Can Traffic Signs Be Too Bright on Low-Volume Roads?

Paul J Carlson, PhD., PE

Originally Presented at TRB’s 11th International Conference on Low-Volume Roads
Can signs along rural roadways be too bright?
  - Glare
  - Distraction
  - Legibility

If so, develop guidelines for sign sheeting materials
Background

• MUTCD minimum retroreflectivity levels
• Ample research to support minimum nighttime driver needs
• Additional research exists for sign sheeting selection for guide signs
• Practically no research on sign sheeting selection for rural roads
High-Beam Usage

- High Beam Use
- Vehicles per Hour

(Vehicles per Hour (ADT))

- (2,500)
- (10,000)

Texas Site Data (2012)
Hare & Hemion Equation (1968)
Hare & Hemion Extrapolation (1968)
Study Design

• **Metrics**
  – Legibility
  – Detection distance

• **2 Materials**
  – Type III
  – Type XI

• **Participants**
  – 12 Old (>60 yrs)
  – 11 Young (<36 yrs)

• **3 Targets**
Detection Distance Results

- Almost 1200 observations
  - 381 pedestrian
  - 404 wood square
  - 393 deer
Detection Distance by Age

Drivers' age group - Object Type

<table>
<thead>
<tr>
<th>Drivers' age group</th>
<th>Object Type</th>
<th>Detection Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>young</td>
<td>DEER</td>
<td>~350</td>
</tr>
<tr>
<td>old</td>
<td>PED</td>
<td>~300</td>
</tr>
<tr>
<td>young</td>
<td>WOOD</td>
<td>~250</td>
</tr>
<tr>
<td>old</td>
<td></td>
<td>~200</td>
</tr>
</tbody>
</table>
Average Detection Distances

- **No sign present**: 371 ft
- **Type III sign**: 302 ft
- **Type XI sign**: 258 ft

**Detection Distance (ft)***
Legibility Results

- Over 1100 observations
  - 567 Type III material
  - 563 Type XI material

Legibility Distance (ft)

- Type III sign: 444 ft
- Type XI sign: 432 ft
Conclusions

• Can signs be too bright?
  – Legibility
    • Maybe
    • LED signs
  – Detection distance
    • Yes
Recommendations

• Avoid unnecessary signs because of glare, maintenance, potential hazards, disrespect for TCDs in general

• For rural highways with ADT < 5000 vpd:
  – Use Type III or IV for Regulatory and Warning signs
  – No Type III or IV available in fluorescent colors, so use Type VIII, IX, or XI (sparingly)
Questions

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Greg Schertz, Federal Lands Highway
Michael Chacon, Texas DOT
Cost-Effective Safety Treatment of Trees on Low-Volume Rural Roads

Lechtenberg, Stolle, and Faller
Midwest Roadside Safety Facility
University of Nebraska-Lincoln

Schrum
University of Alabama-Birmingham

TRB Webinar
Safety on Low-Volume Roads
November 2016
Background

- Naturally occurring roadside fixed objects
- 8% all traffic-related fatal crashes (FARS 1999-2009)
- 90% tree impact fatalities located on 2-lane roadways (FARS 1999-2009)
- 30% fatalities occur on low-volume roads (FARS 1999-2009)
- 26% fixed-object fatal crashes (FARS 2009)
Available Guidance

- **AASHTO RDG**
  - Extrapolated from high-speed/high-volume
  - Remove from clear zone

- **AASHTO Guidelines for Geometric Design of Very Low Volume Local Roads**
  - ADT < 400 vpd
  - Documentable accident history

- **NCHRP 500 Vol. 3**
  - Prevent tree growth
  - Eliminate hazard or reduce severity
Problem Statement/Objective

- Roadside trees are dangerous
- Limited safety improvement funds
- No proven methodology
- Need to determine benefit-cost of treating trees on roadways:
  - Less than 500 vpd
  - Posted speed limits ≥ 55 mph
  - Full range of impact speeds in RSAP
Field Investigation

- KDOT typical low-volume roadways
- High frequency of roadside trees observed
- Collected data
  - Arrangements: individual, clusters/groups
  - Tree diameter
  - Cluster dimensions
  - Offset from roadway
  - Widths: roadway, shoulder, travel-way
Road Geometry Modeling

- Rural local road
- Simulated straight, level roadways
  - Conservative
  - Applicable to vertical grades and horizontal curves
- Lane width = 12 ft
Tree Geometry Modeling

- Tree profiles
- Tree offset
- Tree spacing
Tree Profiles

- Predefined tree sizes in RSAP
- Dia. > 4 in. considered rigid fixed object (RDG)
- Dia. ≤ 4 in. reduced fatality probability
- Selected sizes representative of range of larger tree
Tree Offset

- Lateral offset from travel-way to traffic-side of tree trunk
- User specified value in RSAP
- Not responsible beyond clear zone (CZ)
Tree Spacing

- Potential vehicle run-off-road trajectories help determine maximum tree spacing
- $S > 40$ ft allows vehicles to pass, more representative of individual trees
- Close spacing = worst-case tree density
Safety Treatment Options

- **Simulated**
  - “Do nothing” – baseline
  - Tree removal
  - Install longitudinal barrier

- **Other Options**
  - Delineation
  - Edge treatments
Delineation and Edge Treatments

- **Delineation**
  - Only warn, do not shield
  - Densely-forested areas where removal is difficult or not cost-effective

- **Edge treatment**
  - Require paved roadway
  - Common practice min. 400 ADT for rumble strip application

- **Difficult to evaluate in RSAP**
Install Longitudinal Barrier

- High installation costs
  - $18.16/lf plus terminal
  - $45/lf plus terminal

- Viable situations
  - Very long sections of close spaced trees
  - Difficult tree removal
  - Regular new tree growth

- Scenarios evaluated not cost effective
Tree Removal

- Costs from tree removal experts, county forestry commissioners, & county engineers
- Multiple tree removal costs conservative
  - Based on removal of 1 tree
- Upper bound costs = less safety benefit but leave more trees
<table>
<thead>
<tr>
<th>ADT</th>
<th>No. of Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-99</td>
<td>1</td>
</tr>
<tr>
<td>100-199</td>
<td>2-10</td>
</tr>
<tr>
<td>200-299</td>
<td>11-25</td>
</tr>
<tr>
<td>300-399</td>
<td>&gt;25</td>
</tr>
<tr>
<td>400-500</td>
<td>Tree Diameter, Spacing, and Offset Dependent Remove Tree(s)</td>
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</tbody>
</table>
Tree Removal, B/C = 4

<table>
<thead>
<tr>
<th>ADT</th>
<th>No. of Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>0-99</td>
<td>2-10</td>
</tr>
<tr>
<td>100-199</td>
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<td>200-299</td>
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</tr>
<tr>
<td>300-399</td>
<td></td>
</tr>
<tr>
<td>400-500</td>
<td></td>
</tr>
</tbody>
</table>

Tree Diameter, Spacing, and Offset Dependent
Remove Tree(s)
Summary and Conclusions

- Shielding trees
- Tree removal cost-effective treatment
- B/C ratios determined by RSAP and used to make tree removal recommendations
- All cases: B/C ratios > 1.0
  - No safety benefit to leaving trees in place
**Recommendations**

- Engineer encouraged to use guidelines as foundation
- Restricted removal
  - Delineation
  - Edge treatments
  - Install barrier
- Applicable to higher-volume, higher-speed roadways
Acknowledgements

- Midwest States Pooled Fund Program – research funding
- KDOT and Marshall County Officials – field investigation locations
An Inexpensive Retroreflectivity Field Inspection Kit

David P. Orr, PE, PhD
Geoffrey Scott, PE
Cornell University Local Roads Program
Brightness
Retroreflectivity
### New MUTCD Table 2A.3

**Which Sheeting is Allowable (Ground Mounted Only)**

<table>
<thead>
<tr>
<th>Colors</th>
<th>Beaded Sheeting</th>
<th>Prismatic Sheeting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Engineer</td>
<td>Super Eng.</td>
</tr>
<tr>
<td>E MAIN ST</td>
<td><img src="#" alt="Yellow" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td><img src="#" alt="Left Turn" /> <img src="#" alt="Pedestrian" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td><img src="#" alt="Stop" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td><img src="#" alt="Speed Limit 55" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
</tbody>
</table>
Allowable Methods

- Nighttime - calibrated sign
- Nighttime - comparison panels
- Nighttime - consistent parameters
- Measured sign retroreflectivity
- Expected sign life
- Blanket replacement
- Control signs
ASAP Project
Retroreflectometer Sharing Project

<table>
<thead>
<tr>
<th>County</th>
<th>County</th>
<th>Town</th>
<th>City</th>
<th>Village</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genesee</td>
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<td>6</td>
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<tr>
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<td>0</td>
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<td>27</td>
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<tr>
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<td>16</td>
<td>0</td>
<td>9</td>
<td>26</td>
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<tr>
<td>TOTALS</td>
<td>3</td>
<td>46</td>
<td>1</td>
<td>24</td>
<td>74</td>
</tr>
</tbody>
</table>
Goals

- Current status and capability
- Methods to determine condition
- Simple tool to meet retroreflectivity standard
- Multiple jurisdictions sharing a retroreflectometer
Inspections

- Counties – Annual
- Towns and Villages – no pattern
Manpower and Budget

- Counties – Sign crew
- Towns and Villages – no crew
- 24 hour response
Regulation Awareness

- Need for training
- Traffic Sign Handbook
Field Kit

- One panel per color
- Transparency film
- $50 each
Making the Panels

1. Panel above $R_A$ minimum value
2. Measure panel with retroreflectometer
3. Cut and place overhead sheets
4. Measure panel
5. Repeat until below min $R_A$
6. Remove last sheet
7. Confirm RA value
8. Record on back of panel
Making the Panels
Use in the Field
Results

- Wyoming County
- 3 days to inspect all signs vs. 4
- 30 less sign replacements
- $3,000 annual savings
Lifetime of Panels

Retroreflectivity of Comparison Panel

RA = cd/lux/m²

Date

Sheets

0
1
2
3
Thank You

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Cornell University Local Roads Program