Environmental Issues and Mitigations for Low-Volume Roads

Gordon R. Keller, PE, GE
Geotechnical Engineer,
USDA, Forest Service (Retired)
grkeller@fs.fed.us or gordonrkeller@gmail.com

ASCE | KNOWLEDGE & LEARNING

Environmental Issues and Mitigations for Low-Volume Roads

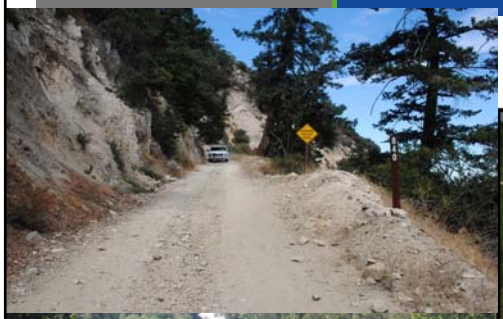
- Gordon R. Keller, PE, GE, is a Geotechnical Engineer with over 40 years of professional experience working with the USDA, Forest Service and as a private consultant.
- Work includes a wide variety of Geotechnical and Geologic Engineering projects, particularly related to infrastructure and low-volume roads. Current work includes considerable training in all aspects of low-volume and forest road planning, design and management, as well as environmental management of roads.

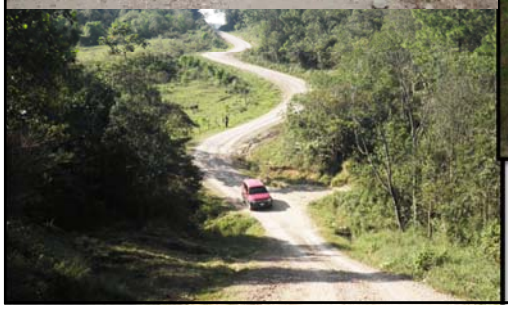
OBJECTIVES OF THE WEBINAR

- Present the many positive and negative impacts of roads.
- Discuss the importance of Environmental Analysis in project planning.
- Appreciate the importance of good engineering design.
- Present environmental mitigations to roads impacts.
- Present useful references on each topic.

What is a Low-Volume Road?

ADT < 400 VPD





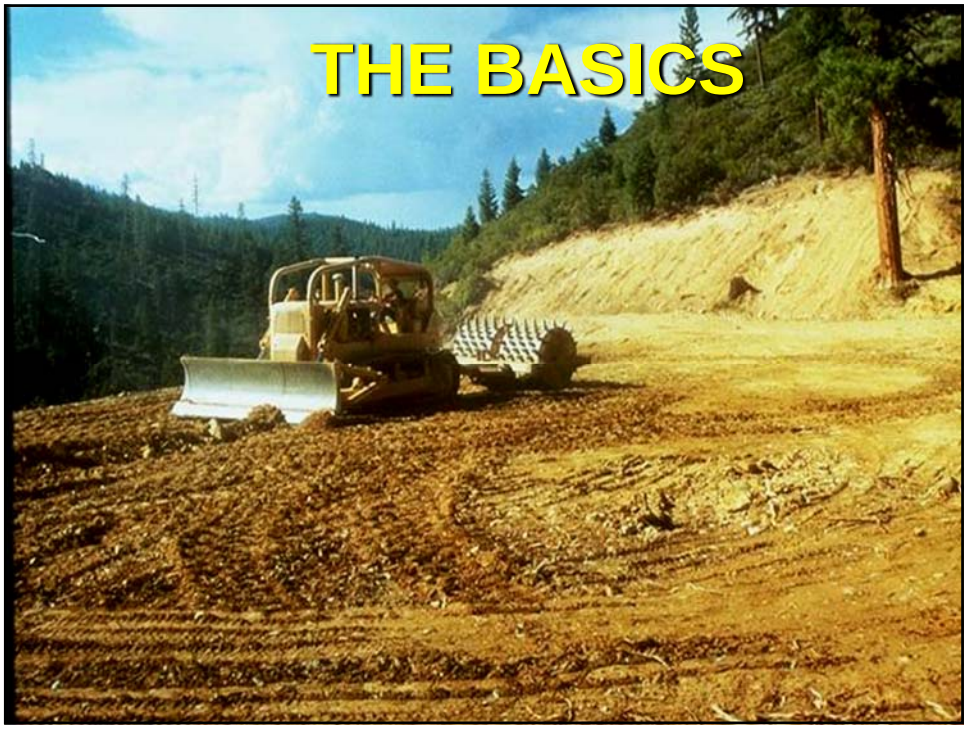
What is a Low-Volume Road?

A WELL BUILT MINIMUM IMPACT ROAD

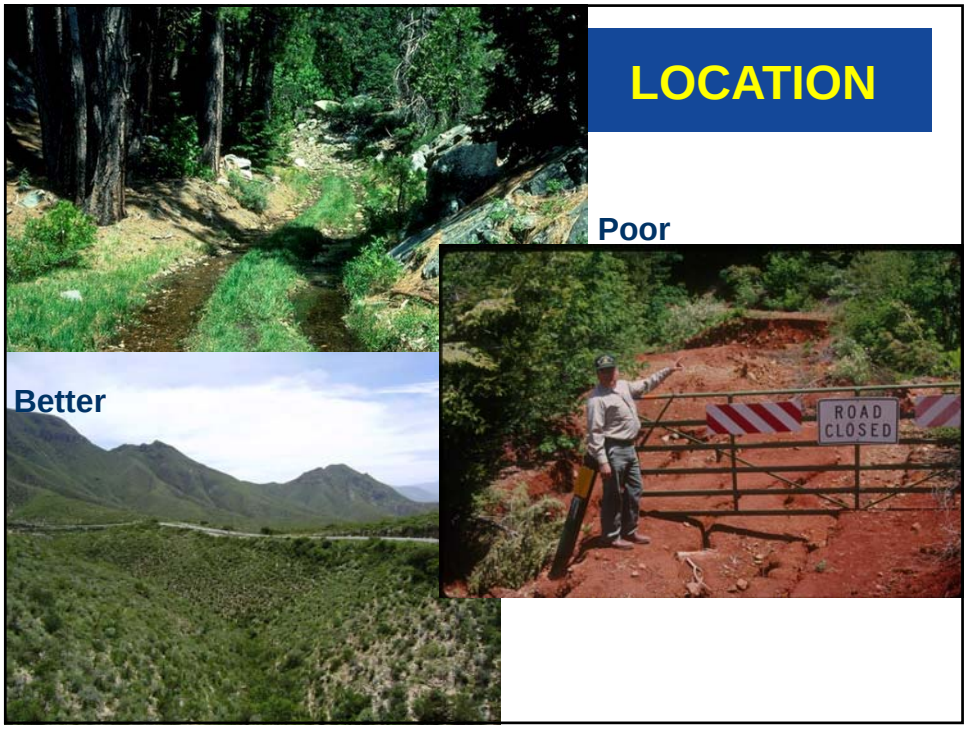
- Planning/Environmental Analysis
- Location
- Design
- Construction
- Maintenance
- Road Closure or Obliteration

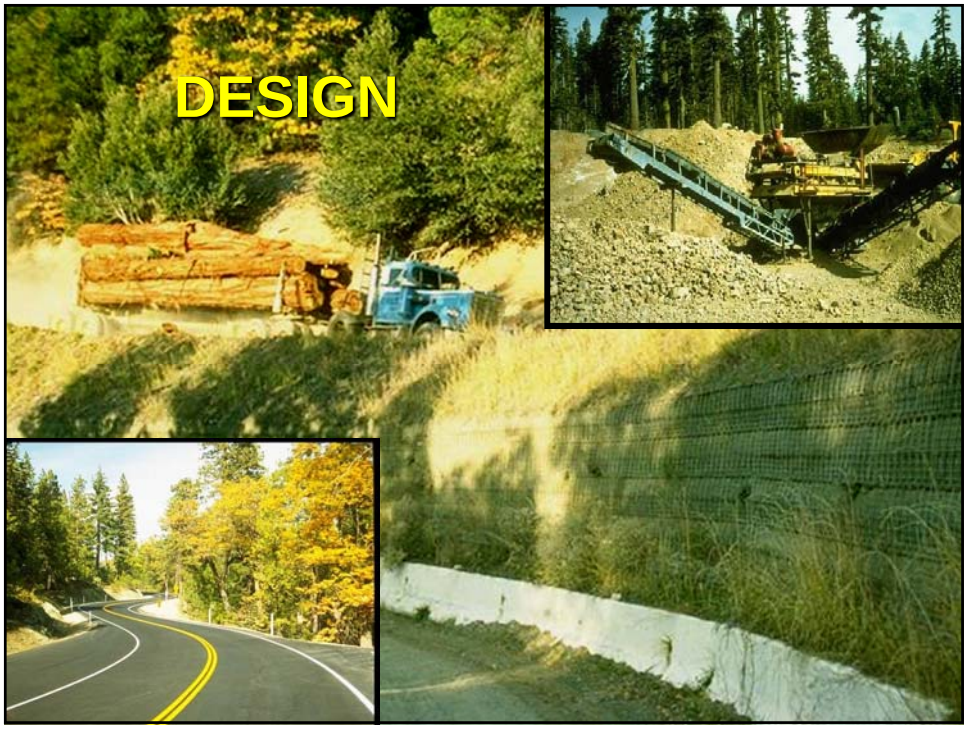
GOOD PLANNING AND DESIGN IS CRITICAL

- LVR design may be relatively basic, but important to prevent negative environmental impacts.
- Today other key issues are commonly:
  -Social
  -Financial
  -Environmental
  -Need for Maintenance


THE BASICS


PLANNING


LOCATION
Poor
Better
ROAD
CLOSED


DESIGN

DRAINAGE DESIGN

ASCE | KNOWLEDGE & LEARNING

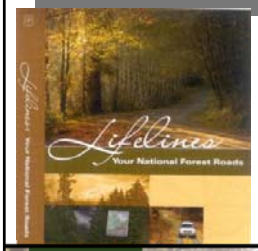
CONSTRUCTION

You Get What You Inspect, Not What You Expect

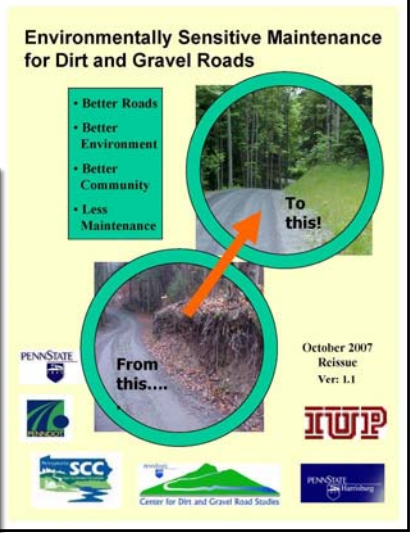
ENVIRONMENTALLY SENSITIVE MAINTENANCE

ASCE | KNOWLEDGE & LEARNING

Environmentally Sensitive Maintenance



"Forest Roads and the Environment" Videos



A Perspective--

GOOD PLANNING +
GOOD ENGINEERING
(with Conscience)
=
GOOD ENVIRONMENTAL MITIGATION

These are Preventable!

ENVIRONMENTAL ANALYSIS

An Environmental Analysis Process

1. Identification of the Project
2. Scoping
3. Data Collection and Interpretation
4. Design of Alternatives
5. Evaluation of Effects
6. Comparison of Alternatives
7. A Decision and Public Review
8. Implementation and Monitoring

21

Benefits of Environmental Analysis

- Encouragement of Public Participation.
- Disclosure of Environmental Impacts and Consequences.
- Study, Develop, and Describe Appropriate Alternatives.
- Identify Environmental Effects and Values.
- Apply an Interdisciplinary Approach, Integrating Natural and Social Sciences.
- Improve the Project /Identify Needed Funding/ Mitigations
- Avoid Project Delays During Implementation
- Mechanism to Provide for Monitoring and Feedback

22

What are the impacts from roads?

Positive Impacts

- Improving quality of life
- Better access to schools and clinics
- Promoting development of areas
- More rapid movement of goods and services
- Lower operating costs
- Lower cost of food and products
- Everybody wants a good road

What are the impacts from roads?

Negative Impacts

- *Degradation of water quality
- *Wildlife mortality and habitat fragmentation
- *Barriers to fish movement and AOP
- *Promoting movement of invasive species
- *Land use changes –forests to crops, tree clearing
- Traffic accidents
- Pollution and trash
- Loss of terrain, impacts on sensitive areas
- Promotion of landslides, stream channel changes
- High cost of road maintenance and repairs

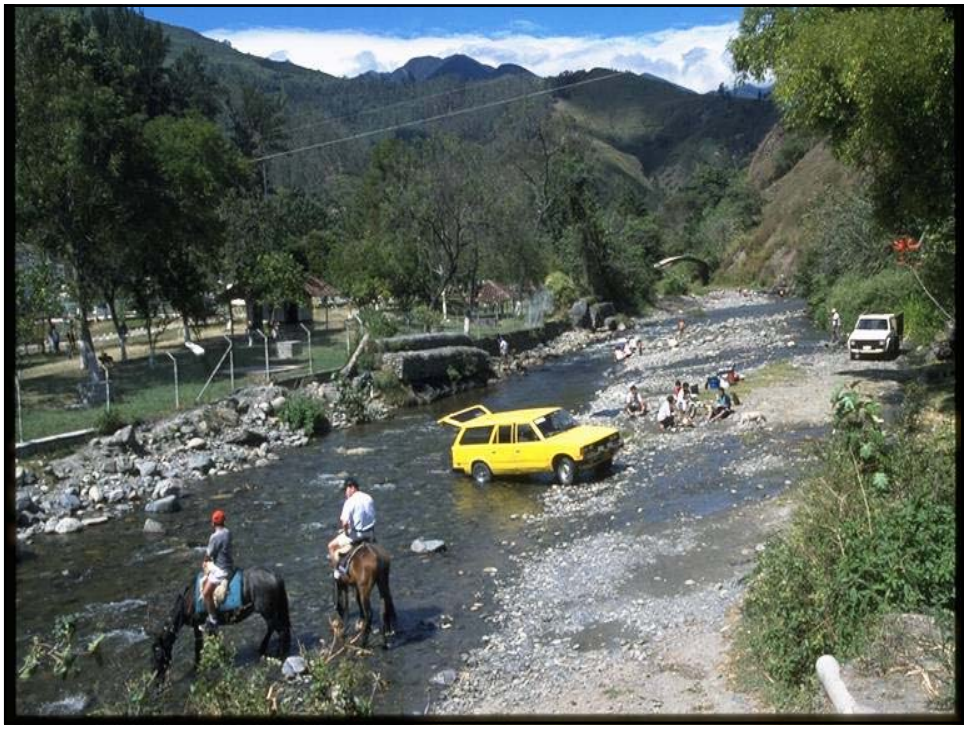
KEY IMPACTS AND HOW WE MITIGATE THEM

- Water Quality Protection
- Wildlife Crossings and Mitigations
- Fish Movement / AOP Passage
- Preventing Invasive Species Movement
- Minimizing Tree Damage/Removal
- Traffic Safety
- Pollution--Dust and Trash Reduction

ASCE | KNOWLEDGE & LEARNING

DEGRADATION OF WATER QUALITY

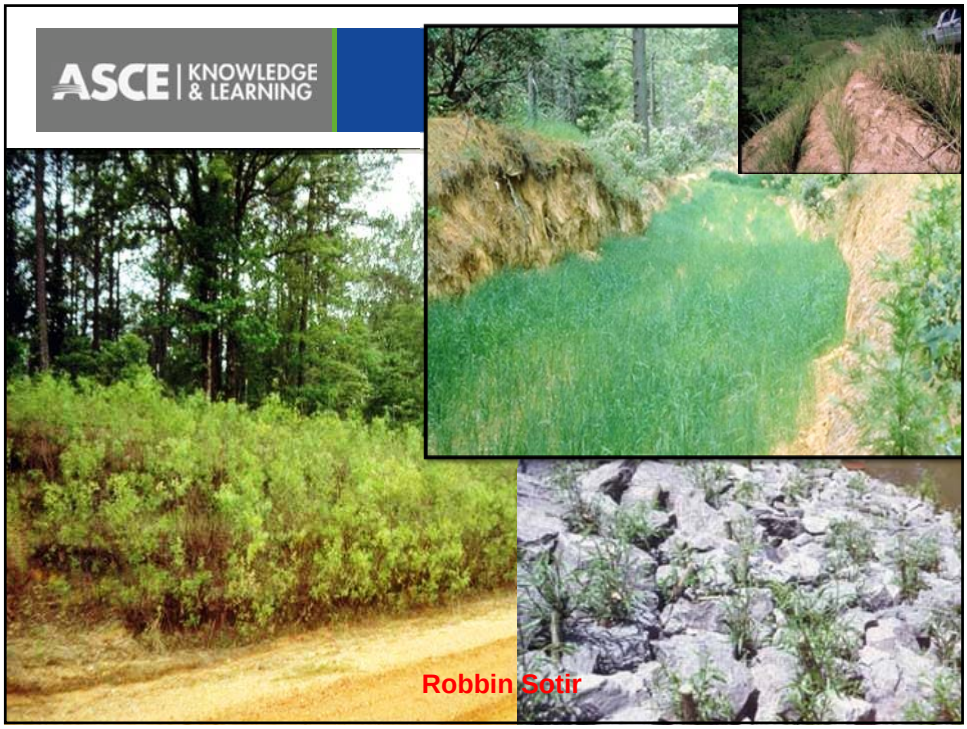
ASCE | KNOWLEDGE & LEARNING




Controlling
Surface Water


ASCE | KNOWLEDGE & LEARNING


ASCE | KNOWLEDGE & LEARNING
Erosion Control for
Water Quality Protection


ASCE | KNOWLEDGE & LEARNING
Robbin Sotir


ASCE | KNOWLEDGE & LEARNING
Protect Water Quality!!
Clean Water
Dirty Water

WATER QUALITY PROTECTION

- Application of Best Management Practices
- Erosion and Sediment Control Handbooks
- Wastewater Management/Nonpoint Source Regs
- http://water.epa.gov/polwaste/
- Gillies, C. 2007. Erosion and sediment control practices for forest roads and stream crossings- A practical operations guide. Forest Engineering Research Institute of Canada. Available from: http://www.feric.ca
- Erosion Control Handbook for Local Roads, 2003-08. Minnesota LTAP, Available at: www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1600

How big of a problem is wildlife mortality, anyway?

- Vehicle-caused wildlife mortality estimated at ***MILLIONS*** of vertebrates.
- Deer/vehicle collisions cost ***BILLIONS*** of dollars ***ANNUALLY.***
- Virtually all wildlife species affected.
- Hundreds of people killed annually.

The Most Significant Types of Impacts

- Vehicle-Caused Mortality
- Loss of Habitat
- Habitat Fragmentation
  - Avoidance of road
  - Habitat Modification
  - Barriers & Reduced Movement

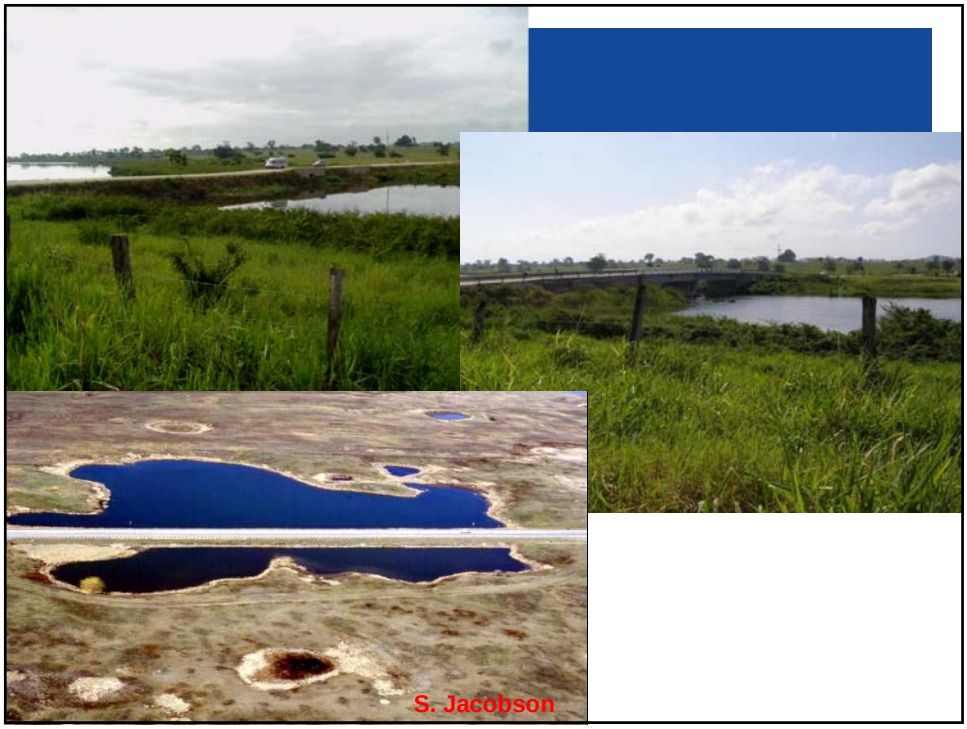
Roads/Riparian Restoration Team

Other Impacts

- Pollutants & Erosion (Trash/Plastics, Dust Abatement, and Deicing agents)
- Increased Poaching
- Noise, Exhaust
- Invasive Species
- More Human Activity

USFS Roads/Riparian Restoration Team


Habitat
Fragmentation


S. Jacobson

Solutions/Mitigations

- Road Closures/Traffic Regulation
  - Seasonal, or maybe nightly
  - Permanent
- Reduced Speed/Signs/Speed Bumps
- Reduced Design Standards
- Roughened Driving Surface
- Crossing Structures (Passages)
- Barriers/Fencing

Roads/Riparian Restoration Team


ASCE | KNOWLEDGE & LEARNING
NEXT
4 MILES


SPEED LIMIT
20 K.P.H.
WARTHOGS and CHILDREN
HAVE RIGHT OF WAY


SLOW
JUDDER BARS
NO DOGS
15


ASCE | KNOWLEDGE & LEARNING
Huan Xi Township, China

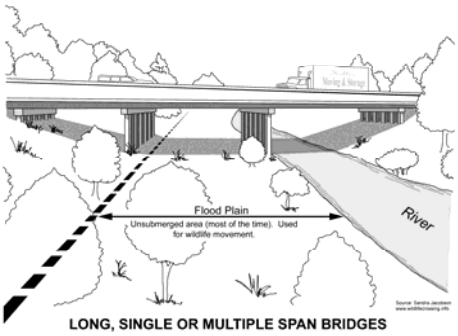
ASCE | KNOWLEDGE & LEARNING

Overpasses

Roads/Riparian
Restoration Team

Underpasses

Underpasses




Barriers/Fencing
Sandra Jacobson

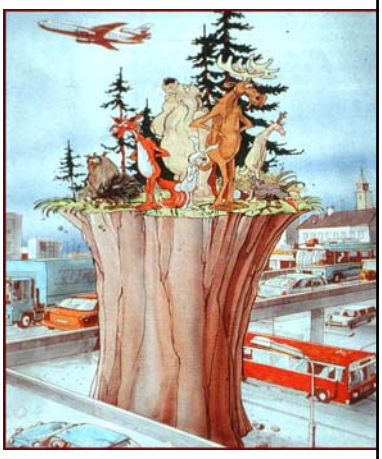

culvert
Lake Jackson
Little Lake Jackson
N
US-27
= temporary fences
= migration directions
Scale =1500 feet
Sandra Jacobson

Paynes Prairie Lipped Wall

Other Fencing, Escape Structures

Actions!

- Do Something
- Do it Early
- Involve Biologists with Engineers
- Think in the Long Term!!



USFS Roads/Riparian Restoration Team

Information Sources

- *Huijser, M.P.; McGowen, P.; Clevenger, A.P.; Ament, R. 2008. Wildlife Vehicle Collision Reduction Study: Best Practices Manual. Western Transportation Institute, Montana State University and Federal Highway Administration http://www.fhwa.dot.gov/environment/wildlifecrossings/
- Clevenger, A.P.; Huijser, M. 2011. Wildlife Crossing Structure Handbook: Design and Evaluation in North America. FHWA-CFL/TD-11-003. Western Transportation Institute and Federal Highway Administration, Washington, DC. 224p.
- http://www.fhwa.dot.gov/environment/critter_crossings/
- http://roadecology.ucdavis.edu
- www.itre.ncsu.edu/cte/cte.html

ASCE | KNOWLEDGE & LEARNING

THE PROBLEM

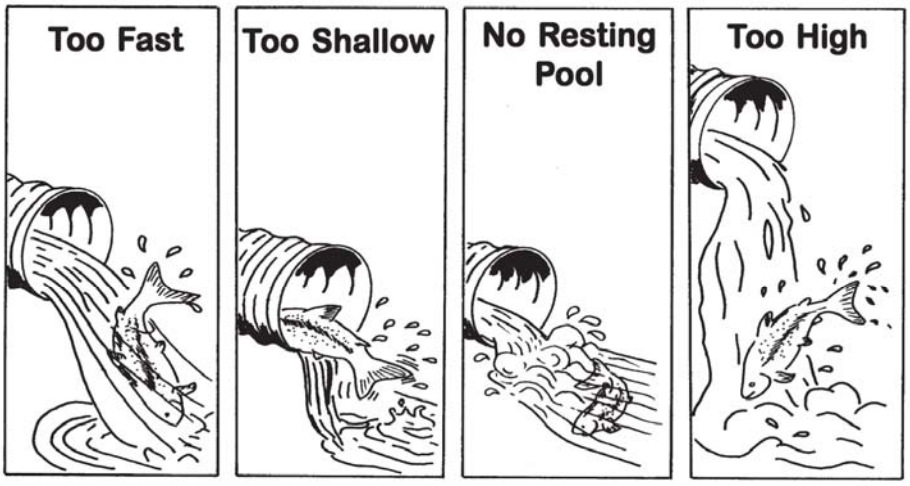
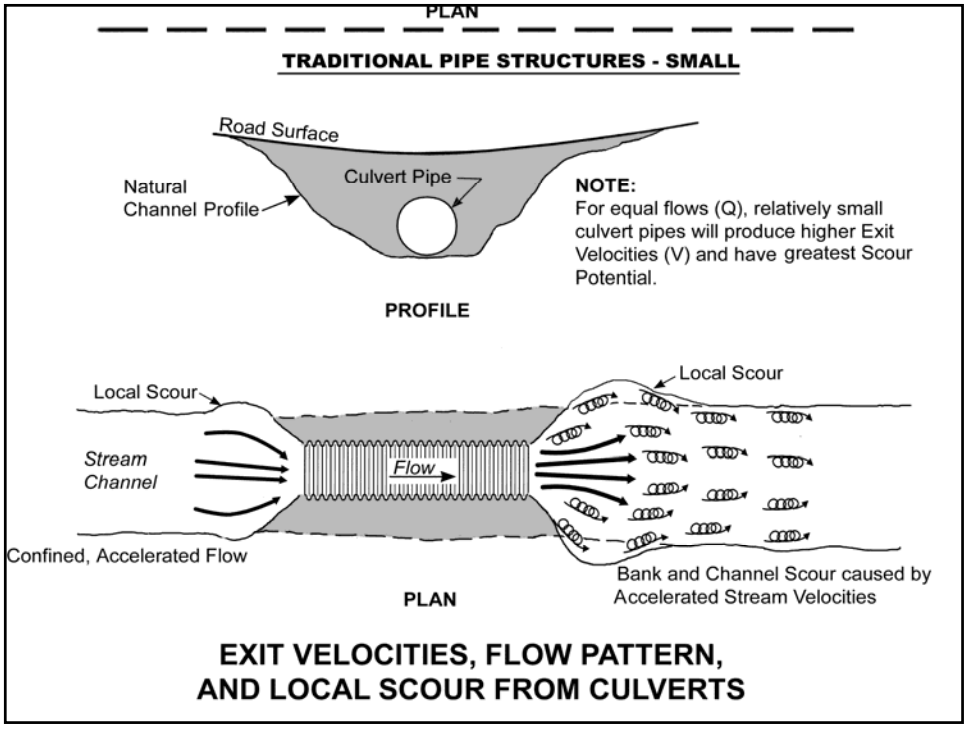
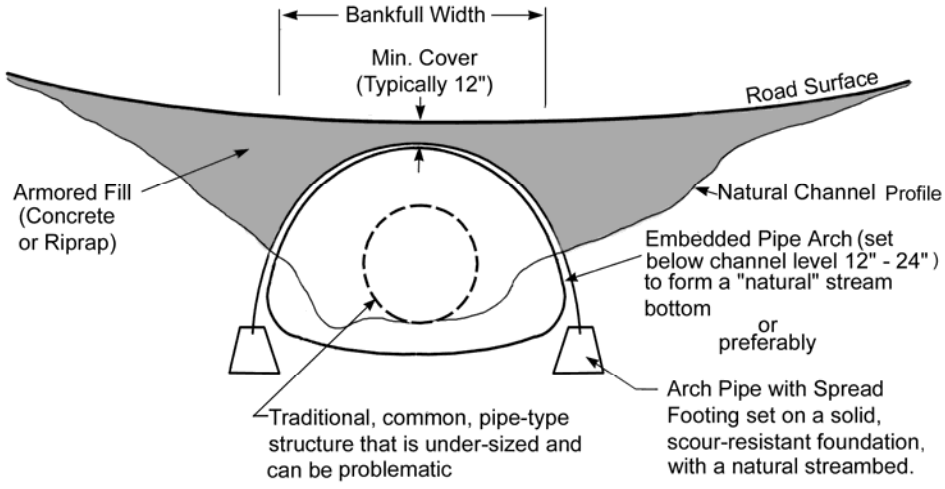


Figure 2.2b Poorly designed or installed culverts with "fish barriers" that prevent fish passage. *(Redrawn from Evans and Johnston 1980)*

Problems


PLAN
TRADITIONAL PIPE STRUCTURES - SMALL
Road Surface
Culvert Pipe
Natural
Channel Profile
NOTE:
For equal flows (Q), relatively small culvert pipes will produce higher Exit Velocities (V) and have greatest Scour Potential.
PROFILE
Local Scour
Local Scour
Stream
Channel
Flow
Confined, Accelerated Flow
Bank and Channel Scour caused by Accelerated Stream Velocities
PLAN
EXIT VELOCITIES, FLOW PATTERN,
AND LOCAL SCOUR FROM CULVERTS

Solutions



"STREAM SIMULATION" EMBEDDED ARCH OR PIPE-ARCH CULVERTS

Hydraulic Design

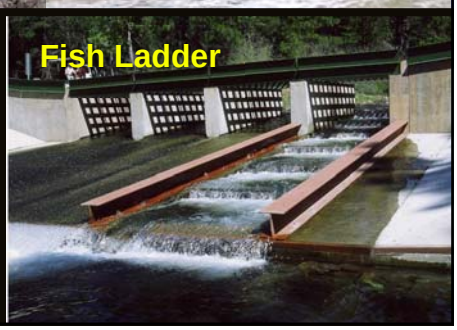
Creates water depths and velocities in culverts that are swimmable for target fish populations.

- Considers culvert slope, size, material, and length.
- Options
  - Baffles
  - Wiers
  - Ladders
  - Oversized rock

Hydraulic Fish Passage Design

Fish Baffles

No Slope



Fish Ladder

Hydraulic Simulation

Uses embedded culverts, natural bed material, or oversize rock to provide hydraulics conducive to fish passage.

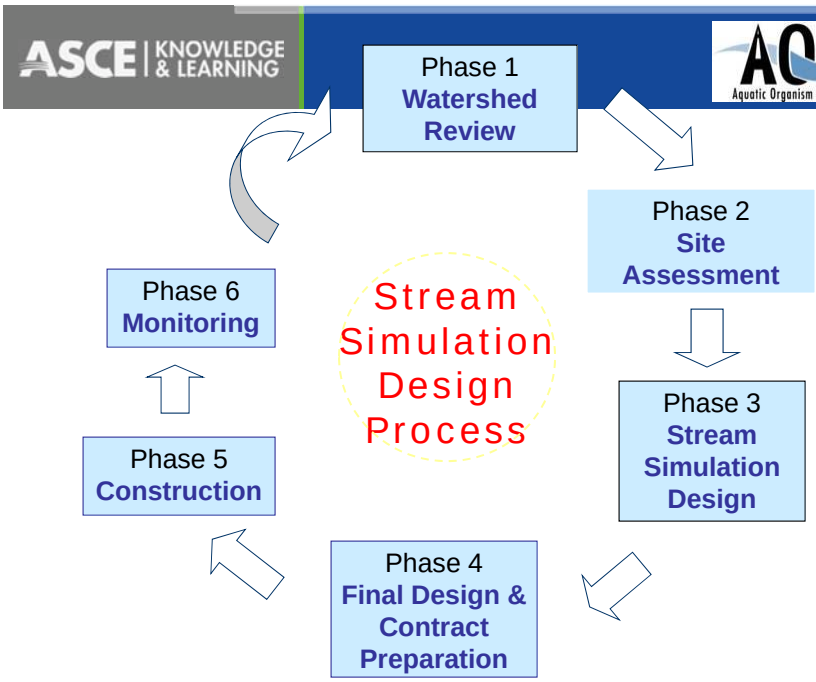
- Creates hydraulic roughness, low flow paths, resting areas.
- Culvert span is ideally close to or less than bankfull.
- Creates a stable channel within the culvert


Culverts? We don't need no stinking culverts!

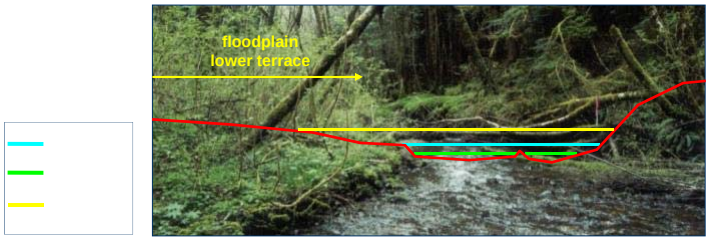
Stream Simulation (Geomorphic Simulation)

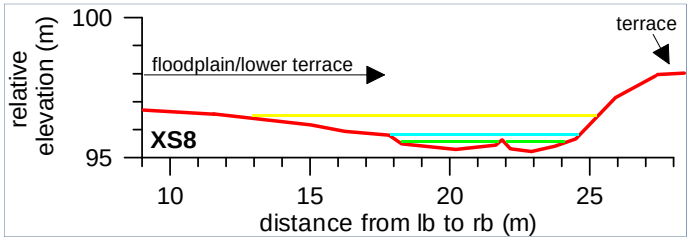
Recreates or maintains natural stream reach geomorphic elements, including slope, channel-bed width, bed materials, and bedform.

- Matches natural channel conditions.
- Passes fish, debris and sediments.
- Design is based upon a reference reach.
- Assumes Fish and AO Passage of all species at all life stages.
- Culver spans at least bankfull.



Site Assessment

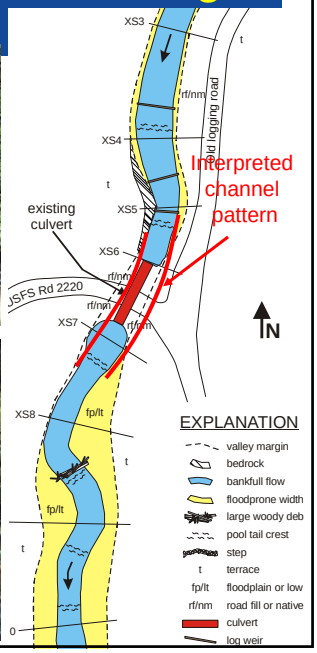




73

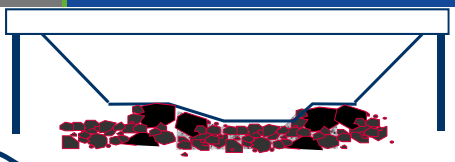
Cenderelli, Clarkin, Gubernick, Weinhold

Stream Simulation Design

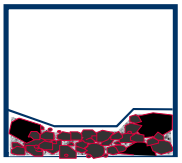


Cenderelli, Clarkin, Gubernick, Weinhold

Final Design Options



a. Bridge



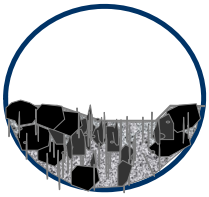
b. Box

c. Pipe Arch

d. Bottomless Arch

- Same stream simulation design bed can usually be constructed for many types of structures.
- Adequate embankment height, sufficient embedment depth, and constructability can be limitations.

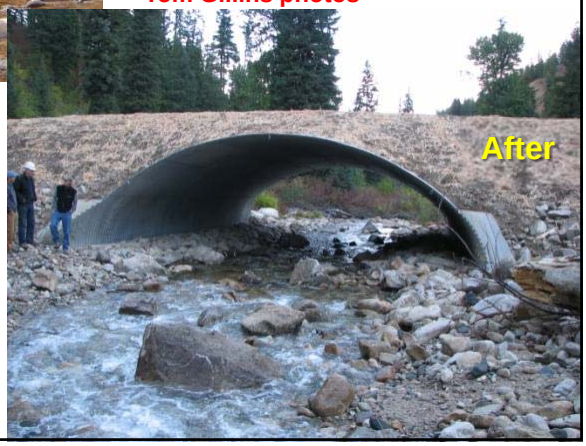
Cenderelli, Clarkin, Gubernick, Weinhold

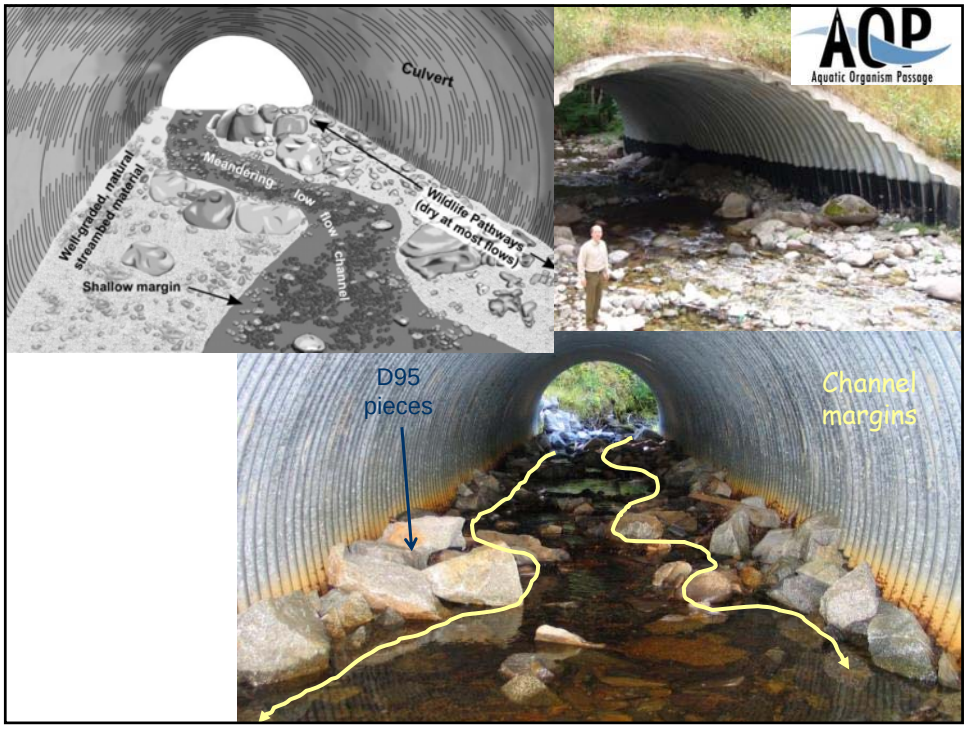


e. Embedded Round

Roaring River, Boise NF IDAHO 2007

Tom Gillins photos





Stream Simulation Works!

Trib. To Bear Creek

6 years old

Structure 117" x 79" Pipe arch, BFW 9', 7.7% slope

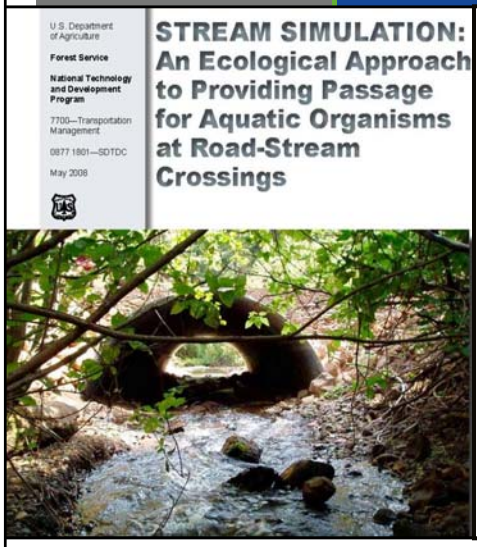
Hehe creek

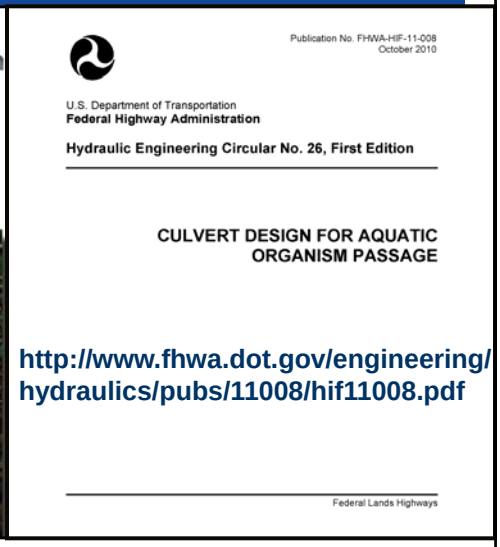
21 years old

Structure 18' x 9' open bottom arch, BFW 17', 6% slope

B. Gubernick

Useful References

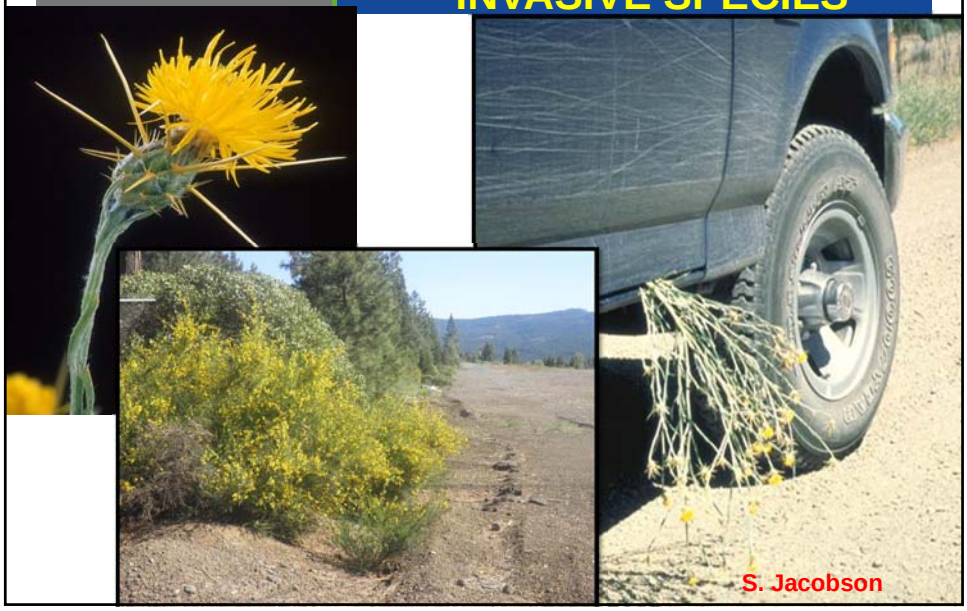




http://www.fhwa.dot.gov/engineering/hydraulics/pubs/11008/hif11008.pdf

http://www.stream.fs.fed.us/fishxing/aop_pdfs.html

NOXIOUS WEEDS/ INVASIVE SPECIES



Roads/Riparian Restoration Team

Where do Invasive Species come from?

***PURPOSEFUL* introductions**

- Ornamental, esthetics and hardiness
- Erosion control problem solvers
- Pasture grasses with forage values

***ACCIDENTAL* introductions**

- **Vehicles, travelers, construction, maintenance**
- Seed in imported crop seeds, In ships
- Animal vectors….birds and other wildlife

Invasive Plants

Where is my Culvert?

Weeds and Seeds in Stockpiles

How Seeds Travel!

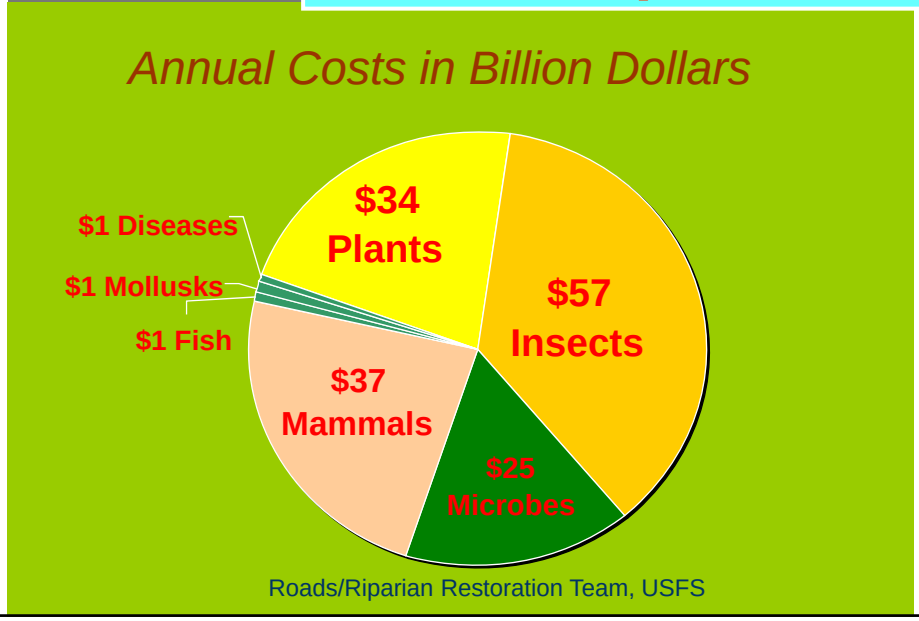
Roads/Riparian Restoration Team

Why Invasive Weeds are Noxious

- Hard to control
- Usually outside of normal biological controls such as predators or herbivory
- May find an unoccupied niche which allows rapid spread
- Many are extremely persistent in seed or root systems

Roads/Riparian Restoration Team

$138 Billion per Year!!



What Can We Do to Prevent Invasive Species

- Disturb as little as possible
- Specify weed-free mulches, sods…
- Import NO soils into a project
- Steam clean gravel at pits
- Wash down equipment before construction
- Clean off mowers between sites
- Train crews to identify weeds early
- Control before populations spread

How to Control Invasives

- **IRVM-Integrated Roadside Vegetation Management**
- **TOOLS include:**
  - •Prescribed Burning
  - •Monitored Bio-Controls
  - •Recorded Spot Spraying
  - •Well-timed Mowings
  - •Herded Goats/Sheep
  - •Planted Native Grasses
  - •Hand-cutting/Pulling

Roads/Riparian Restoration Team

Recommendations

- •Roadside Vegetation Management Plans
- •Identification-Vegetation Inventories
- • Statewide invasives clearinghouse
- • Prevention Training
- • Educational programs
- • Prioritizing Treatments
- • Research & Monitoring

Agencies and Groups Involved

- Environment Canada
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- U.S. Department of Defense
- U.S. Department of Transportation
- U.S. Bureau of Land Management
- Industries (pesticide, timber, pipeline)
- Non-profit Conservation Organizations
- Academic community, Consultants

Roads/Riparian Restoration Team

Sources of Information

- **www.fhwa.dot.gov/roadsides**
- ***Ecological Restoration* Journal, U of Wis.**
- **North American Weed Management Association (www.nawma.org)**
- **National Roadside Vegetation Management Association (www.nrvma.org)**
- **Federal Interagency Committee for the Management of Noxious and Exotic Weeds**

www.ficmnew.fws.gov or www.invasivespecies.gov

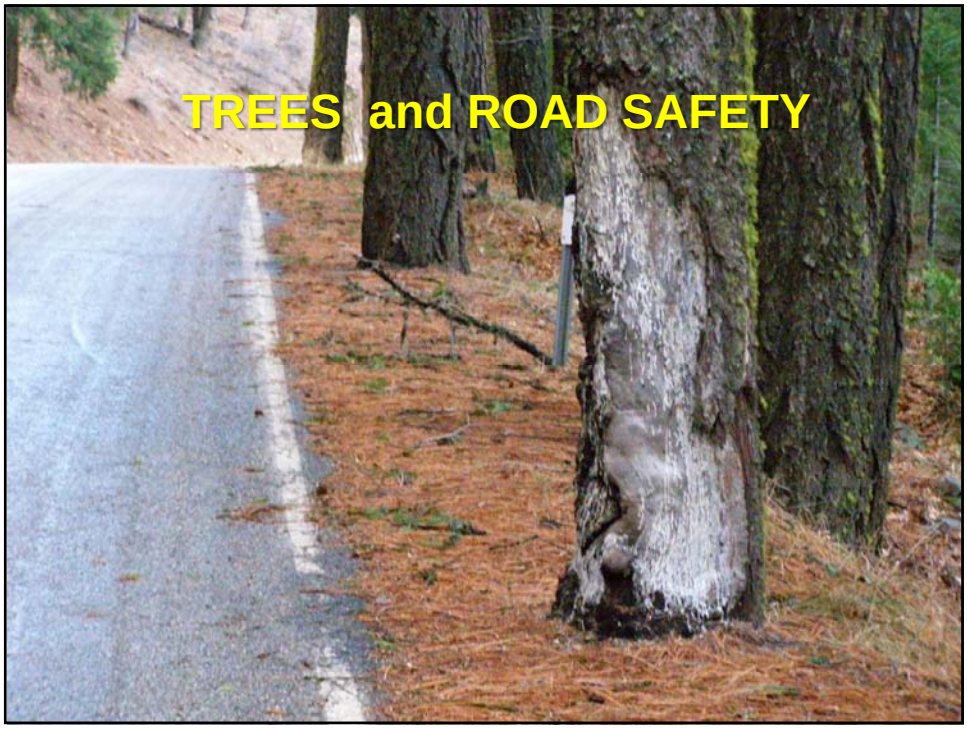
References

California Invasive Plant Council. 2012. Preventing the Spread of Invasive Plants: Best Management Practices for Transportation and Utility Corridors. Cal-IPC Publication 2012-01, California Invasive Plant Council
http://pollinator.org/PDFs/TransportationUtilityCorridorsPreventionBMPs.pdf

Steinferld, D.; Riley, S.; Wilkinson, K.; Landis, T.; and Riley, L. 2007. Roadside Revegetation: An Integrated Approach to Establishing Native Plants. FHWA-WFL/TD-07-005, Federal Highway Administration
http://www.wfl.fhwa.dot.gov/programs/td/publications/

Safety Issues on Low-Volume Roads

- *Roadside Hazards--Trees
- Poor Sight Distance, Dust
- Poor or Missing Signs
- Inconsistent Design Standards
- Loose/Unsafe Roadway Surfacing Materials/Lack of Maintenance
- Rockfalls, Animals, and other Hazards
- Lack of Driver Training


TREES and ROAD SAFETY


Trees Along Roads-
NO??
YES??

Clear Zones, Brush, Barriers

Improving Sight Distance

Bad Sight Distance

Improved Sight Distance

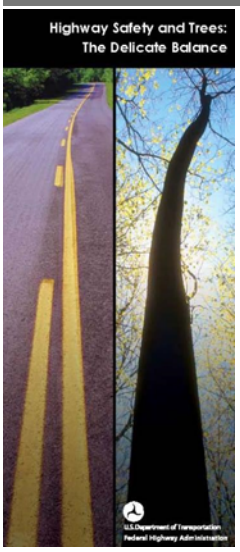
Improving Sight Distance But Preserving Some Trees

"The Delicate Balance"

Tree Protection In a Construction Zone

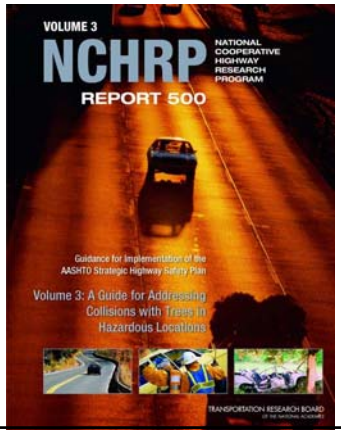
ASCE | KNOWLEDGE & LEARNING

Sources of Information

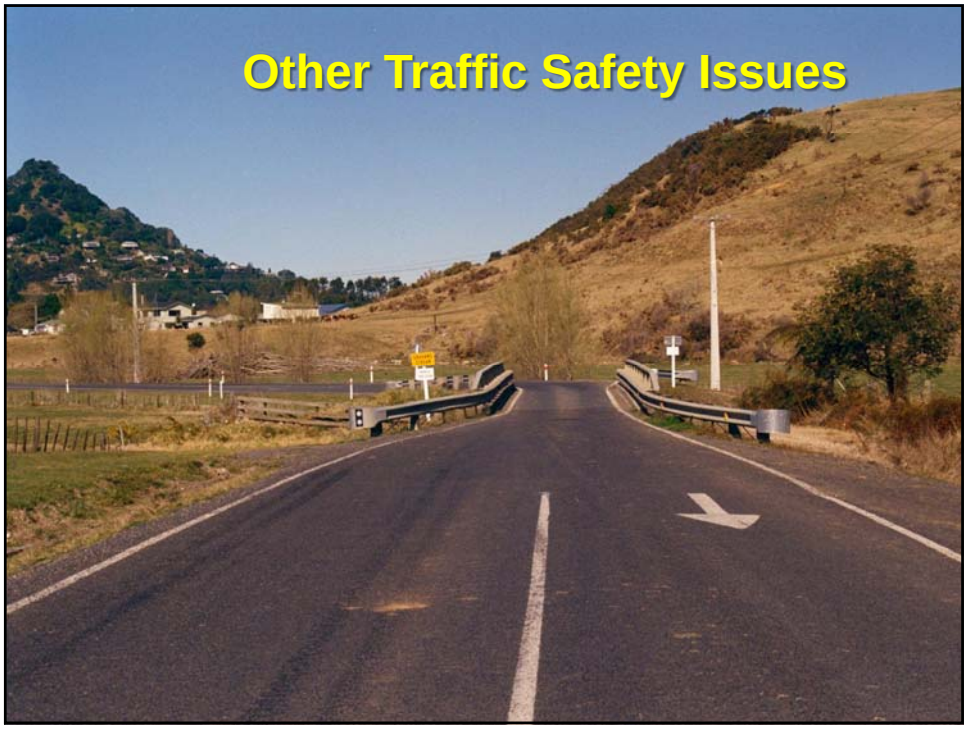


DVD Available: Highway Safety and Trees- The Delicate Balance, FHWA

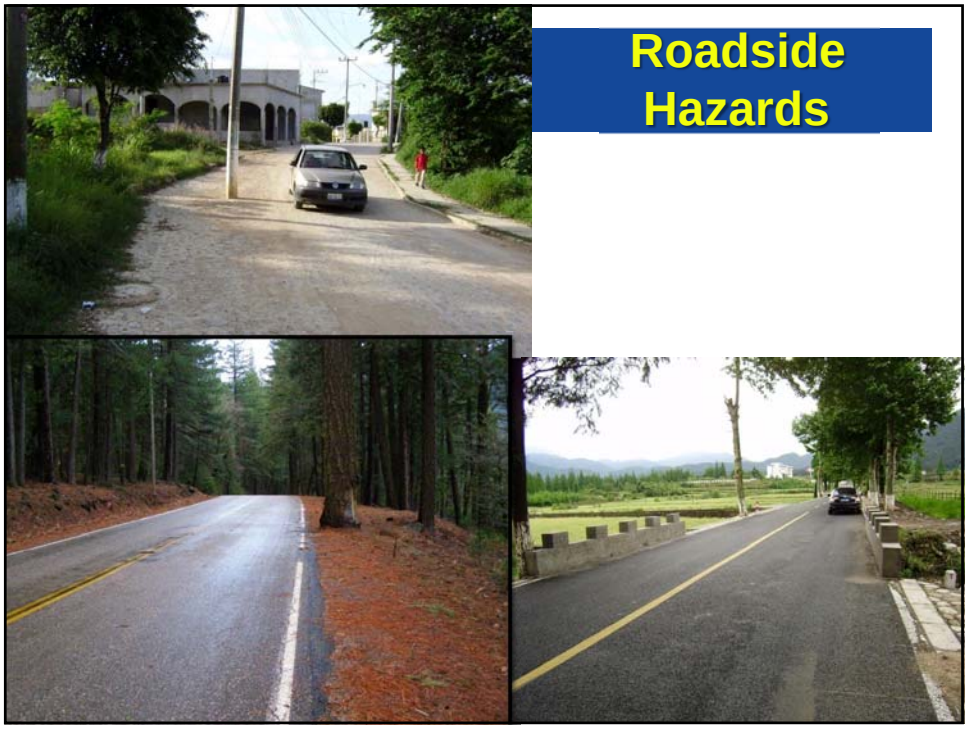
http://safety.fhwa.dot.gov/roadway_dept/clear_zones/fhwasa0612/fhwasa0612.pdf



http://safety.transportation.org/guides.aspx


Other Traffic Safety Issues

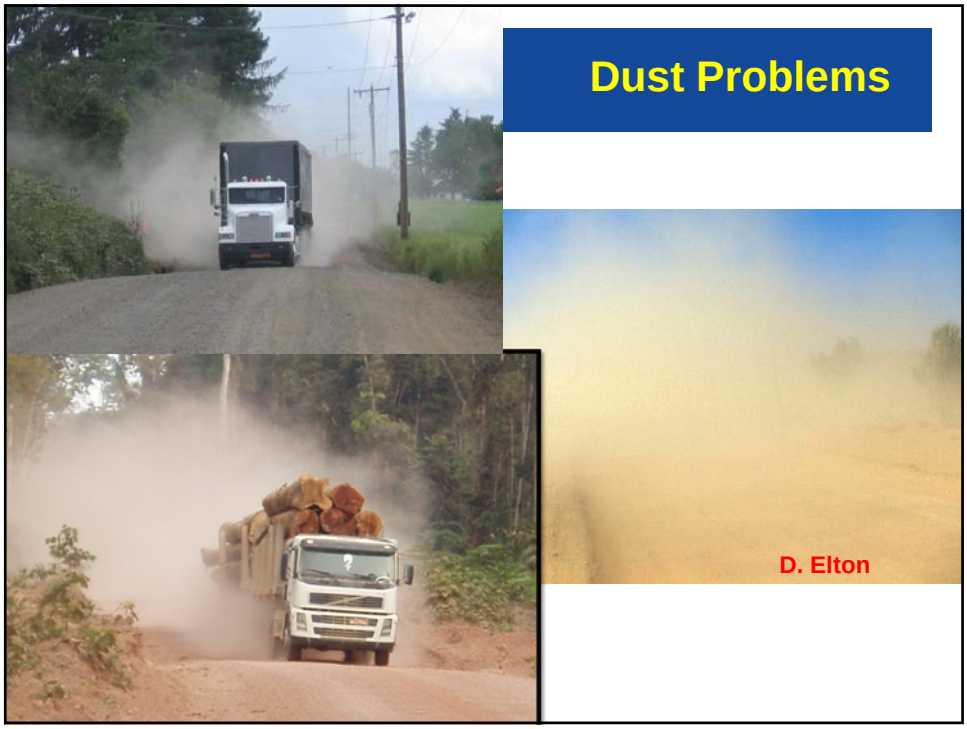

Too Many Rural Road Accidents!
H. Fernandez


Roadside Hazards


ASCE | KNOWLEDGE & LEARNING
Poor, Damaged, or Missing Signs
STOP
WRONG WAY

Lack of Driver Training

Need For Road Safety Audits


Dust Problems
D. Elton


Solutions to Dust

TRASH

Solutions to Roadside Trash

- Environemntal Education
- Trash Cans
- Fines for Littering

MANY ASPECTS OF ENVIRONMENTAL PROTECTION

Other "Roads and Environment" Information Sources

Forman, R. T.; Sperling, D.; et al. 2003. Road Ecology: Science and Solutions. Washington, DC: Island Press. UC Davis
http://roadecology.ucdavis.edu

www.**icoet**.net/

http://www.westerntransportationinstitute.org/research/roadecology/

http://www.itre.ncsu.edu/

Other Useful References

Why BMPs and Environmental Mitigations

ASCE | KNOWLEDGE & LEARNING

Thank You!!