Summary of Selected Information on Wet Weather Log Hauling and Impacts to Water Quality

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CAL FIRE
March 1, 2011

Outline

- ODF Wet Season Road Use Monitoring Study
- JDSF Hare Creek Wet Weather Hauling Study
- Sullivan PALCO Crossing Study
- HMP and MCR Monitoring Results
- Published Papers Summary
- Take Home Messages

FOREST PRACTICES MONITORING PROGRAM
TECHNICAL REPORT # 17

Oregon Department of Forestry
Wet Season Road Use Monitoring Project
June 2003

Keith Mills, Liz Dent, and Josh Robben

Study Goal

Study designed to identify factors that contribute to turbidity when roads are used during wet periods.

Road Surface and Hauling Impacts

Study Objectives

How do these factors affect turbidity?

- **Rainfall conditions that result in road runoff entering streams**
- **Road surface aggregate**
- **Road segment length draining to streams**

Study Sites

- Private industrial and state-managed forestlands in Western Oregon.
- Low elevation sites—not snow covered.
- Sites were located in both the OR Coast Range and the Cascades.
- Only roads with active winter timber hauling.
- All roads were gravel surfaced.
- Roads included primary haul roads and secondary roads accessing logging units.
- Roads cross small streams that flow all winter.
- 174 stream crossings were studied; 438 crossing pairs (upstream and downstream were analyzed for change in turbidity.

Study Design

- **Not random sampling design.**
- **Samples collected above and below crossings during periods of heavy rainfall.**
- **Results cannot be used to characterize average water quality conditions resulting from wet weather hauling.**
- **Study provides data on factors affecting stream turbidity during wet season road use.**

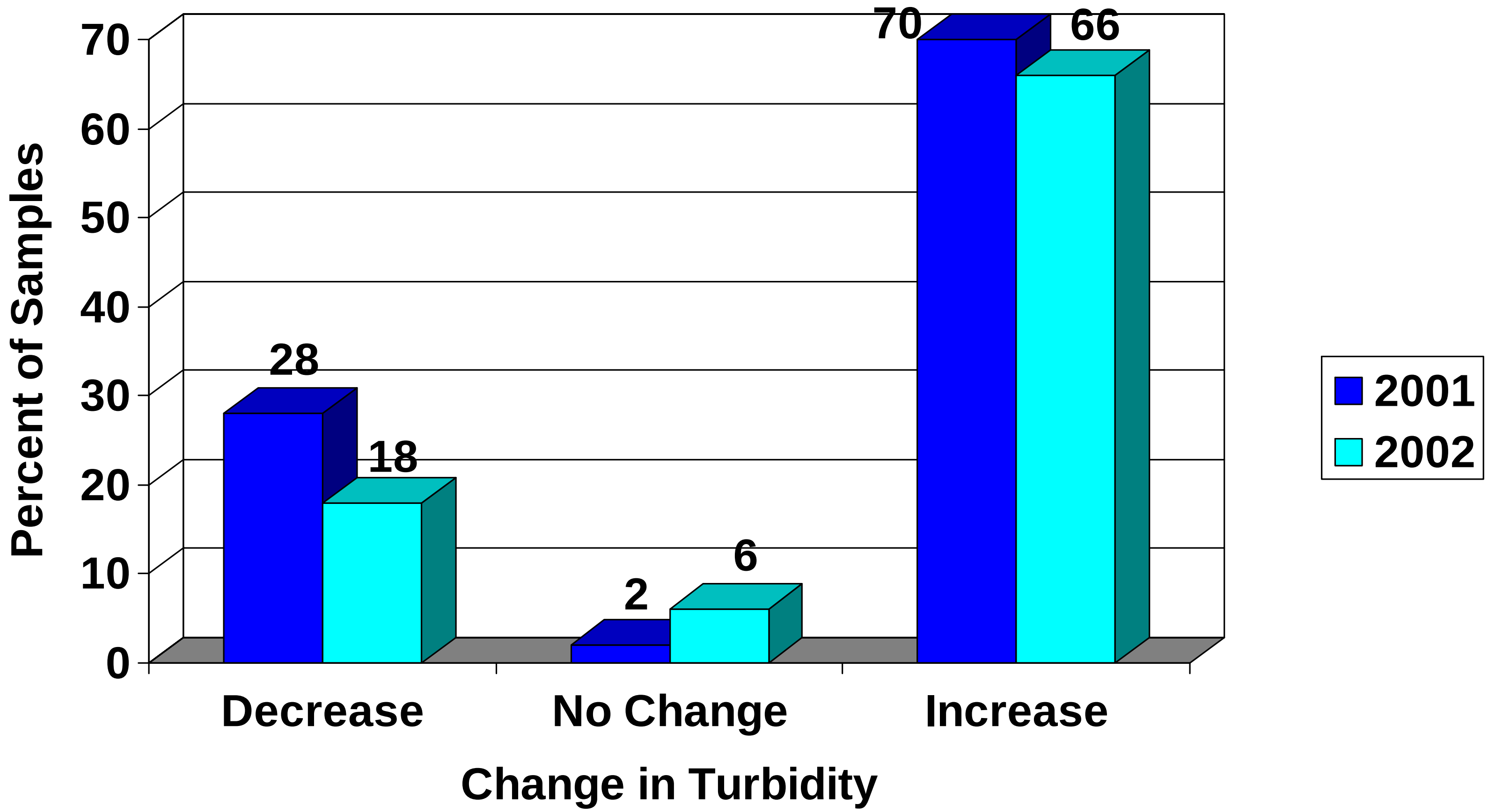
Road Segment Parameters

- **Average road gradient**
- **Ditch length draining to stream**
- **Depth of road surfacing material**
- **Sample of surfacing material**

Other Data Recorded

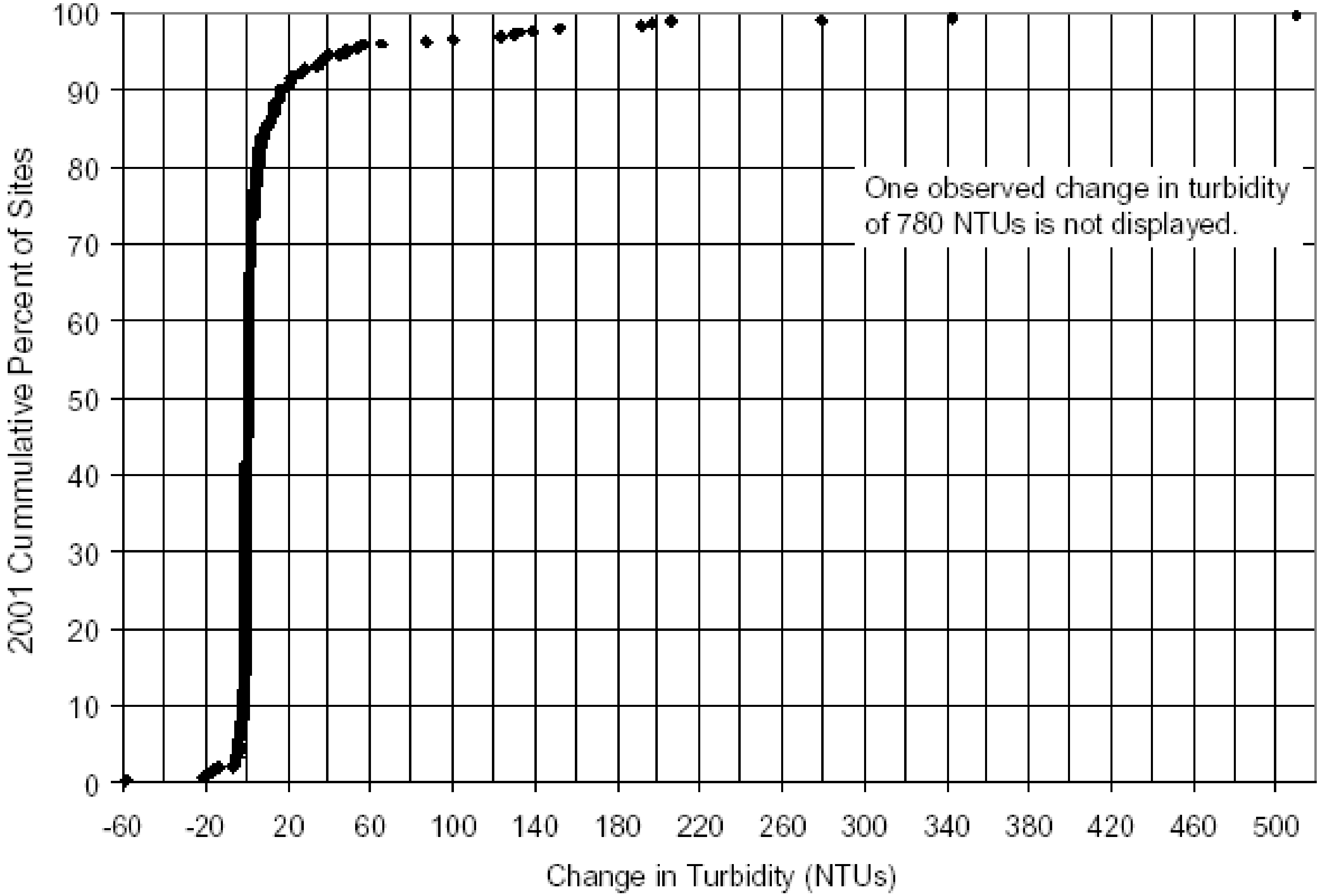
- Log truck traffic level
- Condition of road surface (rutting, mud depth)
- Recent maintenance activity
- Sources of sediment delivery to channel other than road surfacing
- Precipitation from nearest station
- Amount of ditchflow—estimated as % of streamflow

Crossing Turbidity Samples



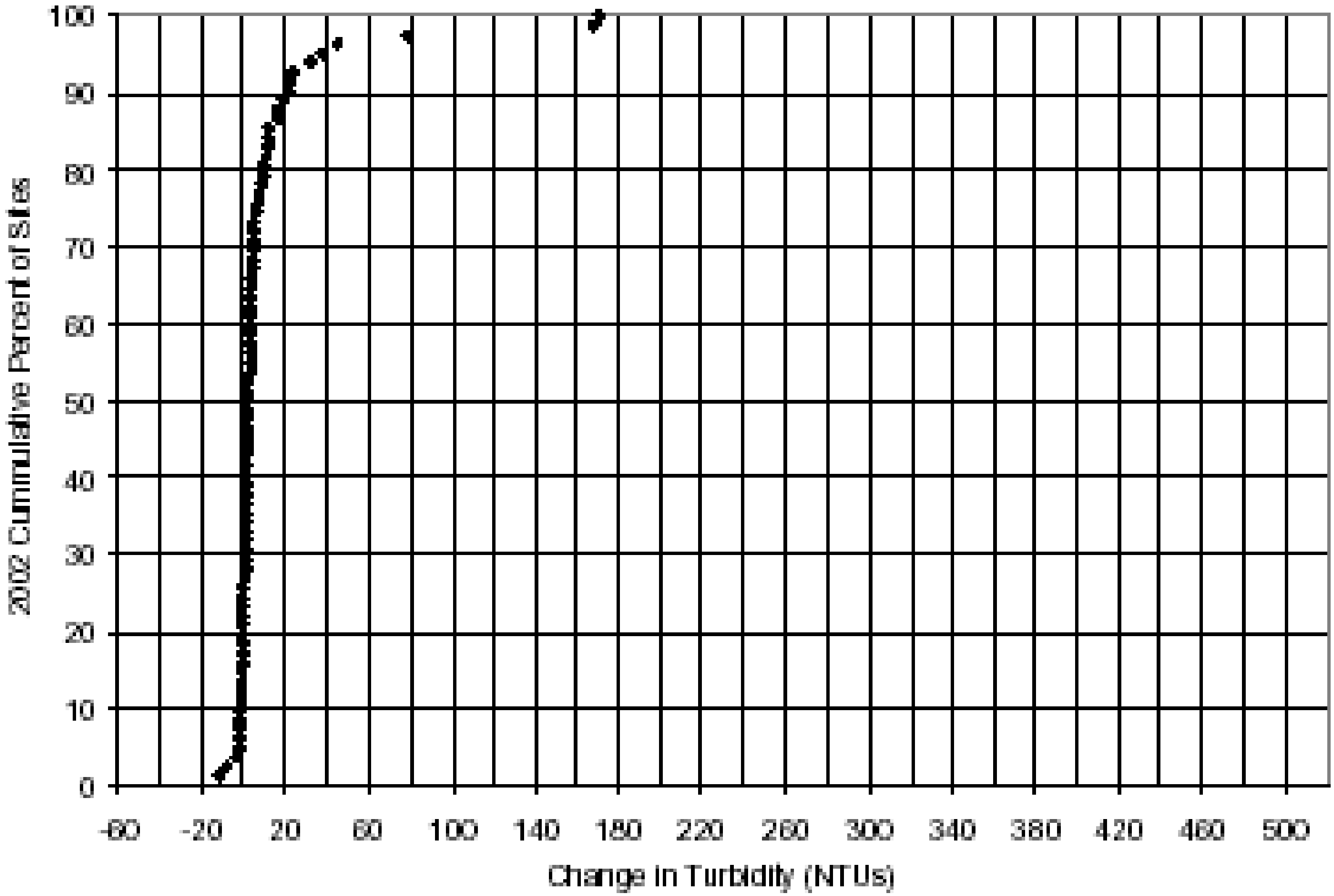
Road Surface Water Entering a Stream

Distribution of Turbidity Changes for **2001** Crossing Samples



A change of 20 NTUs or less was observed for ~90% of the sample pairs.

Distribution of Turbidity Changes for **2002** Crossing Samples



A change of 20 NTUs or less was observed for ~90% of the sample pairs.

Summary of Turbidity Changes

- **89-90% (2002 and 2001 seasons respectively) of the sample pairs showed a change of 20 NTUs or less.**

- **The remaining 11 to 10% ranged from an increase of 20 to 780 NTUs.**

Possible Reasons for Decreased Turbidity Below Crossings

- Changes <10 NTUs cannot be distinguished from measurement error.

- Changes >10 NTUs could be due to:
  - Settling of materials between sampling points
  - Poor mixing of suspended materials

Factors with Potential to Influence <u>Changes in Turbidity</u>

- Precipitation (3 day total)
- Depth of surfacing material
- Percent fines in surfacing material
- Durability of surfacing material
- Length of road ditch draining directly to the stream
- Traffic levels

2001 Multiple Linear Regression Model <u>for Observed Increases in Turbidity</u>

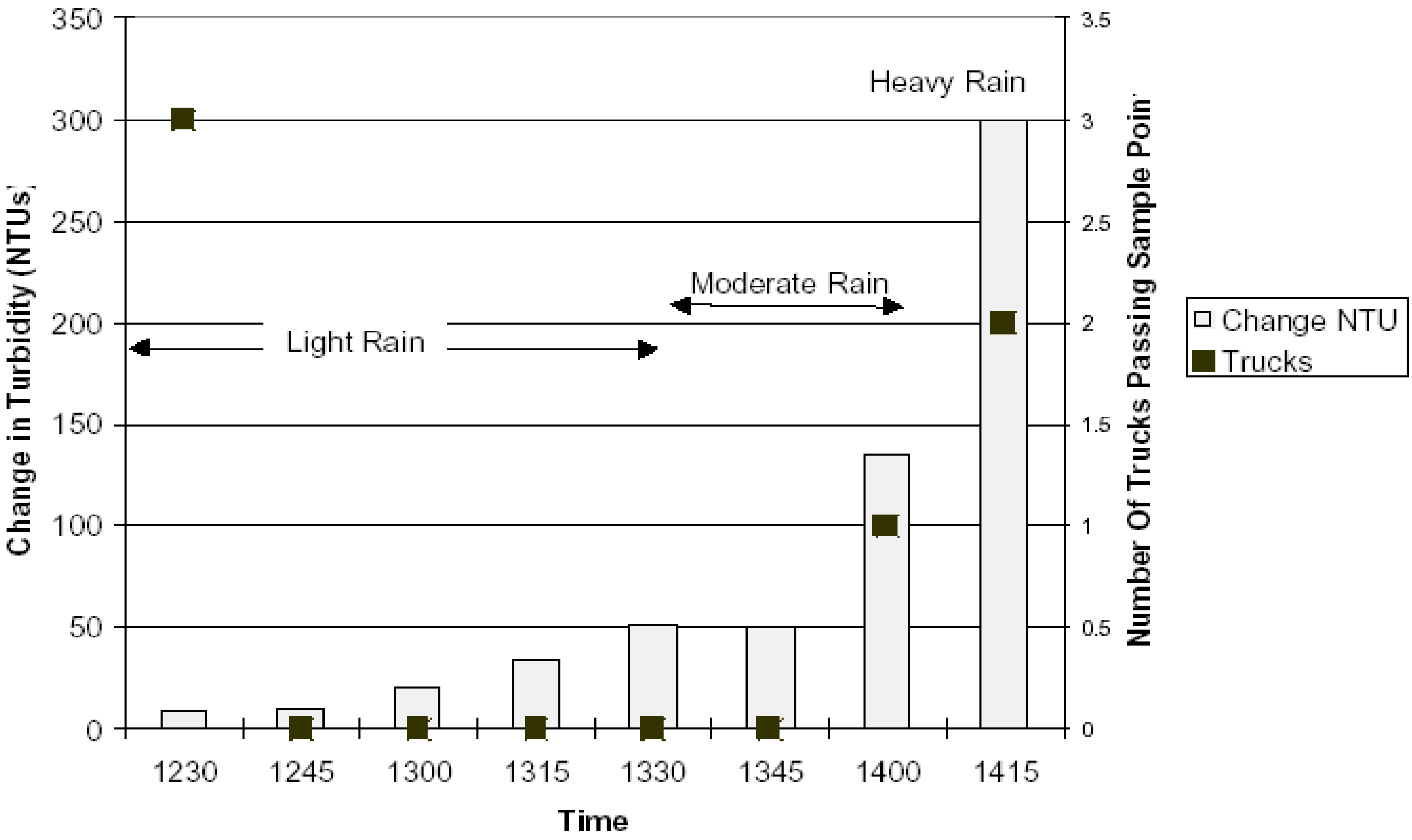
Log NTU = -3.474 + 5.9 (3-day precipitation) + 0.494 (ditch length)

Model is highly significant ($p < 0.001$);

r^2 =0.66

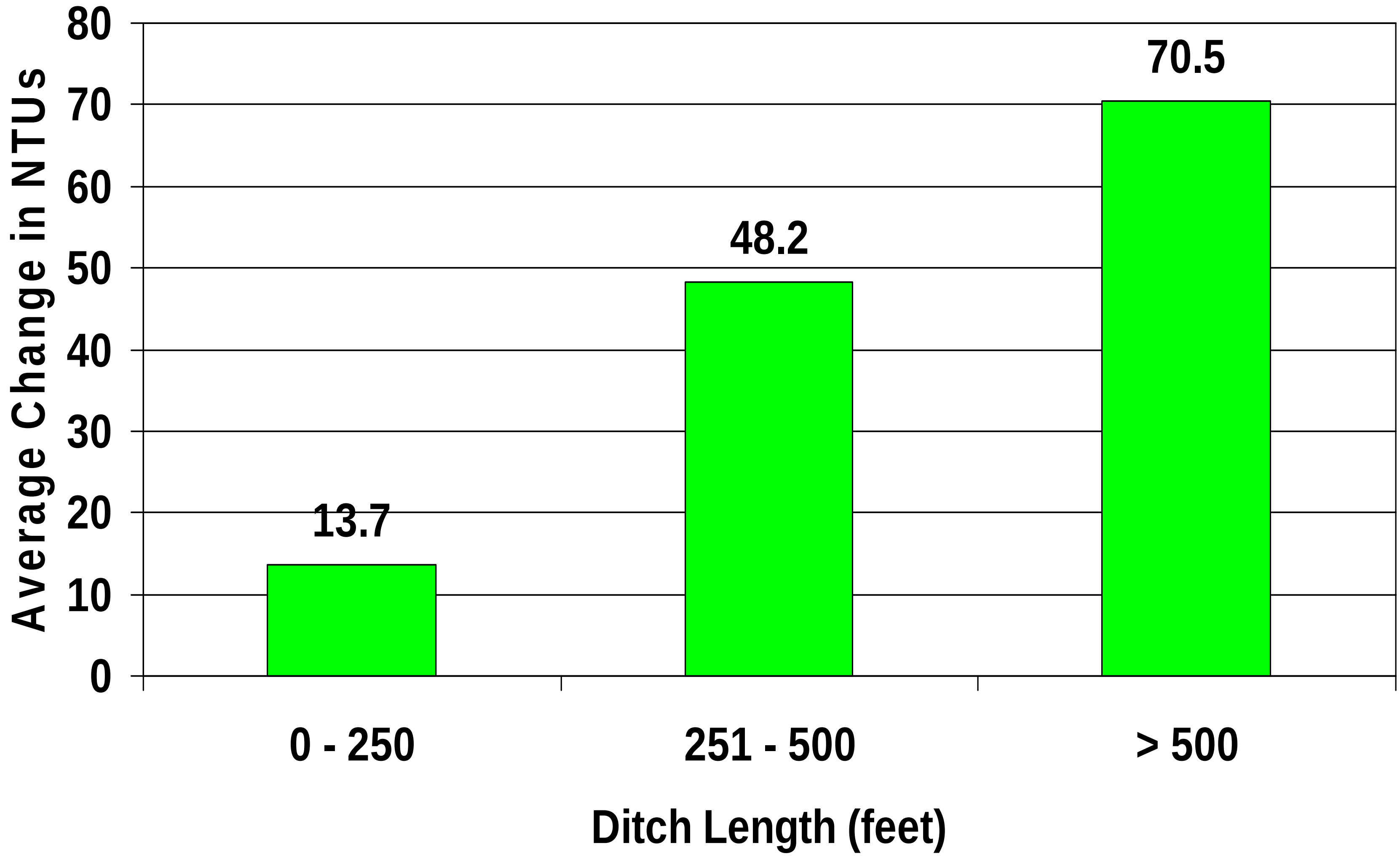
2002 model had a low r^2 value but indicated that percent fines (<0.075 mm or pass #200 sieve) in surface aggregate affected turbidity.

Changes in Turbidity Over Time at One Crossing Every 15 Minutes Over 2 Hours

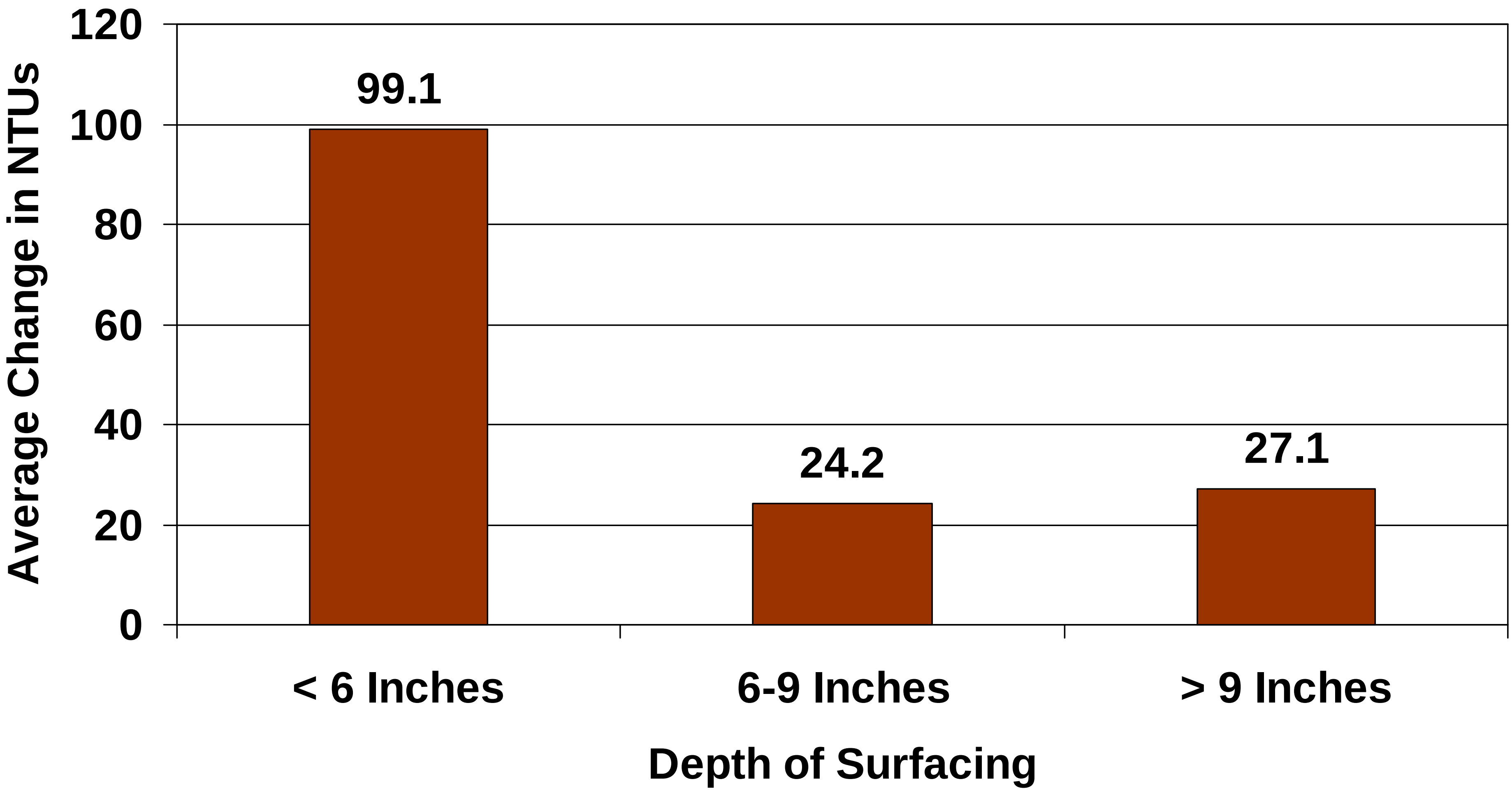


As truck traffic and rain increases, so does turbidity.

Average Change in Turbidity vs. Ditch Length Draining into Streams at Crossings



Average Change in Turbidity vs. Depth of Road Surfacing



Adequately Surfaced Road that Received 3 inches of Rain in 1 Day

Shows that a durable surface can limit or prevent turbidity entry into a watercourse.

Photo: K. Mills, ODF

Summary

- **Turbidity increases were associated with longer drainage ditches, fines in the aggregate, heavy truck traffic, and shallower rock surfacing.**
- **At crossings, 90% of sample pairs showed a change of 20 NTUs or less.**
- **The remaining 10% of the observations ranged from an increase in turbidity of 20 to 780 NTUs.**

Six Factors Identified as Most Important for Turbidity Increases

- 3 day precipitation between 1.5 – 3.0 in.
- Size distribution of road surfacing material
- Over 250 feet of ditchline draining to channel
- Depth of surfacing material <6 inches
- Durability of surfacing material of less than a 17 Los Angeles abrasion rating
- Traffic levels of 10 or more trucks per day.

Recommendations

- Use aggregate containing the minimum percentage of fines needed to bind, pack and seal the surfacing.
- Use at least 6 to 10 inches of sound aggregate (igneous or metamorphic rock).
- Reduce length of segments that deliver sediment to less than 250 feet by adding cross drains or other structures.
- Prioritize inspection of active winter operations during first moderate rainfalls to determine if immediate repairs are needed or ceasing road use is necessary.

Results were used to develop new rules for wet season road use

ODF FPR 629-625-0700

Wet Weather Road Use

- Operators shall use durable surfacing or other effective measures that resist deep rutting or development of a layer of mud on top of the road surface on road segments that drain directly to streams on active roads that will be used for log hauling during wet periods.

- Operators shall cease active road use where the surface is deeply rutted or covered by a layer of mud and where runoff from that road segment is causing a visible increase in the turbidity of Type F or Type D streams as measured above and below the effects of the road.

Turbid Water From Hauling Entering a Fish Stream


Hare Creek
Road Runoff
Turbidity Study

Hare Creek
Road Runoff Turbidity Study

- Serious road runoff problems were noted as part of the Hare Creek 1988 Timber Sale.

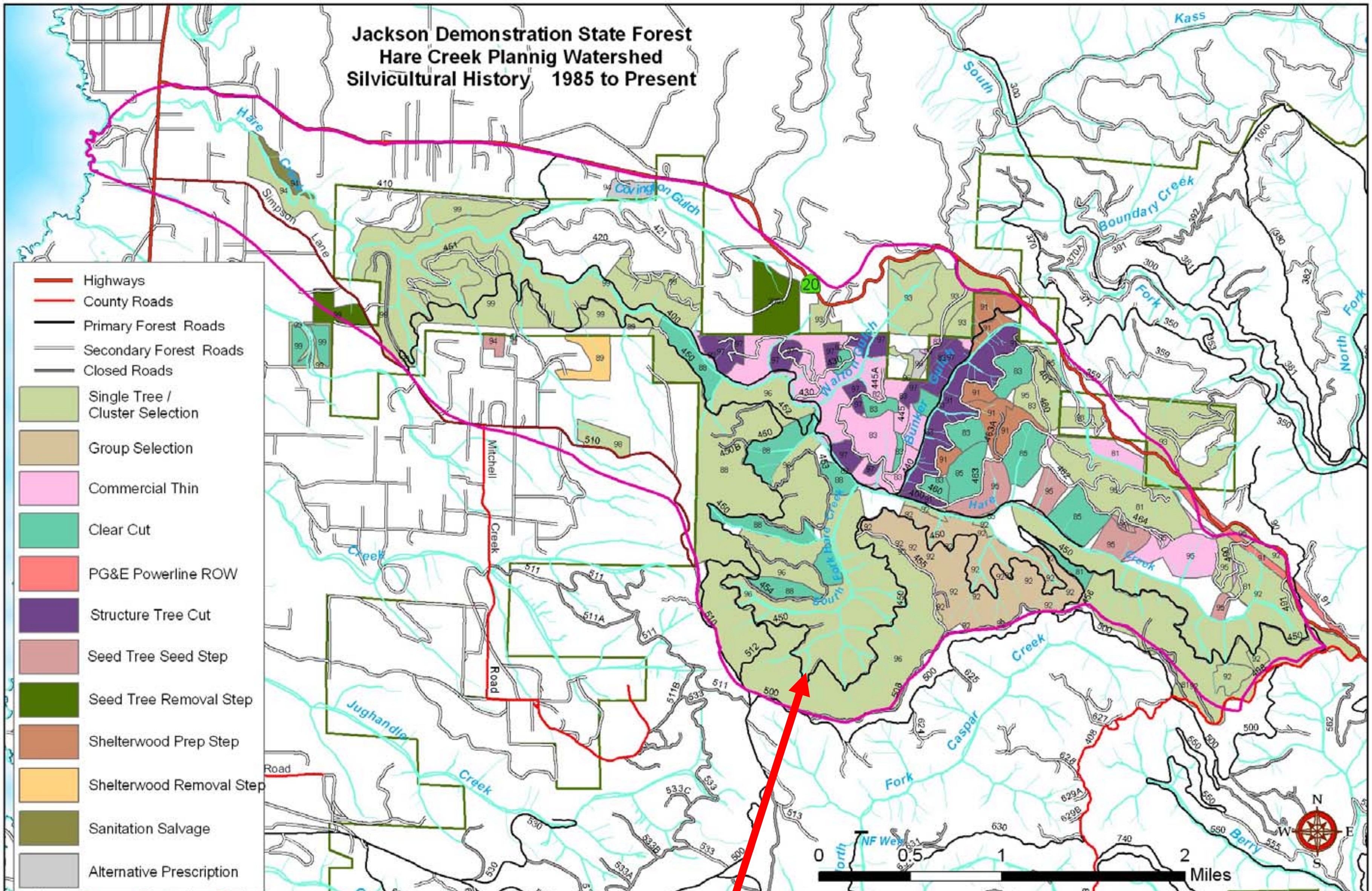
- The rock which was applied to Road 450 failed to adequately surface the road.

- In many locations, the road bed was soft and rutted.

- Sampling stations were set up at locations where small streams crossed Road 450 through culverts (one station was a control out of the sale area).

- Storm events were sampled 5 times in March 1989, both above and below the stream crossings.

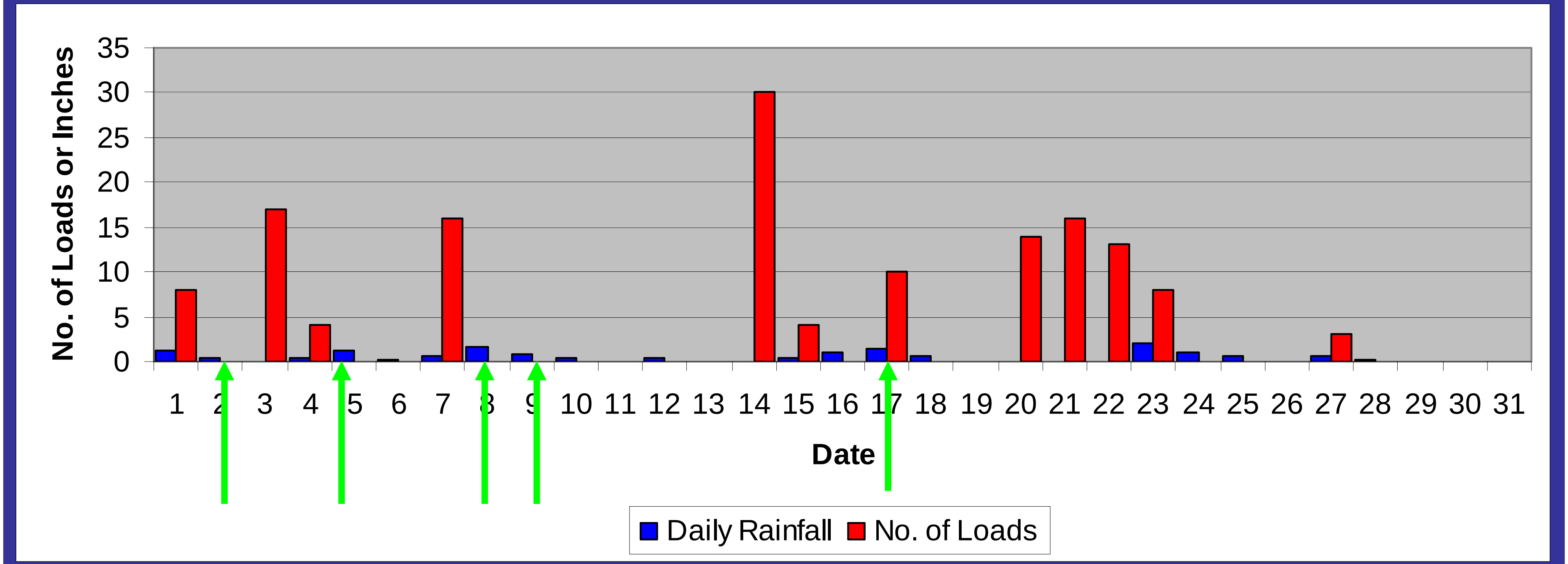
Hare Creek Planning Watershed



Road 450

Hare Creek Road Runoff Turbidity Study

Hauling and Rainfall Data for March 1989

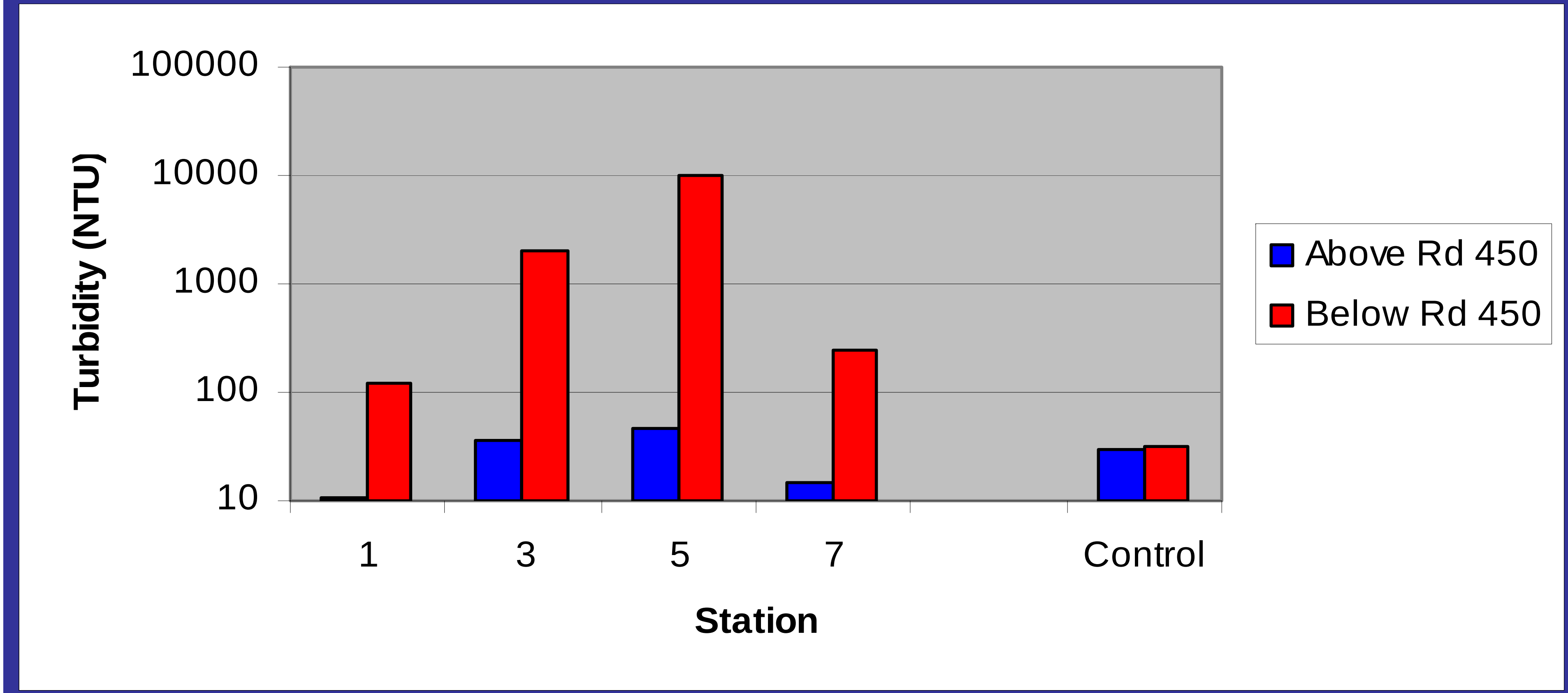


Green arrows indicate sampling periods

Data from
Cafferata 1989

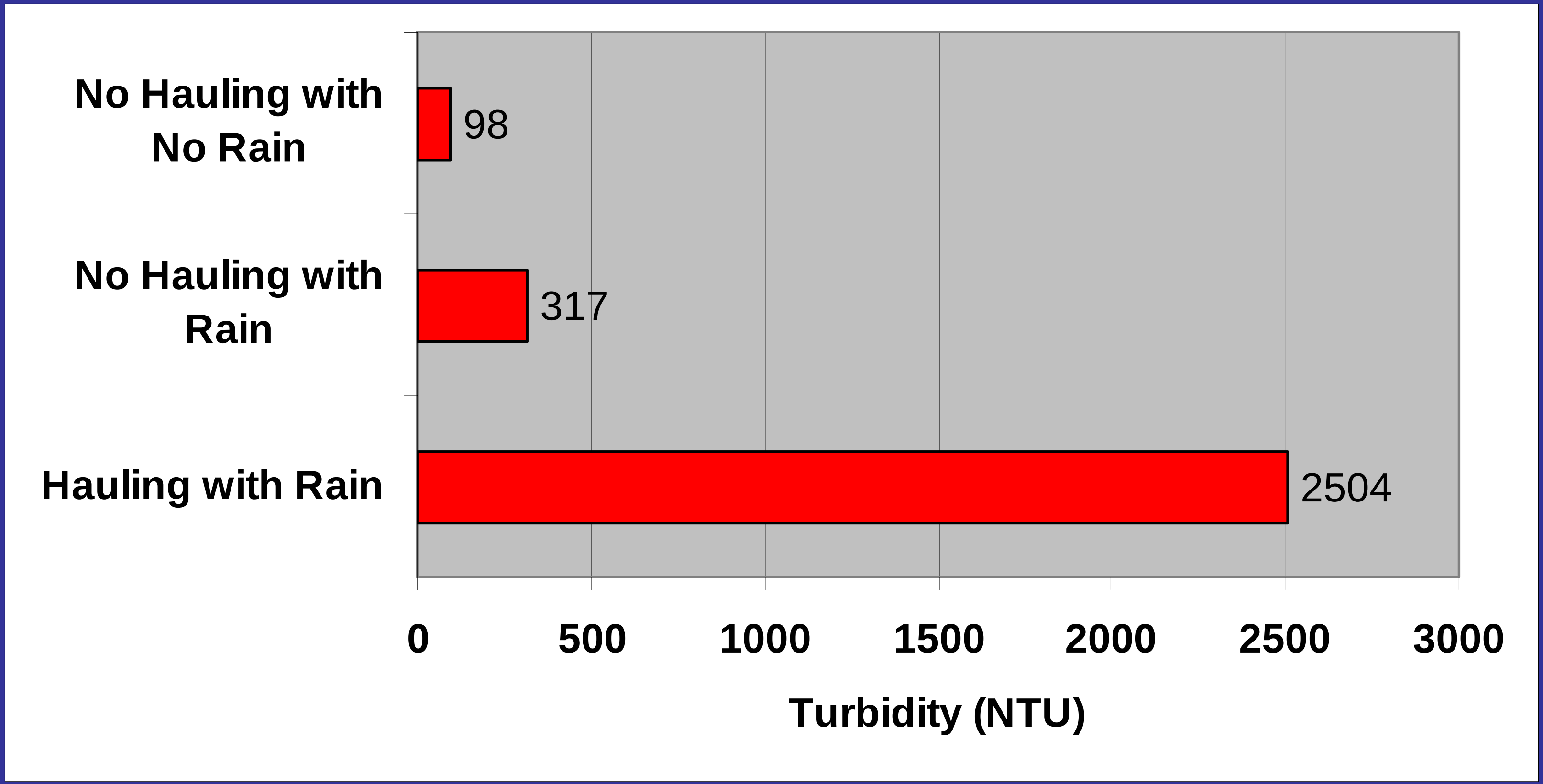
Hare Creek Road Runoff Turbidity Study

Sale area stations had an average turbidity of 115 NTUs above the road and 678 NTUs below the road



4 of the 5 stations had much higher turbidity <u>below crossings</u>

Hare Creek Road Runoff Turbidity Study



Higher turbidity below watercourse crossings demonstrated that log hauling and road practices needed modification. The results showed that by limiting log hauling during and for a short time following rainfall, damage to water quality can be substantially reduced.

Hare Creek Road Runoff Turbidity Study

- **Changes made (see JDSF Road Management Plan):**
  - **No log hauling will occur if greater than 0.25 inch of precipitation has fallen during the preceding 24 hour period.**
  - **Hauling can resume only after rain has ceased for 24 hours and no road-related turbid water is observed in inside ditches along the roads where hauling may occur.**
  - **Log hauling will not occur when "pumping" of fines from the road surface produces sediment that enters inside ditches and causes turbid water to flow in ditchlines with direct access to watercourses.**
  - **Only surfaced roads will be considered for wet weather log truck traffic. If road rock begins to significantly break down, wet weather use of that road will cease until the road is adequately repaired.**

Water quality grab sampling to find sediment sources during winter forest operations

Presentation by Dr. Kate Sullivan
PALCO (currently HRC)
Monitoring Study Group Meeting
Oct 16, 2003

Sediment Sources

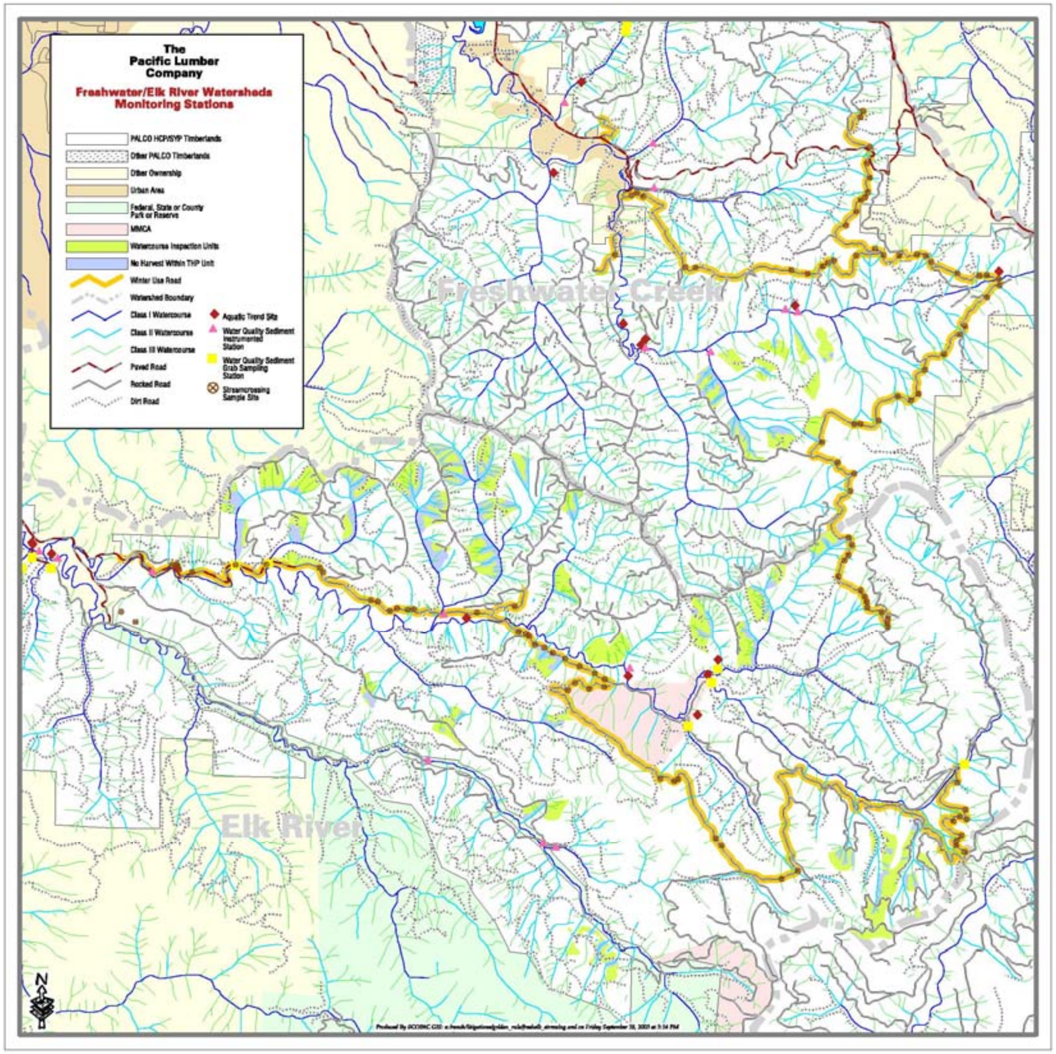
- Intent of this sampling was to identify sediment sources
- Observe during storms
  – Approximately 1” in 24 hours
- Look at active THP units and road crossings

Effectiveness
Monitoring Road Runoff

Above and Below Grab Sampling-compare downstream to upstream

Image + photos: Dr. Kate Sullivan, HRC

Water Course Crossing Samples Locations



Freshwater Creek

- 57 crossings observed

Elk River

- 64 crossings observed

Over 400 samples collected

Image: Dr. Kate Sullivan, HRC

PALCO Above and Below Grab Sampling

- Most stations were sampled 10 times during the winter of 2002-2003.
- A threshold of greater than 20% above background was used to identify a significant difference for this work (i.e., downstream turbidity values more than 20% greater than upstream levels).
- It was common to have greatly elevated downstream turbidity for one sample period, while the other samples were approximately the same above and below the crossing.

Summary of Road Crossing Sampling Results—All samples Combined:

17% of 400+ samples collected at 121 crossings over the 2002-03 winter had downstream turbidity levels 20% greater than upstream levels

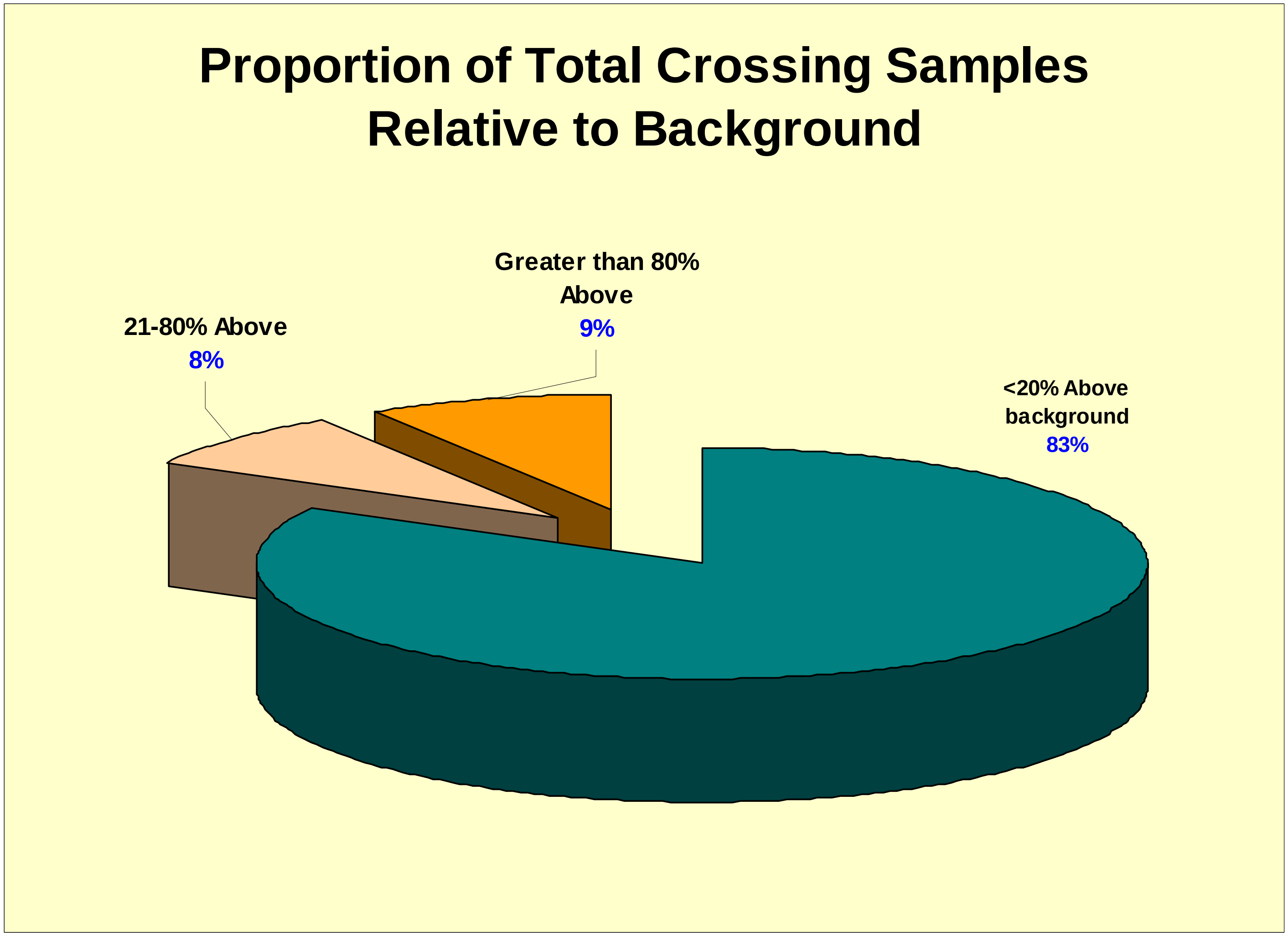


Image: Dr. Kate Sullivan, HRC

Roads Summary

- Many road crossings were always within 20%.
- Some were chronically high.
- Some occasionally exceeded.
- Some were repaired during the season and never showed up again.

PALCO Road Crossing Turbidity Data Published—Harris et al. 2007

- Elk River and Freshwater Creek watersheds; about **7%** of 2300 samples collected at 225 crossings over a 3-year period had downstream turbidity levels more than 20% greater than upstream levels.

- Potential impacts depend on erosion control measures implemented at the sites.

MONITORING STUDY GROUP
CALIFORNIA STATE BOARD OF FORESTRY AND FIRE PROTECTION

HILLSLOPE MONITORING PROGRAM

MONITORING RESULTS FROM 1996 THROUGH 2001

Andrea E. Tuttle
Director
Department of Forestry and Fire Protection

Mary D. Nichols
Secretary for Resources
The Resources Agency

Gray Davis
Governor
State of California

DECEMBER 2002
SACRAMENTO, CALIFORNIA
BOARD OF FORESTRY AND FIRE PROTECTION

Findings Related to ROAD APPROACHES

- The road surface cutoff drainage structure above the crossing allowed all or some of the water running down the road to reach the crossing at about 23 percent of the sample sites (~8% allowed all the water to drain to the crossing).

- Approximately 2-3% of road surfaces draining to crossings had significant rutting, rilling, and gullying.

MONITORING STUDY GROUP
CALIFORNIA STATE BOARD OF FORESTRY AND FIRE PROTECTION

Modified Completion Report
MONITORING PROGRAM

Implementation and Effectiveness of
Forest Practice Rules related to Water Quality Protection

MONITORING RESULTS FROM 2001 THROUGH 2004

Ruben Grijalva
Director
Department of Forestry and Fire Protection

Mike Chrisman
Secretary for Resources
The Resources Agency

Arnold Schwarzenegger
Governor
State of California

July 2006
SACRAMENTO, CALIFORNIA

Findings Related to ROAD APPROACHES

- **The road surface cutoff drainage structure above the crossing had minor or major problems ~25% of time.**
- **Major problem 4% of the time.**

- **Approximately 6% of road surfaces draining to crossings had major and minor gullying.**
- **Major problem ~0.5% of the time.**

- **16.5% of the road surfaces draining to crossings had major and minor rutting.**
- **Major problem ~1% of the time.**

Information from Selected Papers

- **Reid and Dunne 1984**
  - Log truck traffic on forest roads during winter storms increased the yield of fine sediment during these storms by up to several orders of magnitude in western Washington.

- **Bilby, Sullivan, and Duncan 1989**
  - The amount of sediment produced was related to traffic rate.
  - Accumulated material flushed rapidly from the road surface during precipitation, leading to a decrease in sediment concentration in the ditch with time during a storm.

- **Luce and Black 2001**
  - Ditch pulling has more impact than traffic on a road with quality aggregate (i.e., no ruts).

- **Toman and Skaugset 2007**
  - To minimize wet weather sediment production, design aggregate surfacing to resist rutting.
  - Rut formation is a function of aggregate depth.
  - Study completed on GDRCO timberlands.

Take Home Messages

- **Log truck traffic on forest roads during winter storms can increase the yield of fine sediment by up to several orders.**
- **Turbidity increases are associated with longer drainage ditches, fines in the aggregate, heavy truck traffic, and shallow rock surfacing.**
- **With current practices, $\leq$10% of samples taken above and below crossings show much higher turbidity levels downstream.**
- **In California, 4-8% of road cut off drainage structures above crossing allow all or most of the water to reach the crossing. Minor and major problems occur on ~25%.**
- **One way to minimize wet weather sediment production is to design aggregate surfacing to resist rutting by having an adequate aggregate depth.**