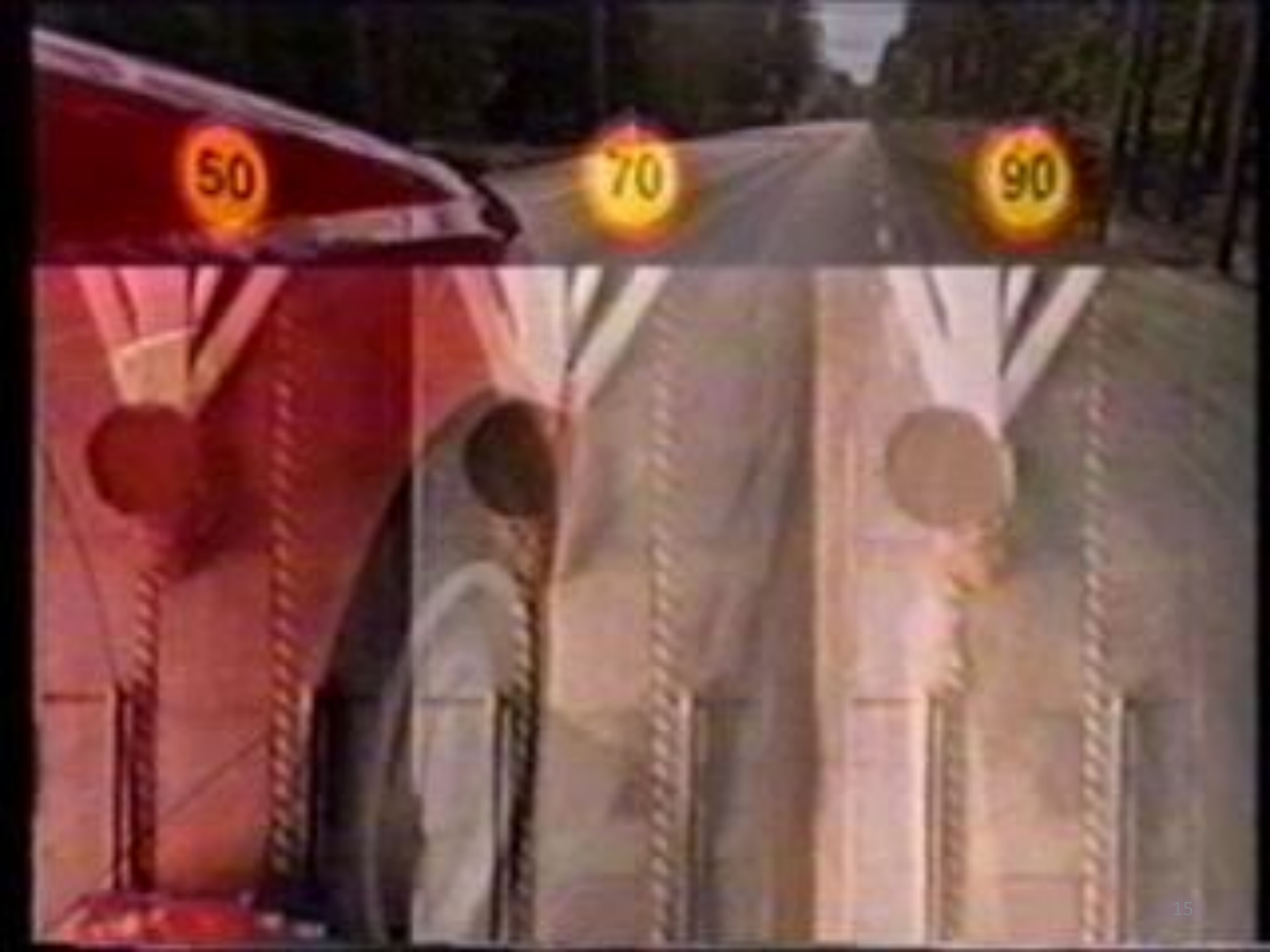


Trees are 50% of Fixed Object Fatalities

A large number are in “Low Speed” Environments

Deaths in fixed object crashes by speed limit, 2010

Speed limit	Deaths	%
No limit	22	<1
<35 mph	1,003	14
35-40 mph	1,389	19
45-50 mph	1,446	20
55+ mph	3,277	45
Total*	7,272	100
*Total includes other and/or unknowns		


50
70
90

Side Impact crashes can be more severe

Do trees at the curb line affect pedestrians?

Pedestrians Vs Motorists

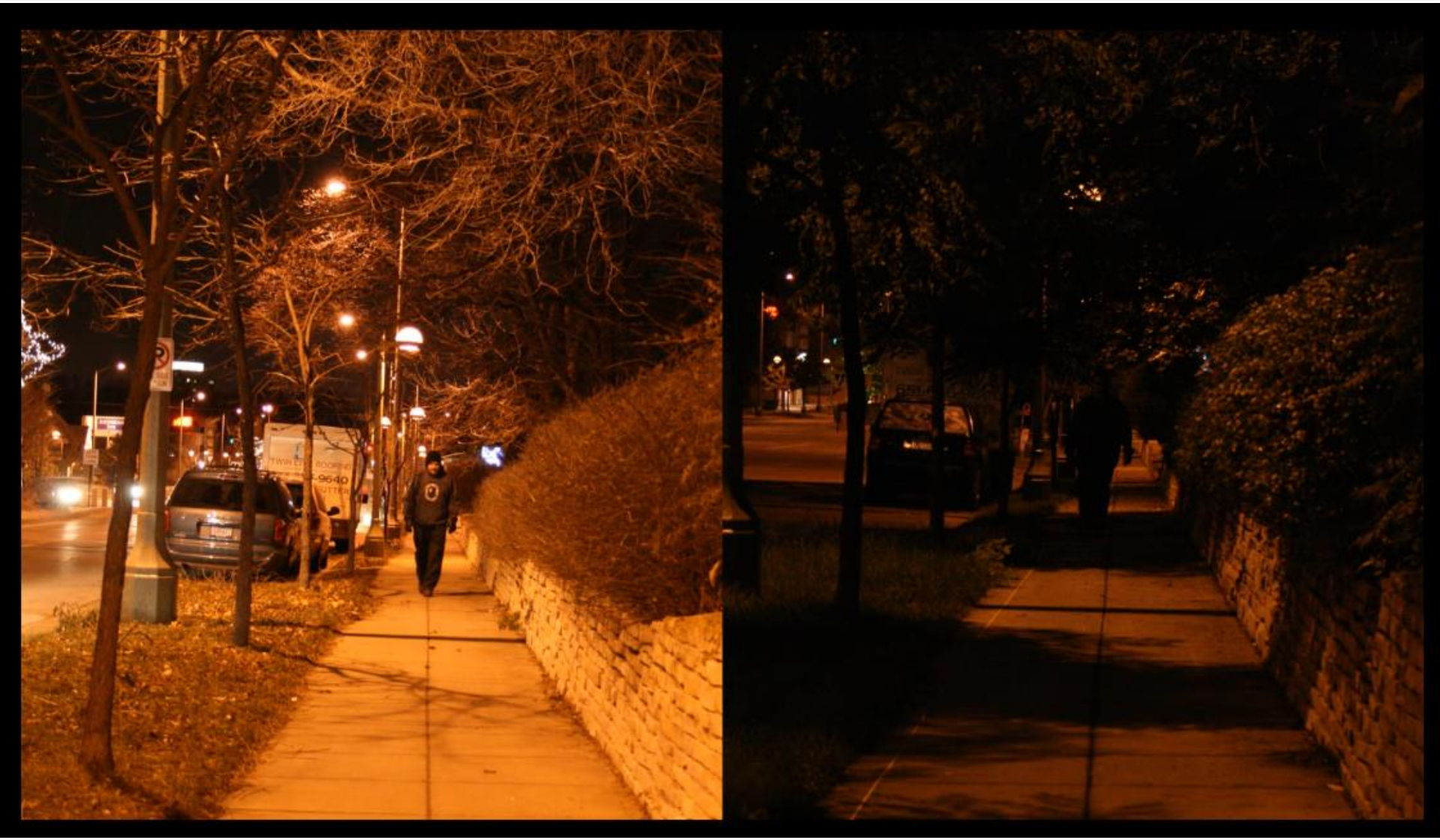
For urban other principal arterials, minor arterials, and collectors shows that:

- 48 pedestrians were killed on the roadside.
- 395 people were killed from impacts with trees on the same streets.

Source: 2008 Fatality Analysis Reporting System (FARS)
http://www-fars.nhtsa.dot.gov/Main/index.aspx

Trees at the curb can reduce the ability for drivers to see the pedestrian or signs

Trees reduce the effectiveness of lighting



Roots can cause buckling of sidewalks

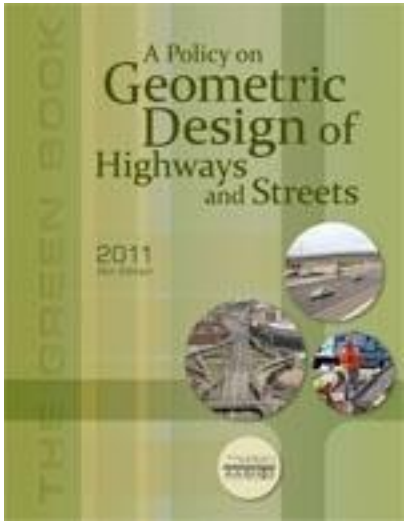
Trees don’t like being there

Bicycle Lane Impacts

Are all “Urban Streets” the same?

AASHTO Green Book

- In an urban environment, right of way is often extremely limited and in many cases it is not practical to establish a full-width clear zone using the guidance in the *AASHTO Roadside Design Guide*

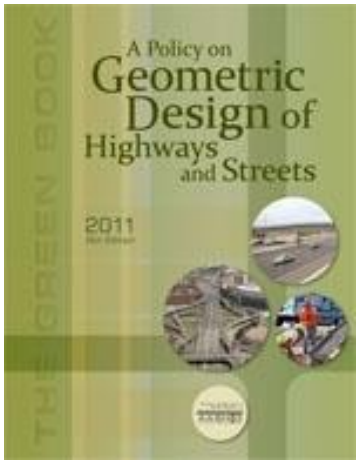


Page 4-15 of the AASHTO Green Book

AASHTO Green Book

- In these environments, a lateral offset to vertical obstructions (signs, utility poles, luminaire supports, fire hydrants, etc., including breakaway devices) is needed to accommodate motorists operating on the roadway and parked vehicles.

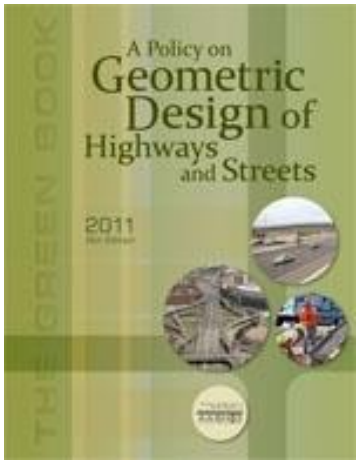
Page 4-15 of the AASHTO Green Book



AASHTO Green Book

This lateral offset to obstructions helps to:

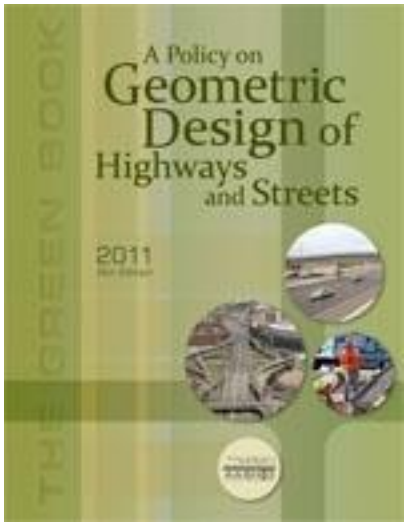
- Avoid adverse impacts on vehicle lane position and encroachments into opposing or adjacent lanes
- Improve driveway and horizontal sight distances
- Reduce the travel lane encroachments from occasional parked and disabled vehicles
- Improve travel lane capacity
- Minimize contact from vehicle mounted intrusions (e.g., large mirrors, car doors, and the overhang of turning trucks)



Page 4-15 of the AASHTO Green Book

AASHTO Green Book

- On curbed facilities located in transition areas between rural and urban settings there may be an opportunity to provide greater lateral offset in the location of fixed objects.
- These facilities are generally characterized by
  - higher operating speeds
  - sidewalks separated from the curb by a buffer strip

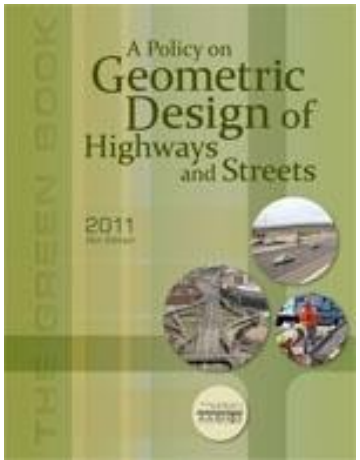


Page 7-37 of the AASHTO Green Book

AASHTO Green Book

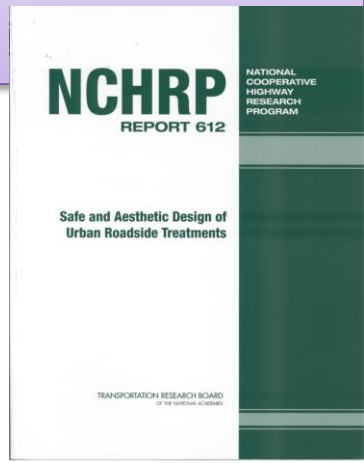
- Where establishing a full-width clear zone in an urban area is not practical due to right-of-way constraints, consideration should be given to establishing a reduced clear zone, or incorporating as many clear zone concepts as practical such as removing roadside objects or making them crashworthy.

Page 4-15 of the AASHTO Green Book



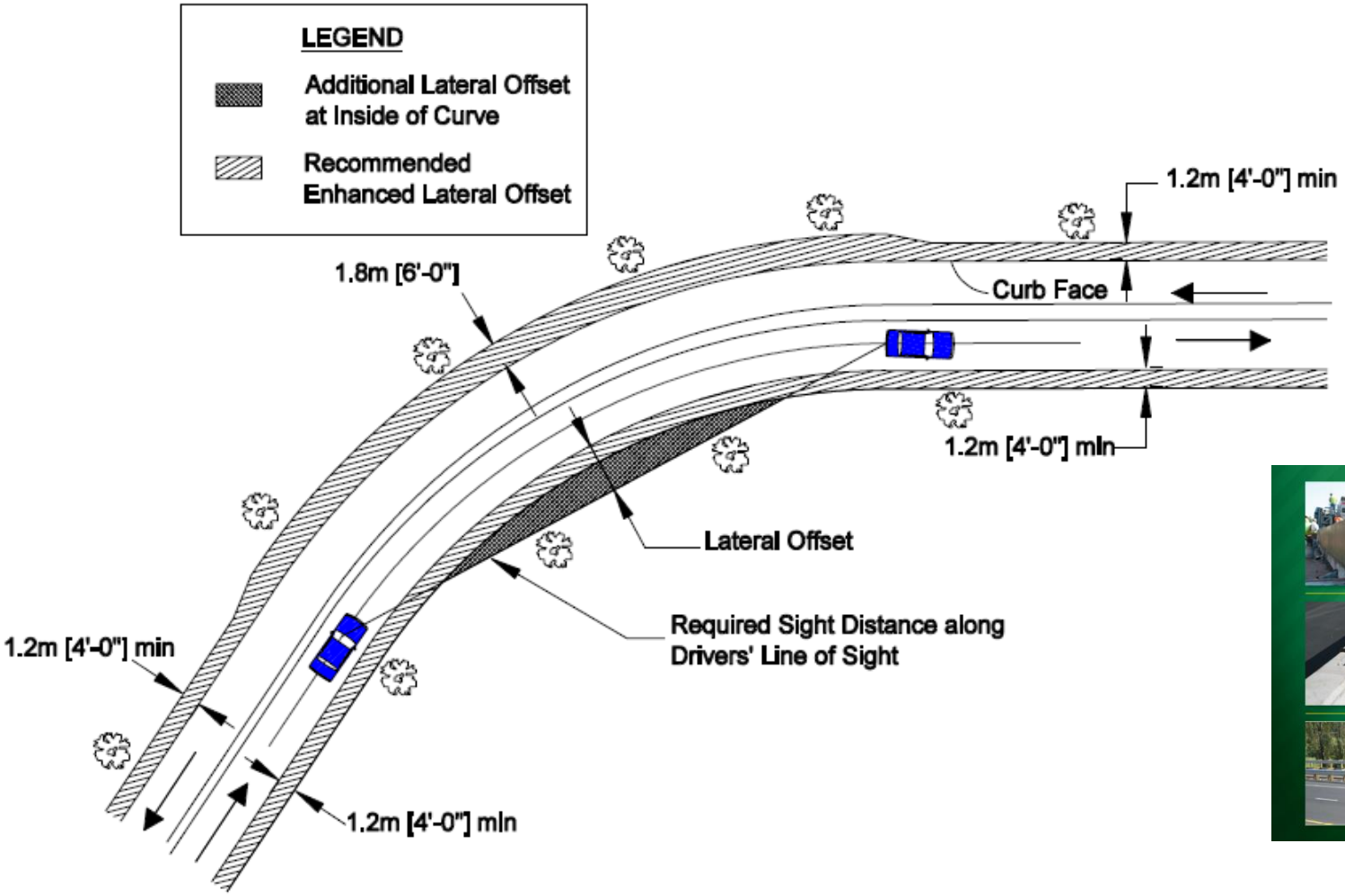
Fixed Object Crashes

Lat. Dist.	Crashes	%	Cumul.%
0-1’	129	28.3%	28.3%
1-2’	157	34.4%	62.7%
2-4’	90	19.7%	82.5%
4-6’	50	11.0%	93.4%
6-8’	23	5.0%	98.5%
8-10’	6	1.3%	99.8%
10-15’	1	0.2%	100%
Total:	456	100%	



Source: NCHRP Report 612

Enhanced Lateral Offset



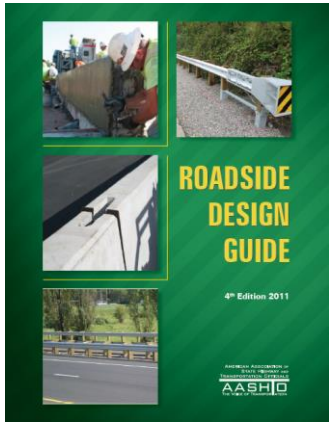
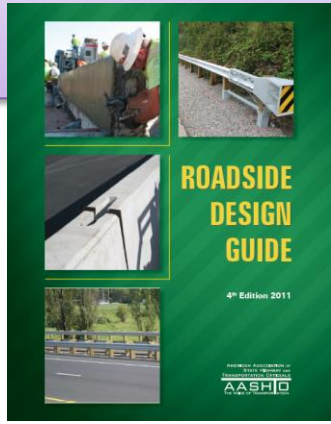


Figure 10-1. Lateral Offset for Objects at Horizontal Curves on Curbed Facilities

Lane Merge / Acceleration Lane Tapers



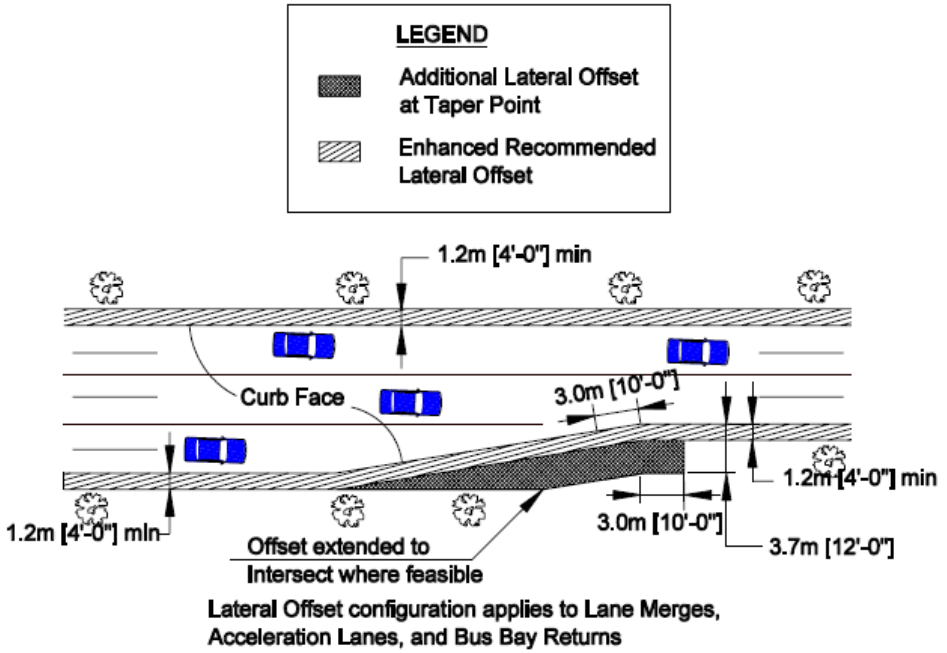
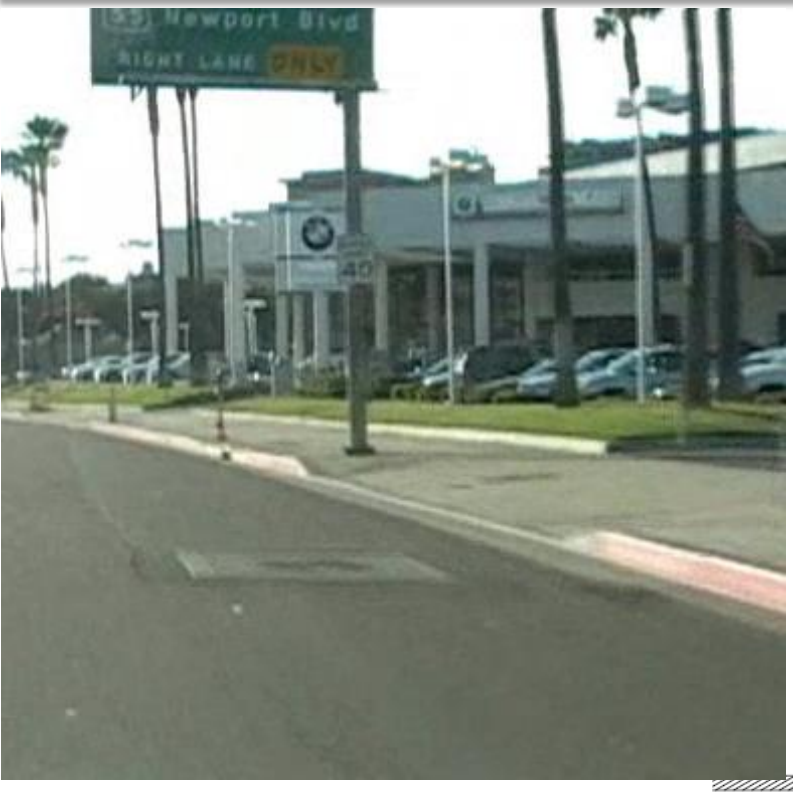
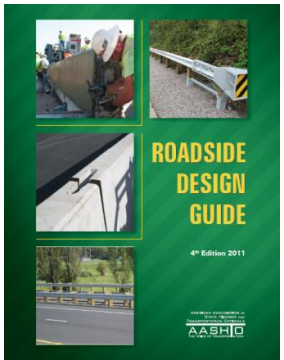


Figure 10-2. Enhanced Lateral Offsets at Merge Points

Driveways





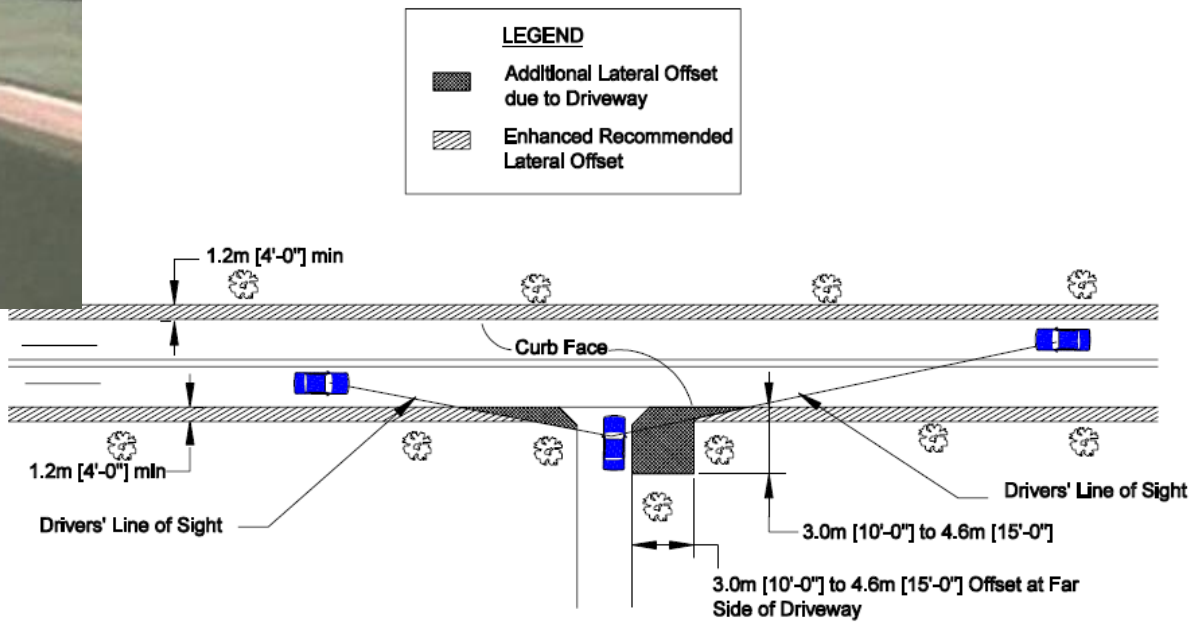


Figure 10-3. Enhanced Lateral Offsets at Driveways

Landscape Buffer (Planting Strip) Configuration

Landscape Buffer (Planting Strip) > 4’ wide

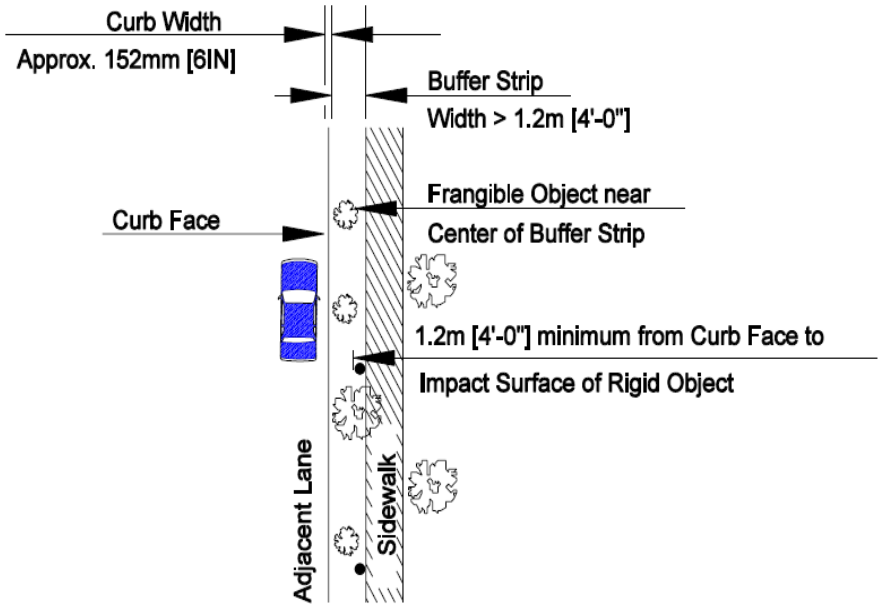
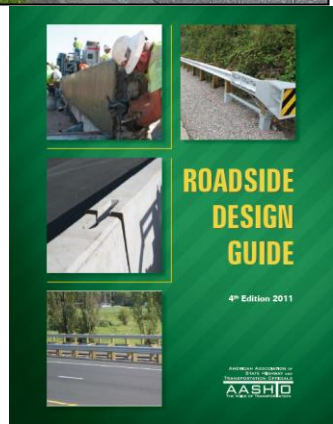
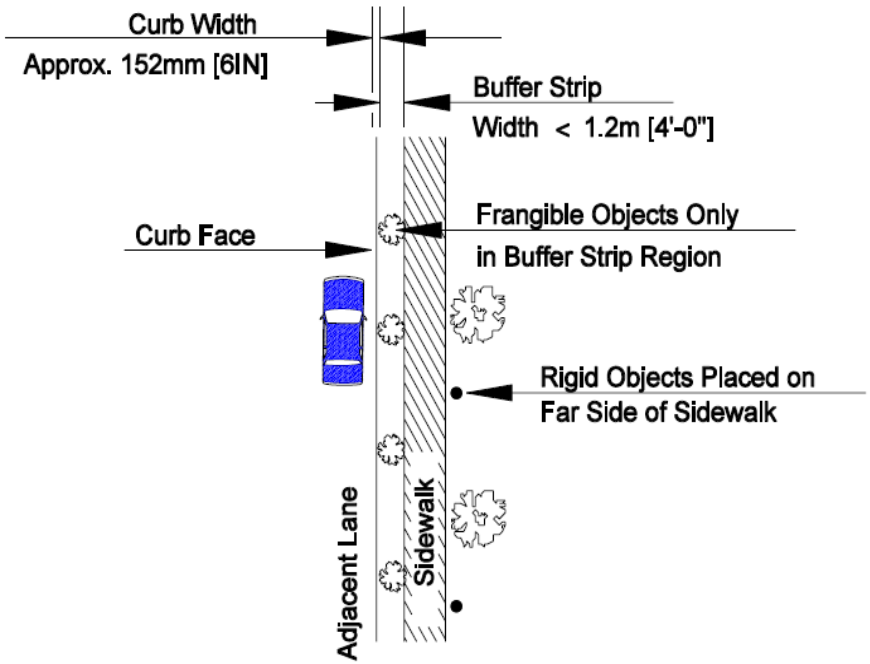


Figure 10-4. Landscape and Rigid Object Placement for Buffer Strip Widths ≤1.2 m [4 ft]



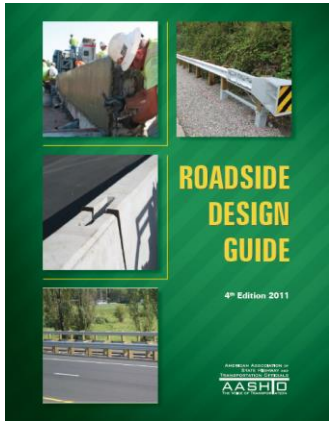
Source: NCHRP Report 612

Landscape Buffer (Planting Strip) < 4’ wide



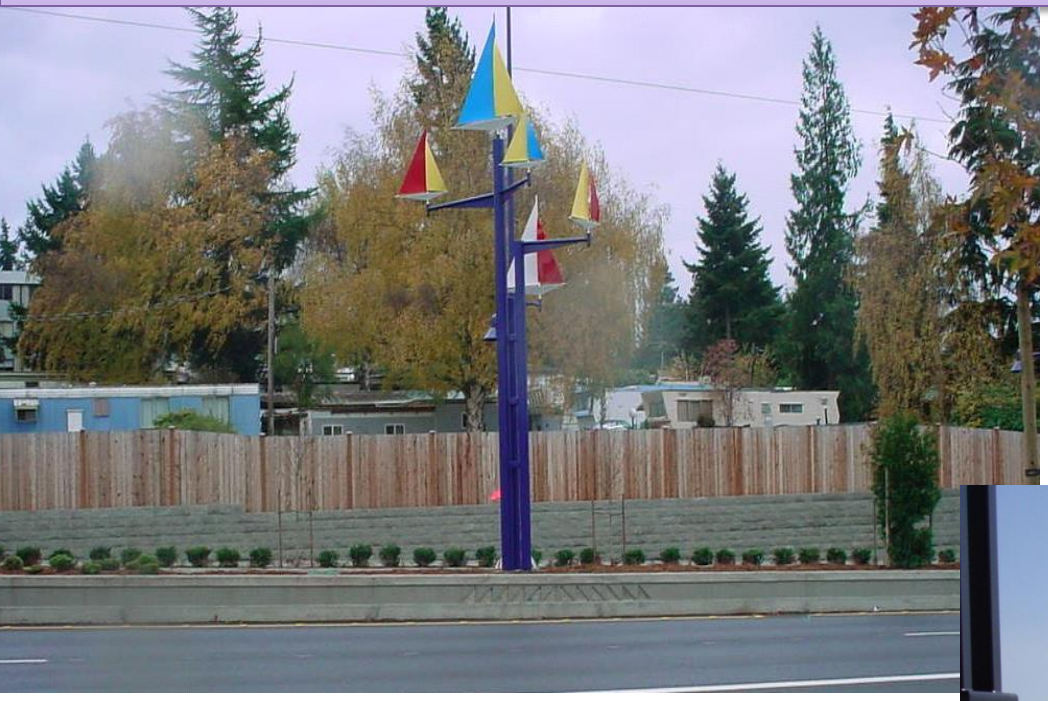
NARROW BUFFER STRIP

Figure 10-5. Landscape and Rigid Object Placement for Buffer Strip Widths >1.2 m [4 ft]



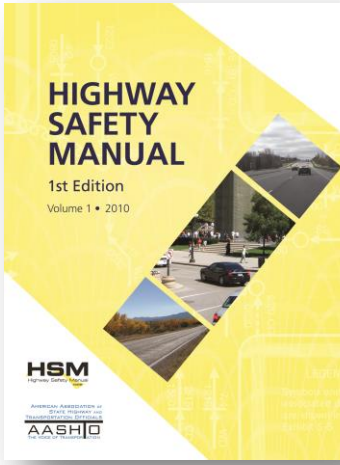
Source: NCHRP Report 612

TL-2 Median Barrier



CMF for Roadside Fixed Objects

$$CMF_{2r} = f_{offset} * D_{fo} * p_{fo} + (1 - p_{fo})$$



Where:

f_{offset} = fixed object offset factor from Table12-20

D_{fo} = fixed object density (fixed objects/mi)

p_{fo} = fixed-object collisions as a proportion of total crashes, Table 12-21

- Only point objects that are 4 inches or more in diameter and do not have breakaway design are considered.
- Point objects that are within 70 feet of each other longitudinally are considered as a single object

CMF for Roadside Fixed Objects

Table 12-20. Fixed-Object Offset Factor

Offset to Fixed Objects (O_{fo}) (ft)	Fixed-Object Offset Factor (f_{offset})
2	0.232
5	0.133
10	0.087
15	0.068
20	0.057
25	0.049
30	0.044

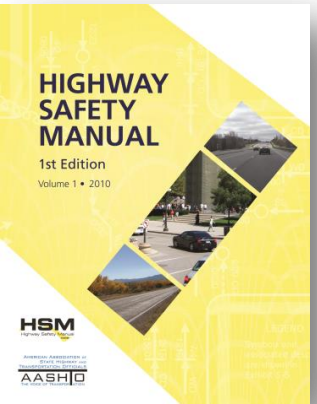
EX: For 4-Ln Urban undivided street (4U) with trees at 2 ft offset

$f_{offset} = 0.232$

$p_{fo} = 0.037$

Table 12-21. Proportion of Fixed-Object Collisions

Road Type	Proportion of Fixed-Object Collisions (p_{fo})
2U	0.05
3T	0.034
4U	0.037
4D	0.036
5T	0.016



CMF for Roadside Fixed Objects: Example

For one mile of 4-Ln Urban undivided commercial curbed street (4U) with trees on *both* sides on 50 foot spacing 2 feet from edge of travel way:

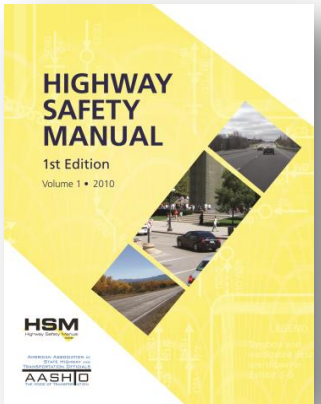
$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})$$

$= 0.232 (5280/70)(2)(0.037) + (1 - 0.037)$

$= 0.232 \times 150.8 \times 0.037 + (0.963)$

$= 1.295 + 0.963$

$= 2.258$



CMF for Roadside Fixed Objects: Example

For one mile of 4-Ln Urban undivided commercial curbed street (4U) with trees on *both* sides on 50 foot spacing 5 feet from edge of travel way:

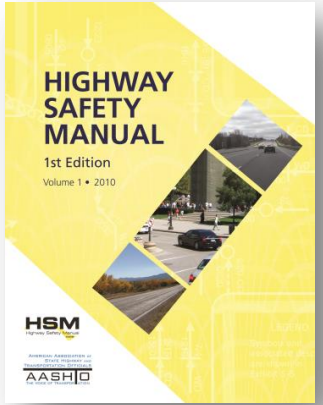
$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})$$

$= 0.133 (5280/70)(2)(0.037) + (1 - 0.037)$

$= 0.133 \times 150.8 \times 0.037 + (0.963)$

$= 0.742 + 0.963$

$= 1.705$



CMF for Roadside Fixed Objects: Example

For one mile of 4-Ln Urban undivided commercial curbed street (4U) with trees on *both* sides on 50 foot spacing 10 feet from edge of travel way:

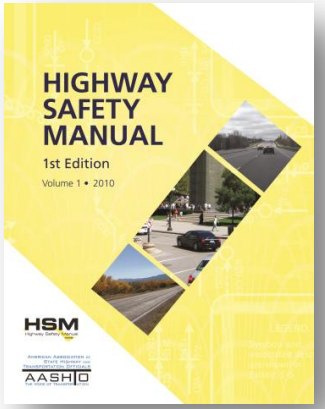
$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})$$

$= 0.087 (5280/70)(2)(0.037)+ (1 - 0.037)$

$= 0.087 \times 150.8 \times 0.037+ (0.963)$

$= 0.486 + 0.963$

$= 1.449$



Summary

- Crashes into trees are a significant contributor in fatal crashes – even in “low speed (45 mph or less)” urban environments
- The benefits of trees need to be balanced with other trade-offs
- Recent changes in AASHTO encourage greater lateral offsets to fixed objects (minimum of 4’ to 6’)
- Risk of crashes decreases as the fixed objects are moved further from the travelled way

Introduction

- **Landscaping of Highway Medians at Intersections Research** by **CUTR**. We will cover the following:
  - Need for Research and Background
  - Research Objectives and Methodology
  - Conclusion and Recommendations

Need for Research and Background

- Landscaping of Highway Medians at Intersections Research
  - Validation of Index 546 and its criteria
  - Propose changes to Index 546 based on:
    - Median width
    - Tree diameter
    - Tree spacing
    - Vehicle speed

Need for Research and Background

- Context Sensitive Solutions
  - Effective November 20, 2008
  - Collaborative, Interdisciplinary Approach
  - Develop a transportation facility that
    - Fits its physical settings
    - Preserves
      - Scenic
      - Aesthetic
      - Historic
      - Environmental resources
    - Maintaining safety and mobility

Need for Research and Background

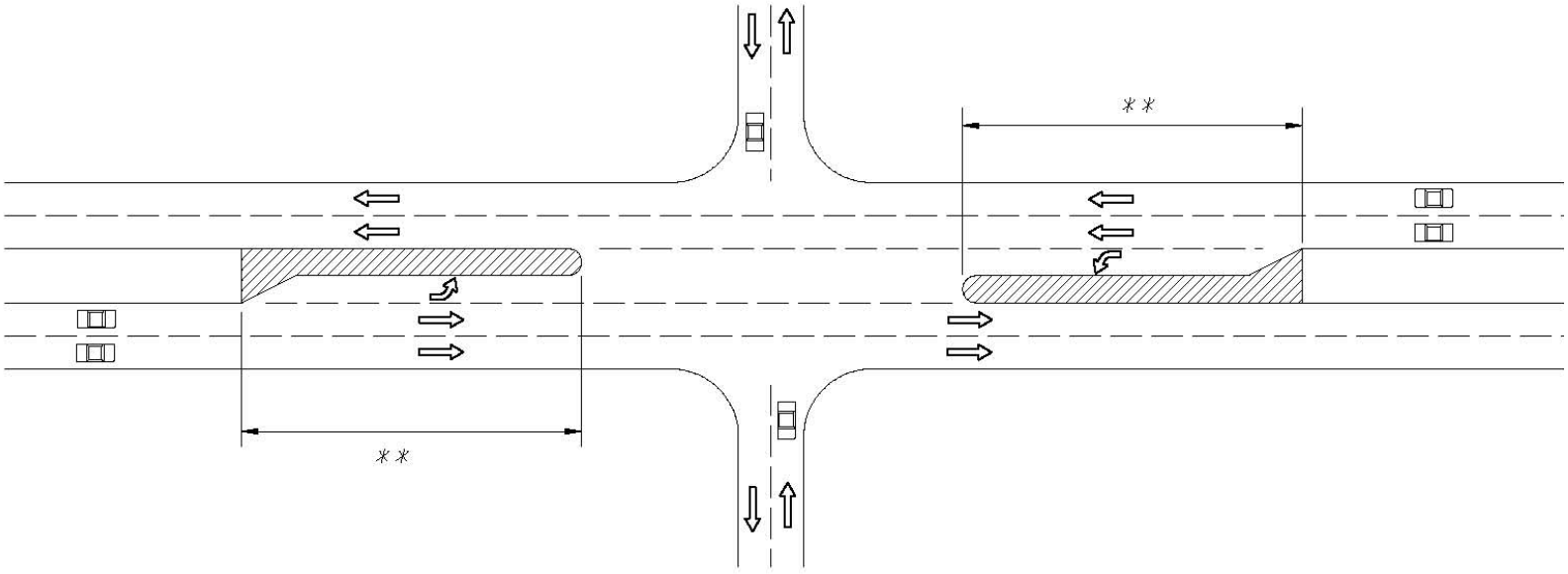
- Highway Beautification and the Bold Landscaping Policy
  - Many Trees
  - $30 Million/ Year for Highway Beatification

Need for Research and Background

- 2010 - Roadway Design Bulletin 10-04
  - Tree placement within an intersection median
    - Horizontal Clearance
    - No left turn present
    - Left turn present (signalized or not)
      - Low speed facilities (100’ Setback)
      - High speed facilities (200’ Setback)

Need for Research and Background

- Before Roadway Design Bulletin 10-04



PLAN

Special Areas Limited to Ground Cover

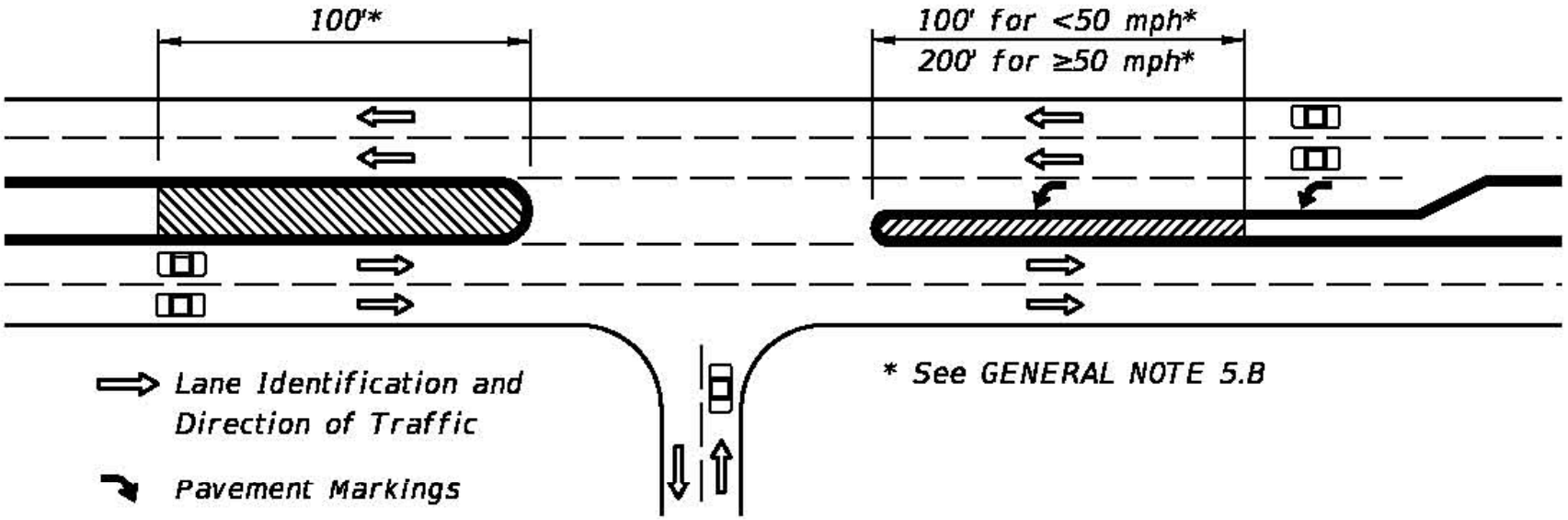
** For Signalized and unsignalized intersections, the median area along left turn lanes, including the taper, shall be limited to ground cover with height not greater than 18" below the sight line datum regardless of whether or not the area is within the limit of clear sight.

Need for Research and Background

- Before Roadway Design Bulletin 10-04

Need for Research and Background

- After Roadway Design Bulletin 10-04



PLAN
Special Areas Limited to Ground Cover

Need for Research and Background

- After Roadway Design Bulletin 10-04

Research Objectives and Methodology

- Landscaping of Highway Medians at Intersections Research
  - Main Objectives
    - Review current landscaping criteria
    - Provide a computational procedure to analyze landscaping configurations
    - Perform an empirical study of the Safety Performance of Standard Index 546

Landscaping Policy in other States

- AASHTO's landscaping policy for intersections has two main parts
  1. Drivers require an unobstructed view of the intersection
  2. Does not strictly forbid landscaping near intersection approaches

Table 2-1. Selected Landscaping Criteria in Other States

State	Median Tree Placement Criteria	Setback Restriction
California	▪Barrier is required for speeds 45 mph or less ▪Mature trees (4" or greater in diameter) require an 11' or more wide median	▪Signalized Intersections: 100' from intersections ▪Unsignalized Intersections: ○25 mph - 150' from intersections ○30 mph - 200' from intersections ○35 mph - 250' from intersections
Louisiana	▪Only allows shrubbery and ground cover in the clear sight triangle area with heights less than 2.5' above roadway surface ▪No trees allowed in the clear sight triangles	▪30 mph -300' from median nose ▪40 mph -400' from median nose ▪50 mph- 500' from median nose ▪55 mph -550' from median nose

Landscaping Policy in Florida

Table 2-2. Detailed Median Landscaping Policy for Florida

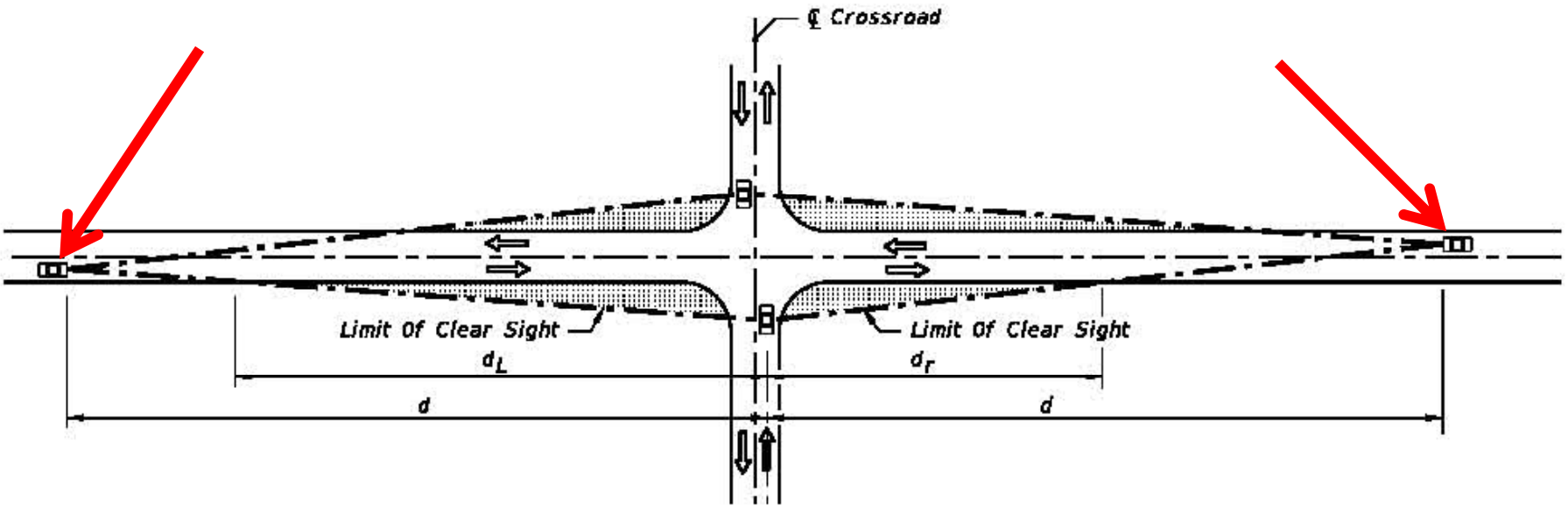
Median Trees Guidelines at Intersections	Florida			
	Ground Cover	Top of ground cover to sight line datum: Ground cover only, > 18″ For ground cover in combination with trees and palms: > 24″ for trees and palms ≤ 11″ diameter > 18″ for Sabal Palms >11″ but ≤ 18″ diameter		
	Setback Restrictions (Trees/Trunked Plants)	100′ from pavement edge for design speeds < 50 mph 200′ from pavement edge for design speeds ≥ 50 mph		
	Trunked Plants	Diameter ≤ 4″ ≥5′ above the sight line datum Minimal space: 20′		
	Trees	Diameter ≤ 18″ Distance to bottom of canopy 8′6″		
		Minimal tree spacing (center to center of trunk)	**Speed (mph)**	**Diameter > 4″≤ 11″**	**Diameter > 11″≤ 18″**
			30	22	91
			35	27	108
			40	33	126
			45	40	146
			50	45	165
			55	52	173
			60	60	193

Research Objectives and Methodology

- Sight Distance and Index 546
  - Approach Sight Triangles
  - Departure Sight Triangles

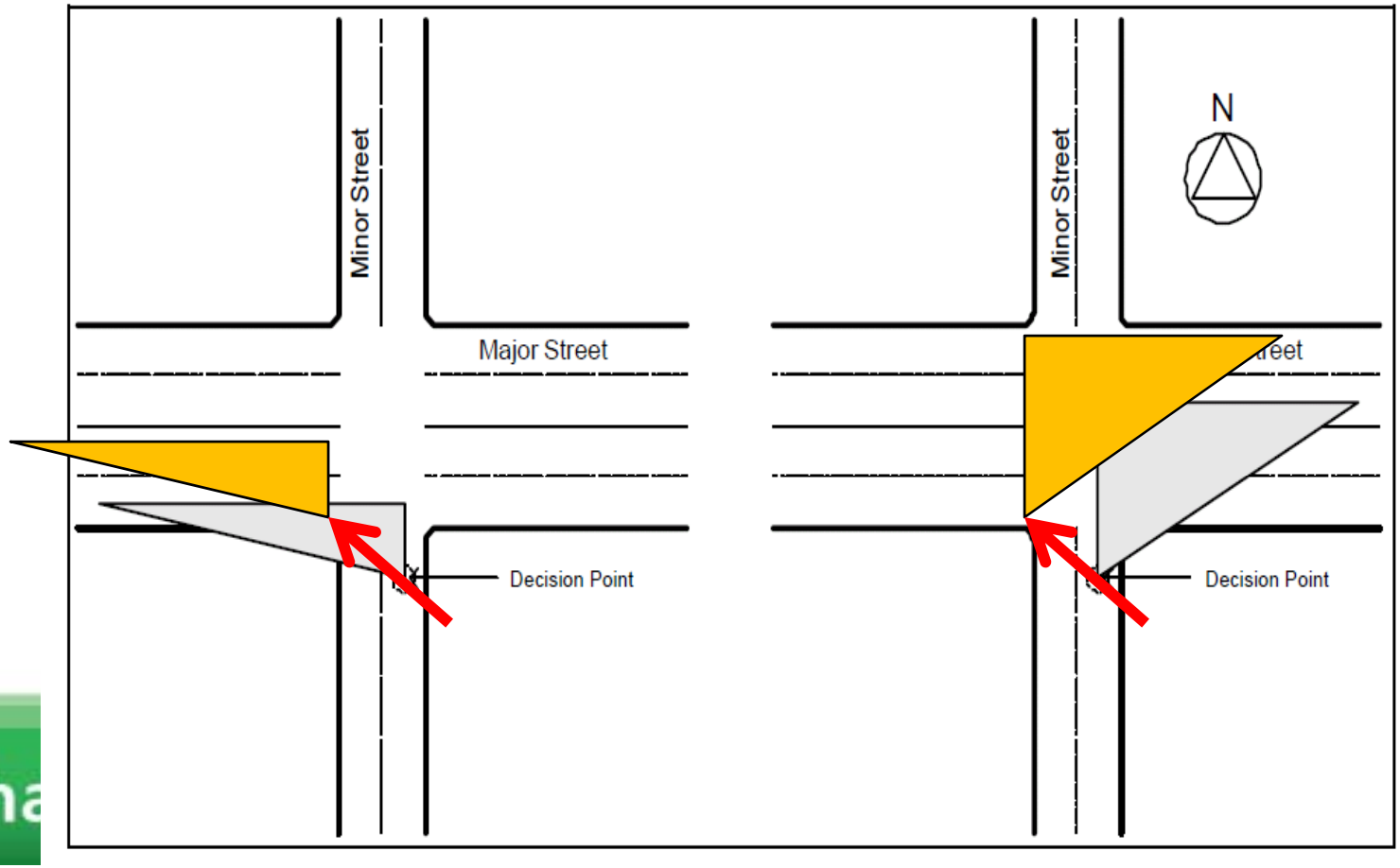
Research Objectives and Methodology

- Sight Distance and Index 546
  - Approach Sight Triangles



Research Objectives and Methodology

- Sight Distance and Index 546
  - Departure Sight Triangles



PBIC Webina

Research Objectives and Methodology

- Studied intersections divided into 3 groups for controlled intersections (signalized or stop sign on minor road)
  - No median trees near the intersection
  - Median trees near the intersection (compliant with Index 546)
  - Median trees near the intersection (noncompliant with Index 546)

Research Objectives and Methodology

- Validation of FDOT Standard Index 546 on Computational Values
  - Sight Distance Tables

Design Speed	d	d_L	d_r
30	375	265	80
35	440	315	95
40	500	355	110
45	565	400	120
50	625	445	135
55	690	490	150
60	750	530	160
65	815	580	175

Passenger Vehicle

Design Speed	d	d_L	d_r
30	480	340	105
35	560	400	120
40	640	455	135
45	720	510	155
50	800	570	170
55	880	625	190
60	960	680	205
65	1040	740	220

SU Vehicle

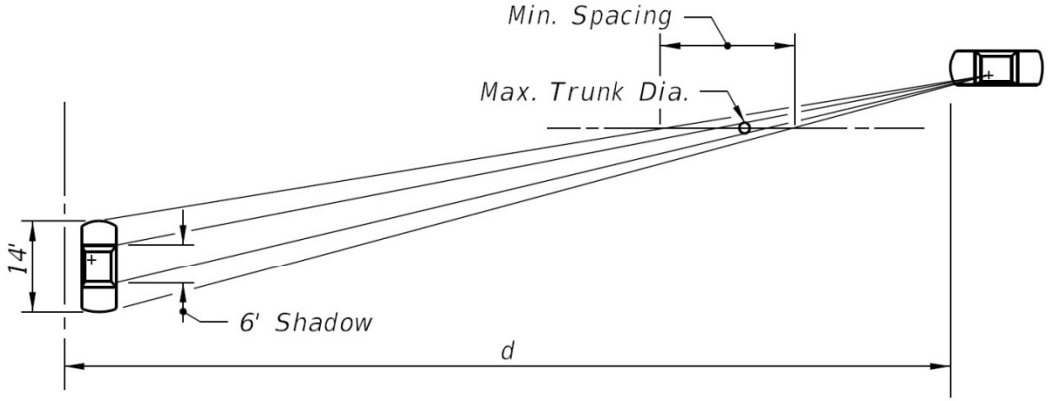
Design Speed	d	d_L	d_r
30	570	405	125
35	665	470	145
40	760	540	165
45	855	605	185
50	950	675	205
55	1045	740	225
60	1140	810	245
65	1235	875	265

Combination Vehicle

SIGHT DISTANCE (d) AND RELATED DISTANCES (d_L, d_r) (FEET)
4 LANE UNDIVIDED WITH OPTIONAL LANE

Research Objectives and Methodology

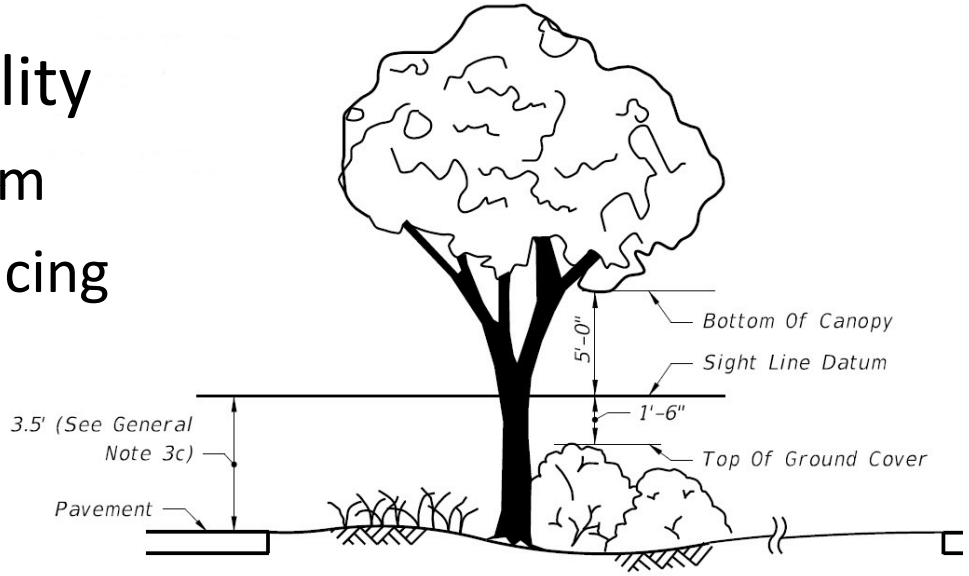
- Visibility Criteria
  - Restricted Visibility
    - 50 Percent visible area
    - Stopped vehicle profile



SHADOW DIAGRAM

Research Objectives and Methodology

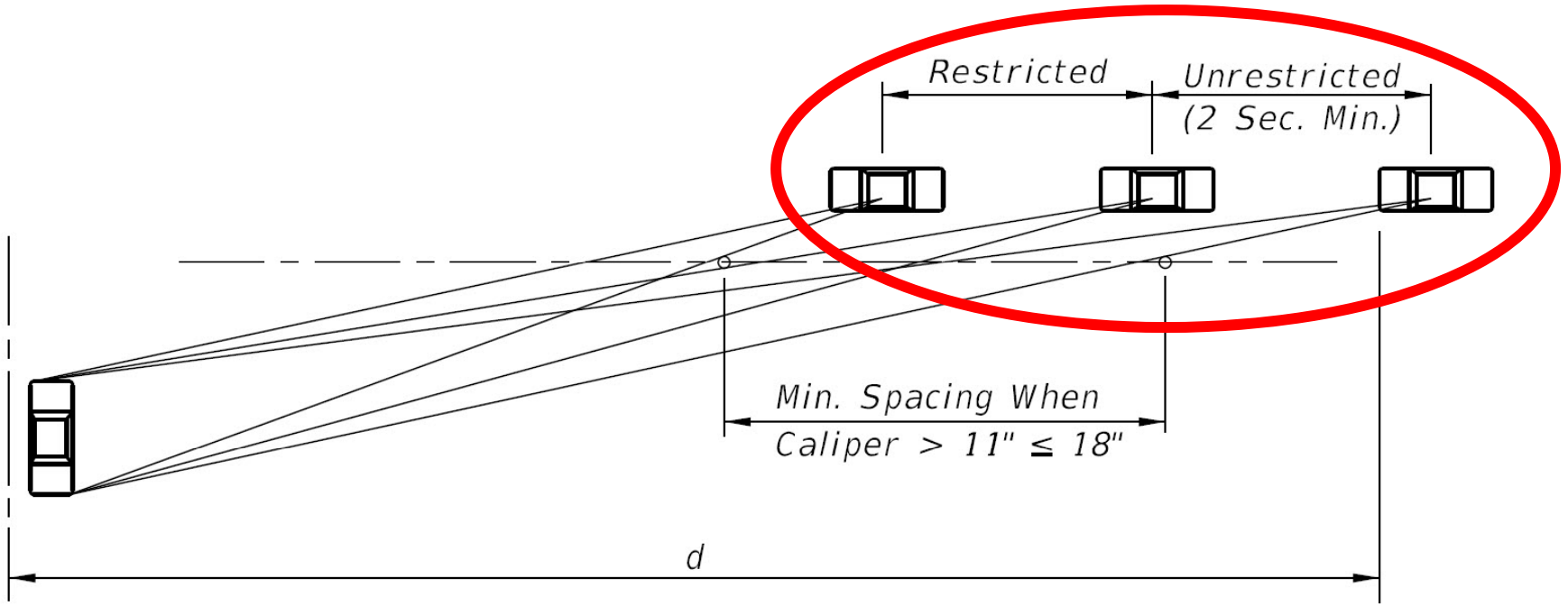
- Visibility Criteria
  - Unrestricted Visibility
    - 2 seconds minimum
    - Minimum tree spacing



The Intent Of This Standard Is To Provide A Window With Vertical Limits Of Not Less Than 5' Above And 1'-6" Below The Sight Line Datum, And Horizontal Limits Defined By The Limits Of Clear Sight.

PICTORIAL
WINDOW DETAIL

Research Objectives and Methodology



PERCEPTION DIAGRAM
SETTING SABAL PALM (STATE TREE) SPACING

Research Objectives and Methodology

- Validation of FDOT Standard Index 546 on Computational Values
  - Tree Spacing Table

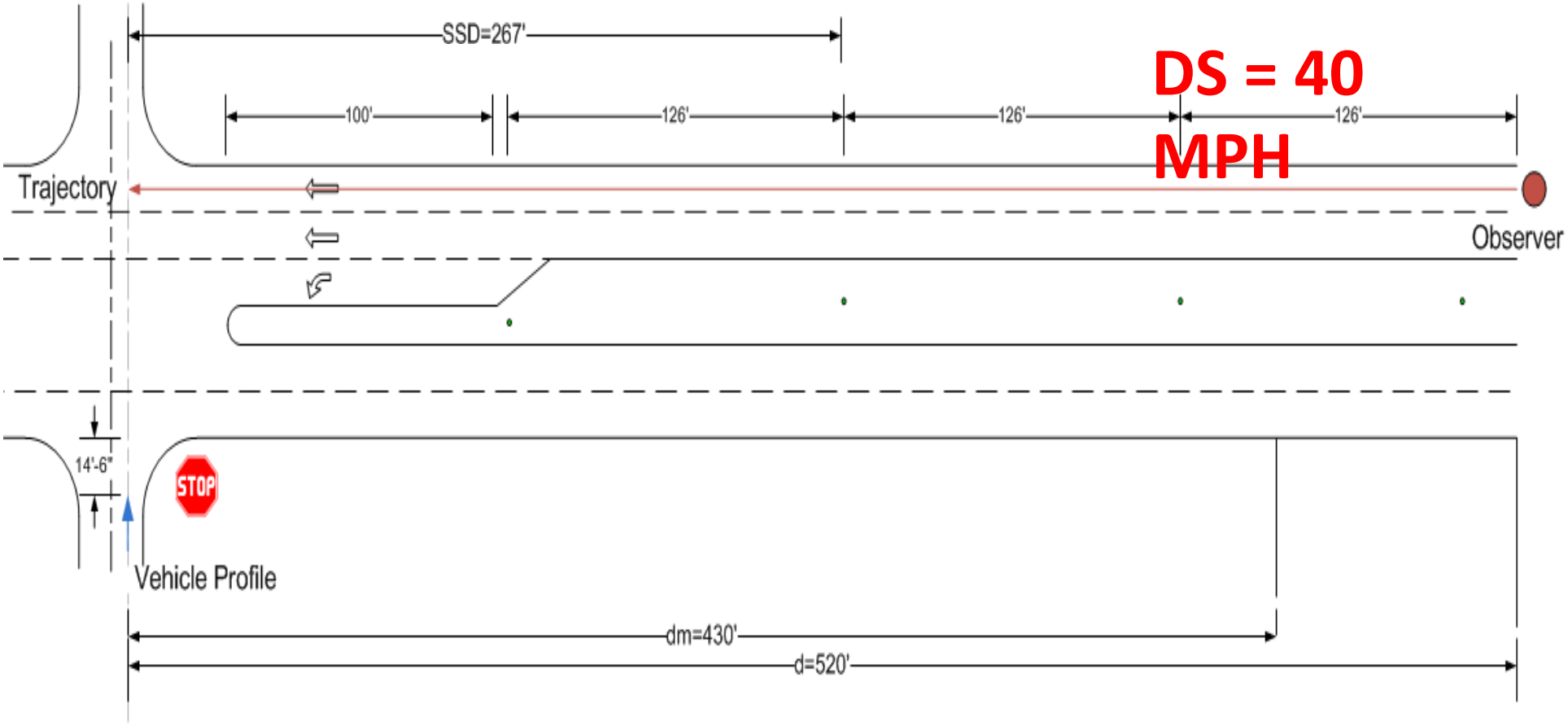
TREE SPACING TABLE **

Speed (mph)													
30		35		40		45		50		55		60	
(Inches)													
>4≤11	>11≤18	>4≤11	>11≤18	>4≤11	>11≤18	>4≤11	>11≤18	>4≤11	>11≤18	>4≤11	>11≤18	>4≤11	>11≤18
(Feet)													
25	90	30	105	35	120	40	135	50	150	55	165	60	180

Conclusion and Recommendations

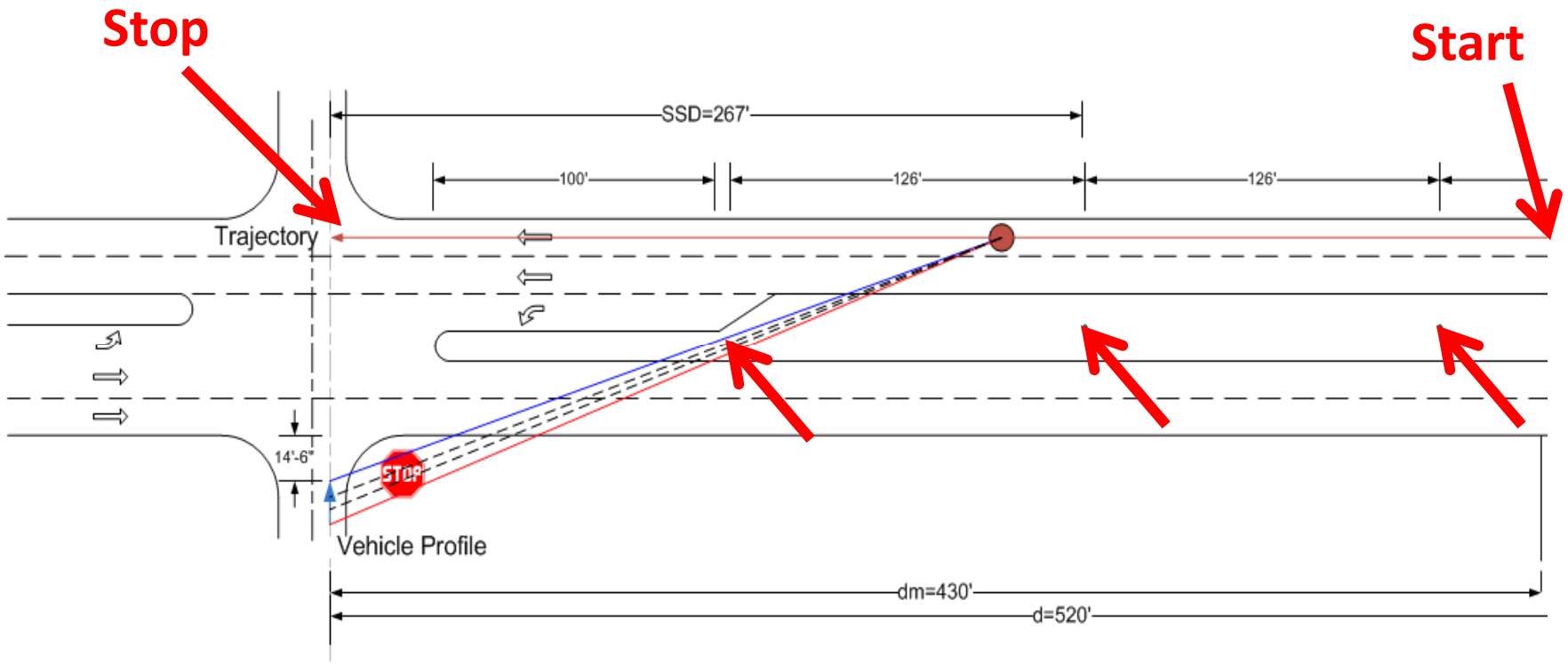
- Visibility Simulator Tools
  - Computational Tool
    - Evaluate visibility
    - More flexibility in the design of landscaping configurations
      - Change intersection plan views
      - Change tree spacing and configuration
      - Design Speeds
      - Vehicle path
    - Simulation
      - Measures performance
      - Output file

Conclusion and Recommendations



Conclusion and Recommendations

- Base Scenario in Visibility Simulator



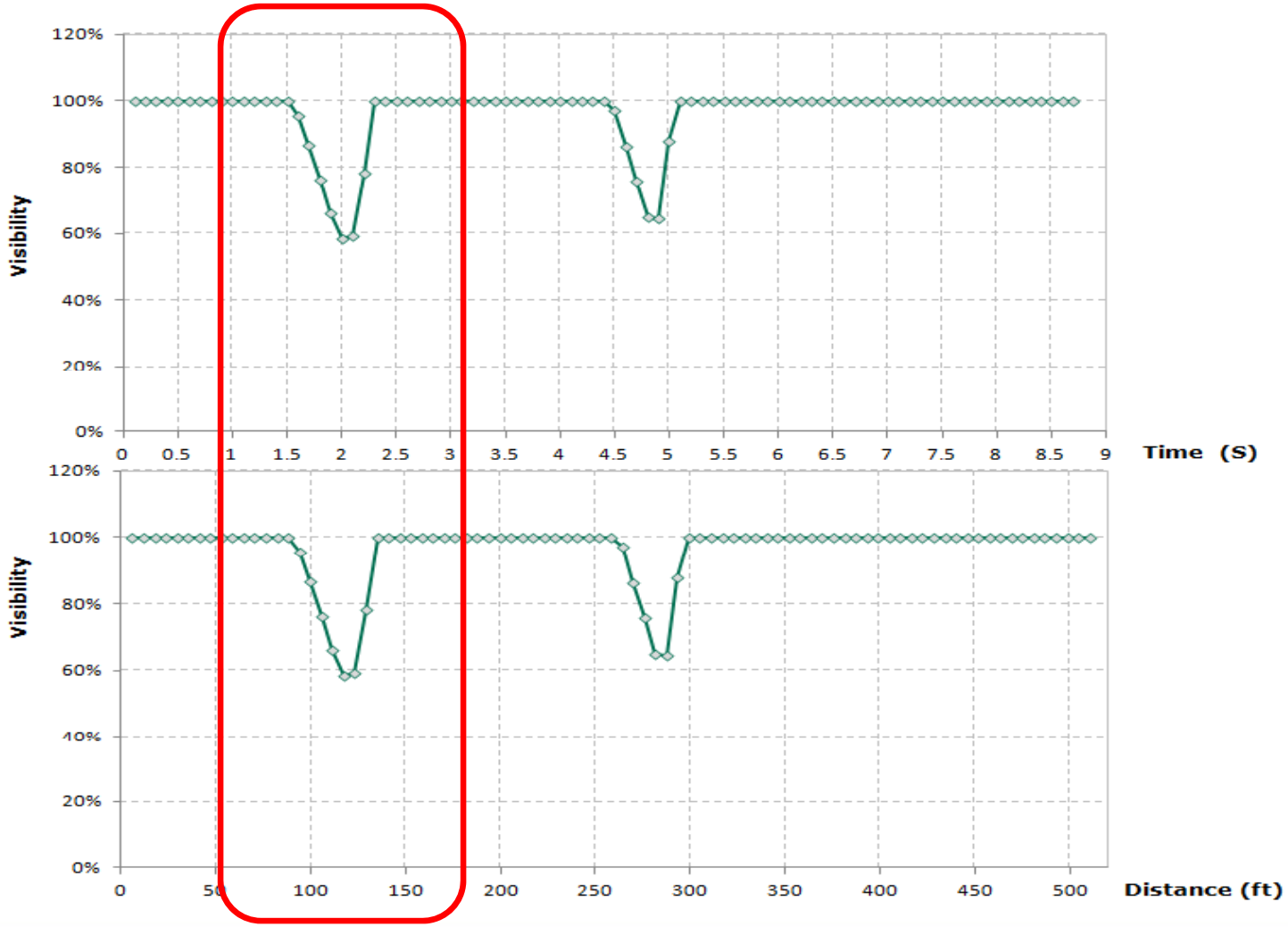
Conclusion and Recommendations

- Simulation Results for Baseline Scenario

Time	Distance	Visibility
8.7	510.4	100%

	Average Visibilty	Unobstructed Visibility Time	Max Unobstructed Visibility Time
Total	96.51%	7.3	3.7
Before Threshold Distance	95.81%	3.5	2

- Visibility Profile for the Baseline Scenario



Conclusion and Recommendations

- Research Completed in September 2013
  - Validating Index 546
    - Tree Spacing Table (Sheet 1 of 6)
    - Sight Distance Tables (Sheets 2 through 6)
  - Recommended Setback from median nose
    - 120 feet for DS < 50 mph
    - 200 feet for DS $\geq$ 50 mph

Summary

- Design Standard Index 546 Sight Distance at Intersections
  - Landscaping of Highway Medians at Intersections Research
    - Need for Research
      - Validation of current criteria
      - Recommended changes
    - Research Objectives and Methodology
      - Reviewed current landscaping criteria
      - Provided a computational procedure to analyze landscaping configurations
      - Performed an empirical study on the safety performance of Standard Index 546

Summary

- Conclusion and Recommendations
  - Visibility Simulator Tool
    - » Handles flexibility in design of landscaped configurations
    - » May be available in the future for design of medians with trees
  - Tables have been revised
    - » Tree spacing
    - » Sight Distance
  - Setbacks for medians have been updated
    - » 120 feet for DS < 50 mph
    - » 200 feet for DS $\geq$ 50 mph

Summary

- Landscaping at Roundabouts

Summary

- Tree Maintenance Concerns

Summary

- Index 546 Compliance

Thank You!

- **Archive at www.pedbikeinfo.org/webinars**
  - Downloadable/streaming recording and presentation slides
- **Questions?**
  webinars@hsrc.unc.edu

Roadside Landscaping and Safety

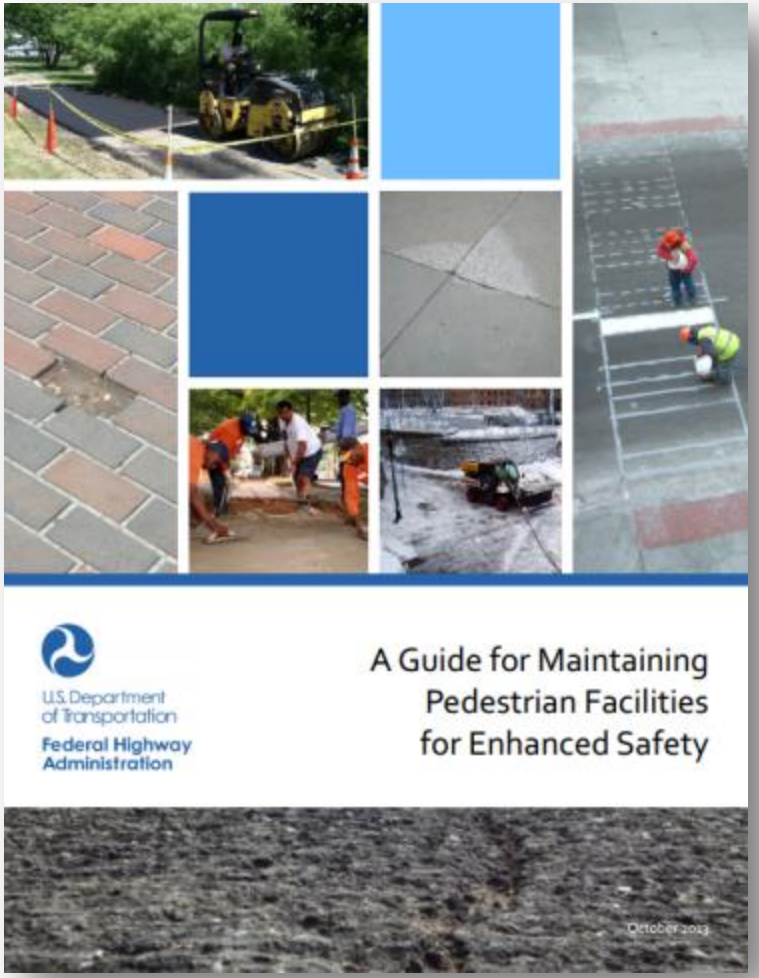
ADDITIONAL RESOURCES

Guide for Maintaining Pedestrian Facilities for Enhanced Safety

Released by FHWA in 2013

Chapter 6.6 focuses on street trees, specifically:

- Soil selection and volume
- Tree pit recommendations
- Selecting tree types
- Tree placement



Available at:

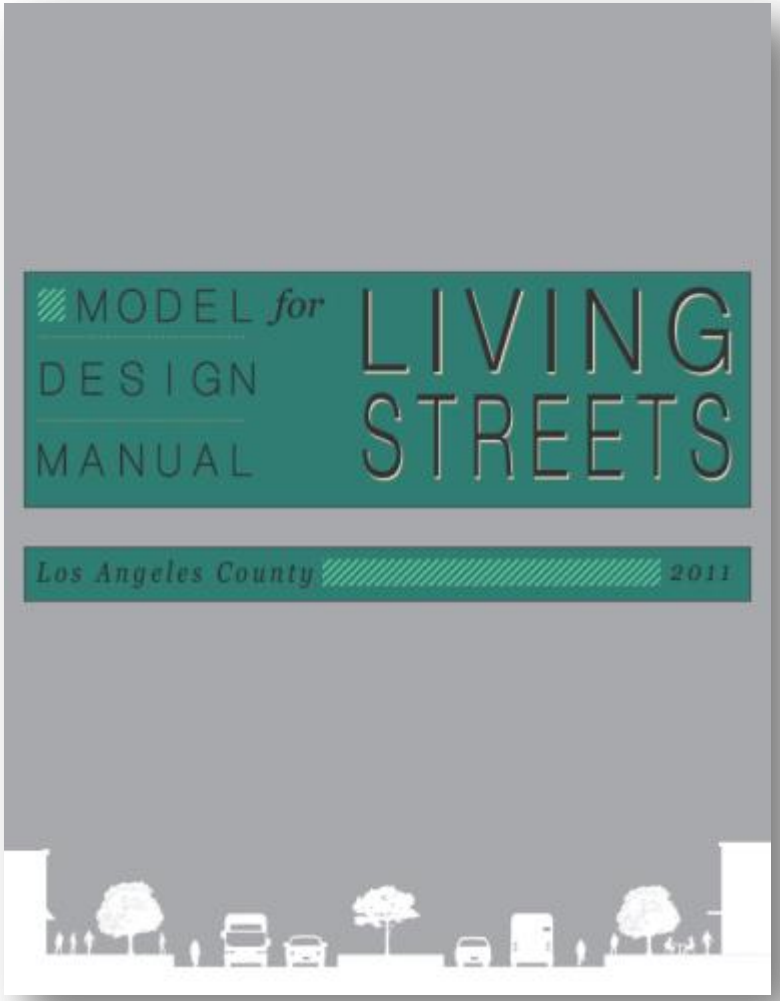
http://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa13037/fhwasa13037.pdf

Model Design Manual for Living Streets

Developed for the LA County Dept of Public Health in 2011

Chapter 11 addresses the Streetscape Ecosystem, including recommendations for:

- Planting sites
- Climate and soil
- Species selection
- Tree spacing and lighting

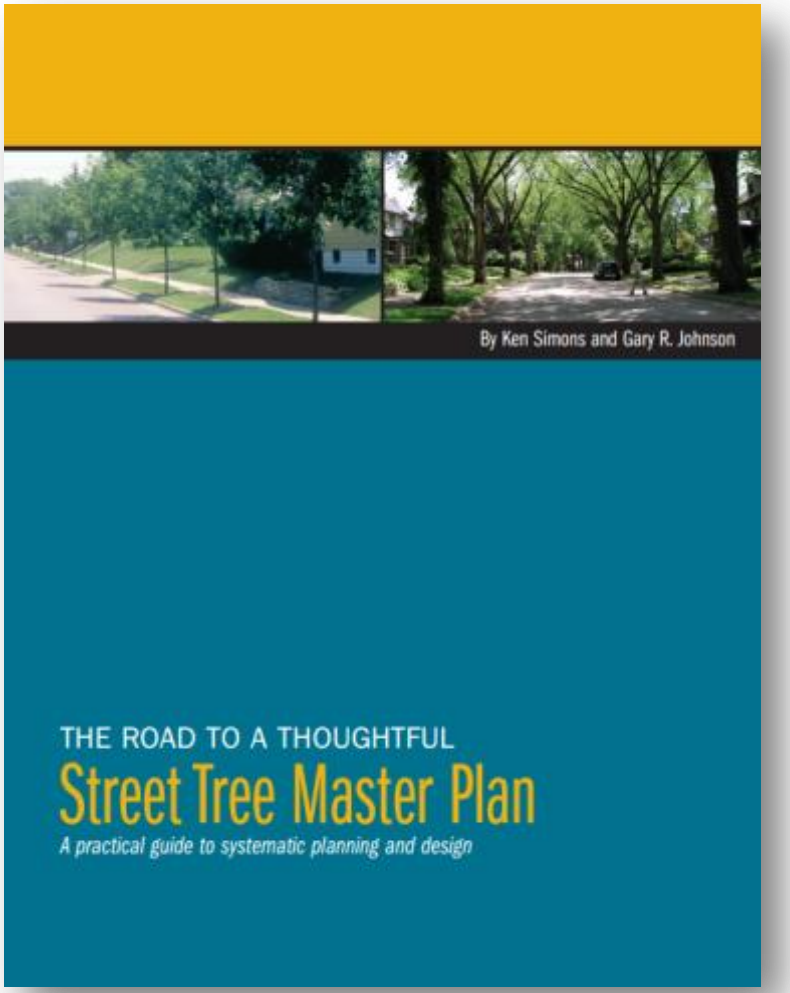


Available at:
www.modelstreetdesignmanual.com/

Road to a Thoughtful Street Tree Master Plan

Developed for the Minnesota Local Roads Research Board

Provides local officials, engineers, planners and landscape architects with a guide for developing a master plan for street trees.



Available at:

http://www.myminnesotawoods.umn.edu/wp-content/uploads/2008/12/Street-Tree-Manual.REVISED_20082.pdf

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