Field Performance of Timber Bridges: A National Study

Brian Brashaw

University of Minnesota

James Wacker

USDA Forest Products Laboratory

Frank Jalinoos

Federal Highway Administration

2nd International Conference on Timber Bridges

September 30 – October 2, 2013 – Las Vegas, Nevada USA

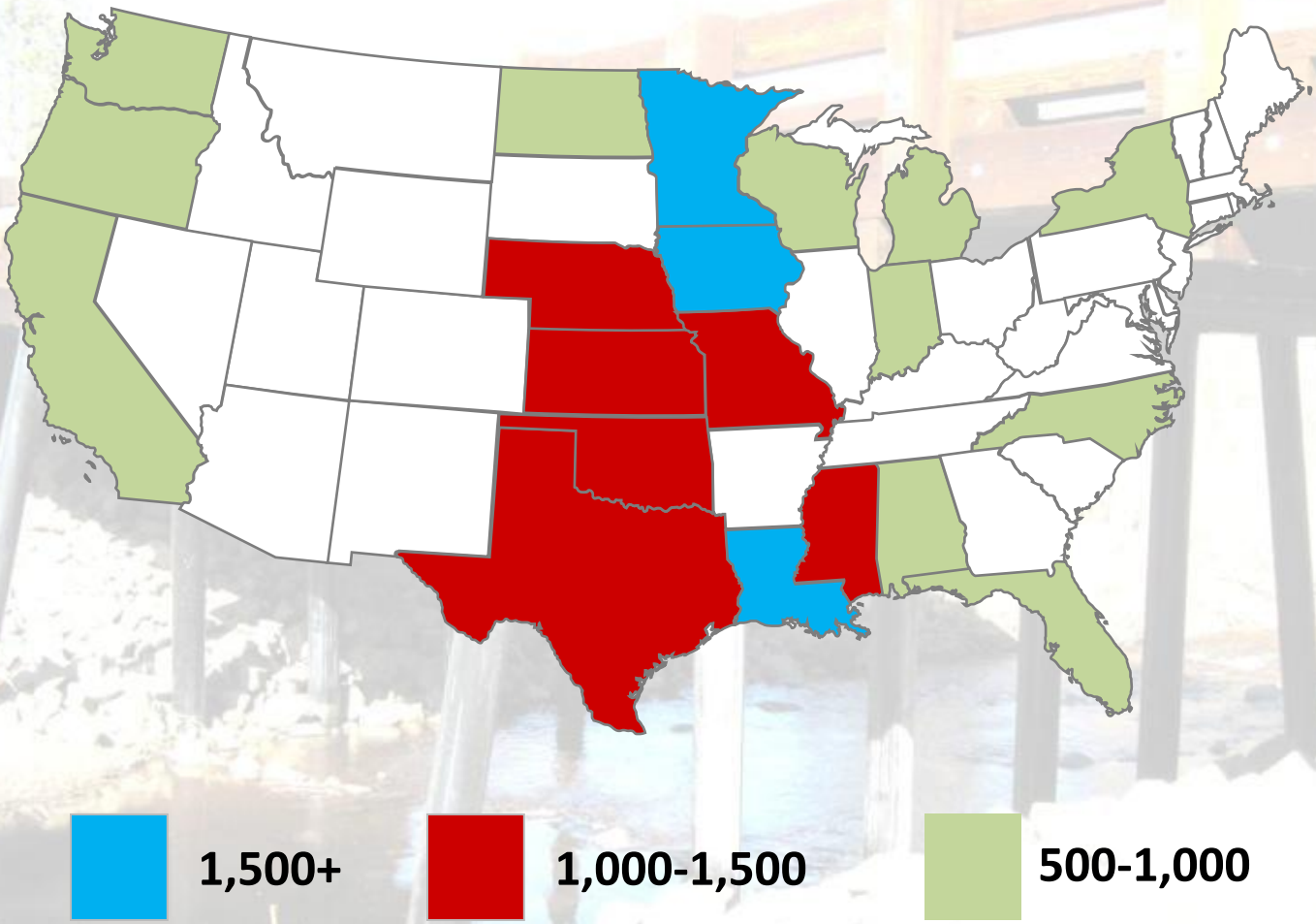
Topics Covered

- Introduction
- Objective / Scope
- Bridge Selection Criteria
- Inspection Protocol
- UMD Upper Midwest Inspections
- Summary

Profile of U.S. Timber Highway Bridges

- 48,759 (10.3%) utilize timber as a structural component in the superstructure
  - 24,267 all timber superstructure
  - 24,492 timber deck, steel beam
- Often rural highways with <300 vehicles

National Timber Bridge Inventory



DECAY

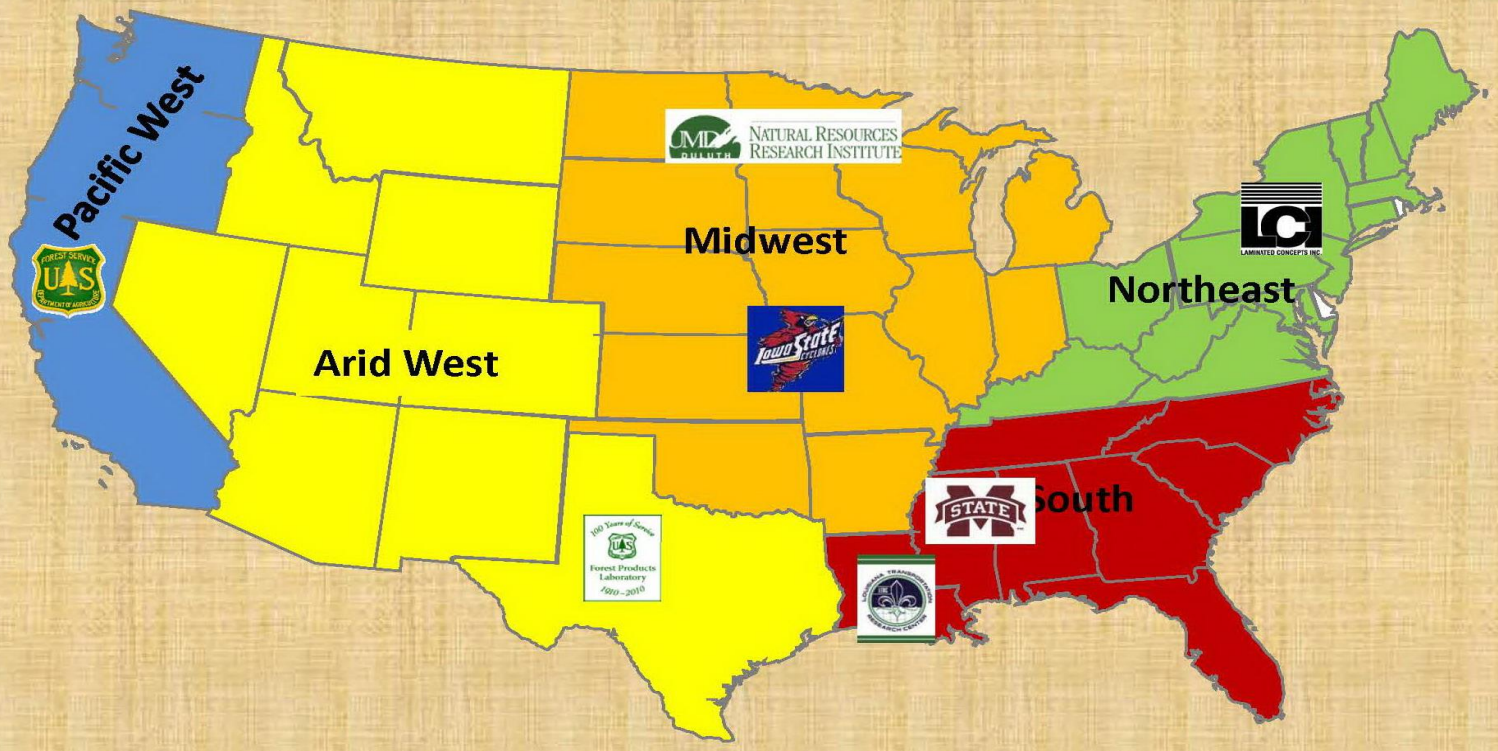
Wood Is A *NATURALLY* Renewable Resource & A Green Bridge Material

National Bridge Inspection Study

- **Purpose** – Provide a better understanding of the design, performance, and durability characteristics of timber bridge structures
- **Objective** - Assess the condition of over 100 timber highway bridges in various climatic regions and establish a baseline for evaluating future performance
- **Outcome** - Consolidate findings into a comprehensive final report and to support future service life predictions and improved bridge designs

Region & Team Designations

Field Performance of Timber Highway Bridges: A National Study



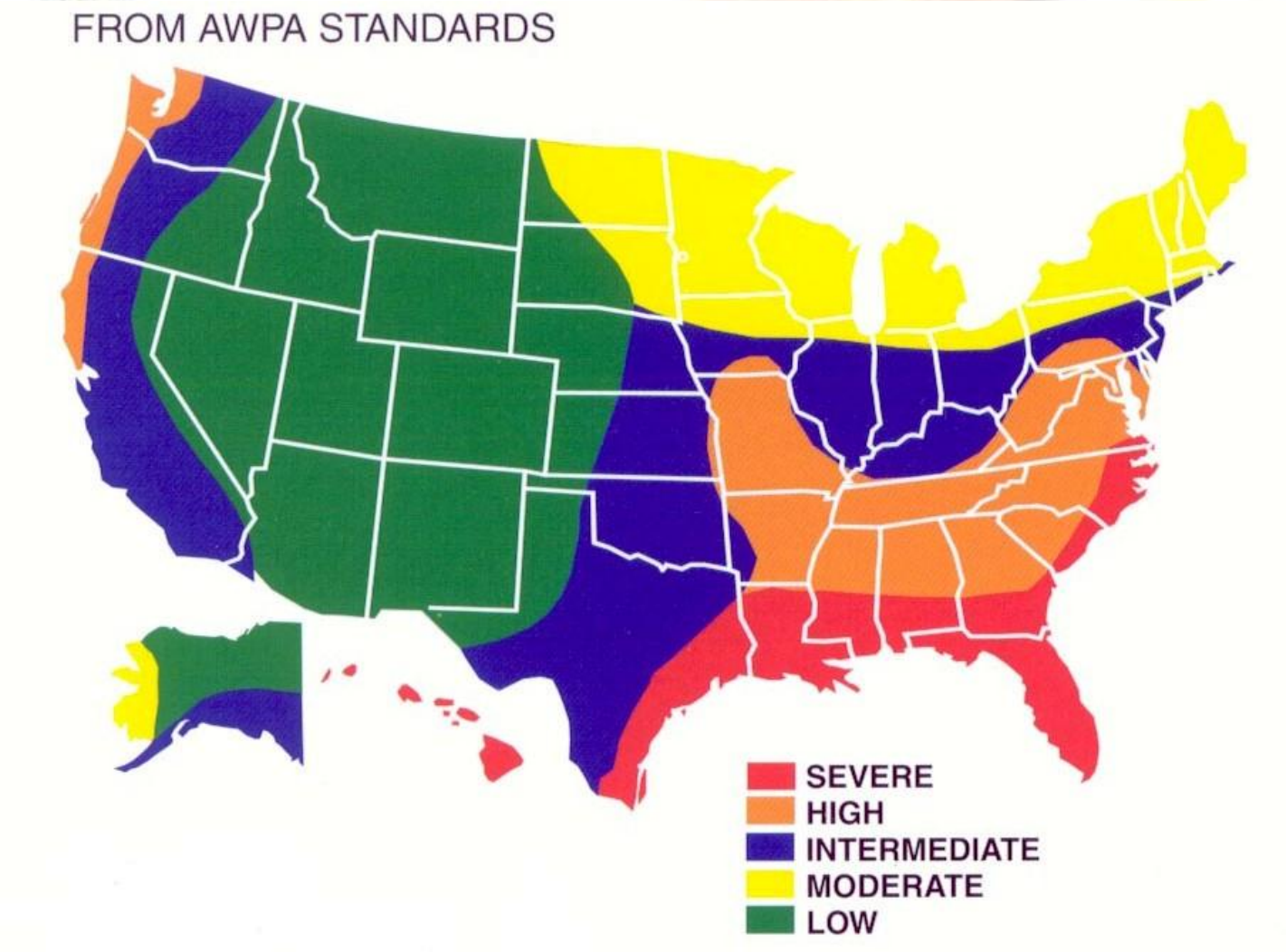
Project Team Members:
USDA Forest Products Laboratory
US Forest Service - Region 6
FHWA's Turner-Fairbank Highway Research Center

Project Team Members:
University of Minnesota Duluth
Iowa State University
Mississippi State University
Louisiana Transportation Research Center

Project Team Members:
Laminated Concepts Inc.
Williamson Timber Engr. LLC
State of Alabama
State of Georgia
State of North Carolina

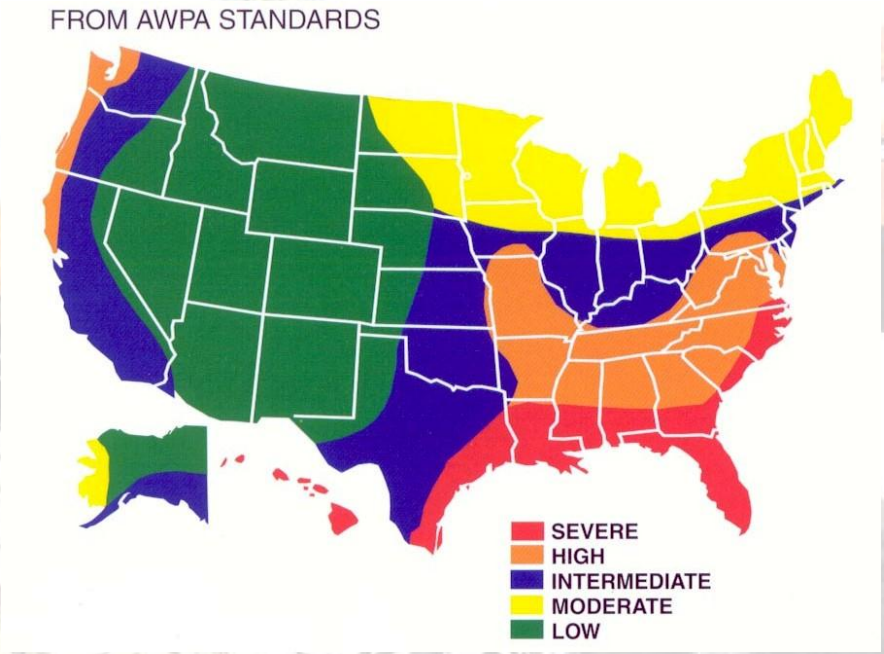
Wood Decay Hazard Zone Map

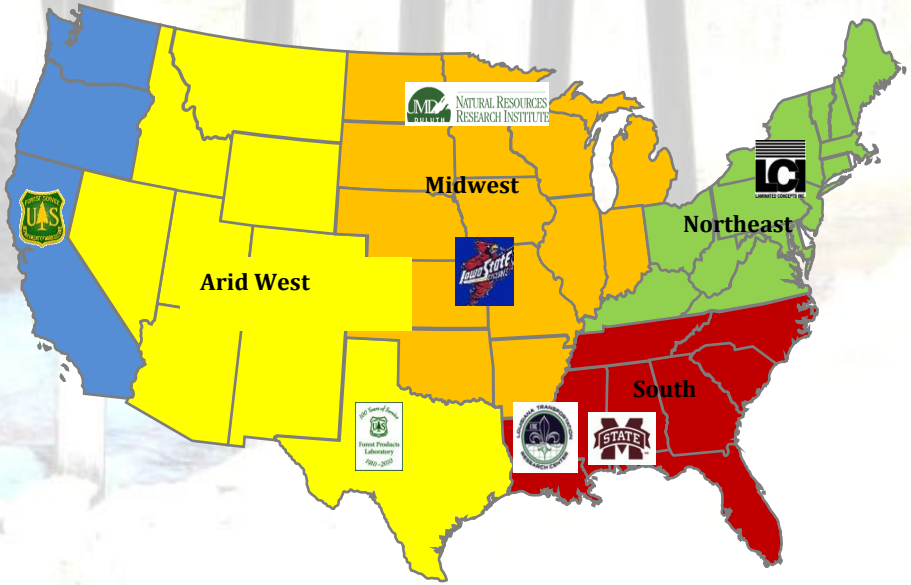
American Wood Protection Association



Wood Decay Hazard Zone Map

American Wood Protection Association





Key Bridge Selection Criteria

- Located on a public roadway
- 15 years minimum service
- Good documentation of all repair or rehabilitation work
- Safe access for arm's length inspection work

Standard Inspection Protocol

A 5-Step Field Procedure

In-Depth Inspection

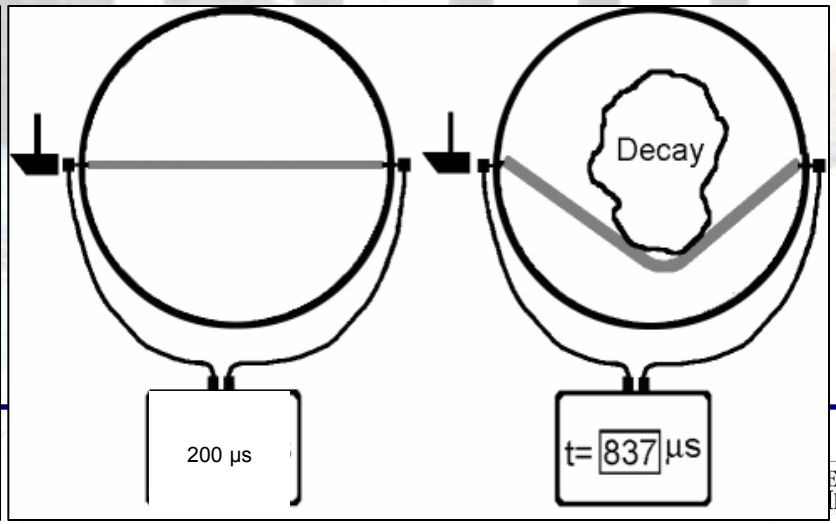
1. Visual assessment
2. Sounding
3. Moisture content surveys
4. Stress wave timing
5. Resistance microdrilling

NDE tools used to characterize size & extent of decayed zone

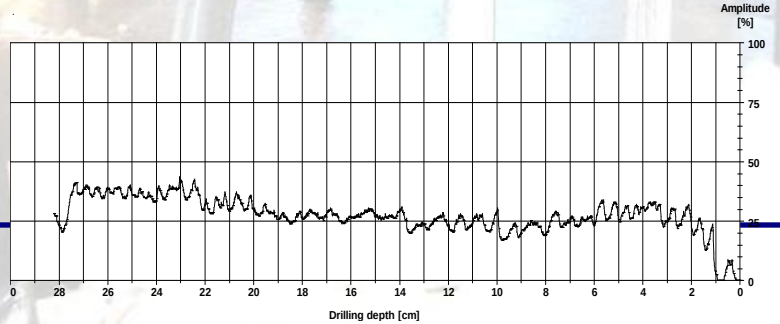
Visual Inspection

Hammer Sounding & Moisture Content

Stress Wave Timing

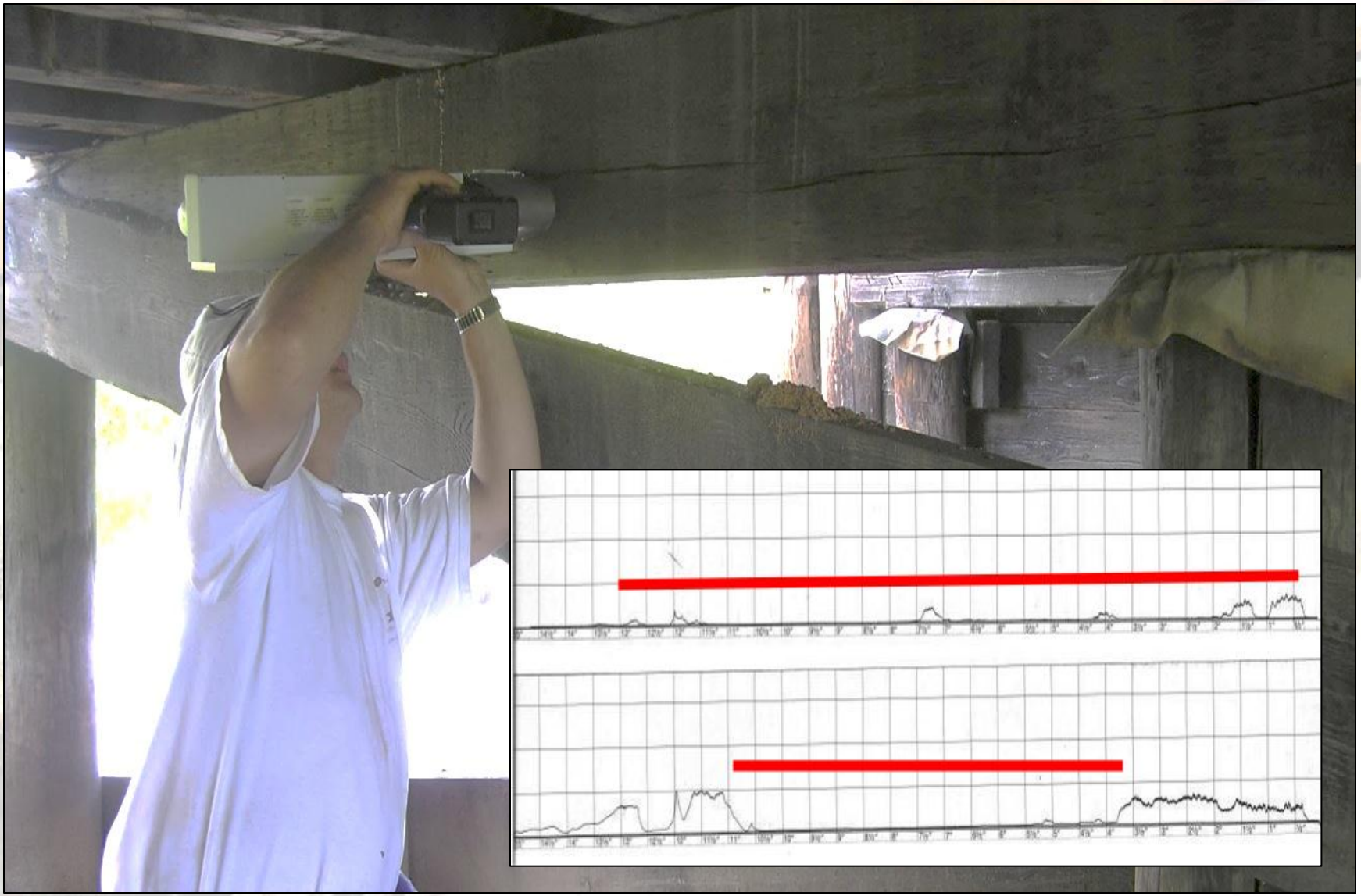


Resistance Microdrilling



Relative density plot characterizes internal decay zone

Resistance Microdrilling



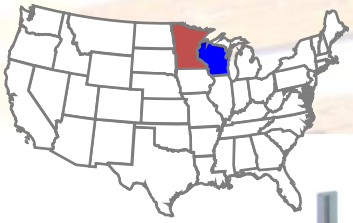
National Bridge Inventory (NBI) – Condition Ratings

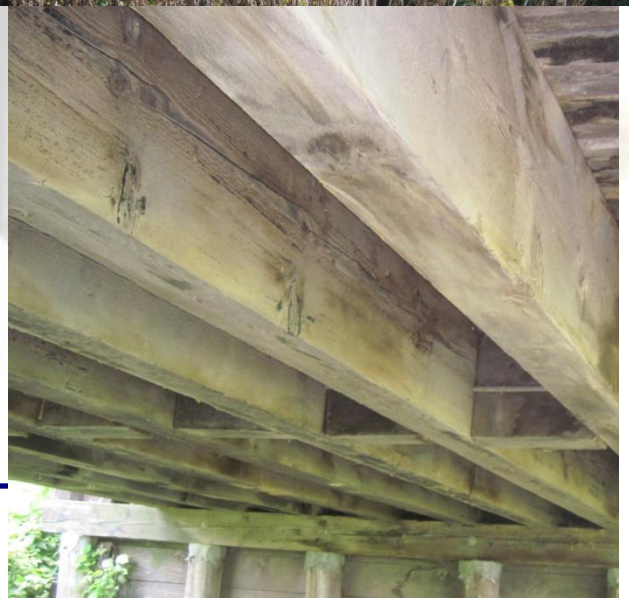
Condition Rating Code	Condition Rating Description
N	NOT APPLICABLE
9	**EXCELLENT CONDITION** - New or like new condition.
8	**VERY GOOD CONDITION** - No problems noted.
7	**GOOD CONDITION** - Some minor problems but no structural defects at critical locations (wood decay is a defect).
6	**SATISFACTORY CONDITION** - Structural elements show some minor defects and/or deterioration at critical locations. No measureable section loss.
5	**FAIR CONDITION** - All primary structural elements are sound but may have minor to moderate defects and/or deterioration with measurable section loss at critical locations. No significant reduction in primary structural member load carrying capacity.
4	**POOR CONDITION** - Primary structural elements show moderate to serious defects, deterioration, corrosion, cracking, crushing, and/or scour. Advanced section loss at critical locations. Diminished load carrying capacity of members is evident.
3	**SERIOUS CONDITION** - Serious and widespread defects have substantially reduced load carrying capacity of primary structural members. Local failures may be evident. Deflection/misalignment of members may be evident. Signs of severe structural stress are visible. Fatigue cracks in steel, shear cracks in concrete, and severe decay, checking, splitting, and crushing of beams or stringers in wood elements may be present.
2	**CRITICAL CONDITION** - Advanced deterioration of primary structural elements. Defects have now resulted in significant local failures. Scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	**IMMINENT FAILURE CONDITION** - Major deterioration or section loss present in critical structural components and/or obvious vertical or horizontal movements affecting structure stability. Bridge is/should be closed. However, correction action may put bridge back in light service.
0	**FAILED CONDITION** - Out of service. Beyond corrective action.

Upper Midwest Inspection Locations

Solid Sawn Stringer/ Timber Deck

- Southern Minnesota
  - County (4)
- Northern Wisconsin
  - Forest Service (4)
  - 1-3 spans
    - 6-10 m, 20-35 ft length
    - 1 and 2 lanes wide
  - Gravel, bituminous, timber plank over timber deck
- Superstructure NBI (5-7)
- Deck NBI (5-7)





Glulam Stringer / Timber Deck

- Southern Minnesota
  - County (4)
  - 45 years old
  - Single span
    - 10-12 m, 33-40 ft length
    - 2 lanes wide
  - Bituminous and gravel over timber deck
- Superstructure NBI (6-7)
- Deck NBI (6-7)

Steel Beam / Timber Deck

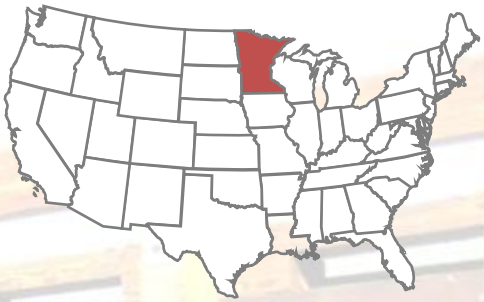
- Northern Minnesota
  - County owned (5)
  - 26-42 years old
  - Single span
    - 9-11 m, 28-35 ft length
    - 2 lanes wide
  - Bituminous over timber deck
- Superstructure NBI (6-7)
- Deck NBI (7-8)

Spike Laminated Slab

- Northern Minnesota
  - County owned (5)
  - 22-32 years old
  - Multiple span
    - 15-18 m, 46-62 ft length
    - 2 lanes wide
  - Bituminous overlay
- Superstructure NBI (5-7)
- Deck NBI (4-5)

Jackson County, Minnesota

Built in 1940 – 73 years of service



- Average Daily Traffic - 1,050
- Condition Rating – 7 on a scale of 0 thru 9 (New)
- Deck replaced in 1991.

Summary

- Nearly 130 timber bridges inspections completed during 2012-2013
- Most common type: sawn lumber girder with a sawn lumber deck (plank or nail-laminated)
- Numerous examples of bridge durability of more than 70 years
- Use of NDE inspection tools was key for collecting reliable inspection data among the six project teams
- All field data currently being analyzed for estimation of service life for bridges in different climatic regions
- Completion of this work will help provide a better understanding of the design, performance, and durability characteristics of timber bridge structures
- Final report to available in fall 2014

Acknowledgements

- Lola Hislop, USDA Forest Service, Rogue River – Siskiyou National Forest
- David Strahl, USDA Forest Service, Pacific Northwest Regional Office
- **Tom Williamson**, T-Williamson Engineering LLC
- **Vijaya (VJ) Gopu**, Louisiana Transportation Research Center
- **Travis Hosteng**, Bridge Engineering Center, Iowa State University
- Robert Vatalaro, University of Minnesota Duluth
- **David Jones**, Mississippi State University
- Joe Dahlen, University of Georgia
- Matthew Smith, Laminated Concepts Inc.
- Kristoffer Ekholm, Chalmers University of Sweden
- Several others, various state and local personnel who assisted with bridge selection and logistical planning
- **Federal Highway Administration** – key financial support of this research project
- Minnesota DOT and St. Louis, Freeborn, Faribault and Jackson Counties
- Chequamegon Nicolet National Forest

Thank you!

UNIVERSITY OF MINNESOTA

Duluth Campus

Brian K. Brashaw

Director, Wood Materials and Engineering Program
Forestry/Forest Products

Natural Resources Research Institute
5013 Miller Trunk Highway
Duluth, Minnesota 55811-1442

218-720-4248
Fax: 218-720-4329
E-mail: bbrashaw@nrri.umn.edu

UMD DULUTH NATURAL RESOURCES RESEARCH INSTITUTE