VIRGINIA TECH.

Conducting Sustainable Forest Operations While Minimizing Environmental Impacts

Chad Bolding, Associate Professor of Forest Operations

Department of Forest Resources & Environmental Conservation

College of Natural Resources & Environment; Virginia Tech

October 7, 2019

42nd COFE and 52nd FORMEC Meeting

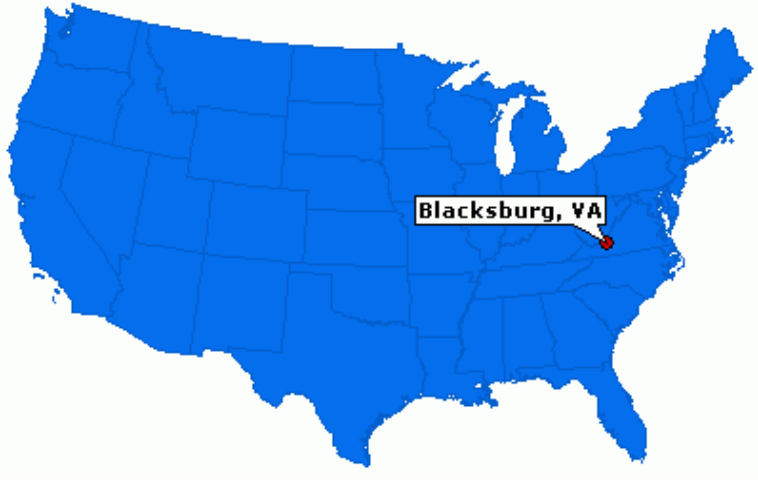
Sopron, Hungary

COUNCIL ON FOREST ENGINEERING

VIRGINIA TECH.

About Me

- Associate Professor, Virginia Tech
  - Forest Operations/Engineering
  - Harvesting, Procurement, Harvesting Systems Evaluation, Forest Field Studies
- Virginia Tech
  - 110 bachelor's degree programs
  - 170 master's and doctoral degree programs
  - 34,440 students
  - 1,967 faculty members
  - Research portfolio of $531 Million



RESEARCH FOCUS AREAS

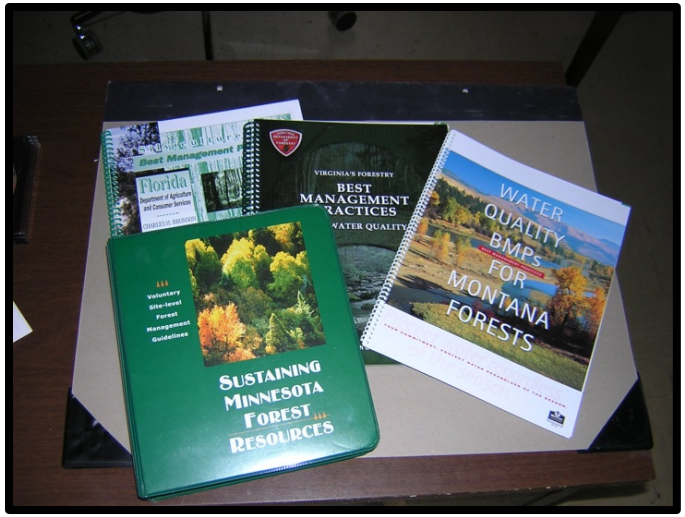
1. Evaluating operations with regard to safety, productivity, planning, and logistics
2. Improving the efficiency and profitability of forest operations
3. Analyzing forest business issues such as supply chain management and biomass utilization
4. Evaluating the environmental impacts of forest operations

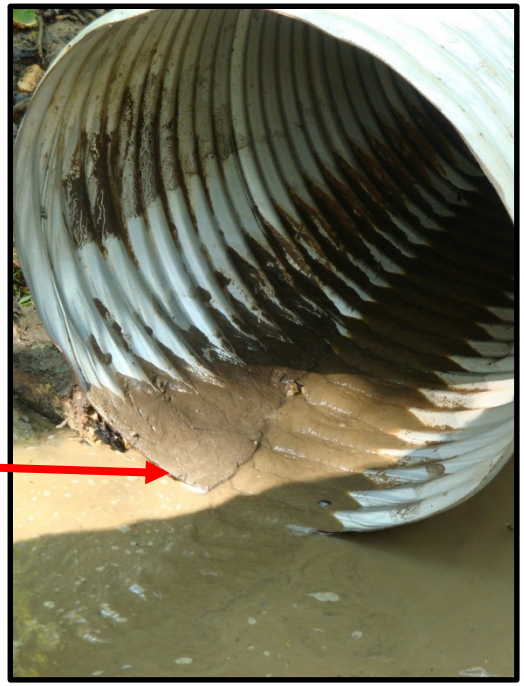
Environmental Impacts in the United States

- **Federal Water Pollution Control Act of 1972 "Clean Water Act" provided the motivation for development of <u>State BMP programs</u> for control of Non-Point Source Pollution.**

State Forestry Best Management Practices

- States developed Forestry Best Management Practices (BMPs)
- Primary goal: to maintain and protect <u>water quality</u> from nonpoint source pollutants such as sediment, temperature, chemicals, excessive organics, biological pollutants.
- <u>Sedimentation</u> is the primary concern for most forest operations.





Forest Operations Typically Monitored by State BMP Programs

- Preharvest Planning
- Roads
- Decks
- Skid Trails
- Stream Crossings
- SMZs
- Firelines
- Harvesting
- Site Preparation
- Fertilization

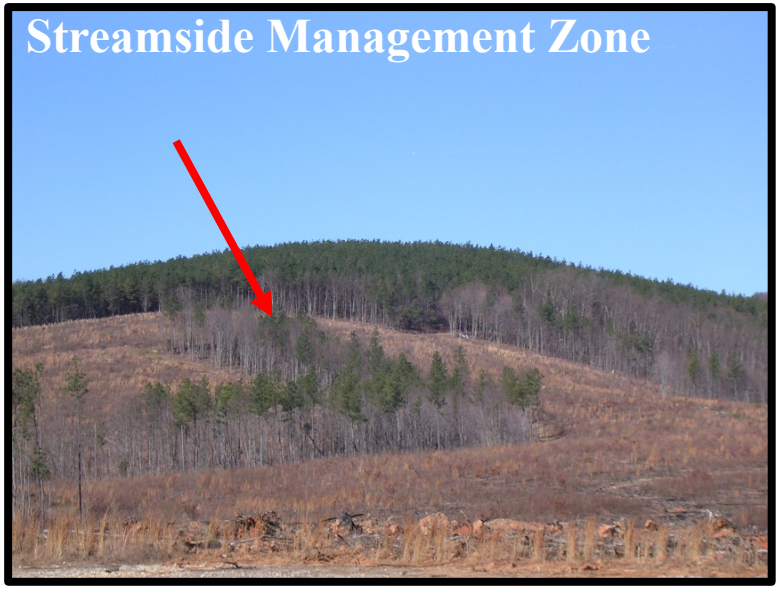
Recent Forest Roads & Environmental Issues

- **Point source vs. Non Point source pollution**
- **US Supreme Court case regarding Forest Roads and Stream Crossings**
  - Questioned the validity of forestry activities being characterized as non-point sources of pollution
  - Led to renewed interest in BMP effectiveness research

Goal of Presentation

- Provide an overview of BMP effectiveness studies conducted at Virginia Tech

1. Can harvesting be conducted without environmental impact?
2. Can impacts be minimized, allowing sustainable harvests?



VIRGINIA TECH.

Forest Operations Graduate Student Projects Related to Roads, BMPs, and Sediment

- **25 graduate students have completed projects since 2008**
  - Preharvest Planning
  - Harvests
  - Roads/Decks/Skid Trails
  - Site Preparation
  - Firelines
  - SMZs
  - Stream Crossings
  - Skid Trail Closure

Lakel et al. 2006, 2010, 2015 evaluated 16 SMZs with 4 levels of BMPs

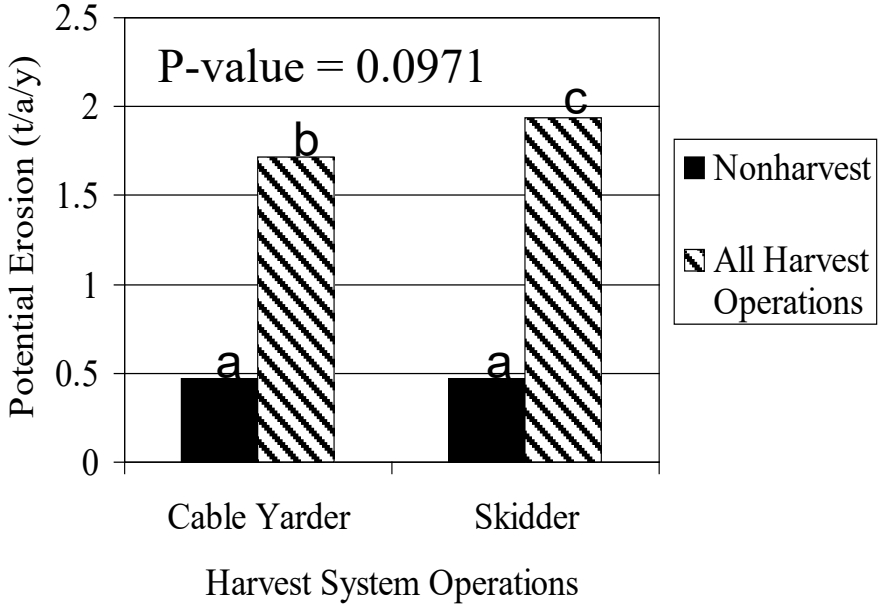
- Evaluated 25, 50, 50 with thinning and 100 ft SMZs in 16 watersheds.
- Sediment Delivery Ratio for all SMZ widths was 3-14%. <u>Trapped 86-97%.</u>
- SMZs failures associated with roads, skid trails, stream crossings.

Aust et al. 2011

- 24 stream crossings (bridge, culvert, pole, ford) during 4 periods (before, install, harvest, close)
- Stream crossing approaches are of more concern than type of crossing
- For sediment, Bridges < Ford/Pole < Culverts
- Highest erosion during harvest - BMPs should be used on crossing approaches during harvest
  - Harvest vs. closure

Worrell et al. 2011

- Cable yarding vs bladed skid trails (3 side-by-side sites)
- Slight overall erosion differences between conventional and cable harvests
- Cable yarding COULD be much better IF spur roads were planned better



Wade et al. (2012)
5 Skid Trail Closure Treatments

Control

Seed

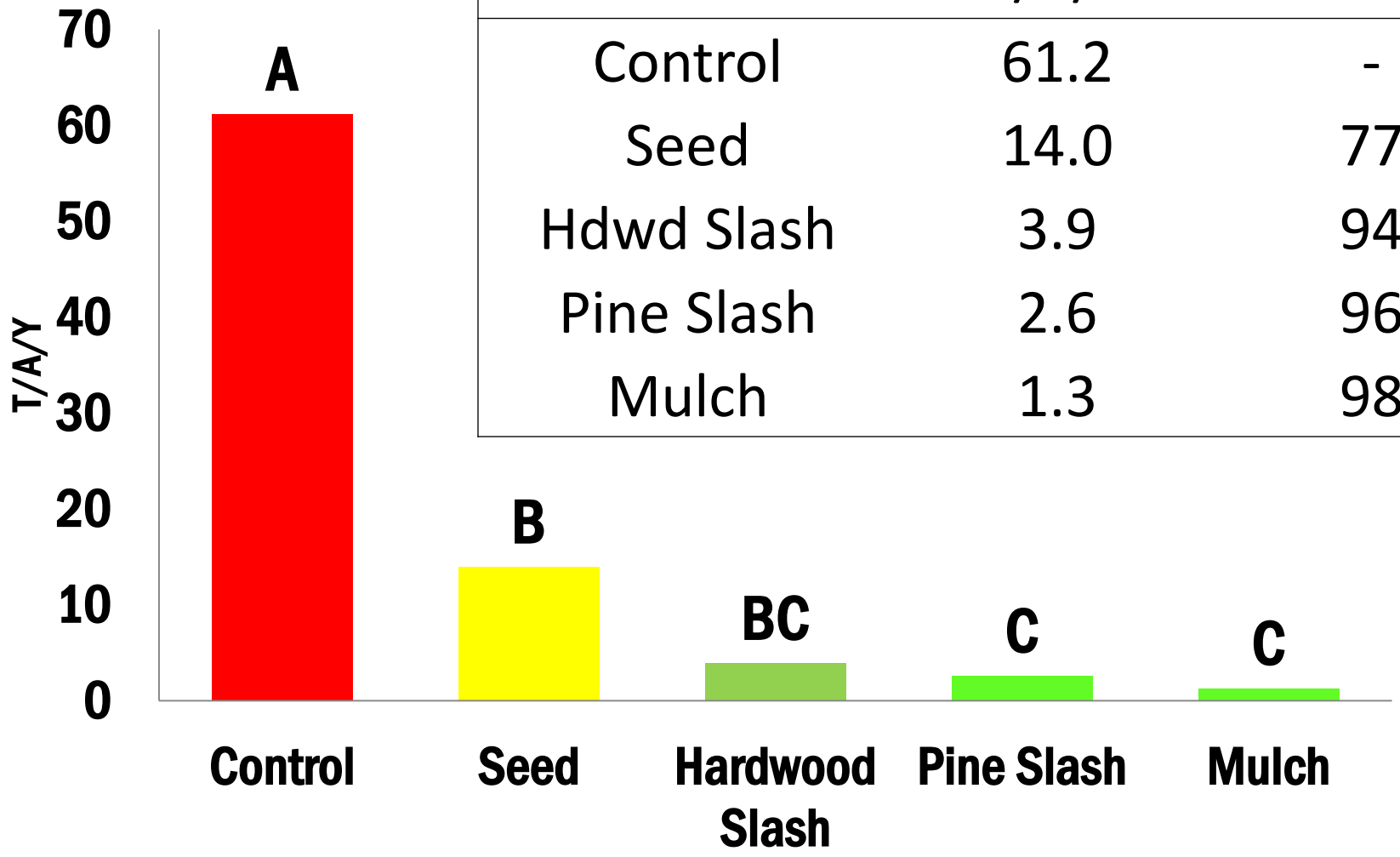
Mulch

Hardwood Slash

Pine Slash

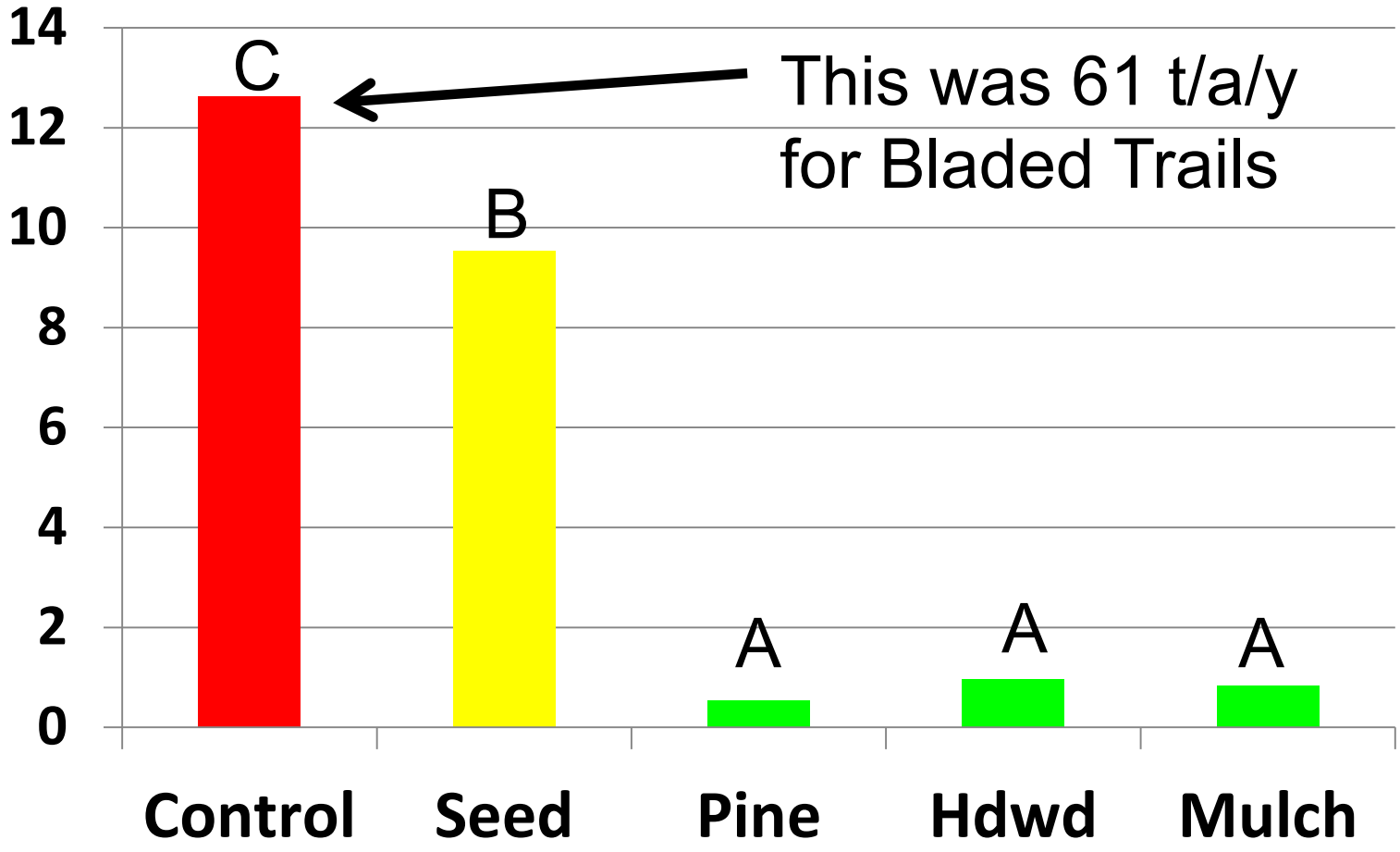
Overall Erosion

Treatment	Actual T/A/Y	% Reduction
Control	61.2	-
Seed	14.0	77
Hdwd Slash	3.9	94
Pine Slash	2.6	96
Mulch	1.3	98



Sawyers et al. 2012
Overland Skidding

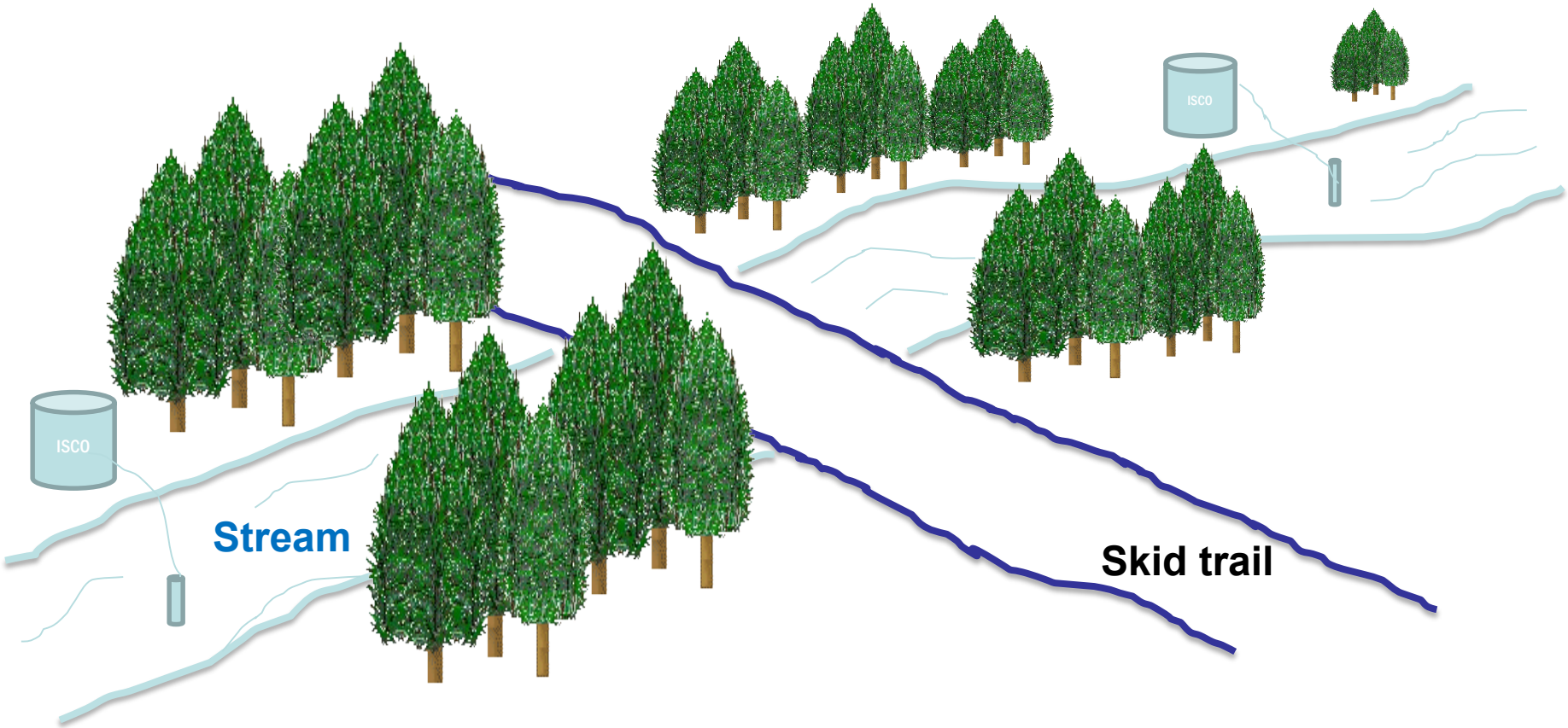
Total Annual Erosion (t/a/y) by Treatment (p=0.0001)



Skidder Stream Crossing Closure BMPs (Wear et al. 2013 - *FEM*)

- Operationally installed by BMP contractors
- <u>Slash</u>: waterbars and piled slash
- <u>Mulch</u>: waterbars fescue, lime, fertilizer, straw mulch
- <u>Mulch + Silt Fence</u>: same as above plus silt fence at stream

Field Methods



VIRGINIA TECH

Field Methods

ISCO automated water samplers

Treatments: Slash

Treatments: Mulch

– seed, fertilizer, and straw mulch

Treatments: Slash + Mulch

- slash, seed, fertilizer, straw, and silt fence

VIRGINIA TECH

Field Methods

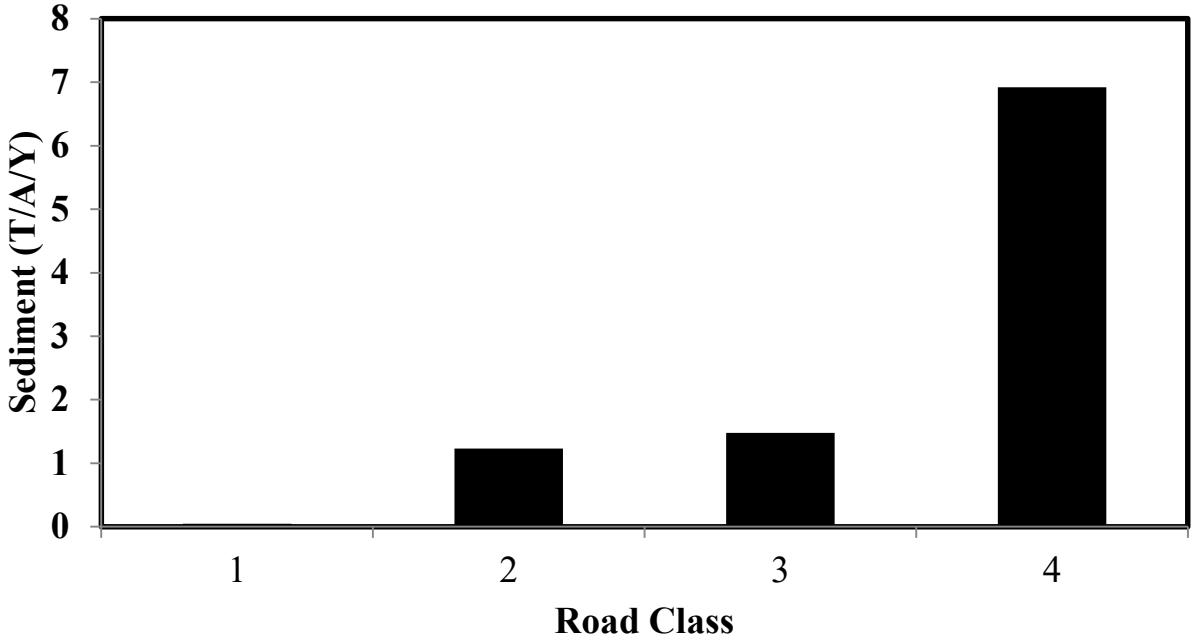
Collected samples every 3 weeks

BMP efficiency % ΔTSS relative to pre-closure

Rainfall category	BMP treatment	Average ΔTSS	BMP Efficiency %
Medium	Pre-closure	76.5	
	Slash	2.1	97%
	Mulch	0.3	99%
	Mulch + Silt Fence	456.7	-497
High	Pre-closure	97.7	
	Slash	31.5	68%
	Mulch	127.0	-30%
	Mulch + Silt Fence	475.7	-386%
Maximum	Pre-closure	100.6	
	Slash	37.5	63%
	Mulch	84.7	16%
	Mulch + Silt Fence	89.9	11%

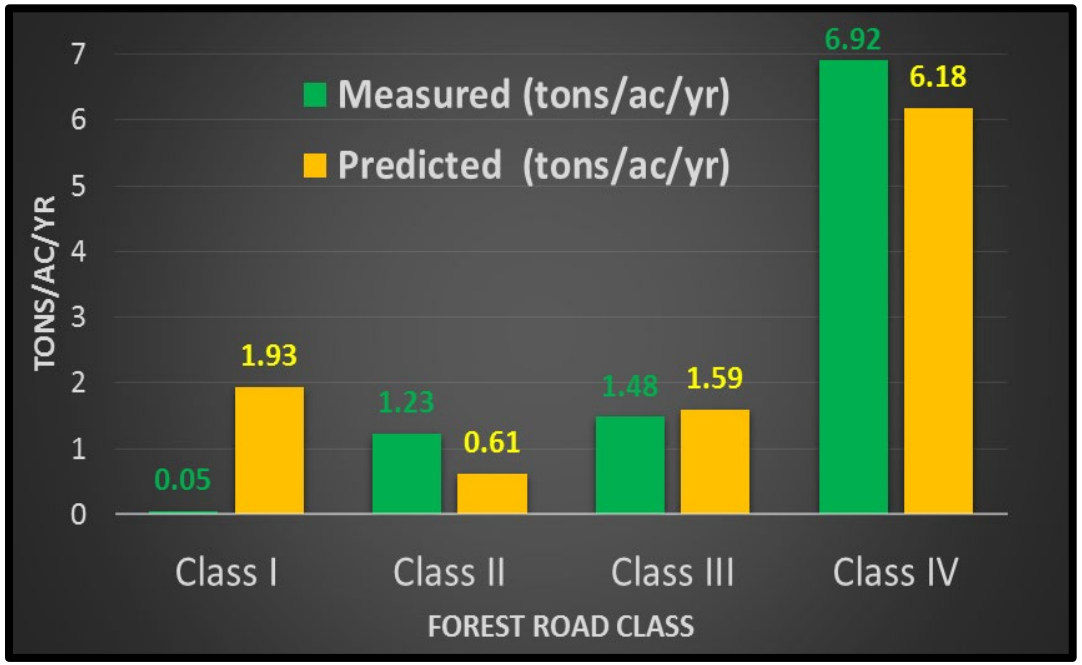
Road Class, Stream Crossings, and Sediment (Lang et al. 2018)

- Evaluated 40 haul road stream crossings
- Sediment was found to be a function of road standards, traffic, BMPs



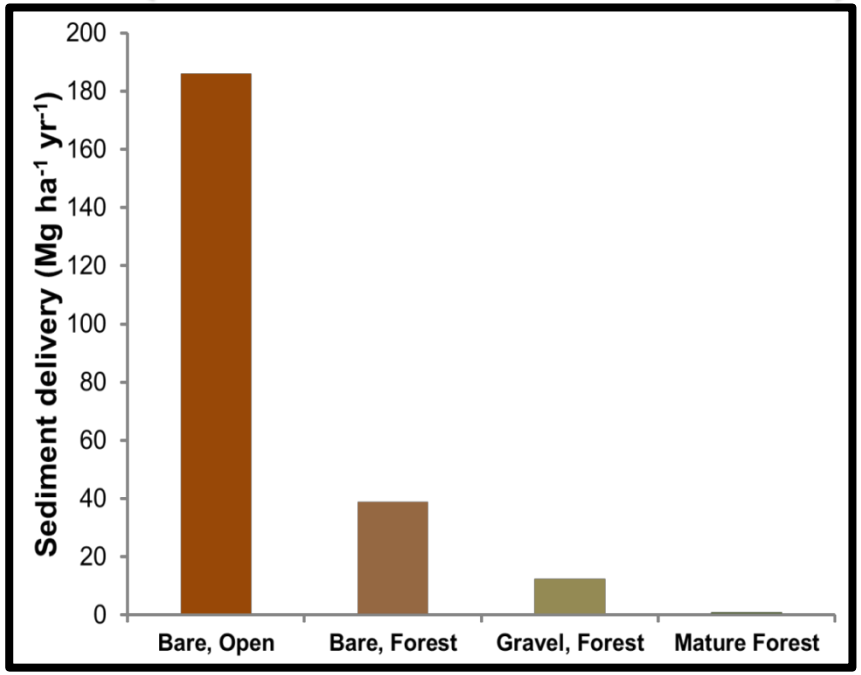
Road Class, Stream Crossings, and Sediment (Lang et al. 2018)

- Categorized >20 road standards into 4 road classes.
- Sediment related to road class & associated BMPs.



Legacy Roads and Sediment (Brown et al. 2013a)

- Evaluated sediment contributions from 15 <u>legacy roads</u>
- Major factors controlling sediment were road area, road length (spacing between water controls), and amount of cover/canopy

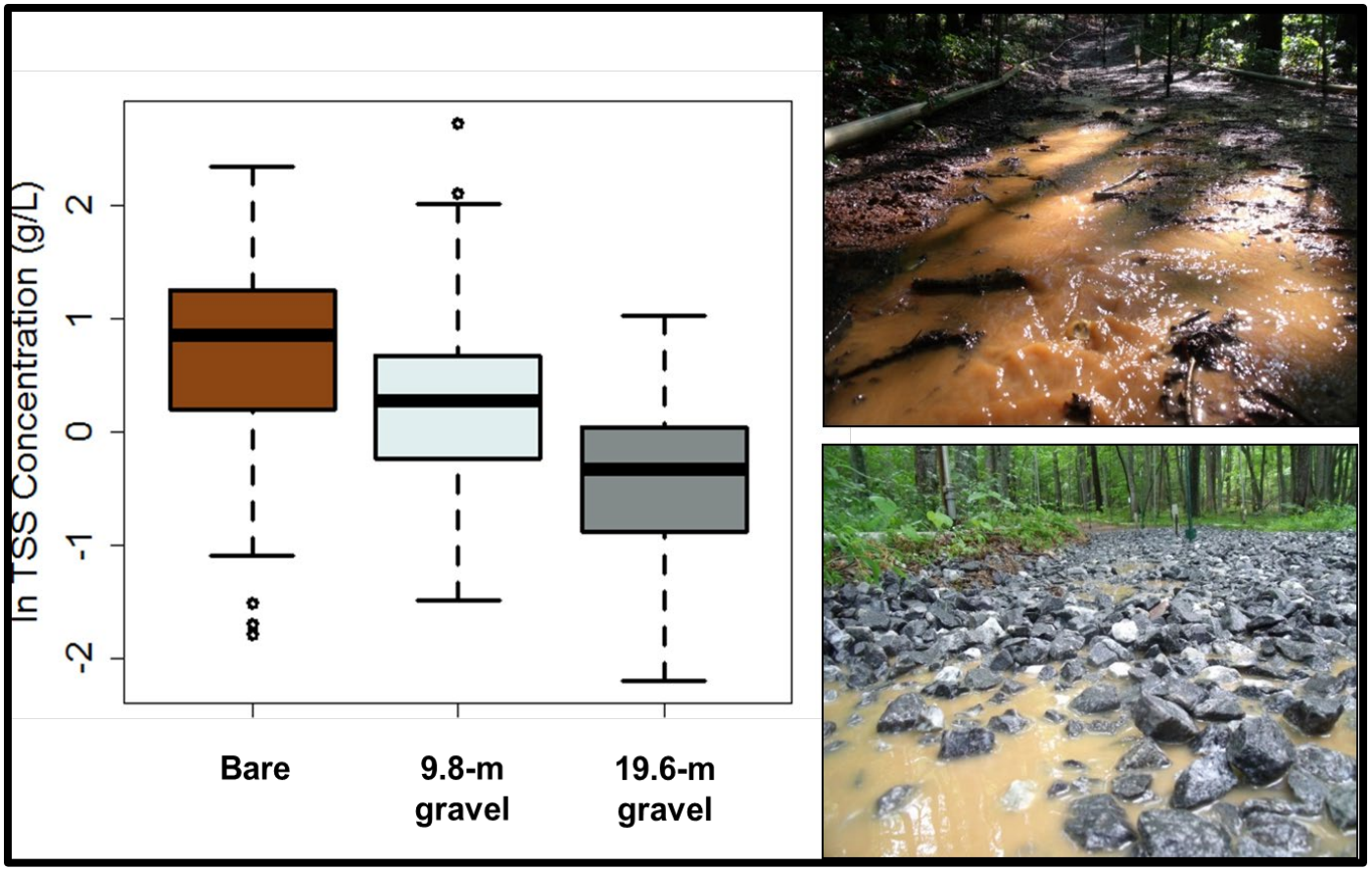


Road Stream Crossings and BMPs (Brown et al. 2013b)

- Used rainfall simulations to evaluate sediment contributions from 3 stream crossings (6 approaches), 3 rainfall intensities, and 3 levels of BMPs (no gravel, ½ approach graveled, full approach graveled).

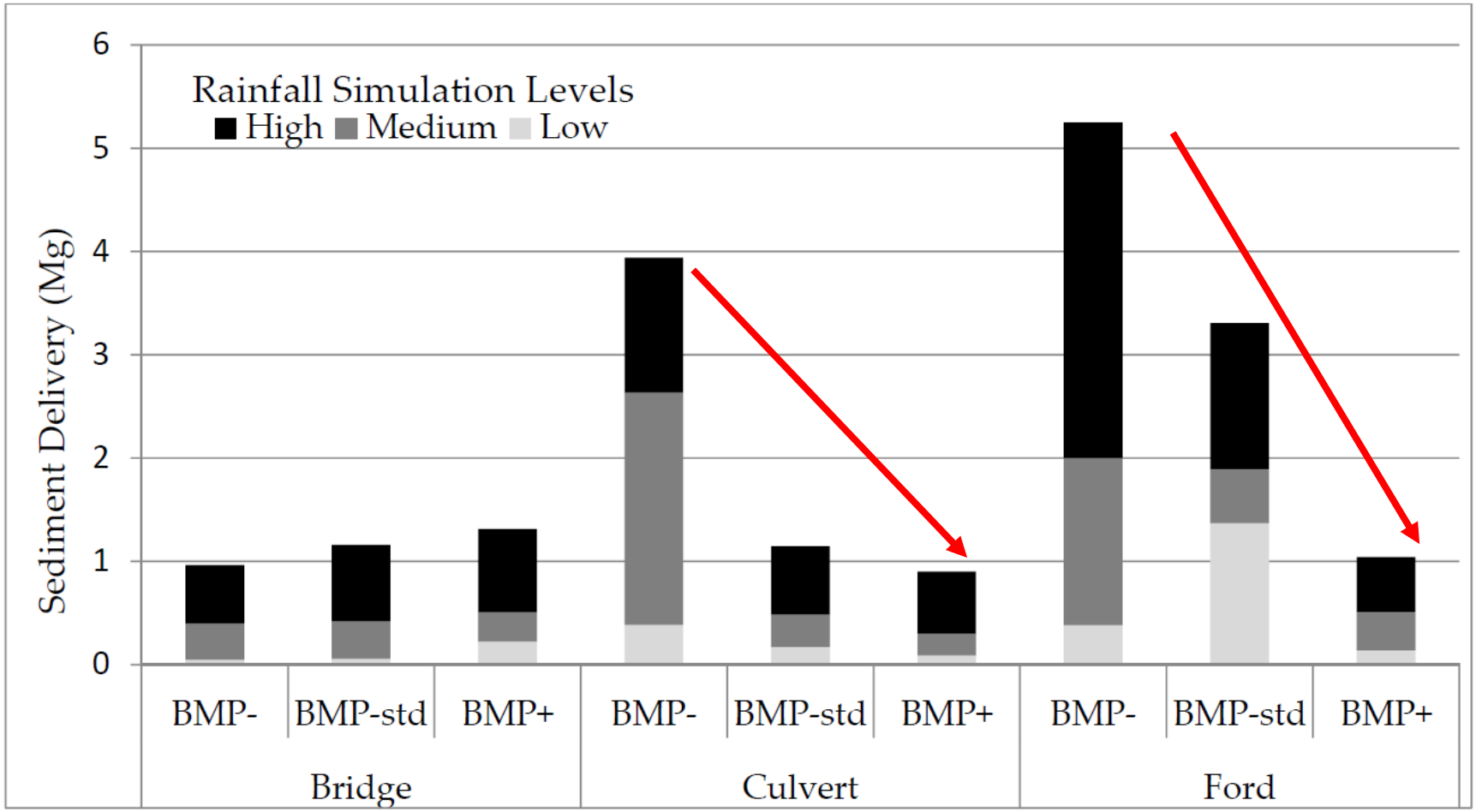
Road Stream Crossings and BMPs (Brown et al. 2013b)

- Concluded that the lowest level of BMPs was contributing 7x more sediment than medium level of BMPs
- Medium level of BMPs provided 2x of the effect of full gravel



Haul Road Stream Crossings (Morris et al. 2016)

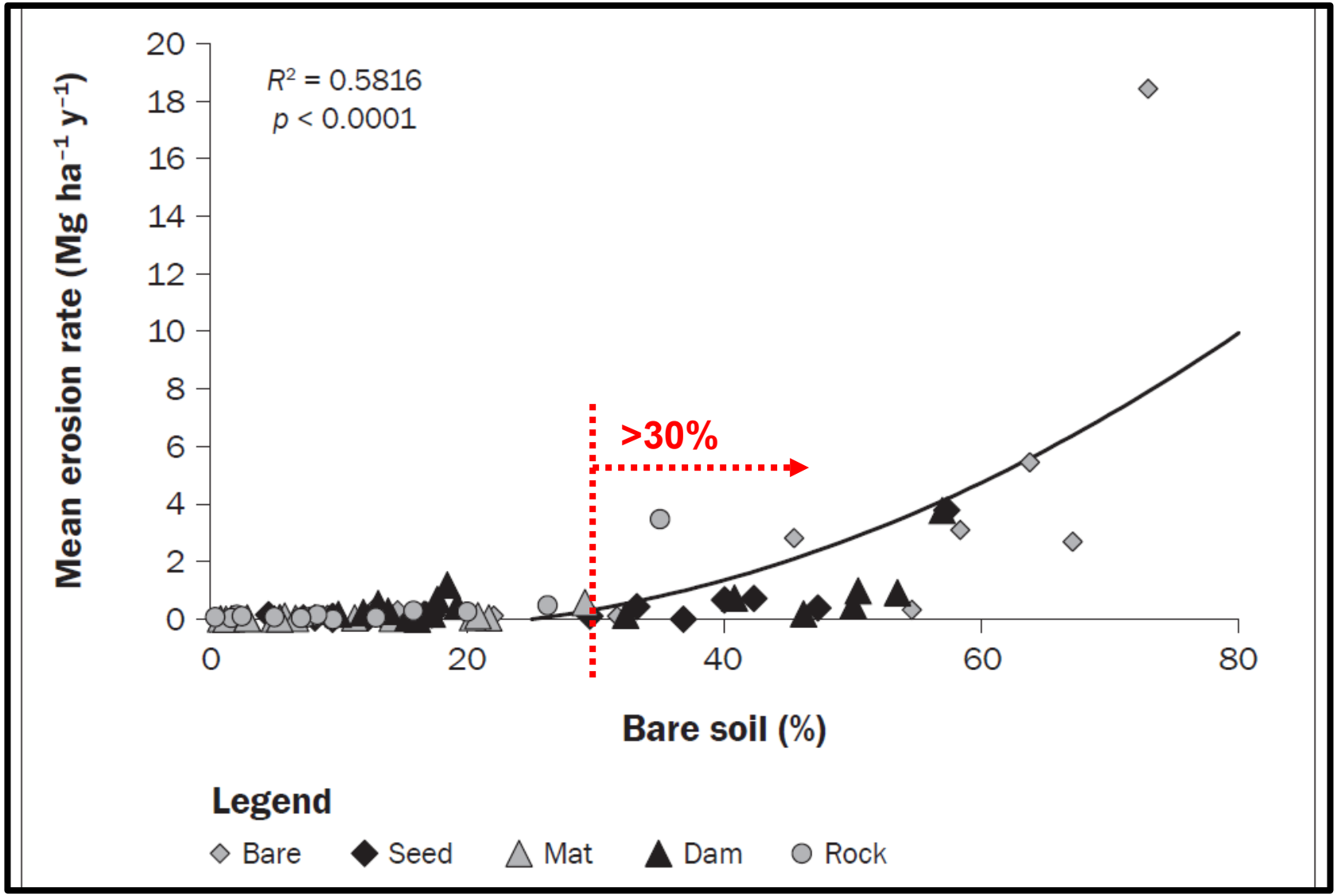
- Compared TSS above and below a bridge, culvert, and geoweb ford
- 3 levels of BMPs
- 3 levels of rainfall simulation



- **Additional BMPs reduced sediment delivery for the culvert and ford crossings**

Lang et al. (2017) evaluated 5 road ditch BMPs and sediment for 60 ditch segments

- All BMPs reduced erosion, but gravel or erosion mat were most effective
- **Erosion mat was also the most cost effective**


R^2 = 0.5816
p < 0.0001
>30%
Mean erosion rate (Mg ha^{-1} y^{-1})
Bare soil (%)
0
2
4
6
8
10
12
14
16
18
20
0
20
40
60
80
Legend
Bare
Seed
Mat
Dam
Rock

Stream Crossing Upgrade (Dangle et al. 2019)

- **Efficacy of Upgraded Best Management Practices at Operational Forest Stream Crossing Approaches (N=154)**
  - BMP- →Below standard
  - BMP_{std} →Standard
  - BMP+ →Above standard
- **What are the benefits/costs of upgrading stream crossings?**

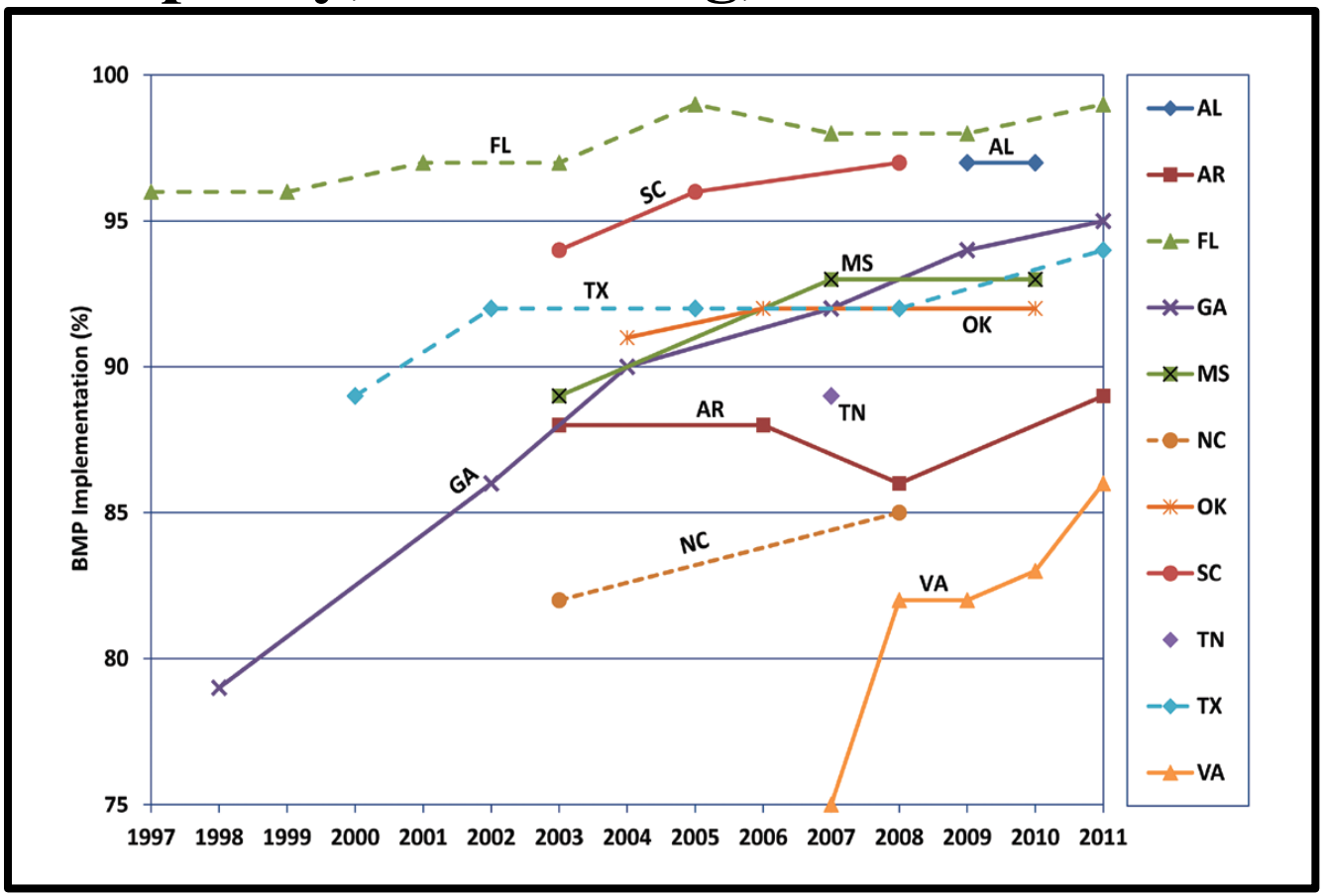
Potential Erosion Reduction and Cost to Upgrade Crossings

		Before upgrade (Mg/yr)	After upgrade (Mg/yr)	Upgrade cost ($)	Benefit cost ratio ($/Mg)
Skid Trail	BMP-	1.93	0.33	36.06	22.54
	BMP_{std}	0.25	0.03	62.23	282.86
Truck Road	BMP-	0.52	0.28	151.65	631.87
	BMP_{std}	0.25	0.05	114.05	570.25

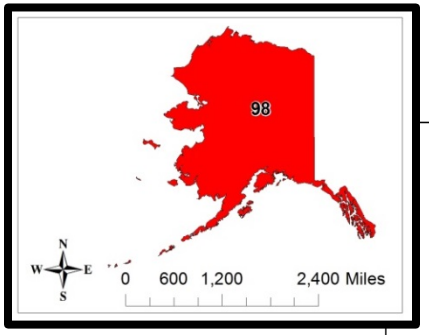
- **Truck road crossings are more expensive to upgrade and less is gained**
- **Resources are better utilized upgrading skid trail crossings**
  - **Minimal cost necessary to upgrade from BMP- to BMP_{std}**

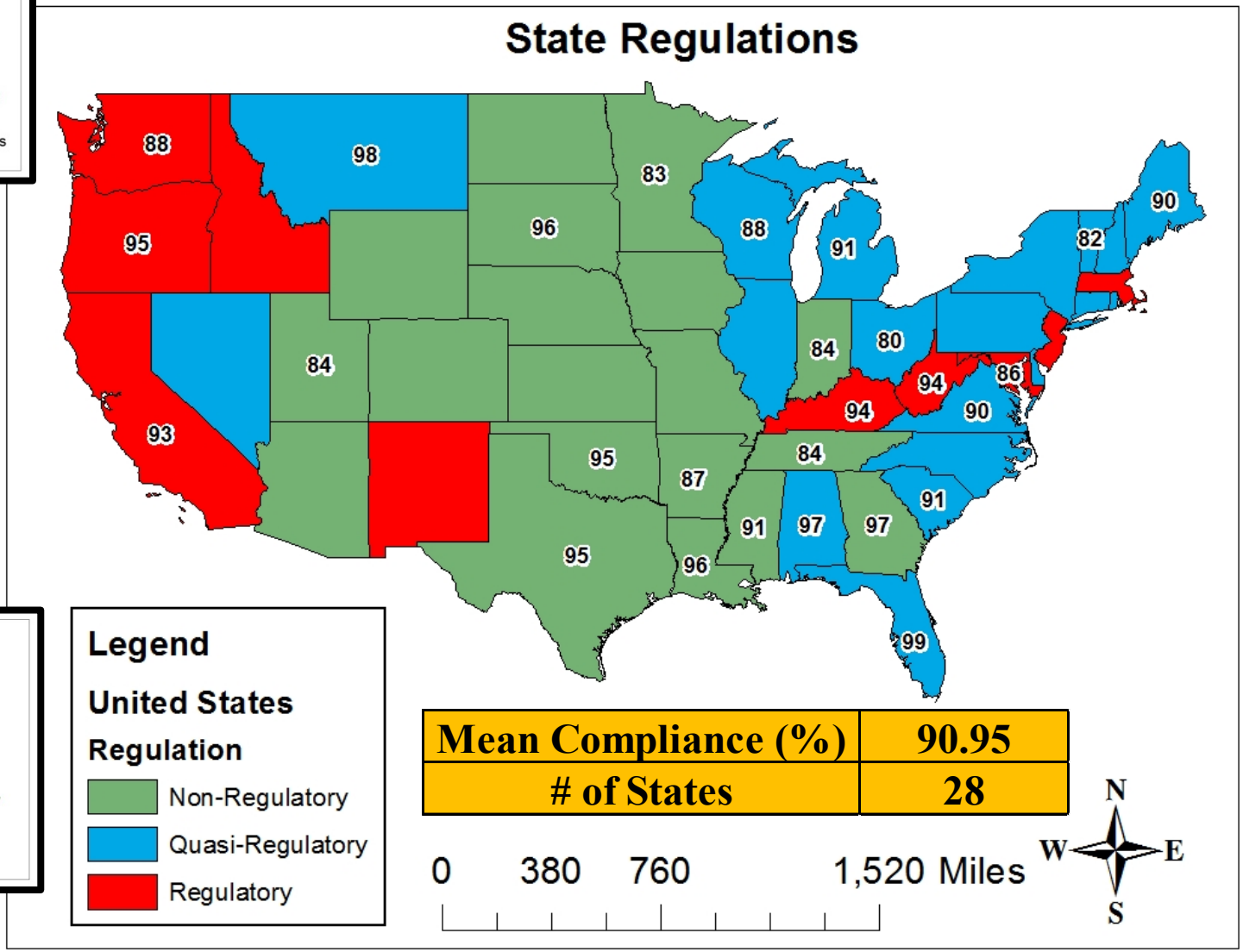
National Evaluation of BMP Programs (Cristan et al. 2018)

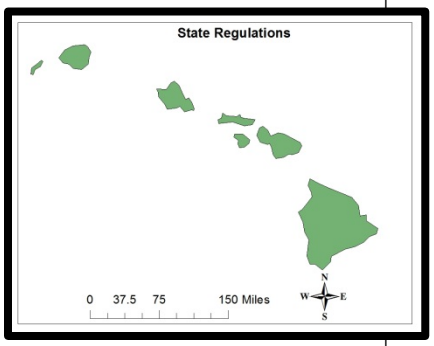
- Surveyed the State Foresters/Water Quality Foresters for 50 states and 8 US territories to evaluate the BMP policy, monitoring, and compliance



Cristan et al. (2018) reported BMP compliance for the US.



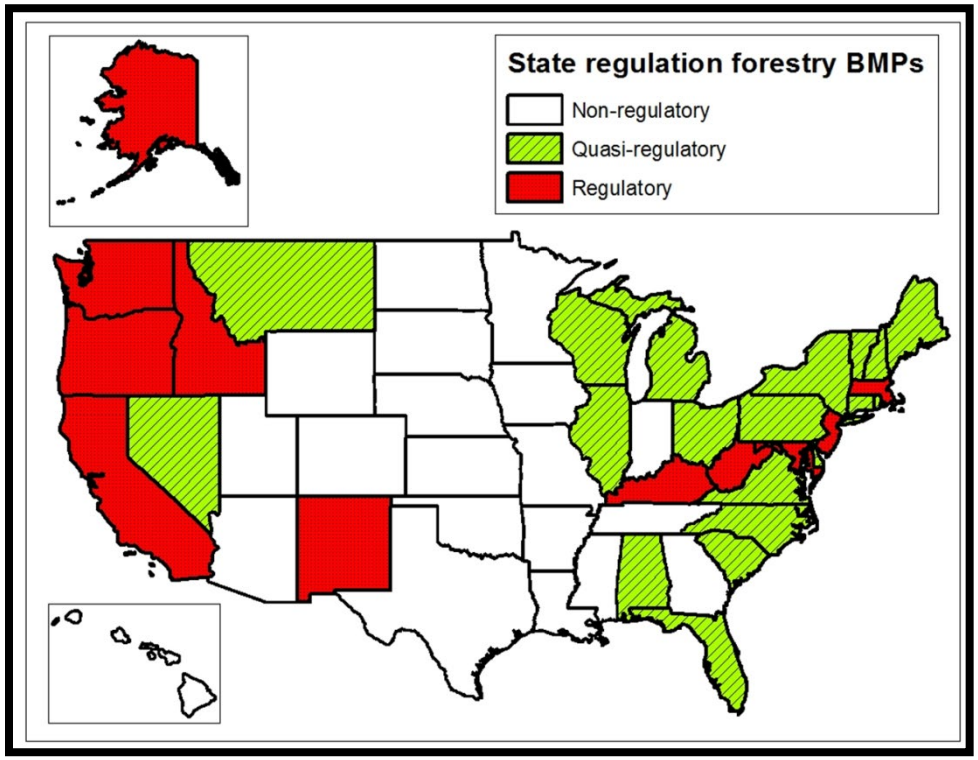




BMP Implementation Rate (%)								
Regulation	*State average	Timber harvest	Forest roads	Skid trails	Log landings	Stream crossings	SMZ	Wetlands
Non-regulatory	90.2 (13)	92.4 (7)	90.5 (11)	88.2 (9)	94.4 (10)	88.5 (11)	87.1 (11)	86.2 (9)
Quasi-regulatory	90.1 (11)	94.6 (7)	89.4 (11)	88.0 (9)	91.6 (7)	84.6 (10)	91.8 (11)	92.8 (8)
Regulatory	93.4 (8)	91.5 (6)	94.0 (8)	92.7 (6)	95.4 (8)	86.9 (8)	93.9 (7)	95.3 (6)

-No Statistical Difference Between Regulations-

*State average may consist of up to 16 BMP categories depending on state



Conclusions

- No statistical difference between BMP implementation rate and state BMP regulation
- National and state BMP implementation rate is high
  - However, some states did show potential deficiencies with some individual BMP categories

	Harvest (%)	Road (%)	Skid Trails (%)	Log Landing (%)	Stream Crossing (%)	SMZ (%)	Wetlands (%)	Reforestation (%)
MIN	81	70	73	70	67	70	51	87
MAX	99	99	100	100	100	99	100	100
Average	92.9	91.0	89.3	93.9	86.7	90.5	90.9	97.0
n	20	30	24	25	29	29	23	10

	Mech Site Prep (%)	Chem Site Prep (%)	Pesticide (%)	Fertilizer (%)	Prescibed Burn (%)	Wildfire Supp (%)	Wildfire Rehab (%)	Public Lands (%)
MIN	74	75	75	98	60	100	100	87
MAX	100	100	100	100	100	100	100	100
Average	93.2	96.5	96.8	99.5	88.5	100.0	100.0	97.2
n	13	11	9	4	13	2	1	12

VIRGINIA TECH

Summary of Research

- Forest operations can be conducted sustainably!
  - Keys for success
    1. Plan operations with forethought
    2. Minimize interaction with streams and steep slopes
    3. Maintain proper streamside management zones
    4. Cover bare soil with slash or seed and mulch
    5. Ensure proper drainage and install water control structures
- BMPs work!
  - Practices must be implemented and enforced
  - Operators need an incentive to implementation

VIRGINIA TECH.

The Industrial Forest Operations program was initiated in 1973 as a cooperative effort among the pulp and paper industry, forest equipment manufacturers, and Virginia Tech to provide undergraduate and graduate education programs that prepare foresters for careers in wood procurement, working with independent contractors, and overseeing the operational aspects of forest industries. To create opportunities for graduate students, research became a larger focus in 1984. Faculty members and students cooperate with forest industry and forest equipment manufacturing personnel in the selection of research projects.

Contact Information:

Chad Bolding, PhD

Associate Professor

Forest Operations/Engineering

228 Cheatham Hall, 0324

Blacksburg, VA 24061

Phone: 540-231-6924

Email: bolding@vt.edu

The Department of

Forest Resources and Environmental Conservation

Forest Operations and Business

WHO WE ARE

Based in *The Department of* **Forest Resources and Environmental Conservation** at Virginia Tech, the Forest Operations Research Group taps a broad range of university and industry resources to provide students with educational and research opportunities and to address forest industry needs.