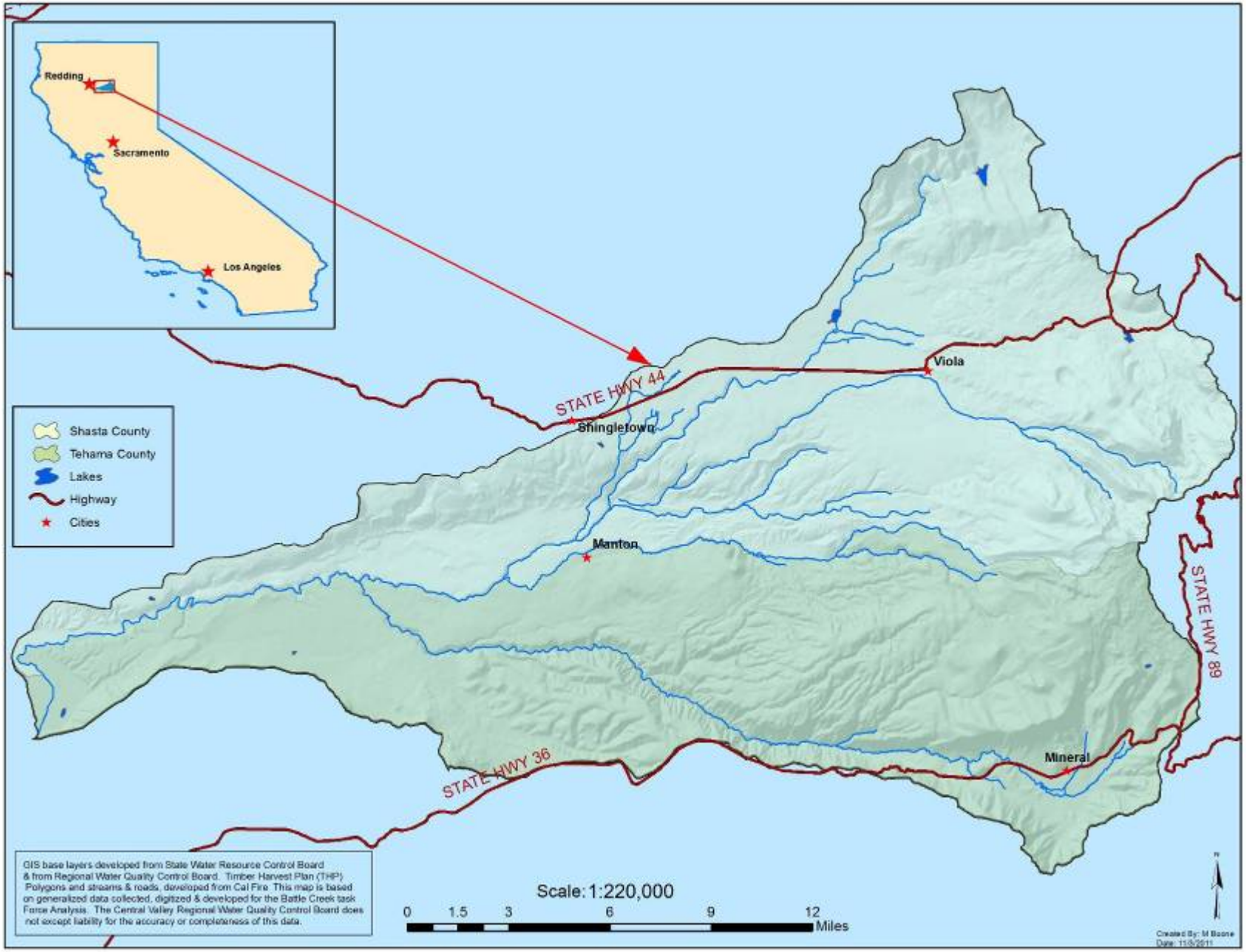
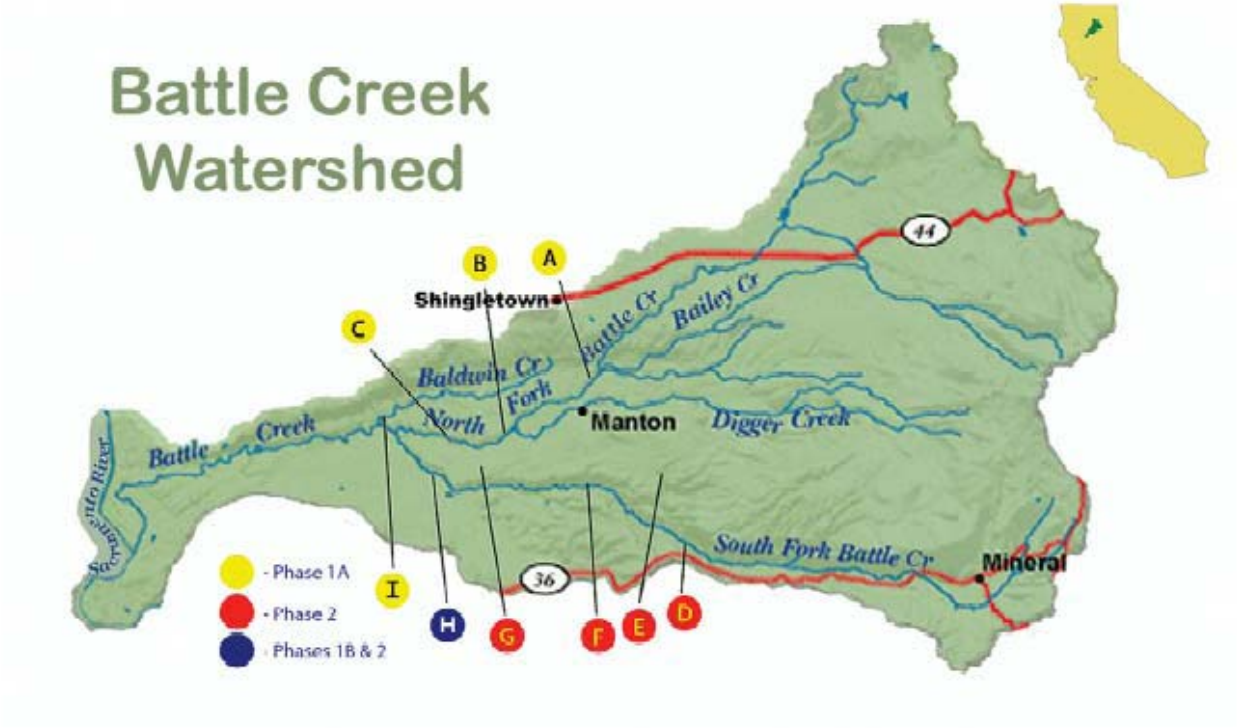
# A Rapid Assessment of Sediment Delivery from Clearcut Timber Harvest Activities in the Battle Creek Watershed, Shasta and Tehama Counties, California


Redding
Sacramento
Los Angeles
Shasta County
Tehama County
Lakes
Highway
Cities
STATE HWY 44
Shingletown
Viola
Manton
STATE HWY 89
STATE HWY 36
Mineral
GIS base layers developed from State Water Resource Control Board & from Regional Water Quality Control Board. Timber Harvest Plan (THP) Polygons and streams & roads, developed from Cal Fire. This map is based on generalized data collected, digitized & developed for the Battle Creek task Force Analysis. The Central Valley Regional Water Quality Control Board does not except liability for the accuracy or completeness of this data.
Scale: 1:220,000
0 1.5 3 6 9 12 Miles
N
Created By: M Boone
Date: 11/8/2011




# The Battle Creek Restoration Project

## . . . benefiting fish and other wildlife

**A. North Battle Creek Feeder Diversion Dam**
Replace fish ladder to improve adult fish passage; replace fish screen to prevent loss of juveniles; increase stream flow to improve habitat

**B. Eagle Canyon Diversion Dam**
Replace fish ladder and fish screen; increase stream flow

**C. Wildcat Diversion Dam, Pipeline, and Canal**
Remove dam, pipeline and canal

**D. South Diversion Dam and Canal**
Remove dam and canal

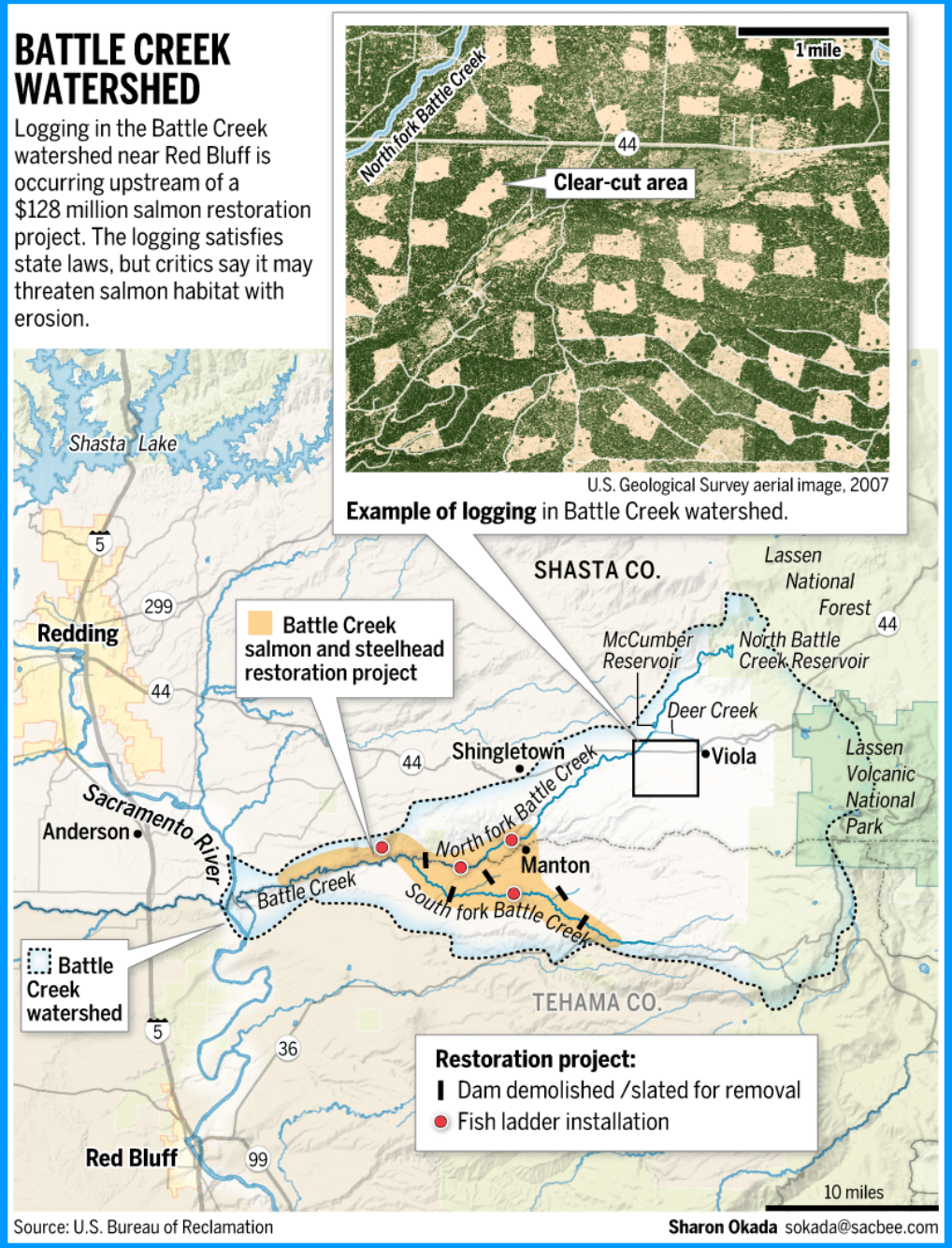
**E. Soap Creek Feeder Diversion Dam**
Remove dam

**F. Inskip Diversion Dam and So. Powerhouse**
Replace fish ladder and fish screen; construct tunnel connector between South Power House and Inskip Canal; increase stream flow

**G. Lower Ripley Creek Feeder Diversion Dam**
Remove dam

**H. Coleman Diversion and Inskip Powerhouse**
Construct tailrace connector between Inskip Powerhouse and Coleman Canal; replace Inskip Powerhouse bypass; remove dam

**I. Asbury Pump Station and Diversion Dam**
Increase stream flow; prevent fish passage above dam




(Sacramento Bee, 2011)

- SPI uses extensive clearcut harvesting
- Concerned environmental stakeholders in the watershed

ENVIRONMENT

# Troubled waters of Battle Creek

**Work is under way on the $128 million project** to restore endangered salmon and steelhead on Battle Creek in Shasta County. But while one agency is managing the project, another is allowing clear-cut logging upstream that could jeopardize the restoration, biologists and residents argue.

STORY BY MATT WEISER | mweiser@sacbee.com
PHOTOS BY RANDALL BENTON | rbenton@sacbee.com

Marily Woodhouse checks a water sample she took near a clear-cut forest. Her group is suing Sierra Pacific, arguing that its logging practice harms salmon habitat.

## BIOLOGISTS, LOGGERS CLASH ON CLEAR-CUTS' EFFECTS ON FISHERY

MANTON – Here at Battle Creek, an icy stream that tumbles off Mount Lassen, state and federal agencies are spending $128 million to bring endangered salmon back to 48 miles of water blocked by dams for nearly a century.

At the same time, another arm of state government is allowing clear-cut logging on thousands of acres just upstream, which some scientists say could jeopardize the costly restoration project.

The Battle Creek Salmon and Steelhead Restoration Project is considered the largest of its kind in the nation. It involves removing five dams owned by Pacific Gas and Electric Co., and modifying four others so steelhead and winter- and spring-run salmon can pass.

Battle Creek may be the last shot at survival for the species, all of which are endangered.

Scientists say the logging, if not managed carefully, could handicap the expensive restoration. The danger: Erosion from clear-cut forest tracts could smother spawning habitat before salmon have a chance to use it.

The apparent conflict in government missions, critics say, points to flaws in the state's management of logging on private land.

"There should be enforcement to pro-

PROJECT | Page A12

(Sacramento Bee, 2011)

- Article implied clearcutting is causing water quality impacts to Battle Creek
- Permitting of clearcutting running counter to goals and objectives of Restoration Project

# TIMELINE

- **19th June, 2011** – Sacramento Bee article.
- **15th July, 2011** - Secretary Laird and staff meet with CAL FIRE, request timely interagency assessment of potential impacts.
- **1st September, 2011** – Battle Creek Task Force formed. Scoping begins.
- **21st thru 29th, September, 2011** – Field assessment over 5 days.
- **Early October to 4th November, 2011** – Analyses and report writing.

# TIMELINE (continued)

- **9th November, 2011** – Presentation of findings to Board of Forestry

- **At request** – Presentation of findings to the Central Valley Regional Water Quality Control Board

- **At request** – Presentation of findings to the Fish and Game Commission

# Battle Creek Task Force Formed

- **Task Force staffed by two members from following THP Review Team agencies:**
  - Central Valley Regional Water Quality Control Board;
  - California Department of Fish and Game;
  - California Geological Survey; and
  - CAL FIRE.

- **Subject matter experts with decades of combined field experience in forestry-water-fish issues**

**Purpose Statement:**

Evaluate whether timber operation associated with SPI clearcut harvesting in Battle Creek has resulted in observable erosion and subsequent delivery of sediment which has resulted in violation of state law or observable negative impacts to fisheries.

# Background

**Significant Water-Quality Impacts**

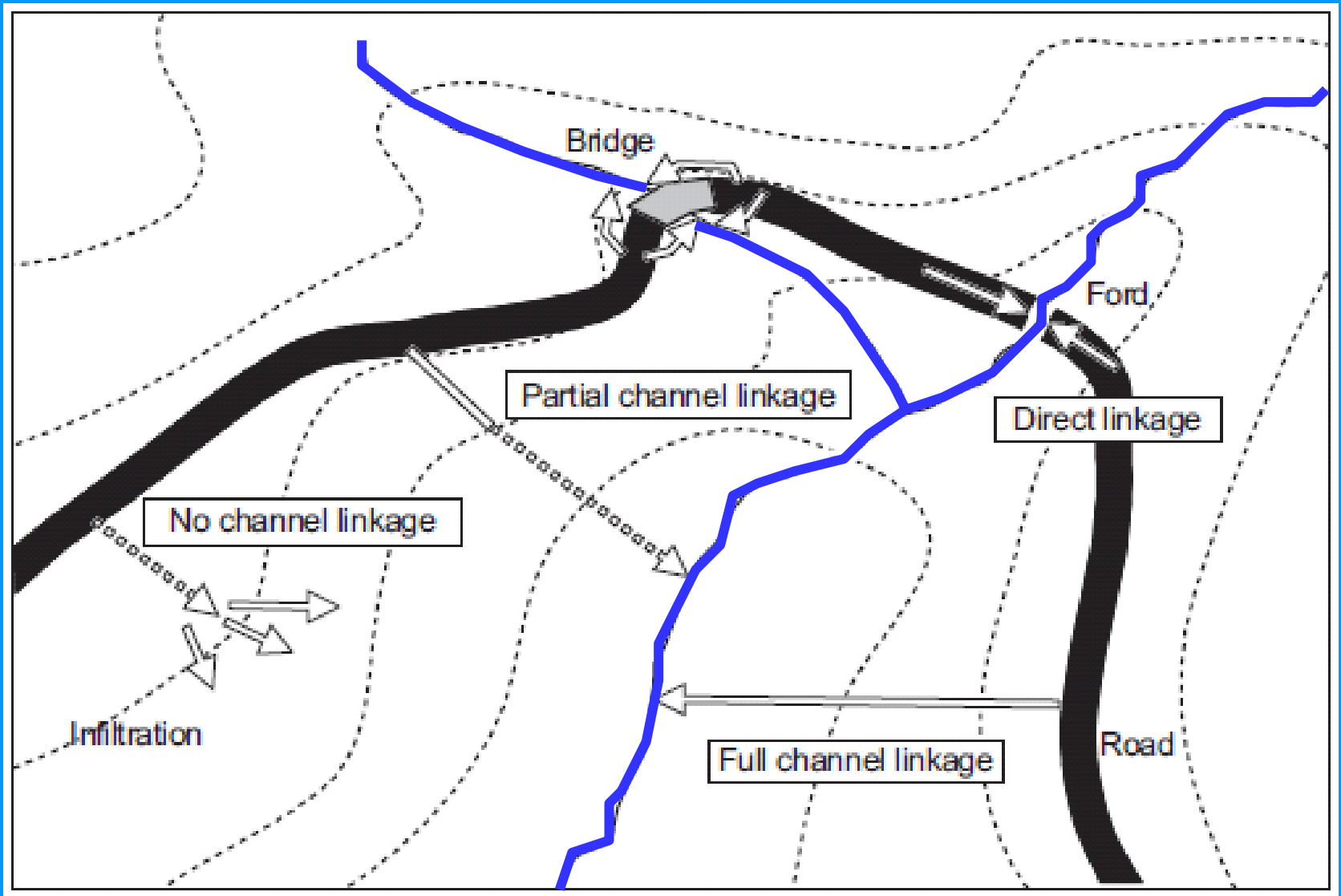
**=**

**Significant Erosion**

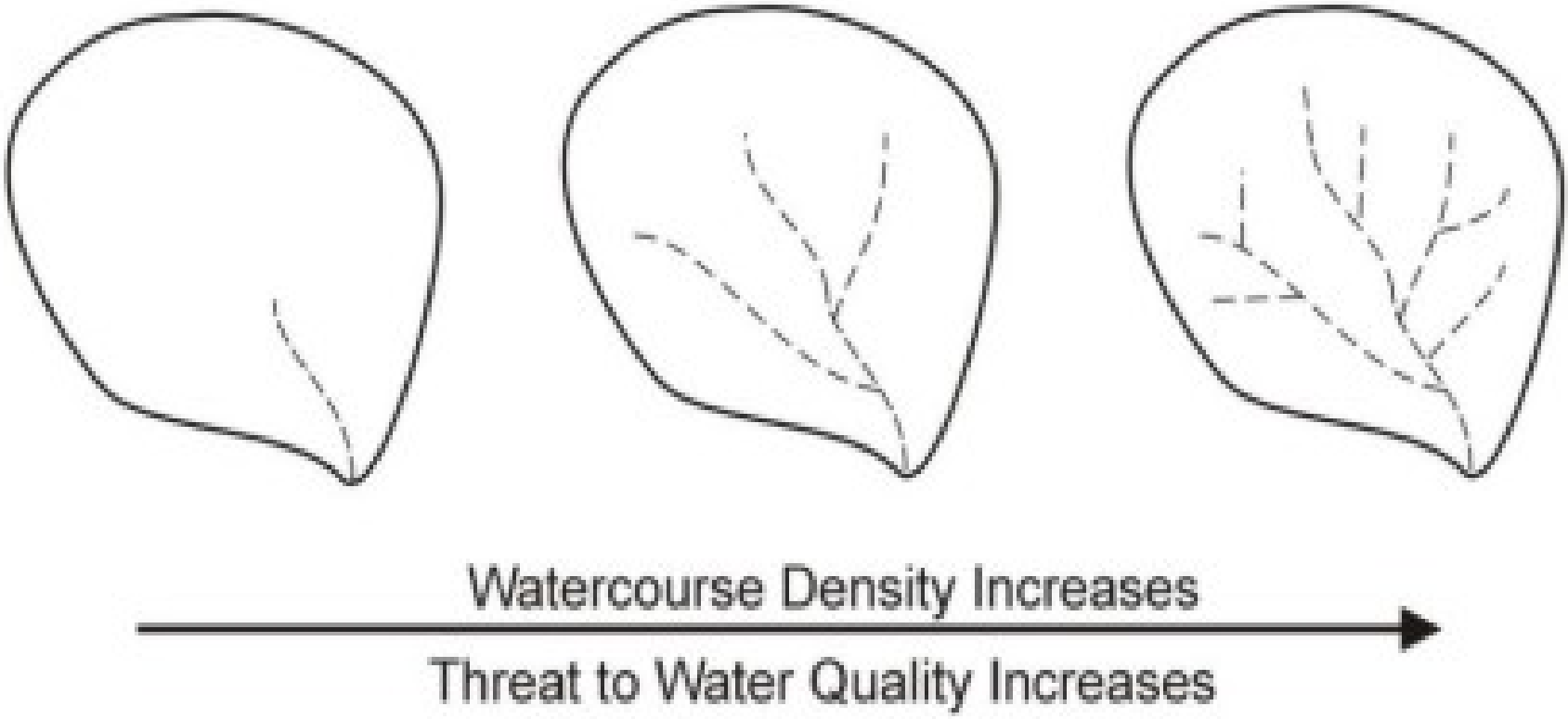
**+**

**<u>Significant Delivery</u> to a Waterbody**

# Proximity of Erosion Source to Stream



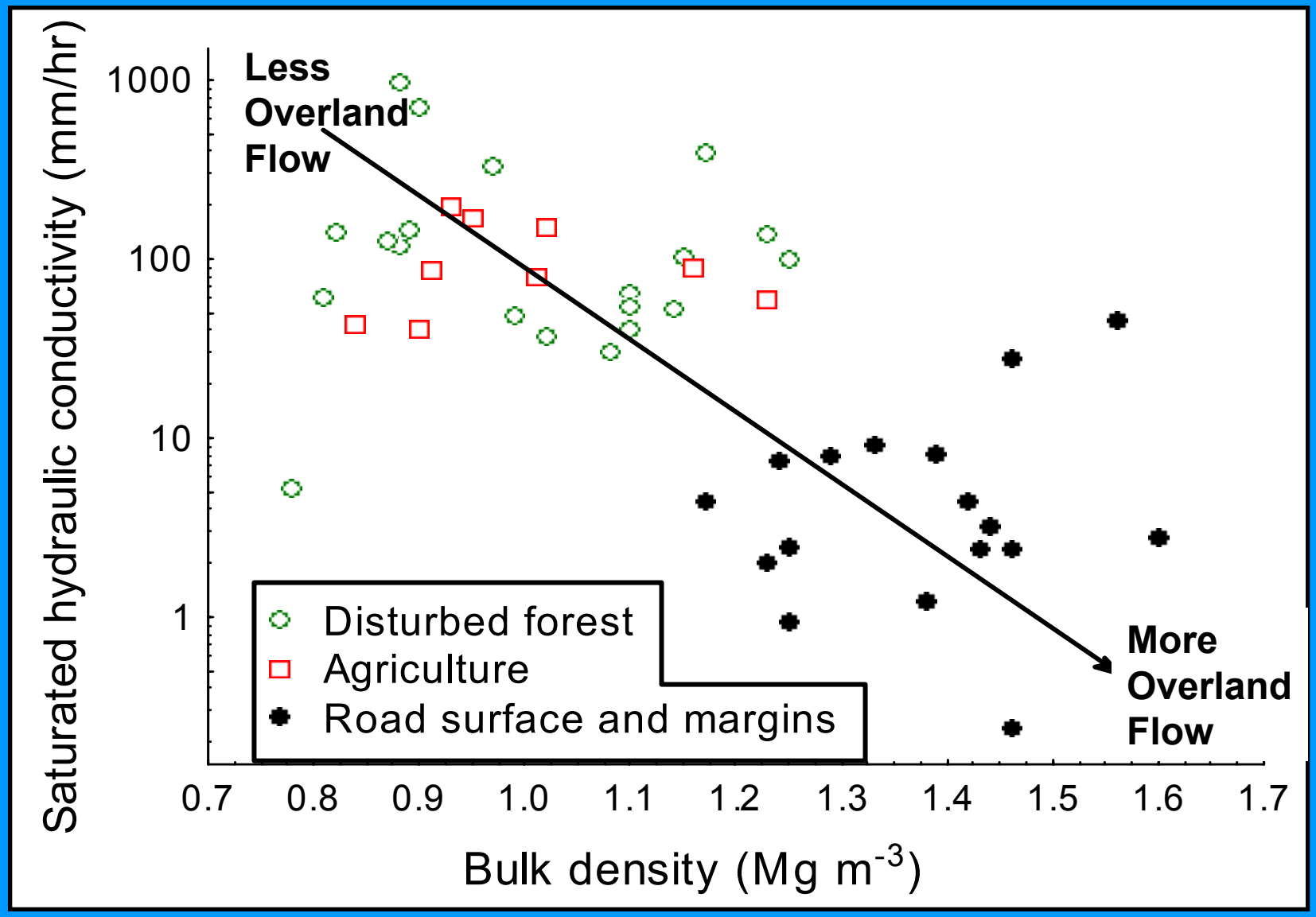

(Croke and Hairsine, 2006)


Watercourse Density Increases
Threat to Water Quality Increases

# Erosion Potential of Activity

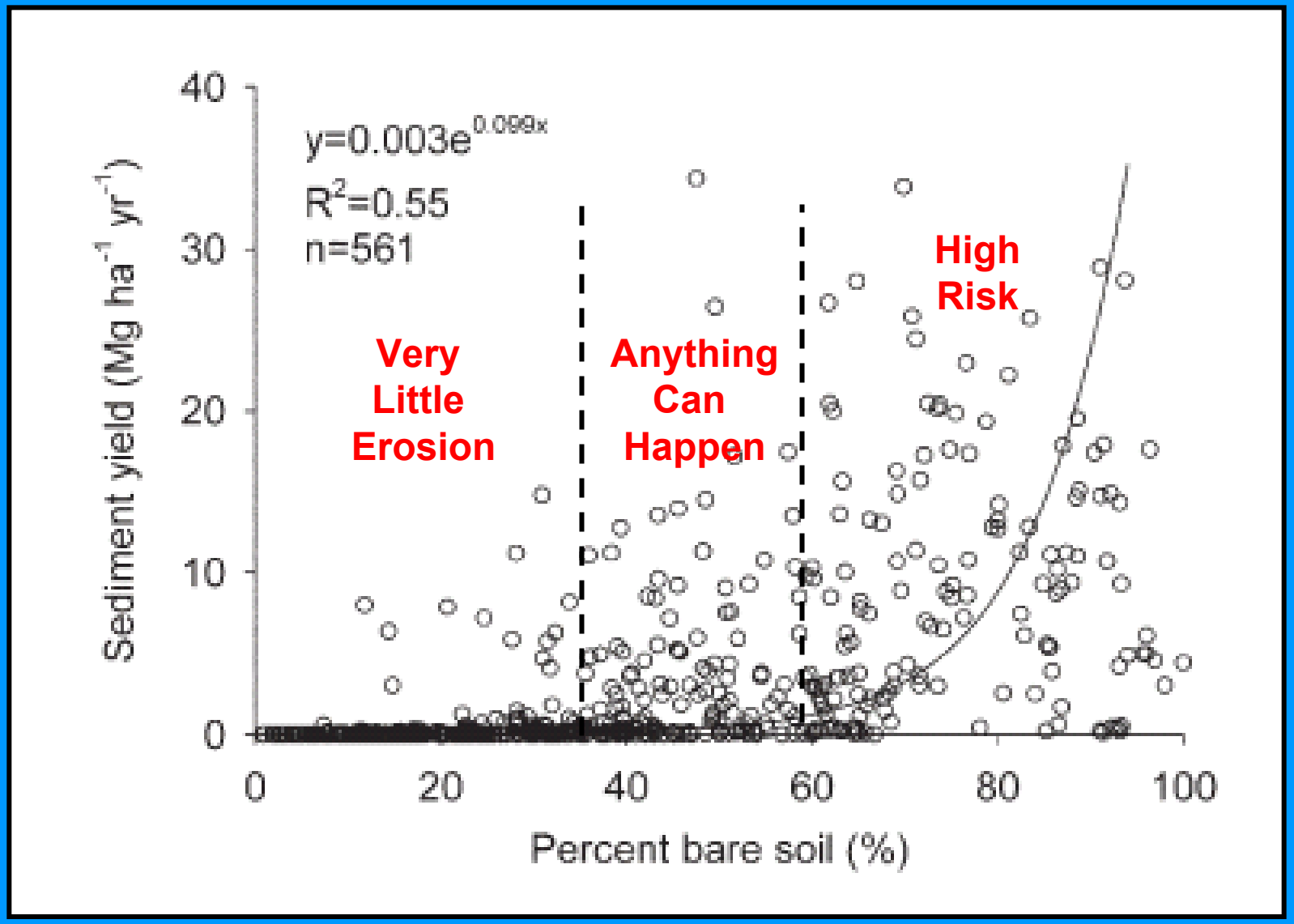
Gully Erosion to a Class III watercourse

# Soil Compaction




(from Ziegler, 2005)

# Surface Cover Removal




(Larsen and others, 2009)

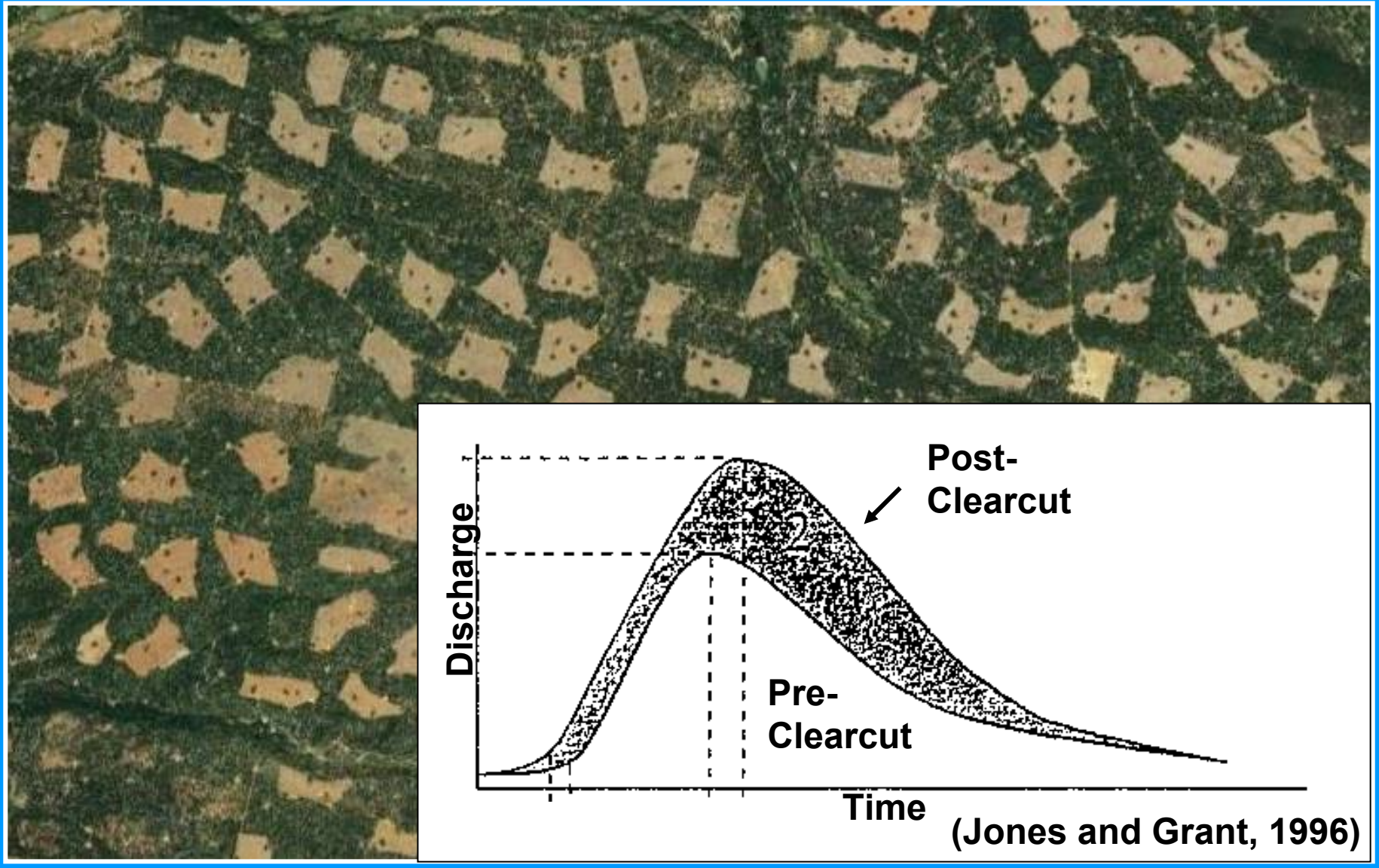
# Flowpath Modification

Rilling on road surface

- Culverts can restrict flow of water
- Road and skid trails can collect, redistribute, and concentrate runoff
- Can increase erosion and risk of landsliding

# Soil/Earth Movement

# Potential Impacts from Overstory Removal



# Hydrogeomorphic Context

- Young volcanics
- Relatively low drainage density
- Ground-water dominated hydrology
- Snow dominated, with rain-on-snow zone

(http://pubs.usgs.gov/fs/2000/fs022-00/images/erupt.jpg)

# Land Use

- Mixture of land uses (timber harvest, grazing, recreation, rural residential);
- Mixture of county-maintained and privately-maintained roads.

# Timber Harvest

- SPI owns 82 percent of Timber Production Zone lands in watershed

- ≈ 20,000 acres harvested using even-aged methods between 1997-2010

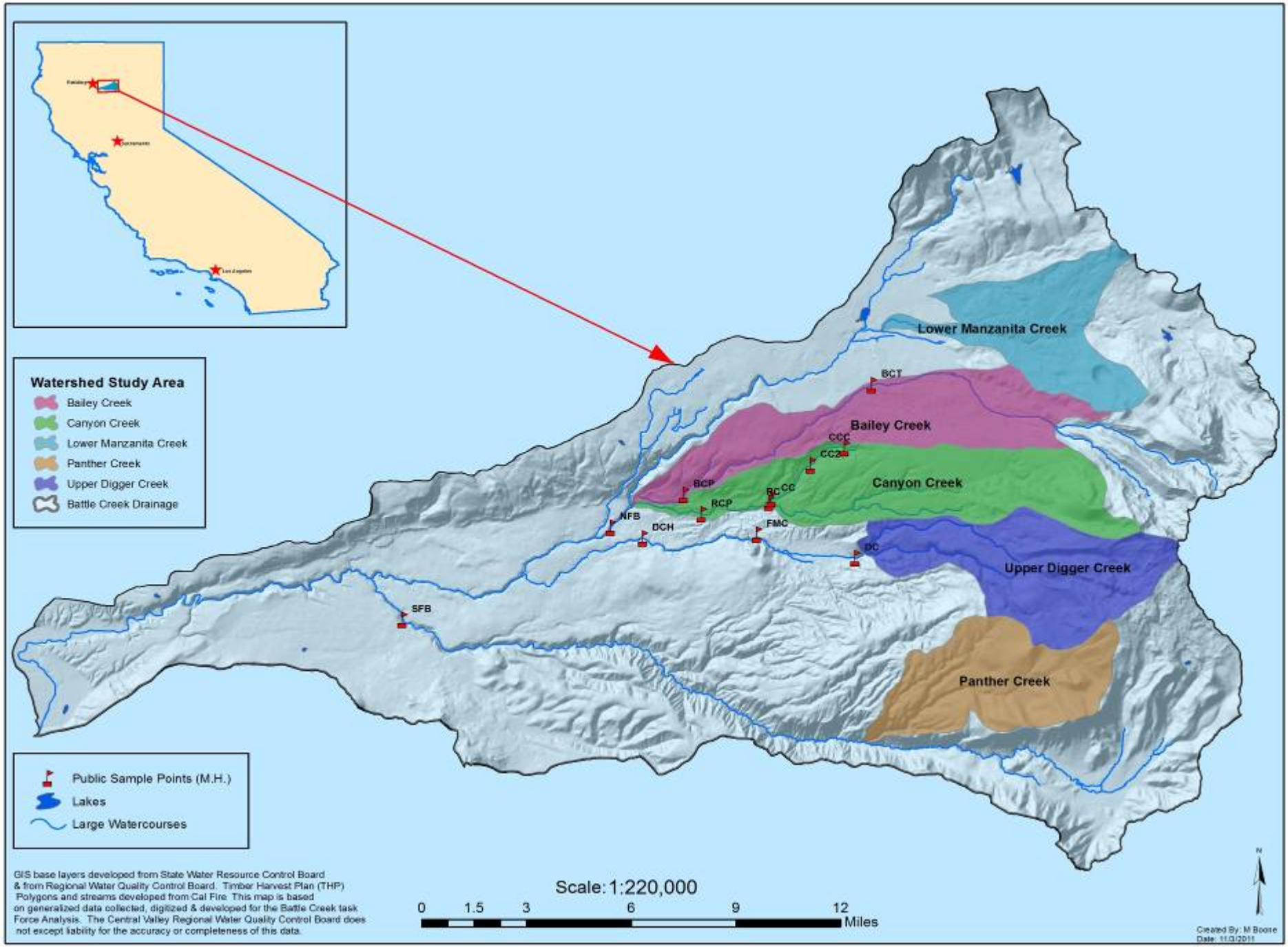
# Site Selection – Clearcuts Adjacent to Watercourses

# Site Selection - Road Crossings

# Site Selection – Watercourse-Adjacent Road Segments

# Site Selection - Tractor Crossings

# Site Selection – Watercourse-Adjacent Landings


Watershed Study Area
Bailey Creek
Canyon Creek
Lower Manzanita Creek
Panther Creek
Upper Digger Creek
Battle Creek Drainage
Public Sample Points (M.H.)
Lakes
Large Watercourses
Lower Manzanita Creek
Bailey Creek
Canyon Creek
Upper Digger Creek
Panther Creek
BCT
CCC
CC2
BCP
RCP
RC
CC
NFB
DCH
FMC
DC
SFB
GIS base layers developed from State Water Resource Control Board & from Regional Water Quality Control Board. Timber Harvest Plan (THP) Polygons and streams developed from Cal Fire. This map is based on generalized data collected, digitized & developed for the Battle Creek task Force Analysis. The Central Valley Regional Water Quality Control Board does not except liability for the accuracy or completeness of this data.
Scale: 1:220,000
0 1.5 3 6 9 12 Miles
N
Created By: M Boone
Date: 11/3/2011

# Site Selection

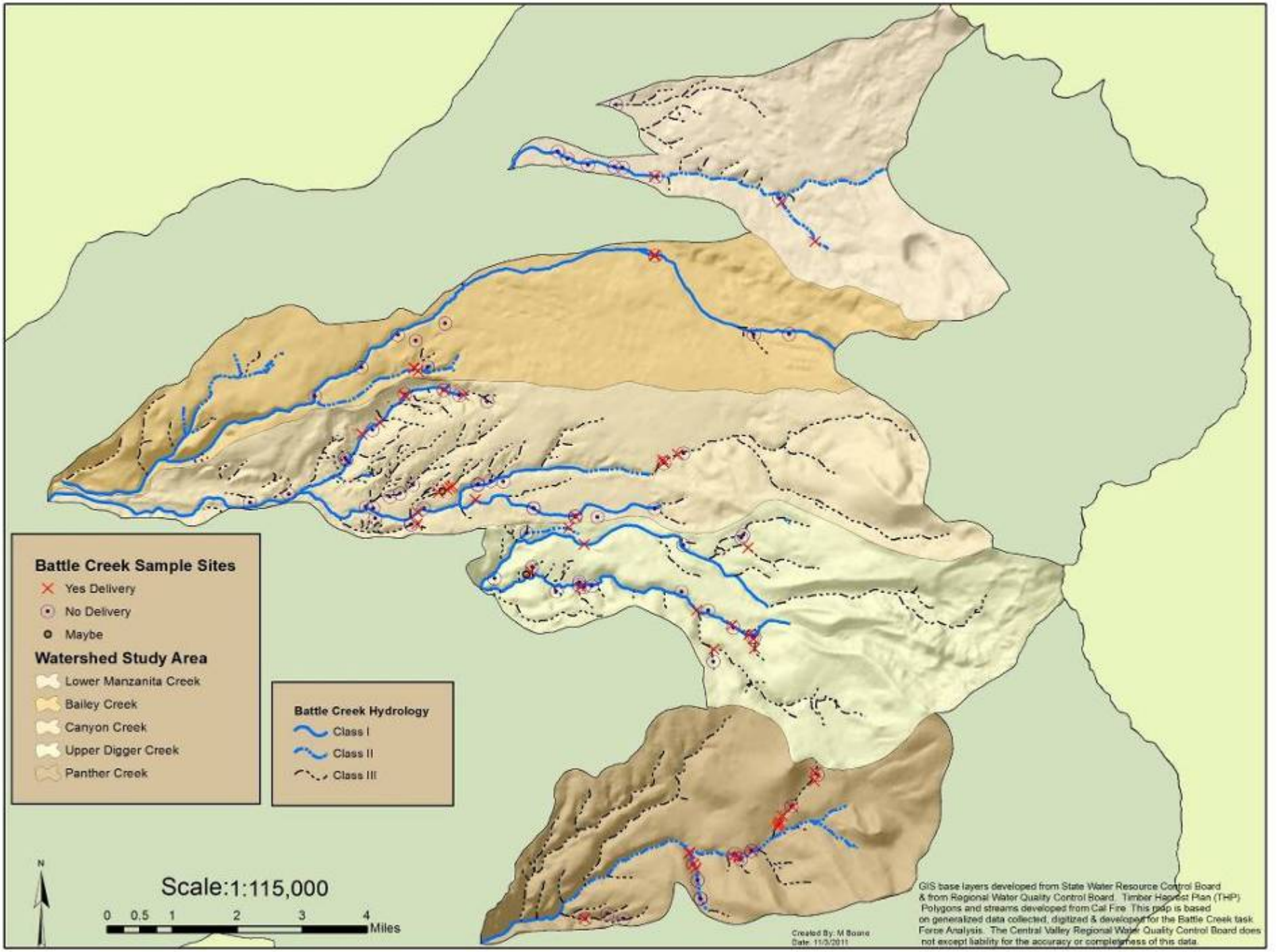
- Placed highest priority on clearcuts with buffers on fish-bearing streams (Class I WLPZs);
- Other prioritization criteria:
  - Time since operation (at least one season of overwintering)
  - Tractor logging
  - Steeper slopes
  - More erodible soils (e.g., rhyolite-derived soils)

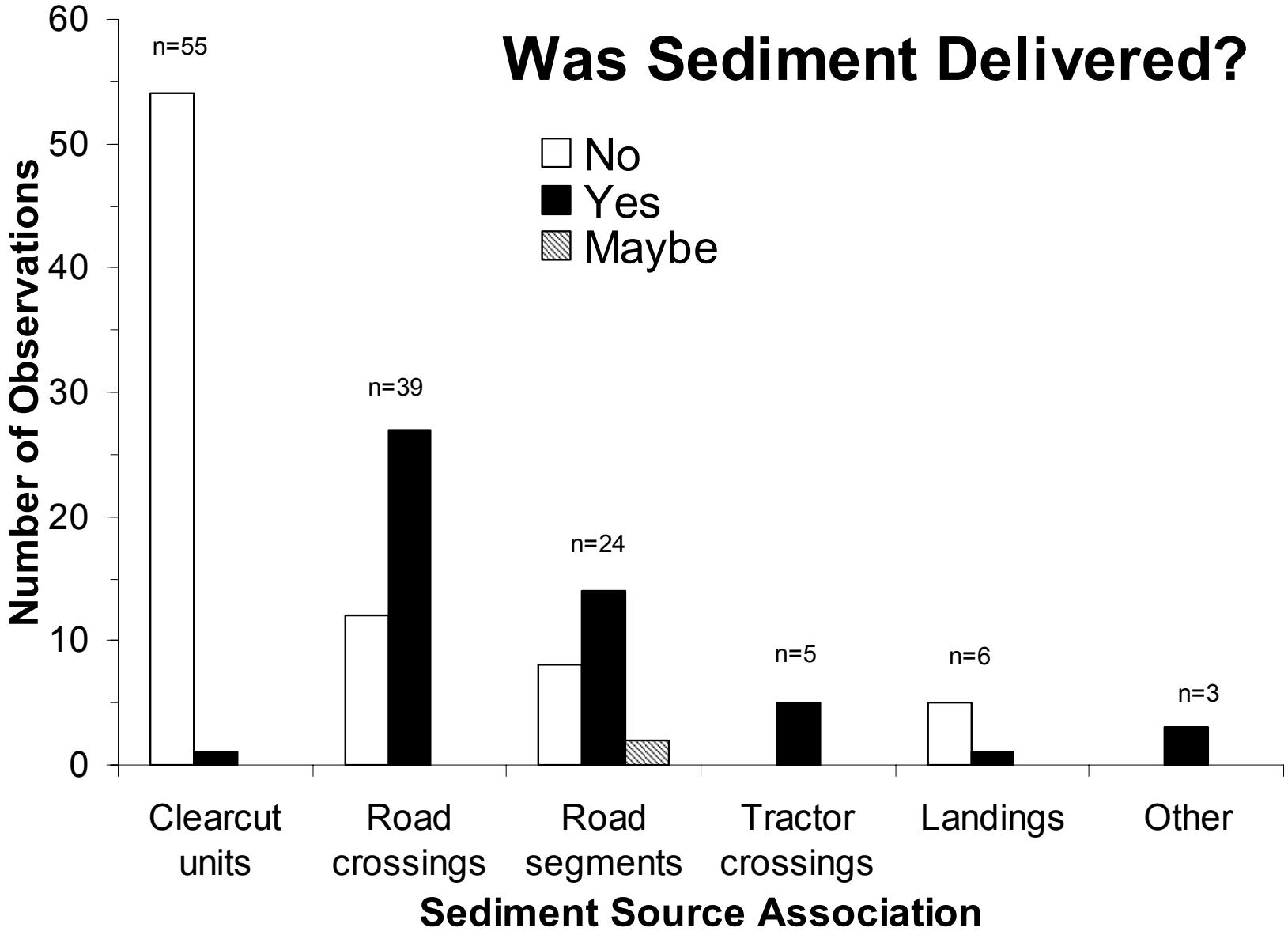
# Methods

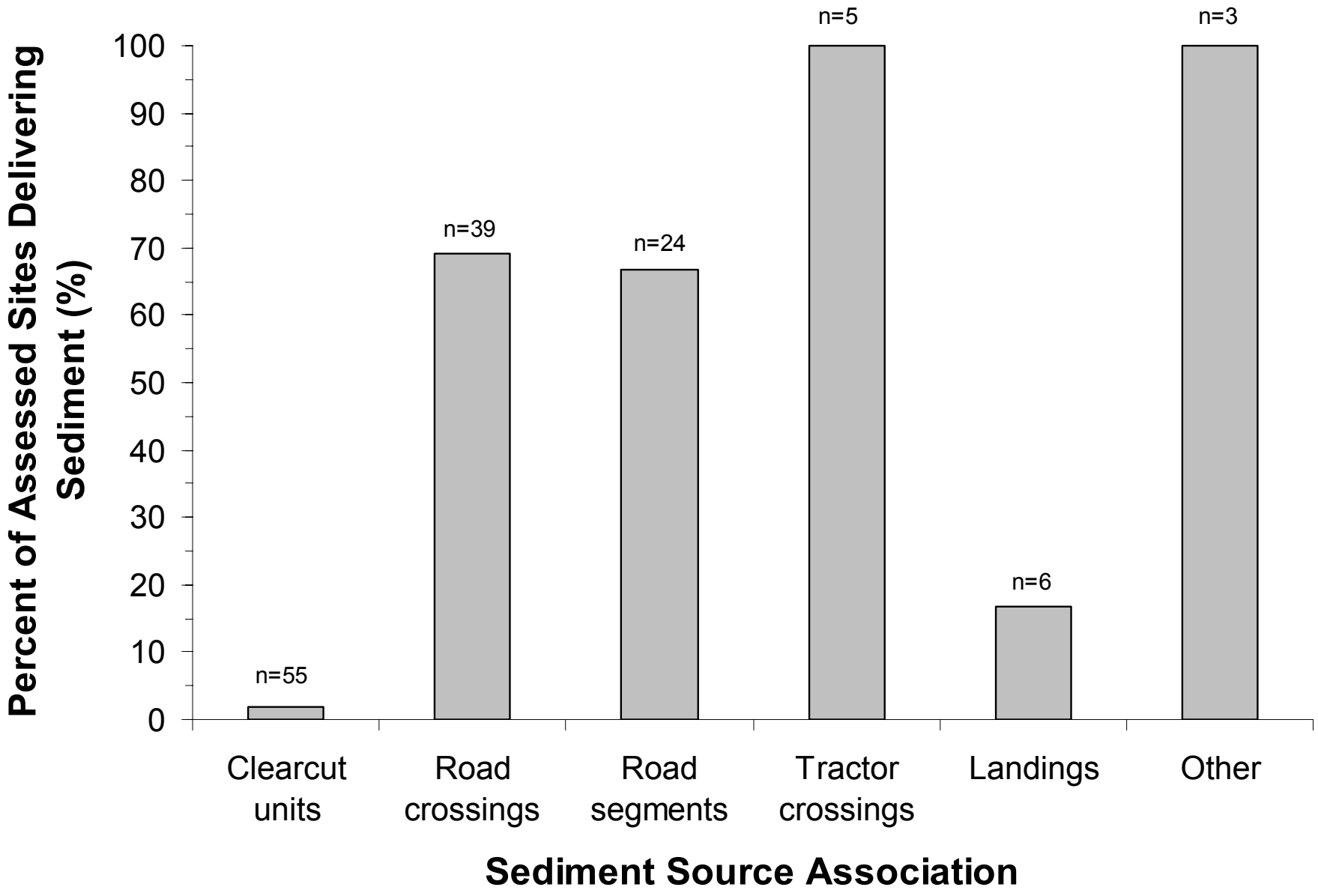
- Walk the interface between clearcut and riparian buffer to look for sediment delivery (Litschert and MacDonald, 2009);
- Visit pre-identified road crossings, tractor crossings, and landings;
- Walk watercourse-adjacent road segments.

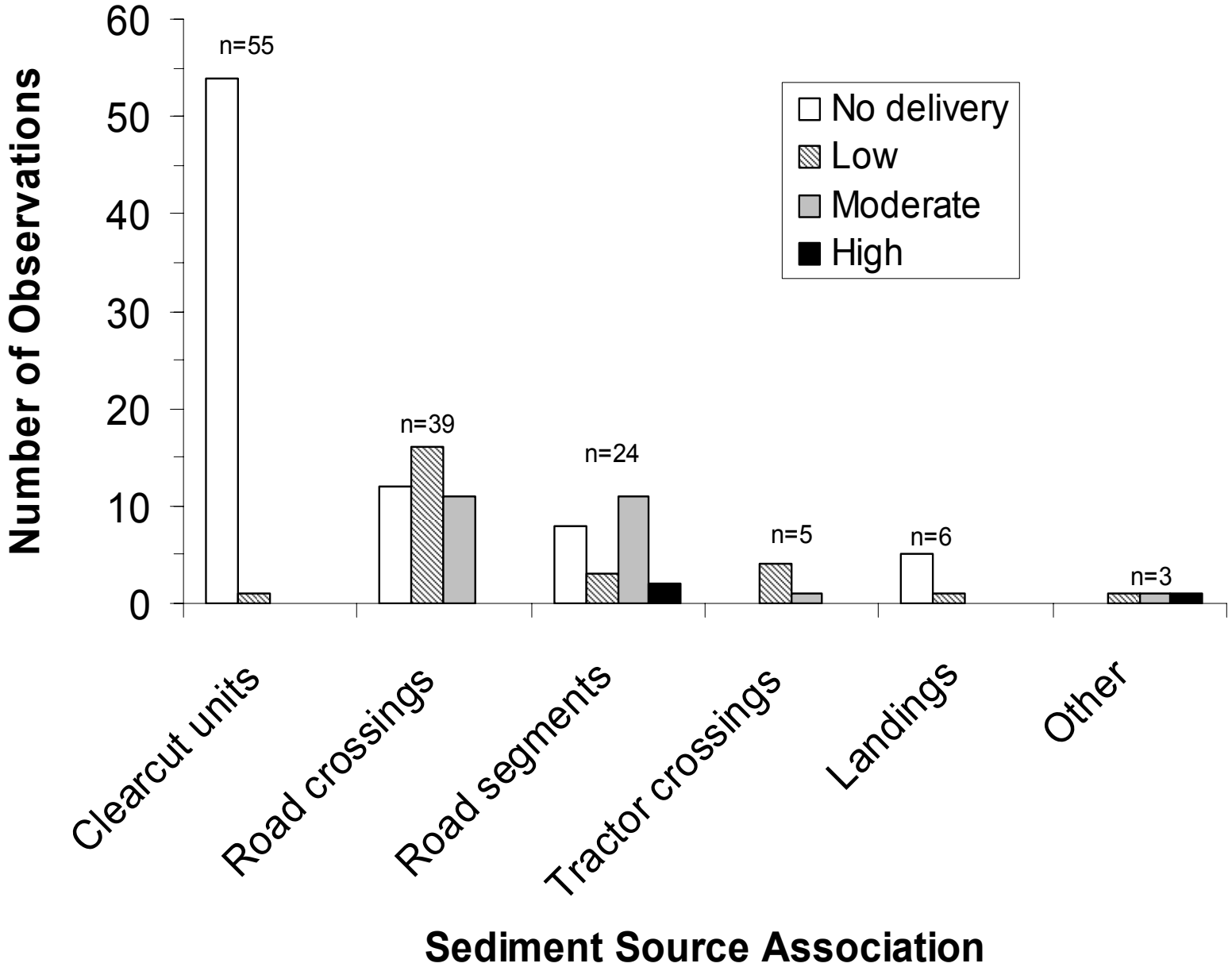
# Methods

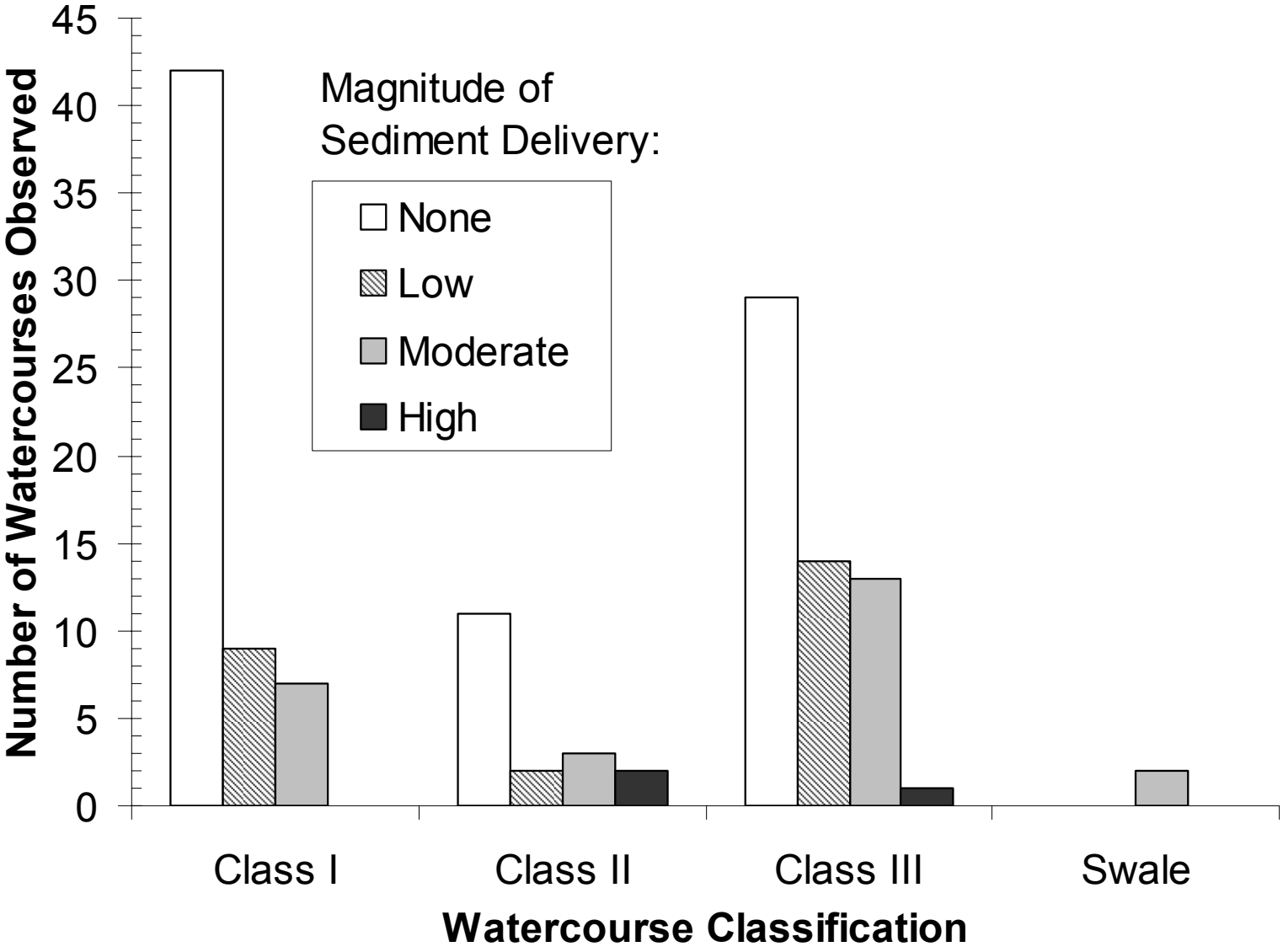
- Identify if sediment was delivered to watercourse;
- Evaluate relative magnitude of sediment delivery:
  - Low (< 1 $yd^3$)
  - Moderate (1 to 10 $yd^3$)
  - High (> 10 $yd^3$)
- Characterize erosion;
- Identify erosion source.

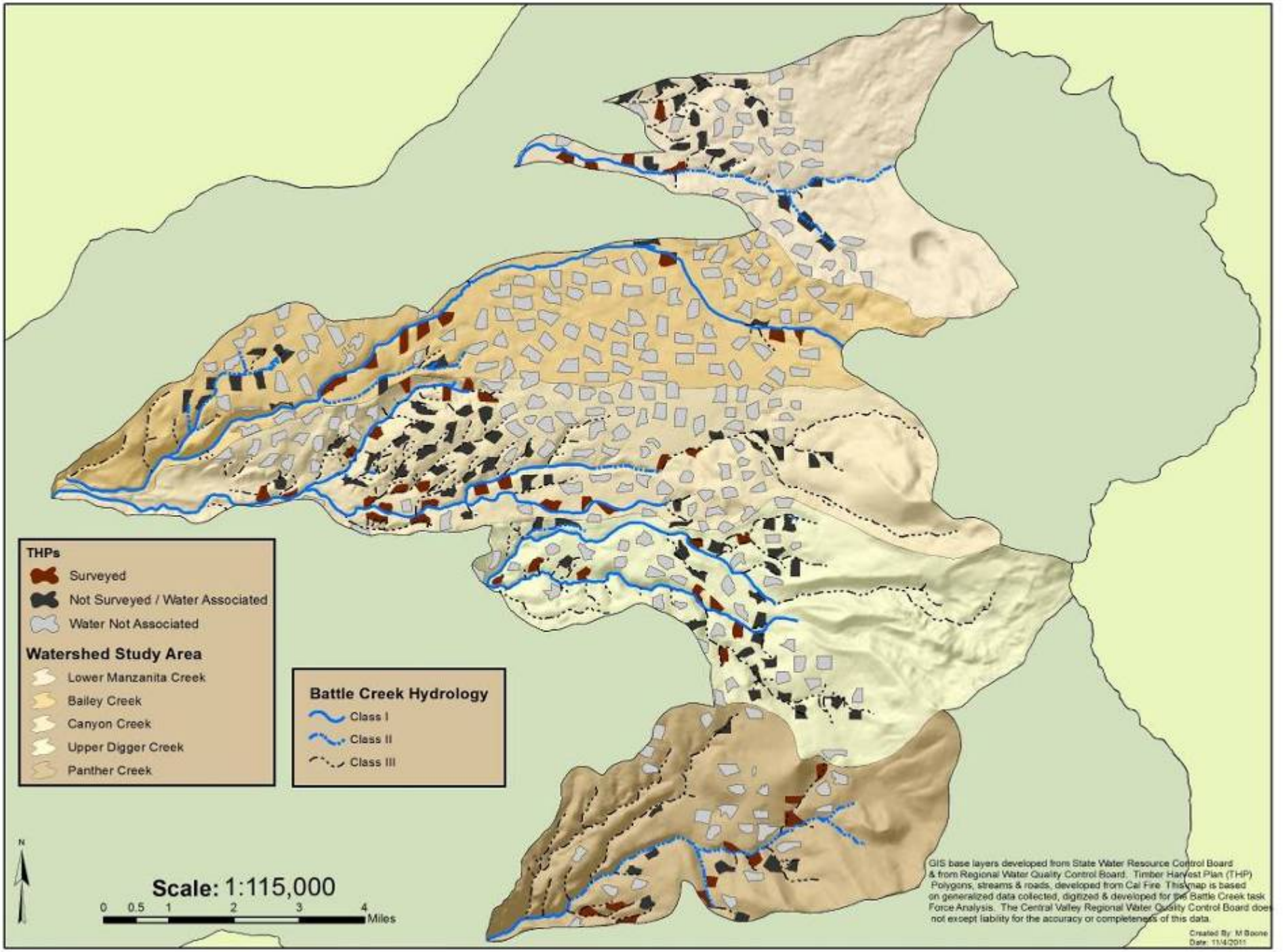

Battle Creek Sample Sites
Yes Delivery
No Delivery
Maybe
Watershed Study Area
Lower Manzanita Creek
Bailey Creek
Canyon Creek
Upper Digger Creek
Panther Creek
Battle Creek Hydrology
Class I
Class II
Class III
N
Scale:1:115,000
0 0.5 1 2 3 4 Miles
Created By: M Boone
Date: 11/3/2011
GIS base layers developed from State Water Resource Control Board & from Regional Water Quality Control Board. Timber Harvest Plan (THP) Polygons and streams developed from Cal Fire. This map is based on generalized data collected, digitized & developed for the Battle Creek task Force Analysis. The Central Valley Regional Water Quality Control Board does not except liability for the accuracy or completeness of this data.


Was Sediment Delivered?
No
Yes
Maybe
Number of Observations
60
50
40
30
20
10
0
n=55
n=39
n=24
n=5
n=6
n=3
Clearcut units
Road crossings
Road segments
Tractor crossings
Landings
Other
Sediment Source Association


Percent of Assessed Sites Delivering Sediment (%)
100
90
80
70
60
50
40
30
20
10
0
n=55
n=39
n=24
n=5
n=6
n=3
Clearcut units
Road crossings
Road segments
Tractor crossings
Landings
Other
Sediment Source Association


Number of Observations
60
50
40
30
20
10
0
n=55
n=39
n=24
n=5
n=6
n=3
No delivery
Low
Moderate
High
Clearcut units
Road crossings
Road segments
Tractor crossings
Landings
Other
Sediment Source Association


Number of Watercourses Observed
45
40
35
30
25
20
15
10
5
0
Magnitude of
Sediment Delivery:
None
Low
Moderate
High
Class I
Class II
Class III
Swale
Watercourse Classification


THPs
Surveyed
Not Surveyed / Water Associated
Water Not Associated
Watershed Study Area
Lower Manzanita Creek
Bailey Creek
Canyon Creek
Upper Digger Creek
Panther Creek
Battle Creek Hydrology
Class I
Class II
Class III
N
Scale: 1:115,000
0 0.5 1 2 3 4
Miles
GIS base layers developed from State Water Resource Control Board & from Regional Water Quality Control Board. Timber Harvest Plan (THP) Polygons, streams & roads, developed from Cal Fire. This map is based on generalized data collected, digitized & developed for the Battle Creek task Force Analysis. The Central Valley Regional Water Quality Control Board does not except liability for the accuracy or completeness of this data.
Created By: M Boone
Date: 11/4/2011

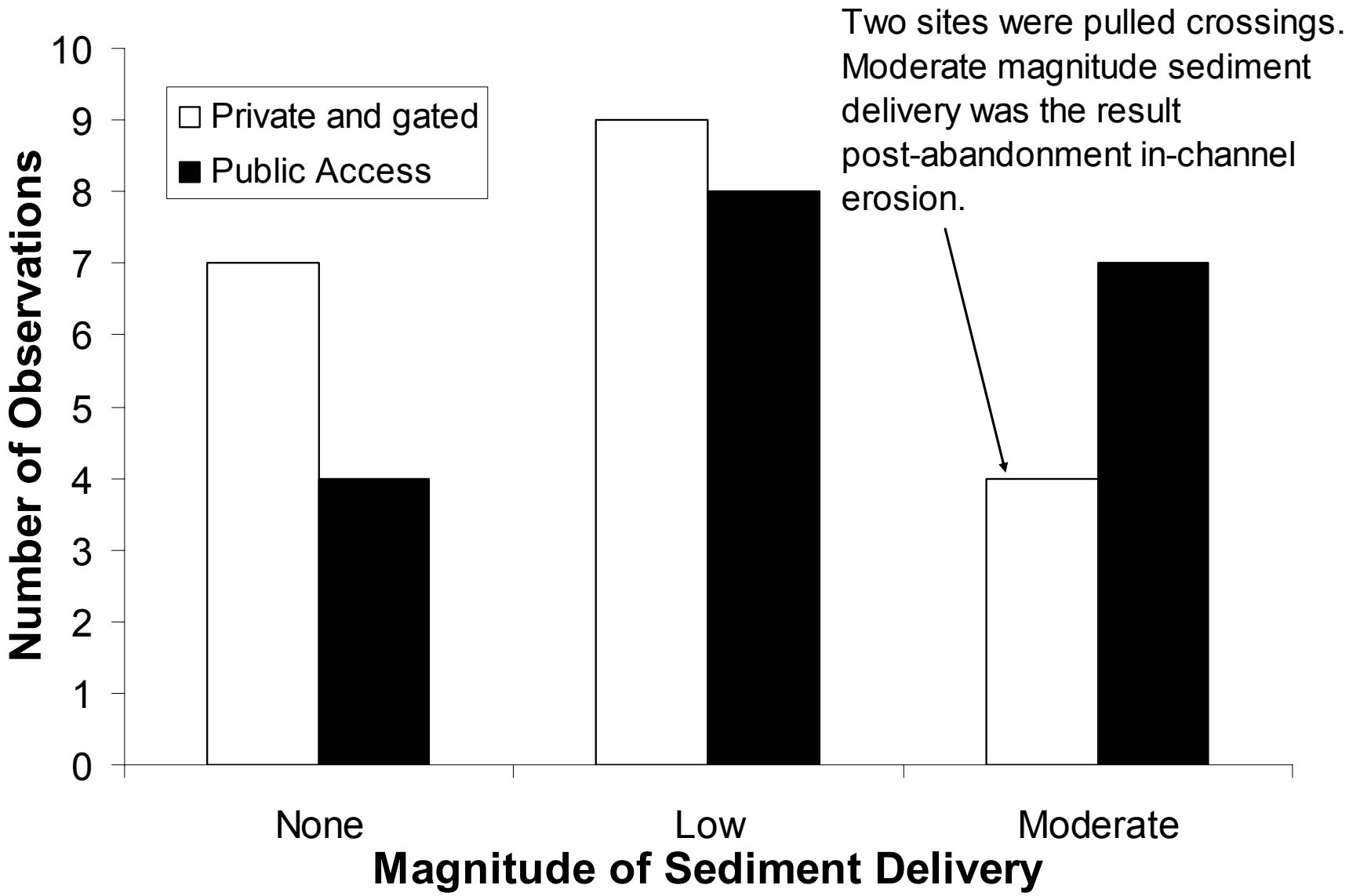
| Watercourse Classification | Total Length of Buffer (miles) | Length of Buffer Assessed (miles) | Percent Assessed |
|---|---|---|---|
| Class I | 7.7 | 6.8 | **88** |
| Class II | 5.1 | 1.7 | 33 |
| Class III | 21.6 | 7.6 | 35 |
| **Total:** | **34.4** | **16.1** | **47** |

Class
III
Encroaching
Waterbar/berm

# Road Crossings

# Road Crossings

- Sediment delivery generally came from crossing approaches
- Privately-maintained road behind gates generally delivered little sediment
- Publicly-maintained roads and roads with public access had  higher likelihood of delivering moderate magnitudes of sediment


Two sites were pulled crossings. Moderate magnitude sediment delivery was the result post-abandonment in-channel erosion.
Private and gated
Public Access
Number of Observations
0
1
2
3
4
5
6
7
8
9
10
None
Low
Moderate
Magnitude of Sediment Delivery

# Watercourse-Adjacent Road Segments

# Watercourse-Adjacent Road Segments

- Segments most likely to deliver when they were within 30 feet of watercourse
- Roads with moderate to high magnitudes of sediment delivery were within 5 to 20 feet
- Sediment delivery often unmitigatible

Class III
Watercourse
Sediment Discharge
Point from Road

# Tractor Crossings and Landings

- All tractor crossings deliver at least a low magnitude of sediment
  - Difficult to return channel to pre-logging condition
  - Delivery limited by general lack of tractor crossing
- Landings generally delivered no sediment due to ample surface cover provided by chipping operations

# Why No Sediment Delivery from Clearcuts?

# BMPs Effective in Preventing Direct Sediment Delivery from Clearcuts

- Strategic skidding and effective drainage (waterbars) limits runoff production and erosion;
- Contour ripping decreases compaction, increases infiltration, and decreases slope length;
- Surface cover remains relatively high (typically greater than 75%);
- Sediment-laden runoff routed to areas relatively undisturbed by heavy machinery;
- Buffer strips effective at infiltrating runoff and filtering sediment.

# Is This An Anomaly?

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Frequency and characteristics of sediment delivery pathways from forest harvest units to streams

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ABSTRACT

Timber harvest is typically the largest area of anthropogenic disturbance in forested watersheds, and harvested areas may generate from one to five times more erosion than undisturbed areas (Motha et al., 2003). When sediment from harvested areas reaches stream channels it can degrade water quality and aquatic habitat. Streamside management zones (SMZs) are often prescribed to minimize sediment delivery, but there is little information about sediment delivery through these zones. Hence the objectives of this study were to: (1) determine the frequency of sediment delivery pathways ("features") from timber harvest units; (2) measure the physical characteristics and connectivity of these features; and (3) develop models to predict the length and connectivity of features from harvest units to streams.

Nearly 200 harvest units with streamside management zones were assessed on four National Forests in the Sierra Nevada and Cascade Mountains of California. Only nineteen features were found below harvest units ranging in age from 2 to 18 years. Feature lengths ranged from 10 m to 220 m, and the length was significantly related to mean annual precipitation, cosine of the aspect, elevation, and hillslope gradient ($R^2 = 0.48$, $p = 0.004$). Six of the nineteen features were connected to streams and five of the six connected features originated from skid trails. The results indicate that timber harvest alone rarely initiated large amounts of runoff and surface erosion, particularly when newer harvest practices were utilized. Sediment delivery from timber harvest may be further reduced by locating skid trails away from streams, maintaining high surface roughness downslope of water bars, and promptly decommissioning skid trails following harvest.

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## 1. Introduction

Anthropogenic sediment sources on forested hillslopes include roads, skid trails, and timber harvest units (e.g., Megahan, 1972; Beschta, 1978; Croke et al., 1999; Barrett and Conroy, 2001; Motha et al., 2003). Most recent research has focused on roads (e.g., Luce and Black, 1999; Jones et al., 2000; Lane and Sheridan, 2002; Coe, 2006), but timber harvest units represent the largest areas of anthropogenic disturbance and can increase erosion rates by one to five times relative to undisturbed areas (Motha et al., 2003).

The delivery of overland flow and sediment from disturbed hillslopes contributes to cumulative effects such as an increase in the size of peak flows (e.g., Jones, 2000; MacDonald and Stednick, 2003), the alteration of channel morphology (Troendle and Olsen, 1994; Madej and Ozaki, 1998), degradation of aquatic habitat (Shaw and Richardson, 2001), reductions in reservoir storage, and increases in pollutant transport (EPA, 2003). The delivery of sediment from hillslope sources to the stream network and the watershed outlet has been defined as sediment connectivity (Bracken and Croke, 2007). Connectivity of hillslope sediment pathways can be in the form of sediment plumes when there is an excess of sediment relative to overland flow, or in the form of rills and gullies when the transport capacity is greater than the sediment load.

For this paper a rill was defined by having incised banks with no minimum depth. Gullies were defined as incised features greater than 30 cm deep or with a cross-sectional area larger than about 1000 cm$^2$. Rills, gullies, and sediment plumes are collectively described as features in this paper, and we use the term rills for both rills and gullies unless otherwise specified.

In recent years forest management techniques have been modified to minimize surface runoff, erosion, and connectivity. Skid trails are often designed to follow hillslope contours (Kreutzweiser and Capell, 2001). Streamside management zones (SMZs) are intended to provide vegetative roughness and maintain infiltration rates that can slow or absorb overland flow and filter sediment out of the overland flow before it reaches a stream or water body (Kreutzweiser and Capell, 2001; Hairsine et al., 2002).

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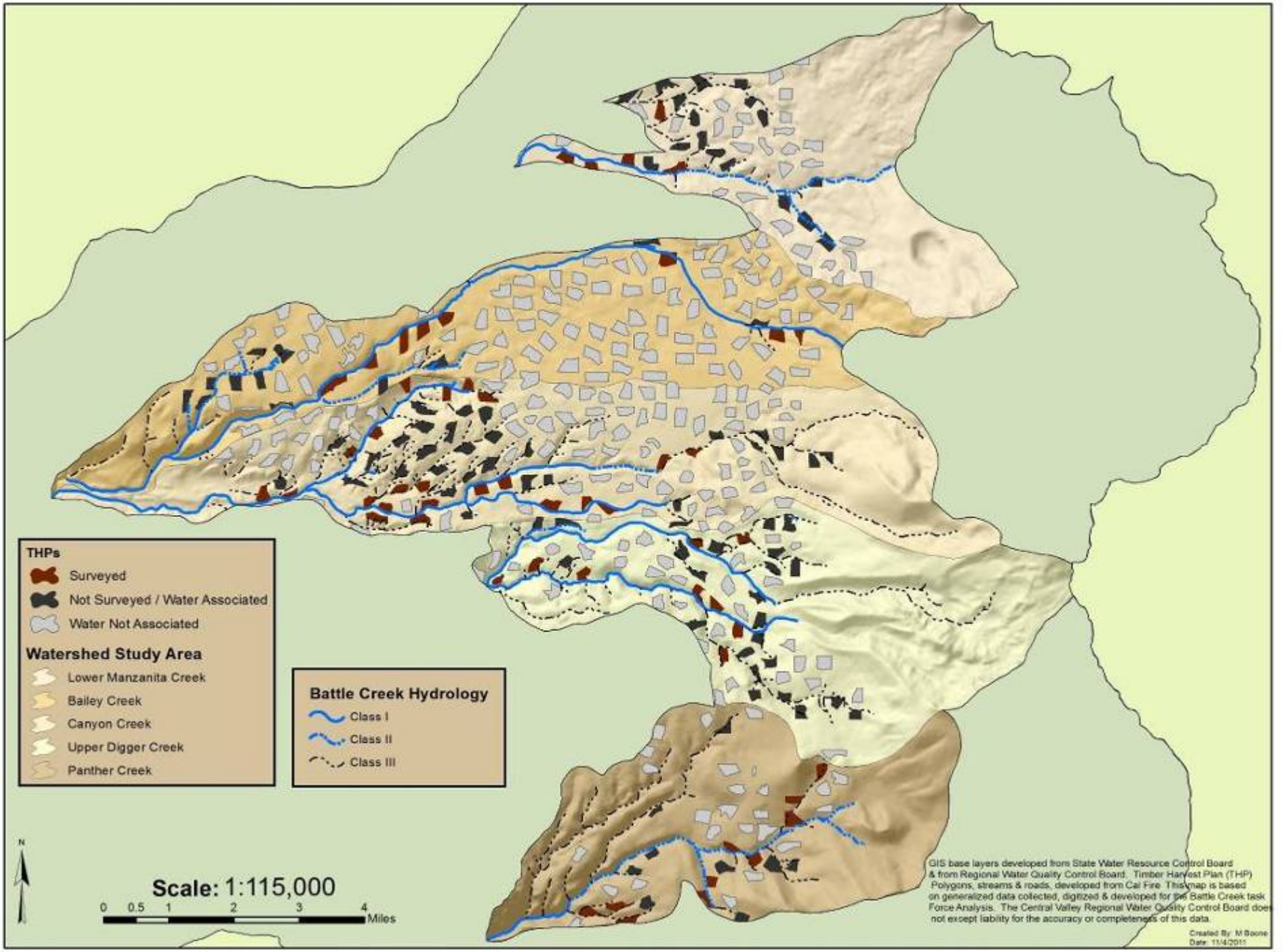
doi:10.1016/j.foreco.2009.09.038

- Litschert and MacDonald (2009) assessed 180 miles of stream buffer adjacent to timber harvest units, including clearcuts, in Sierra Nevada and Southern Cascades;

- Found only 6 erosion features that delivered to watercourses.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Water Not Associated
Watershed Study Area
Lower Manzanita Creek
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Battle Creek Hydrology
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Scale: 1:115,000
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Miles
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Date: 11/4/2011

# Linkage to Fish Habitat

- Clearcuts not causing observable negative impacts to fisheries habitat
- Roads may be causing chronic sedimentation
  - Further study and monitoring needed

# Assessment Limitations

- Unable to look at indirect impacts of clearcutting:
  - Clearcutting can increase peak-flow magnitude and duration, potentially resulting in:
    - Increases in suspended sediment and turbidity
    - Channel changes – increased bank erosion and/or gully erosion

# Assessment Limitations

- Depends on forensic evidence available in field:
  - Erosion features can be transient
  - Erosion features can be modified by subsequent management
  - Assessment area not subject to stressing storm events during recent harvest activity
    - Time frame coincides with turbidity data collected by BCA

# Recommendation #1

- Maintain current emphasis on field review of road crossings, watercourse-adjacent road segments, tractor crossings, landings, and management activities in the WLPZ;

- More emphasis on interagency completion inspections to evaluate adequacy and effectiveness of road-related BMPs.

# Recommendation #2

- Encourage landowners in the watershed to develop road management plans for the roads on their property and/or roads they control.

- Encourage development of a watershed-wide road inventory to identify and prioritize the treatment of road-related sediment sources

# Recommendation #3

- Focus on the hydrological disconnection of privately-maintained and publicly-maintained roads
- Training that highlights how to strategically place waterbreaks (rolling dips) to minimize sediment delivery
- Consider access limitations on sensitive road segments during the rainy season to limit damage of erosion control facilities

# Recommendation #4

- Evaluate the need to treat road surfaces that drain to watercourses
- Focus treatment on roads most likely to deliver sediment
  - Crossing approaches that cannot be disconnected
  - Roads within ≈ 30-50 feet of stream

# Recommendation #5

- Road managers should evaluate the need to abandon and/or relocate watercourse-adjacent roads
  - Target roads within 30 to 50 feet of watercourses

# Recommendation #6

- Support passage of a comprehensive "Road Rules Package" by the Board of Forestry and Fire Protection.
  - Draft version requires implementation of Recommendations 2 and 3 of this report

# Recommendation #7

- Coordinate with counties to develop programs that focus on fish-friendly BMP implementation for county road systems

- Central Valley Water Board will explore regulatory mechanisms to help achieve water quality objectives on county roads

# Recommendation #8

- Provide a road and road crossing BMP component for Licensed Timber Operator (LTO) training

# Recommendation #9

- Encourage outreach workshops for LTOs, local landowners, and county public works supervisors and equipment operators to inform them of state-of-the-art-road-related-BMPs

# Recommendation #10

- Engage in follow-up study to relate results of the assessment to water column data (turbidity) and in-channel physical habitat characteristics.
  - Follow-up study should also address the potential for timber harvest associated peak-flow induced increases to suspended sediment, turbidity, bedload transport, and/or channel alterations.

# Conclusions (1)

- No significant direct water quality impacts related specifically to harvest within clearcuts units

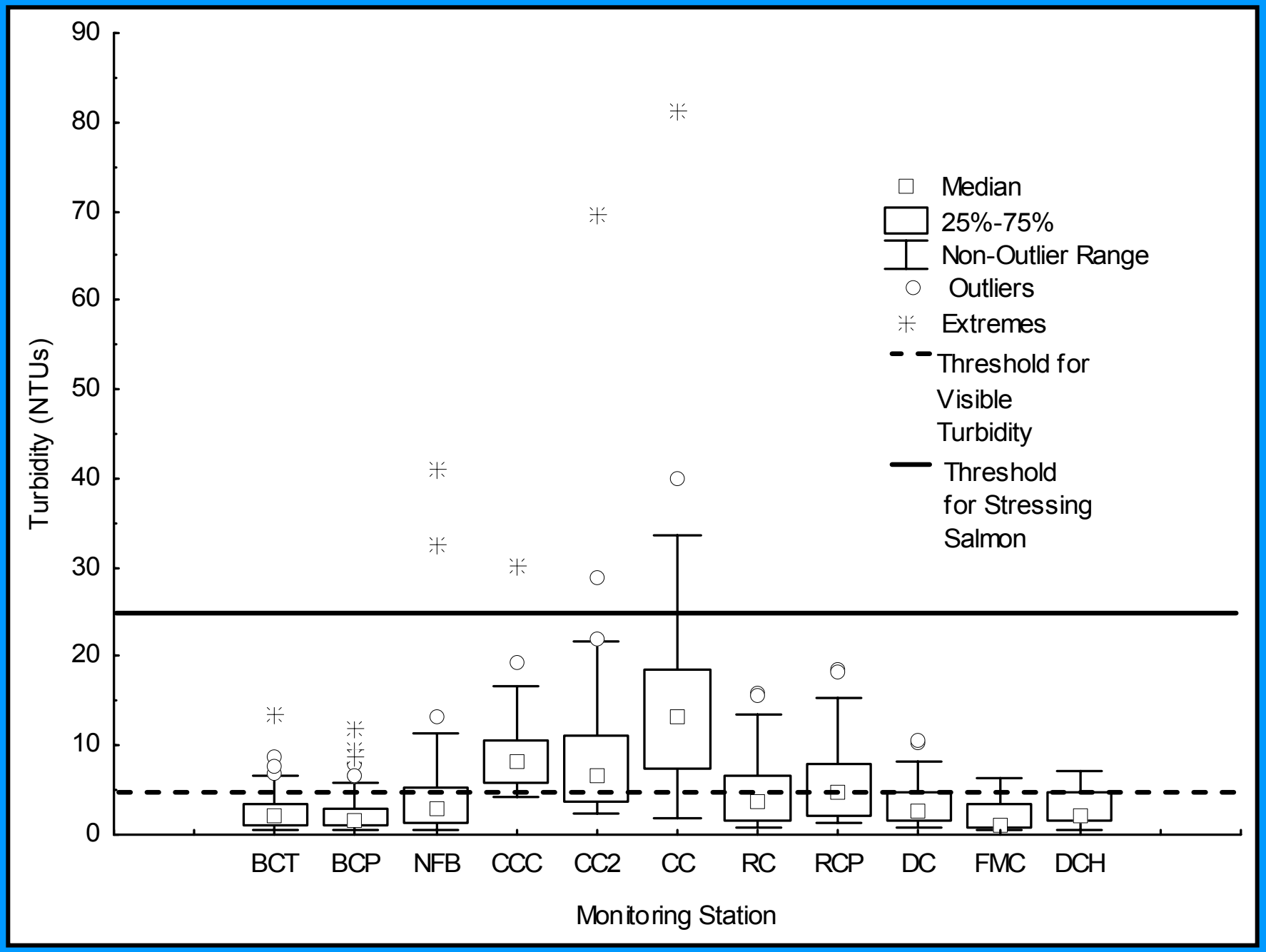
- Most sediment delivery comes from road crossings and watercourse-adjacent road segments

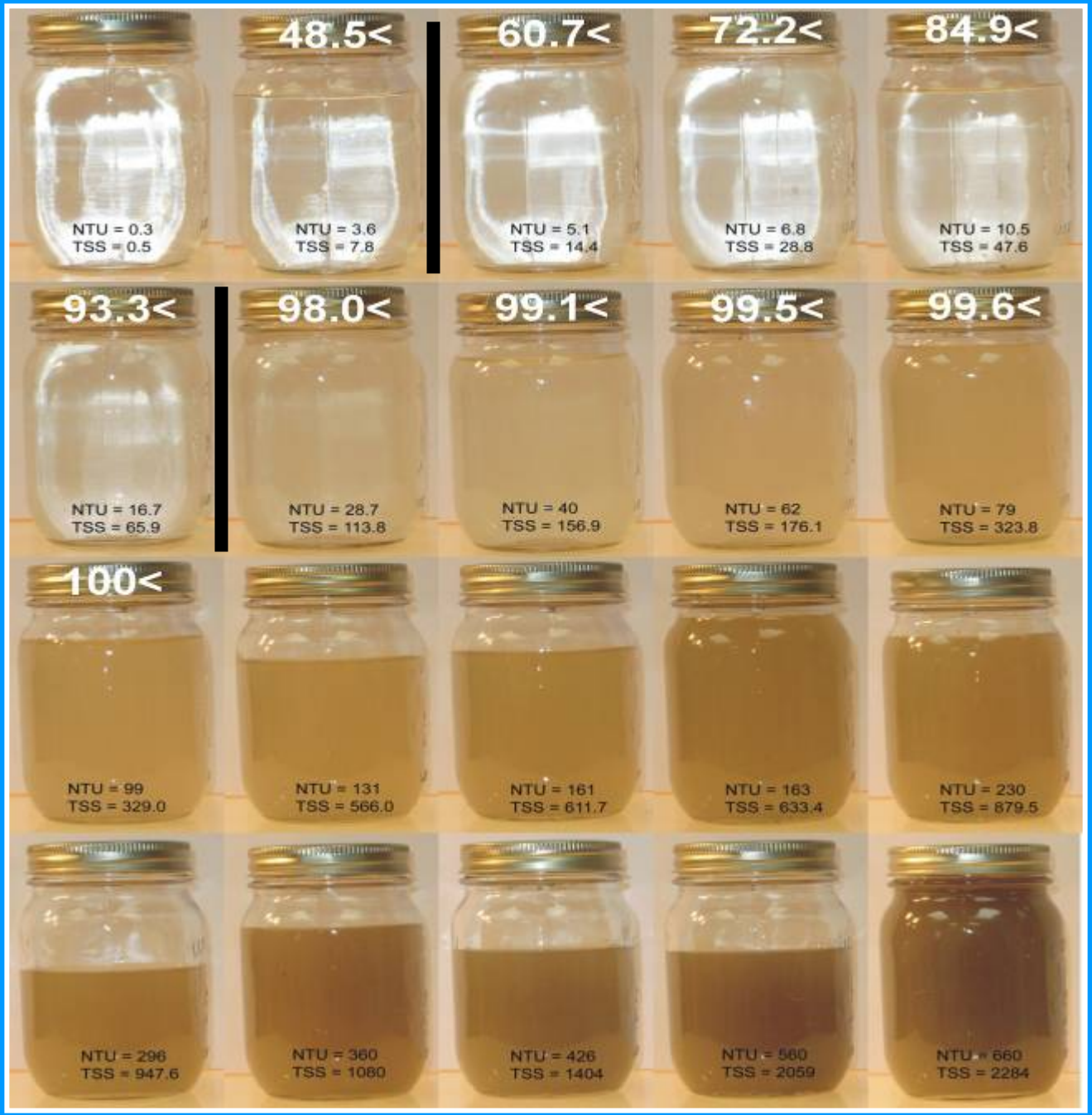
# Conclusions (2)

- Violations of Forest Practice Rules occurred but generally rare and appeared to be of relatively minor significance at scales relevant to salmonids

- Did not assess indirect water quality impacts from clearcuts
  - Water quality impacts due to logging-induced changes in hydrology remains an open question in young volcanic terranes such as the Battle Creek watershed

# Questions?


Turbidity (NTUs)
90
80
70
60
50
40
30
20
10
0
BCT
BCP
NFB
CCC
CC2
CC
RC
RCP
DC
FMC
DCH
Monitoring Station
Median
25%-75%
Non-Outlier Range
Outliers
Extremes
Threshold for Visible Turbidity
Threshold for Stressing Salmon


NTU = 0.3
TSS = 0.5
48.5<
NTU = 3.6
TSS = 7.8
60.7<
NTU = 5.1
TSS = 14.4
72.2<
NTU = 6.8
TSS = 28.8
84.9<
NTU = 10.5
TSS = 47.6
93.3<
NTU = 16.7
TSS = 65.9
98.0<
NTU = 28.7
TSS = 113.8
99.1<
NTU = 40
TSS = 156.9
99.5<
NTU = 62
TSS = 176.1
99.6<
NTU = 79
TSS = 323.8
100<
NTU = 99
TSS = 329.0
NTU = 131
TSS = 566.0
NTU = 161
TSS = 611.7
NTU = 163
TSS = 633.4
NTU = 230
TSS = 879.5
NTU = 296
TSS = 947.6
NTU = 360
TSS = 1080
NTU = 426
TSS = 1404
NTU = 560
TSS = 2059
NTU = 660
TSS = 2284