Eric Dumbaugh | CNU | May 17th, 2007

Effective Roadside Treatments and Traffic Safety:

A Contextual Perspective

Roadside Safety: Currently Unresolved in the CNU/ITE Manual

“Safe”

Palm Beach Gardens, FL

“Livable”

Leesburg, FL

Roadside Safety

- **Roadside Safety**
  - Roughly **12,000** fatal crashes, and **190,000** injury crashes associated with fixed-objects each year (FARS; GES)
  - Current practice encourages the provision of clear runout zones

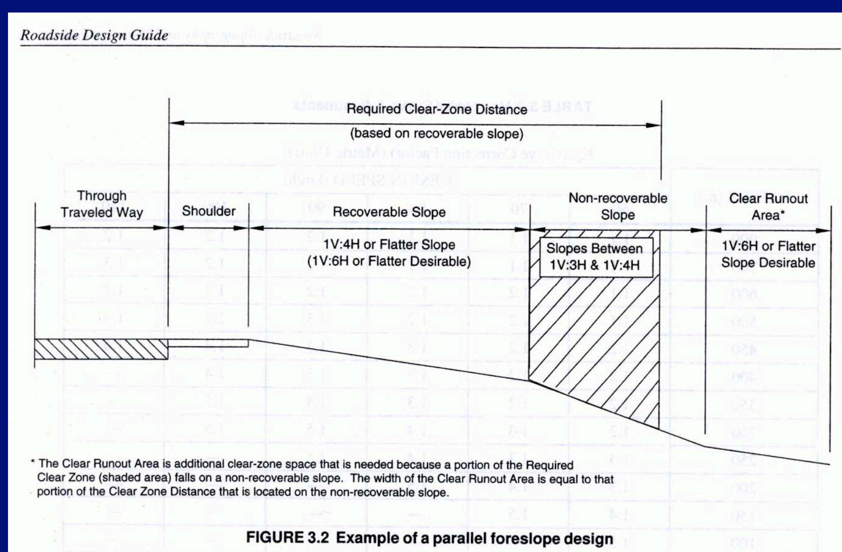


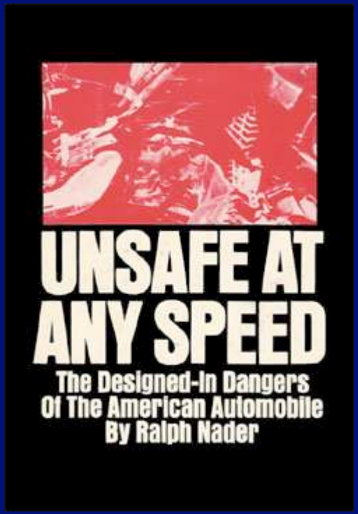
FIGURE 3.2 Example of a parallel foreslope design

Clear Zone Specifications (AASHTO, 2002)

Overview

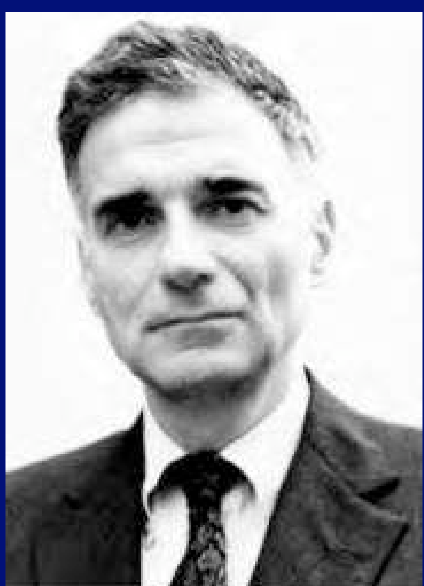
1. The current approach to addressing traffic safety.
2. Considering the evidence on safe roadside design.
3. Understanding the basis of roadside crashes – and strategies for eliminating them.
4. Future Safety Directions for CNU.

Historical Prelude: Why We Address Safety the Way We Currently Do…



- 1965: "Unsafe at Any Speed"
  - "Epidemic on the Highways"
  - Apply principles of epidemiology to address the "designed-in" dangers of vehicles and roadways.
    - Specifically: eliminate environmental sources of injuries and fatalities.
- 1966: Senate/AASHO Highway Safety Hearings
  - Interstates reported fewer crashes than other roadway types.
  - Safety performance attributed to the use of high design values.
    - "Forgiving to error"
  - Resulted in the conclusion that the use of high design values for design speeds, offsets and clear zones enhances safety.

Highway Safety Hearings of 1966



Even if people have accidents, even if they make mistakes, even if they are looking out a window, or they are drunk, we should have a second line of defense for these people… the sequence of events that leads to an accident injury can be broken by engineering countermeasures even before there is a complete understanding of the causal chain.

Highway Safety Hearings of 1966

What we must do is to operate the 90% or more of our surface streets just as we do our freeways… [converting] the surface highway and street network to freeway road and roadside conditions."

Kenneth A. Stonex

Addressing Safety…

"Highways built with high design standards put the traveler in an environment which is fundamentally safer because it is more likely to compensate for the driving errors he ***will*** eventually make."

- AASHTO, 1974

The epidemiological Idea has been carried forward to the AASHTO “Green Book”

“Every effort should be made to use as high a design speed as practical to attain a desired degree of safety.”

- AASHTO, 2001

The Passive Safety Paradigm

Tenets of Passive Safety:

1. Drivers will err, make mistakes, and engage in behaviors that result in crashes and injuries.
2. Driver errors are random and unpreventable.
3. The best strategy for addressing driver errors is to ensure that all roadways are "forgiving" to such errors when they (inevitably) occur.

Passive Safety

Logical Conclusion: Enhance Safety by Widening Shoulders and Clear Zones…

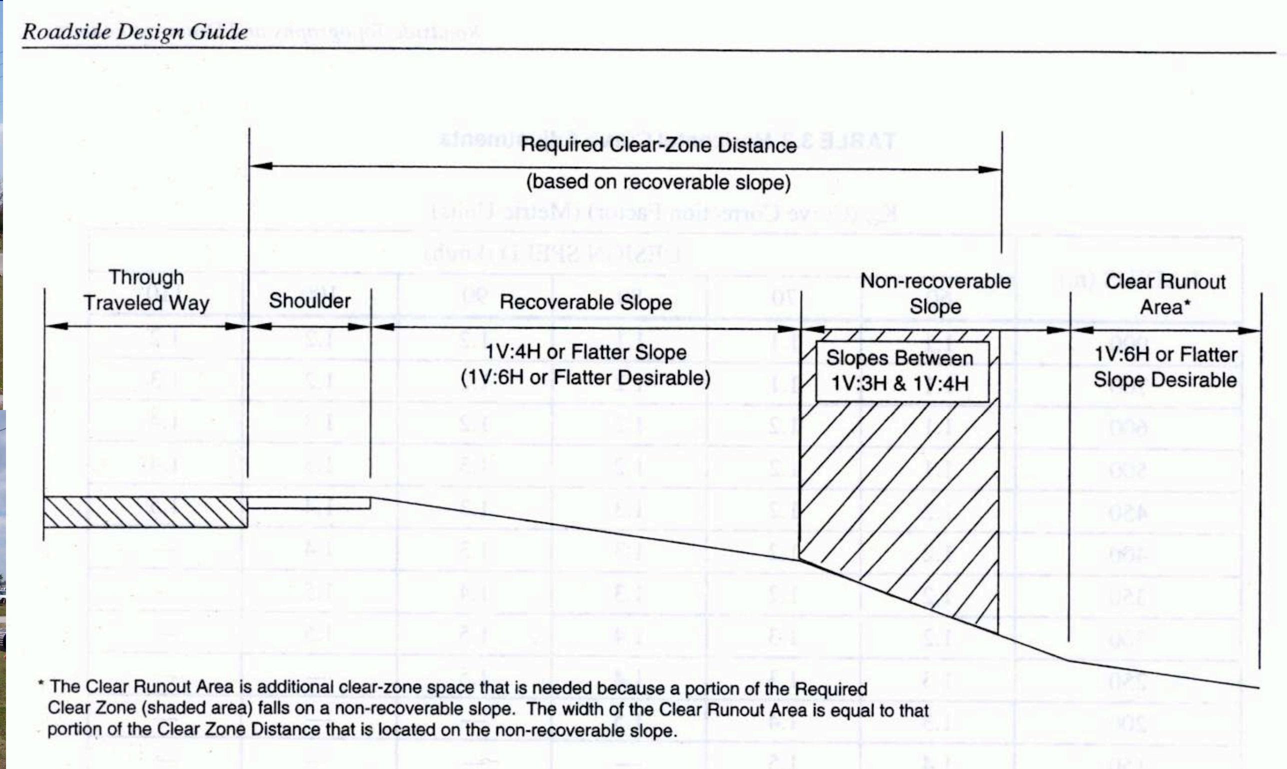
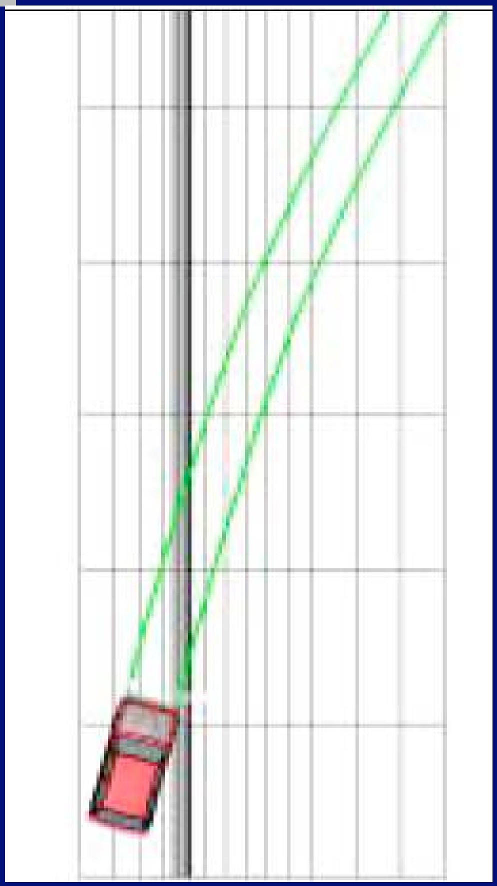


FIGURE 3.2 Example of a parallel foreslope design

Why do Roadside Crashes Occur?



Presumed Roadside Encroachment Pattern

- Presumption is that run-off-roadway events are *random* and *unpreventable*.
- If so, then rates of run-off-roadway events should be relatively constant.
  - This is what is currently assumed in safety applications such as the ROADSIDE program.
- Studies of two-lane, rural roads support this conclusion…

But what about urban areas?

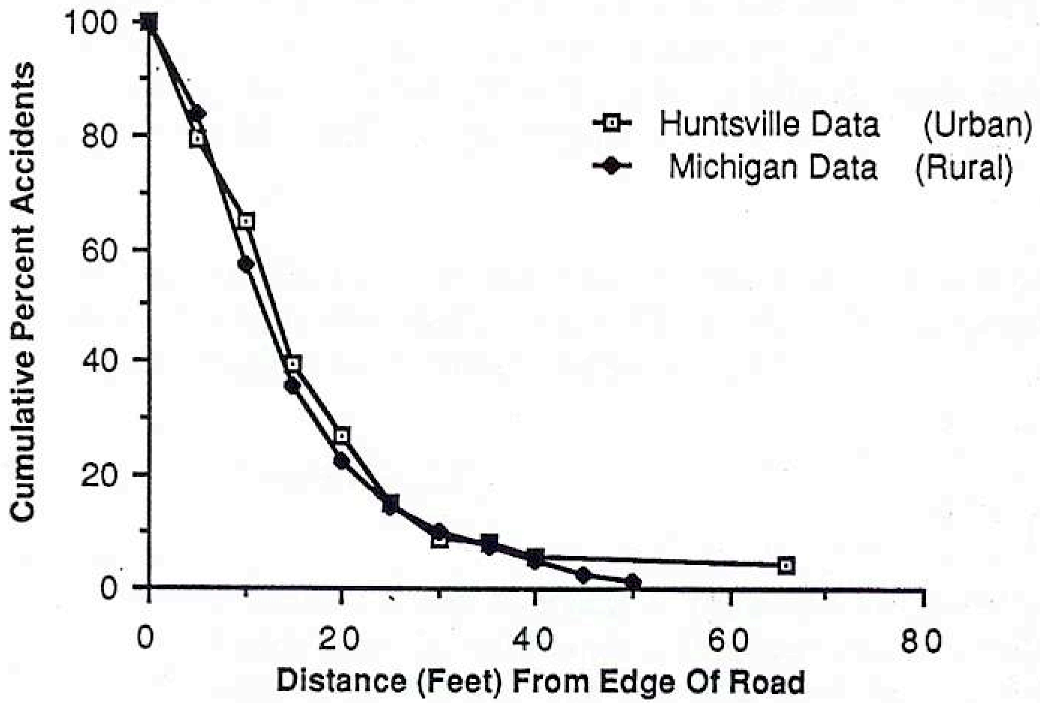


FIG. 8. Lateral Clearance to Trees

Source: Turner and Mansfield, 1990

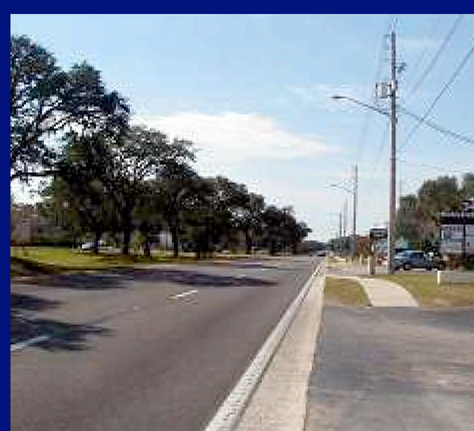
<u>The Evidence:</u>

The majority of urban tree-related crashes occur on roadways with offsets of 30 feet or less.

Study Conclusion:
30 ft clear zones in urban areas are desirable for safety.



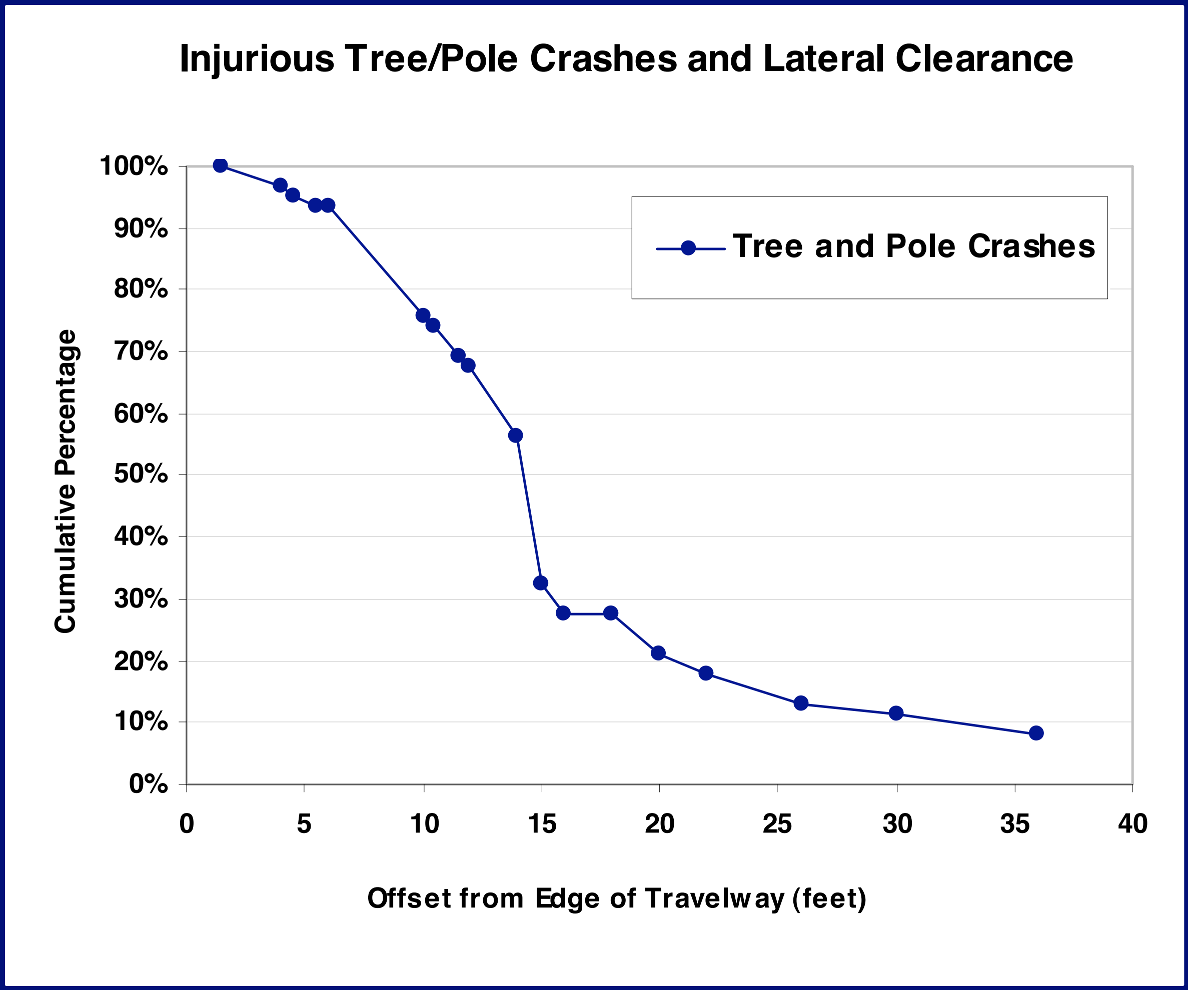


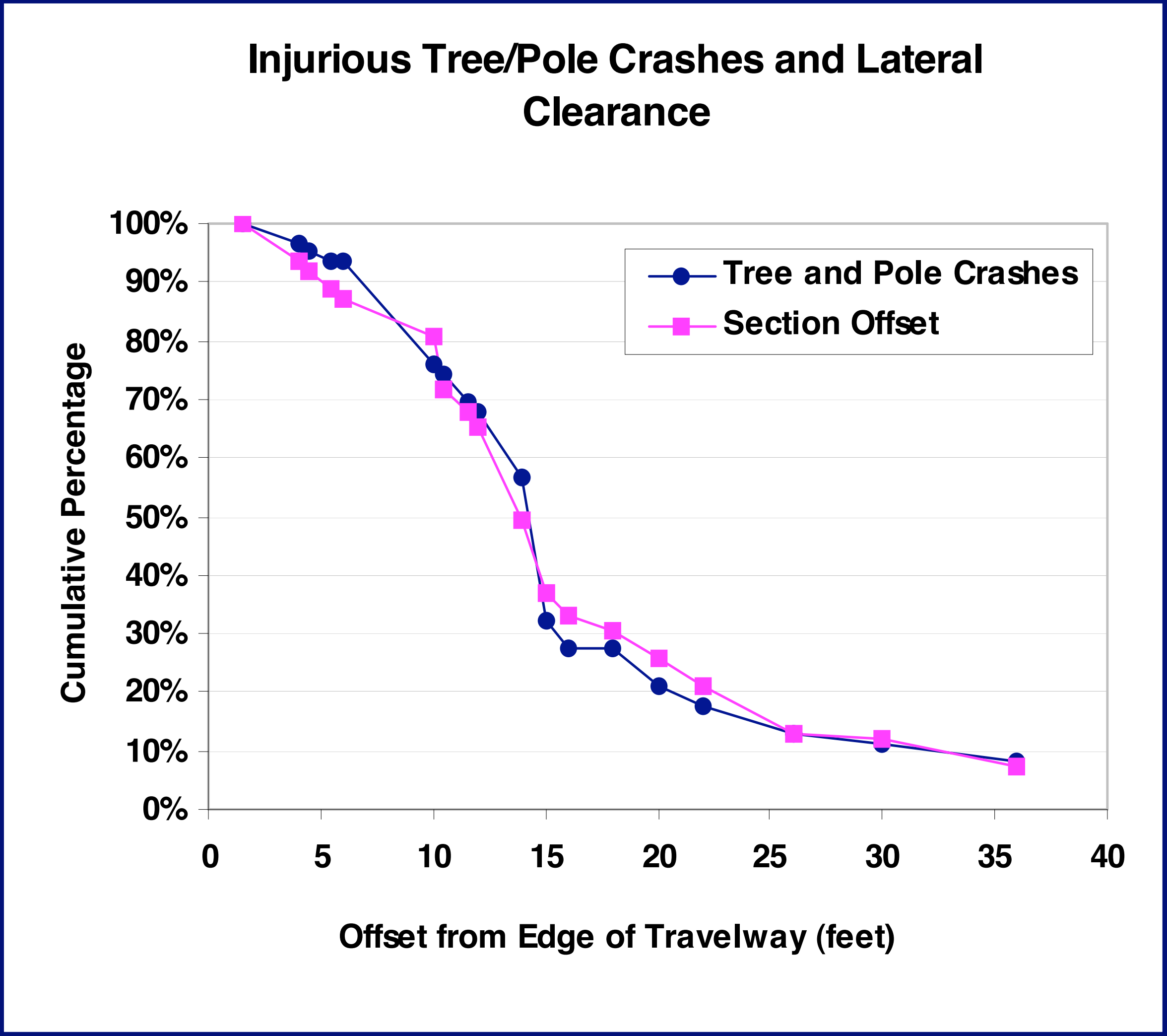
A second opinion…

- Examined entire lengths of arterials traversing urbanized areas three small metro regions.
- Substantial design variation:
  - Pedestrian-oriented “livable” streetscape in downtown core.
  - Conventional suburban.
  - Suburban/rural transition.

Re-Examining Roadside Statistics…



Crash Probability Roughly Constant



Which enhances safety most in urban areas?

- **<u>Negative Binomial Models</u>**

- **Test the safety effects of:**
  - Paved Shoulder Width
  - Unpaved Fixed Object Offset
  - "Livable Street" Dummy Variable

- **While controlling for:**
  - ADT
  - Posted Speed Limit
  - Number of Lanes
  - Lane Width
  - Median Width

Defining Safety

- To be a “safe” roadside treatment…
  - ***Must*** be associated with fewer roadside crashes, and;
  - ***Must not*** be associated with an increase on other crash types that would offset these reductions (e.g., multiple-vehicle crashes or vehicle pedestrian crashes).
  - Consider both total and injurious crashes, since their incidence may be different.
    - From a safety perspective, it is injurious crashes that we care about.

Model Results: Paved Shoulders

Wider shoulders are consistently associated with ***increases*** (though not at statistically-significant levels) in roadside and midblock crashes.

Measure	Coefficient	Z	95% Confidence Interval	
Total Roadside Crashes	0.055	0.85	-0.072	0.181
Injurious Roadside Crashes	0.081	0.92	-0.092	0.253
Total Midblock Crashes	0.004	0.09	-0.07	0.076
Injurious Midblock Crashes	0.055	1.39	-0.023	0.132

Model Results: Fixed Object Offsets

Wider fixed object offsets are associated with ***decreases*** in fixed-object crashes, but have ***no effect*** on midblock crashes.

Measure	Coefficient	Z	95% Confidence Interval	
Total Roadside Crashes	-0.038	-1.51	-0.088	0.011
Injurious Roadside Crashes	-0.053	-1.65	-0.118	0.011
Total Midblock Crashes	0.003	0.24	-0.024	0.031
Injurious Midblock Crashes	0.001	-0.05	-0.029	0.028

Model Results: Livable Streets

Livable street treatments are consistently associated with ***decreases*** in both fixed-object and midblock crashes.

Measure	Coefficient	Z	95% Confidence Interval	
Total Roadside Crashes	-1.533	-2.33	-2.824	-0.241
Injurious Roadside Crashes	-2.020	-1.75	-4.285	0.245
Total Midblock Crashes	-0.650	-1.66	-1.416	0.116
Injurious Midblock Crashes	-0.526	-1.28	-1.329	0.278

How much safer are livable streets?

- Per vehicle mile traveled, the livable streets reported:
  - 40% fewer midblock crashes than roadway averages.
  - 67% fewer roadside crashes than roadway averages.

How much safer are livable streets?

- ***Further:***
  - Not a single injurious fixed object-related crash occurred on the livable sections during the 5-year analysis period
  - Nor was there a single traffic fatality involving either a pedestrian ***or*** a motorist.

Corroborating Research…

- **Ivan, Pasupathy and Ossenbruggen (1999)**
  - Widening shoulders decreases roadside crashes, but increases multiple vehicle crashes.
- **Lee and Mannering (1999; 2001)**
  - Trees and other fixed objects adjacent to the ROW decreases fixed object crash frequency.
- **Ossenbruggen, Pendharkar, and Ivan (2001)**
  - "Urban village" streetscape treatments report fewer crashes than suburban treatments.
- **Naderi (2003)**
  - Aesthetic streetscape improvements reduce midblock crashes.
- **Noland and Oh (2004)**
  - Widening shoulders decreases total crashes, but increases fatal one.

The Problem with Paradigms…

- **Lee and Mannering (1999):**
  - “The results show that run-off-roadway frequencies and severities can be reduced by widening lanes, bridges and shoulders [and] relocating roadside fixed objects.”

Actual Research Results…

Variable	Coefficients	t-statistic
Broad lane indicator (1 if lane is greater than 12 feet, 0 otherwise)	1.684	3.984
Number of isolated trees in a section	-0.093	-1.857
Number of miscellaneous fixed objects in a section)	-0.094	-2.140

Lee and Mannering (1999)

How do we account for these "anomalous" findings?

Representative Urban Fixed-Object Crash

- **<u>Novel Idea:</u>** Examine crash locations.
- **<u>83%</u>** of tree and pole crashes occurred behind an intersection or driveway on higher-speed roadway sections.

Anatomy of an Urban Roadside Crash

Representative Urban Fixed-Object Crash

Systematic Pattern:

- Higher operating speeds along primary arterial
- Attempt to turn onto a driveway or side street at higher speeds.
- Higher-speed turn results in vehicle leaving the travelway behind the side street.

Random vs. Systematic Error

- ***Random Error*** is error that naturally occurs as a result of human fallibility.
  - Humans will err, and a roadway should be “forgiving” when they do.
  - Assumes error is constant and fixed.
  - Strives for a single, “fail-safe” design solution.

- ***Systematic Error*** is a design problem that results from mismatches in the interaction between people and their environment.
  - Recognizes that designs may ***produce*** error.
  - Systematic error occurs when a roadway encourages inappropriate expectations regarding safe operating behavior.
  - Focuses on understanding and addressing unsafe driver behavior, rather than attempting to engineer “fail-safe” designs.

Rethinking Urban Road Safety

- A safe design is one that eliminates systematic error while simultaneously reducing the consequences of random error.
- Two strategies for addressing urban roadside safety:
    1. The Interstate Approach
    2. The Livable Street Approach

1. The Interstate Approach

Interstate Design

- **Random error addressed through "forgiving" design**.
- **Systematic error minimized *by design***:
  - Limited access, with few opportunities for turning maneuvers.
  - Where turns permitted, they are accompanied by ramps that allow for gradual deceleration.

Limited-Access Surface Arterials are OK From a Safety Perspective…

- Similar design solution appropriate on urban arterials where access-management principles are fully applied.
- Similar characteristics:
  - Higher speeds
  - Few driveways and side streets.
  - Deceleration lanes.

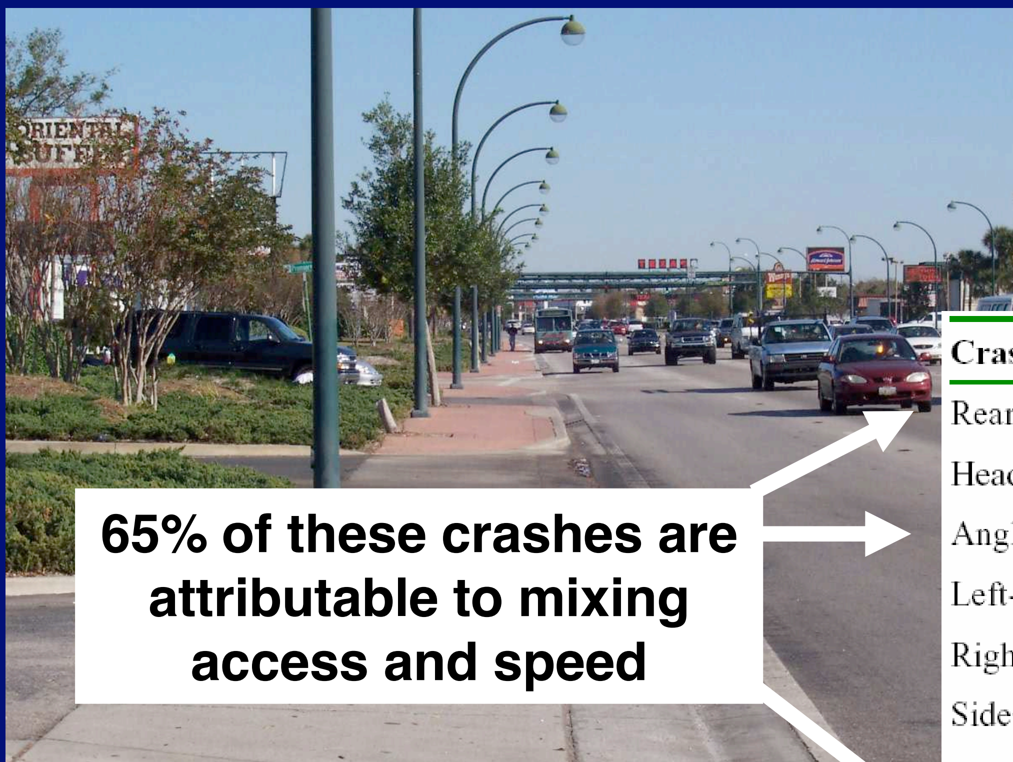
"Access Management"

The Problem: Mixing Speed and Access

A "Suburban" Arterial: Orange Blossom Trail

	Crashes per 100 MVMT		
	Livable Streets (Avg)	OBT	Ratio OBT/Livable
Total Roadside	3.3	12.1	3.7
Injurious Roadside	0	5.3	NA
Total Midblock	23.1	102.2	4.4
Injurious Midblock	18.1	64.6	3.6

The Problem: Mixing Speed and Access

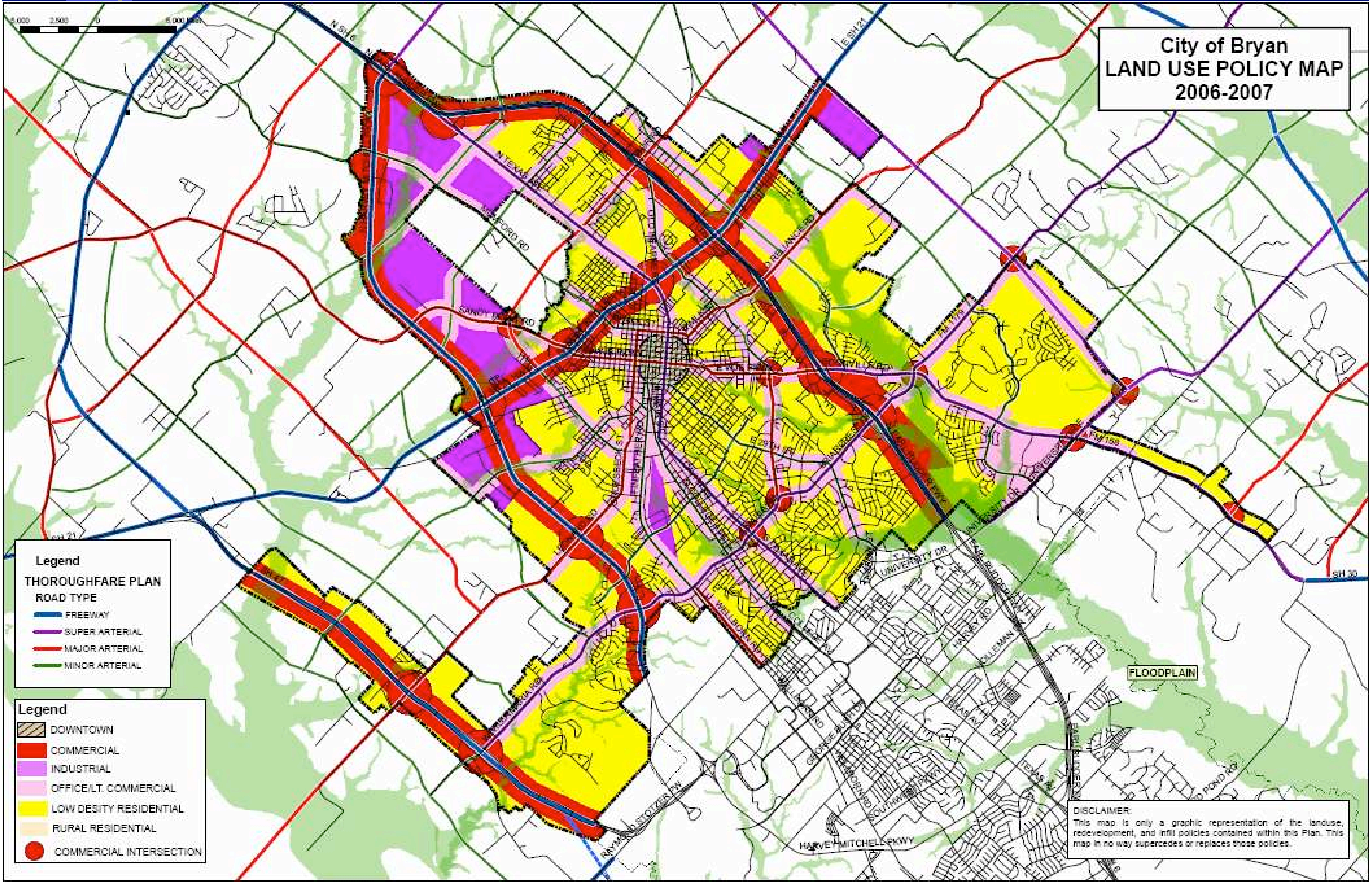


A "Suburban" Arterial: Orange Blossom Trail

65% of these crashes are attributable to mixing access and speed

Crash Type	Count	Percent
Rear-End	188	46.4%
Head-On	6	1.5%
Angle	52	12.8%
Left-Turn	5	1.2%
Right-Turn	1	0.2%
Sideswipe	63	15.6%
Pedestrian/Bicyclist	24	5.9%
Roadside	23	5.7%
Other/System Missing	43	10.6%
Total	**405**	**100.0%**

Don’t Blame the Engineers…



2. The Livable Street Approach

- "Unforgiving" by design:
  - But roadside hazards are obvious and expected, resulting in behavioral compensations from drivers.
- Systematic error substantially reduced:
  - Turning movements safely accommodated because of lower operating speeds.
- Minimizes the consequences of random error:
  - Lower speeds result in less severe crashes when they occur.
  - Lower speeds equate to reduced stopping sight distance, and thus reduced crash frequency.

2. The Livable Street Approach

Case Illustration: Woodland Blvd

5-Year Totals:

- 0 Roadside Crashes
- 4 Injurious Midblock Crashes
- 0 Fatalities

Considerations for CNU

Claim the Safety Issue

- Treat traffic safety as a ***guiding principle***, not as a barrier to be overcome.
  - Too much of the safety debate is focused on “pedestrians vs. motorists.”
  - Even the Transportation Research Board has acknowledged that the engineering profession has abdicated leadership on road safety. Who will champion this issue? Why not CNU?
  - Many safety issues are also urban design issues – on which CNU would have much to say.

U.S. vs. Peer Comparisons

- In **1965**, only Britain surpassed the US in terms of safety
- Currently, U.S. ranks behind **all** other developed countries

Road Traffic Fatalities (2000)	
Country or Area	**Per 100,000 Inhabitants**
Australia	9.5
European Union*	11
Great Britain	5.9
Japan	8.2
Netherlands	6.8
Sweden	6.7
United States	**15.2**

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom

Source: World Health Organization

We're Not Safer When Adjusting for VMT, Either.

TABLE 1: Comparative Fatality Rates per Billion Vehicle-Kilometers Traveled

Country	Rate	Year
Australia	8.0	2003
Canada	8.9	2003
Finland	7.6	2003
Netherlands	7.7	2003
Norway	8.3	2002
Sweden	7.5	2002
Switzerland	8.8	2003
United Kingdom	7.2	2001
United States	9.1	2003

Peer Comparisons

- Reduction in annual traffic fatalities if US safety performance had paralleled safety trends in peer countries:

  Canada: 13,718 fewer deaths – ***32% reduction***

  Britain: 16,695 fewer deaths – ***39% reduction***

  Australia: 20,426 fewer deaths – ***48% reduction***

Adapted from Evans, 2004

European Design Guidelines:
Safe, Mobile Where Appropriate, and Livable.

Step 3

road surroundings	without buildings concentration: low or zero		with buildings concentration: high		
relevant design function	mobility (connector)			access (collector)	local, ped. use
Category Group	A	B	C	D	E

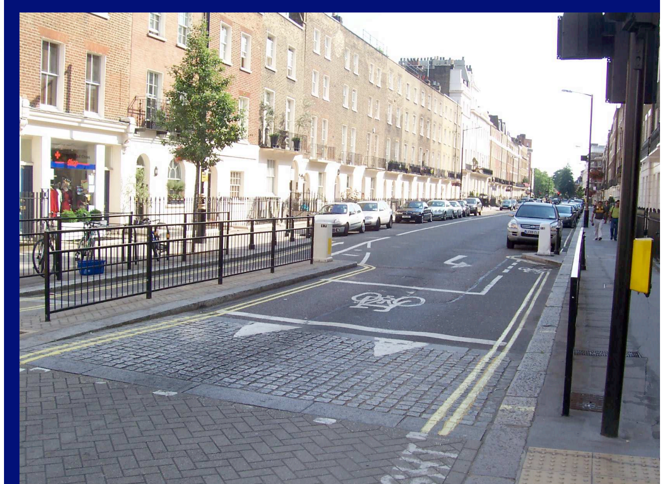
Step 4

Connector Functional Levels for Road Categories A I to AV		Road Categories					
Statewide or Interstate Connection	I	A I	B I	C I		
Overregional/Regional Connection	II	A II	B II	C II	D II	
Connection between Municipalities	III	A III	B III	C III	D III	E III
Area Accessibility Connection	IV	A IV	B IV	C IV	D IV	E IV
Subordinate Connection	V	A V	-	-	D V	E V
Agricultural Sideroad	VI	A VI	-	-	-	E VI

Acceptable
Problematic
Very Problematic
Not Justifiable

Step 5

	Road Category	Travel Speed Range [km/h]
	A I A II A III A IV A V A VI	70 - 100 60 - 90 50 - 80 40 - 60 NO NO
Primary Arterial Secondary Arterial Main Collector	B II B III B IV	50 - 70 40 - 60 30 - 50
Primary / Secondary Arterial Main Collector	C III C IV	30 - 50 30 - 40
Collector Local	D IV D V	20 - 30 NO
Local Pedestrian Use	E V E VI	NO NO



Questions?