Hyperspectral Remote Sensing of Stream Morphology

Idaho State University
Department of Geosciences
Boise Center Aerospace Laboratory
(BCAL; http://geology.isu.edu/BCAL/)

Nancy Glenn, David Streutker, Jacob Mundt

Objectives

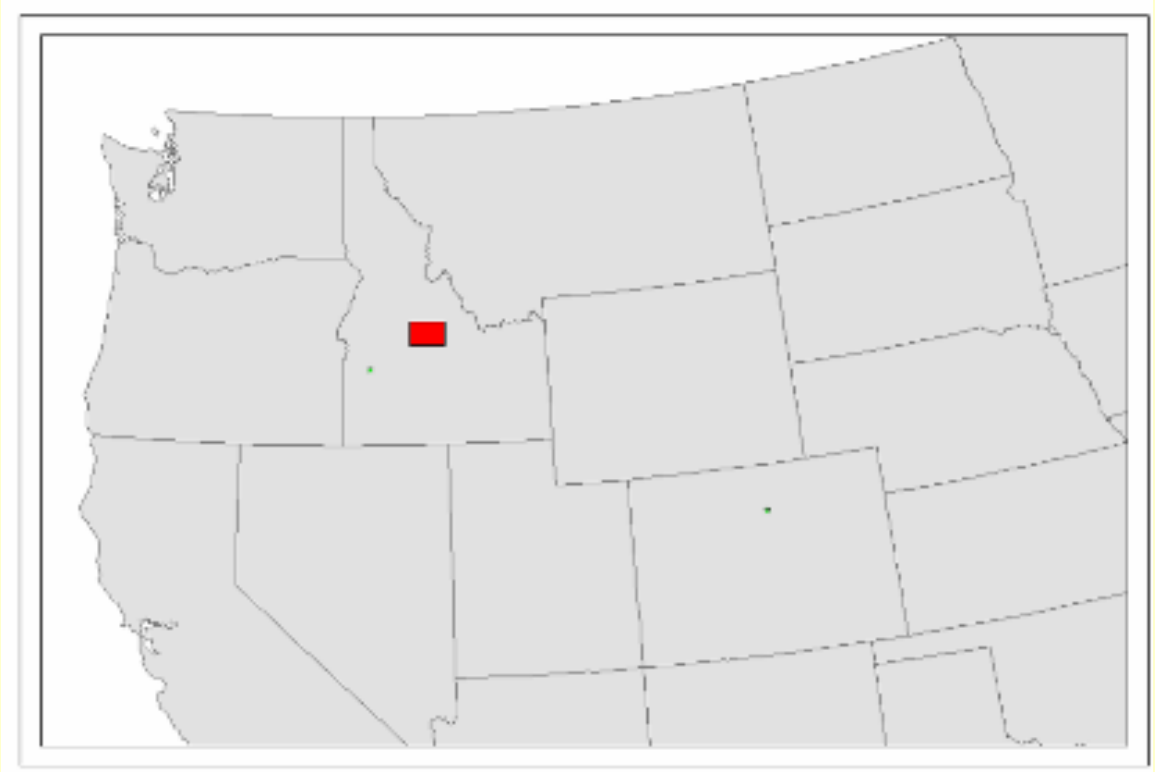
- Characterize:
  - Gravel bars – size, shape, grain size
  - Pools and rifles
- Implications:
  - Channel origin and development
  - Change in channel morphology over time
    - Channel controls (e.g. flooding, debris events) and sediment transport
    - Stream ecology
  - Comparison of channels and drainages within larger scope

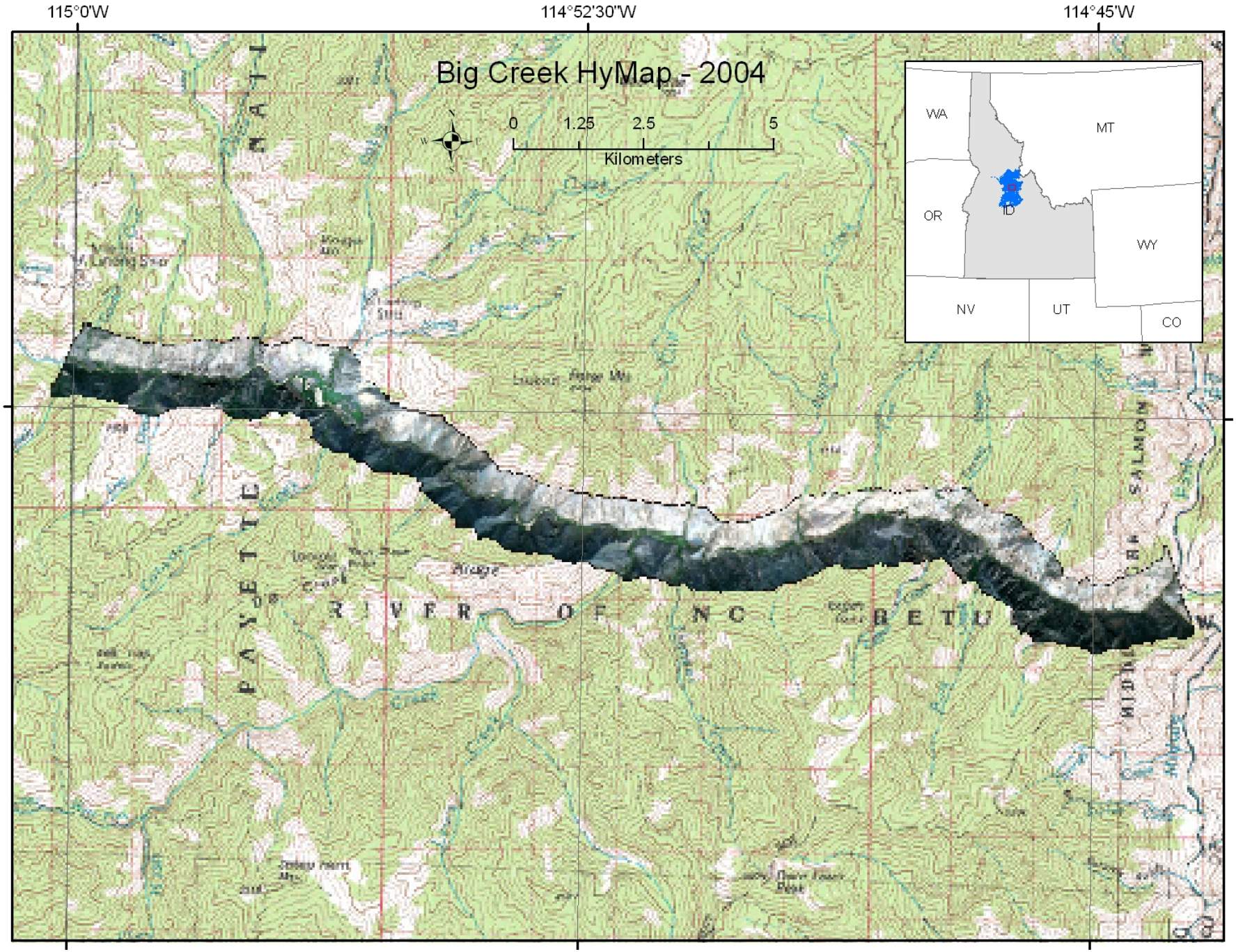
(Global) Significance

- Need quantitative techniques for mapping channel morphology
  - understand channel processes (discharge, channel width, sediment load)
    - geologic origins
    - hydrologic (surface water) systems – flow resistance, flow velocities
    - uplift/incision
  - monitor ecologically significant and vulnerable fluvial systems
    - in-stream habitat
    - fluvial systems are good indicators of disturbance (e.g. wildfires and sediment loads) and change

Study Area

• Big Creek, a major tributary to the Middle Fork of the Salmon River, Frank Church River of No Return Wilderness
•Provides abundant spawning and rearing habitat
•Hydrologic system in relatively pristine condition (link to processes)



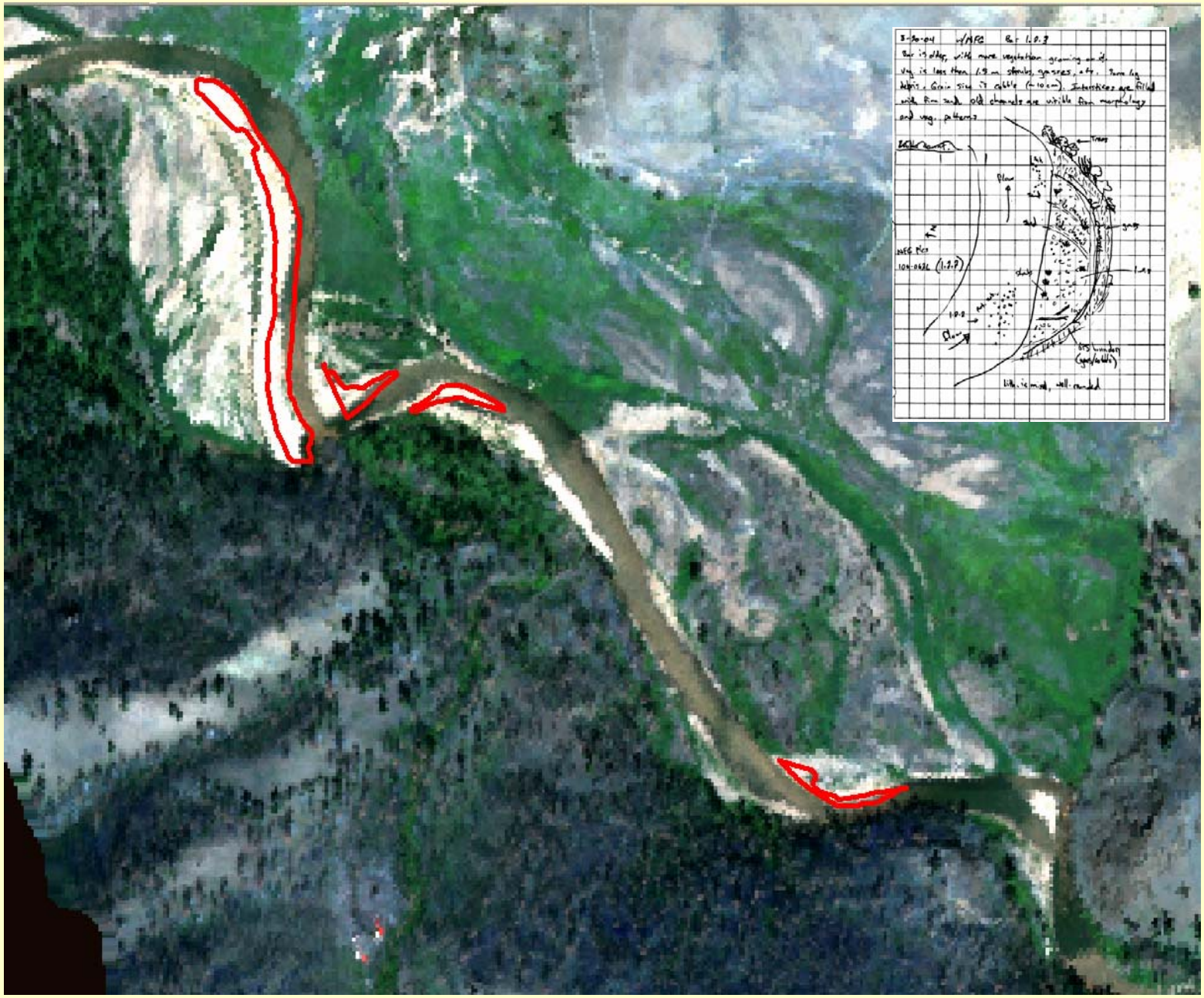

115°0'W
114°52'30"W
114°45'W
45°7'30"N
Big Creek HyMap - 2004
0
1.25
2.5
5
Kilometers
WA
MT
OR
ID
WY
NV
UT
CO
PAYETTE
RIVER
SALMON

Methodology

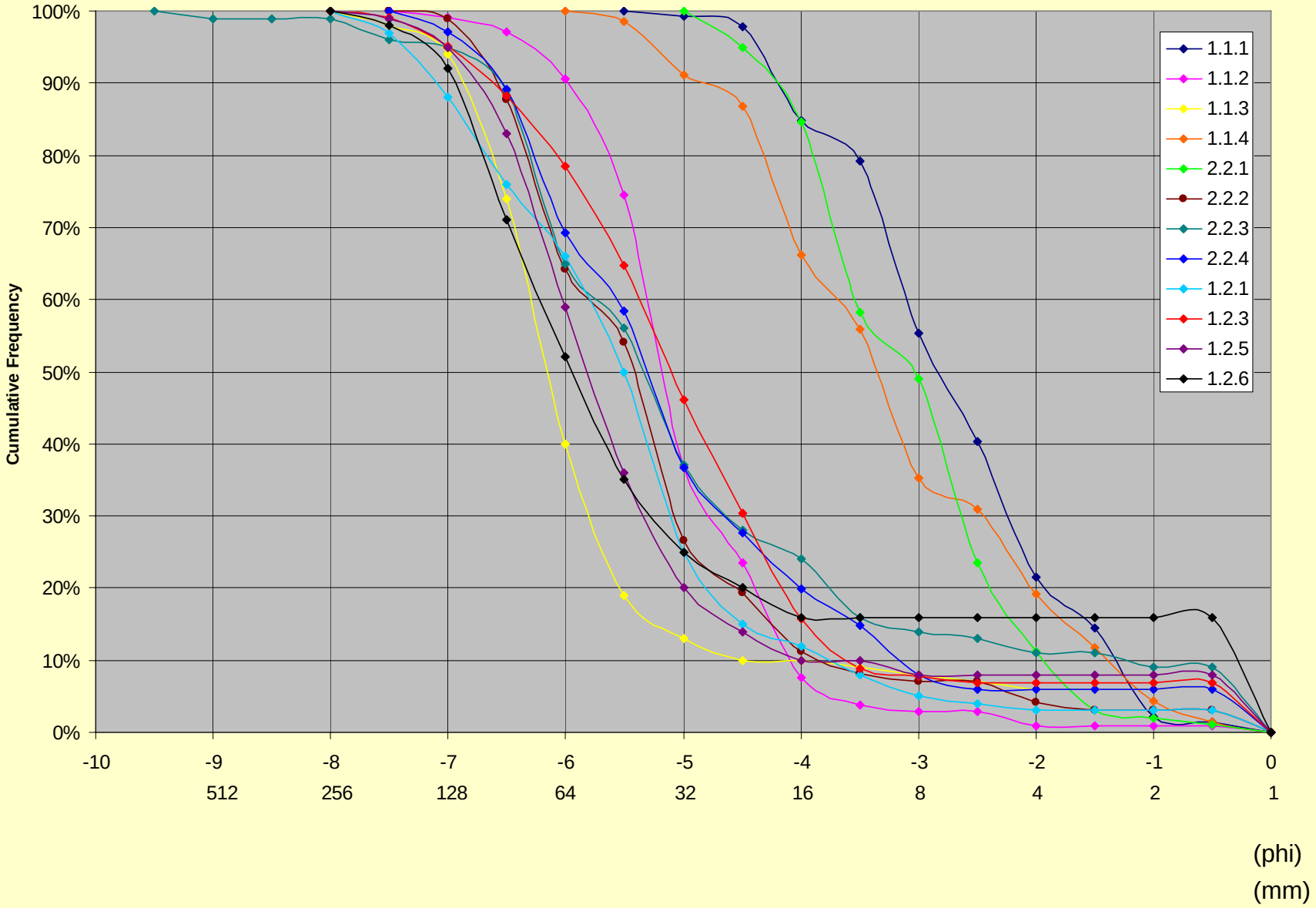
- Field based data
  - Pebble counts
  - GPS of gravel bars
  - Fine-scale digital photos
- Acquisition of hyperspectral data set
- Image processing

Field Data Collection

- Field validation completed in August, 2004 & 2005
- GPS polygons of gravel bar perimeters
- Pebble count transects
- Field sketches and digital photographs


Trees
Flow
Flow

Pebble Counts for Select Gravel Bars



Hyperspectral Data Collection

- 4 lines collected, August 12, 2004 (low water)
- 3 meter spatial resolution, 126 bands, 450 – 2500 nm, ~15nm spectral resolution

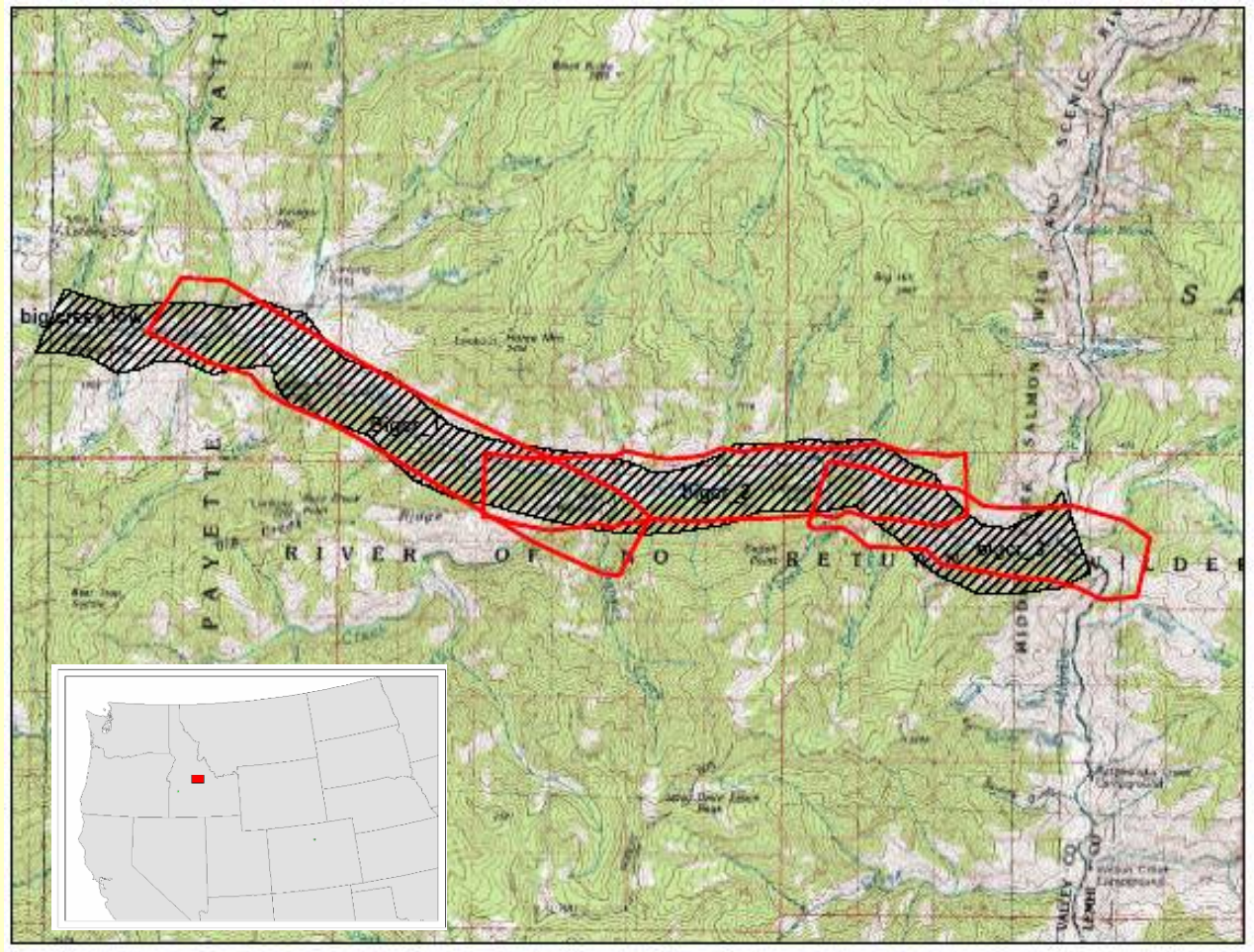
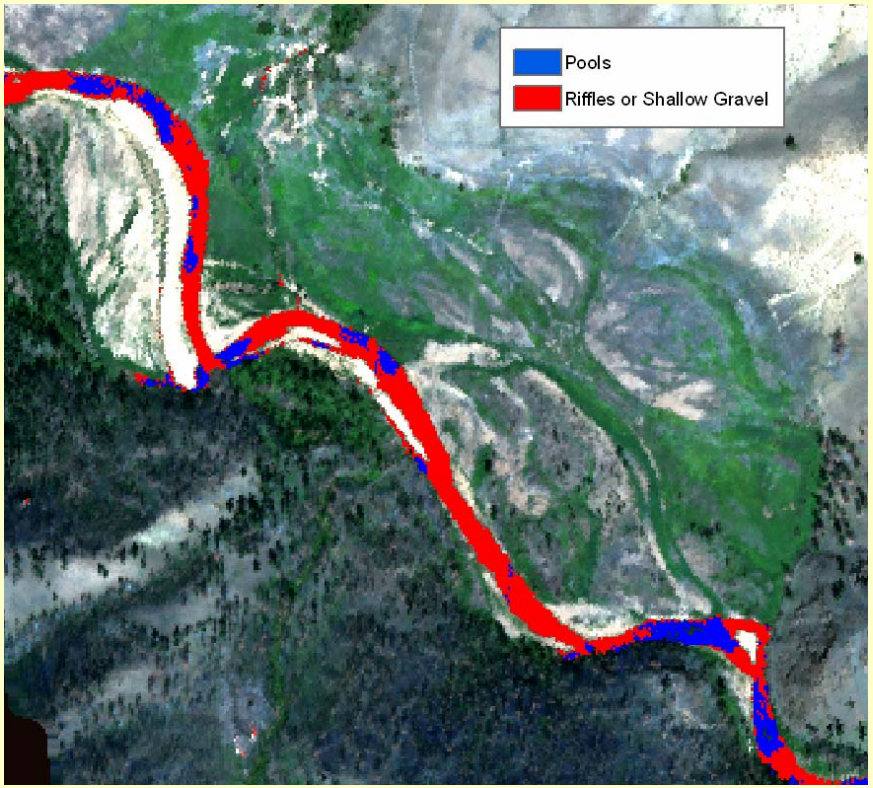


Image Processing

- HyCorr atmospheric correction and conversion of radiance to reflectance
- Spectral endmembers for pools, rifles, and exposed bars were collected from imagery based on GPS data and field knowledge
- Spectral angle mapper (SAM) classifier for exposed bars; then used as a mask; pools and rifles were classified using SAM

Pools and Rifles Classification



Pools and Rifles Classification

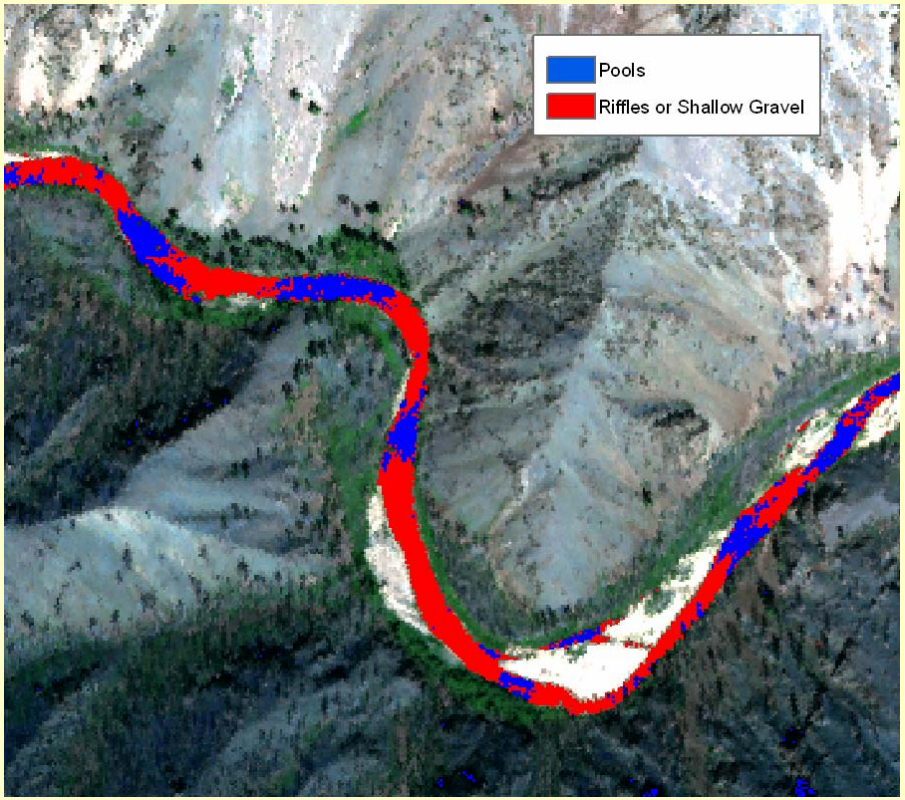
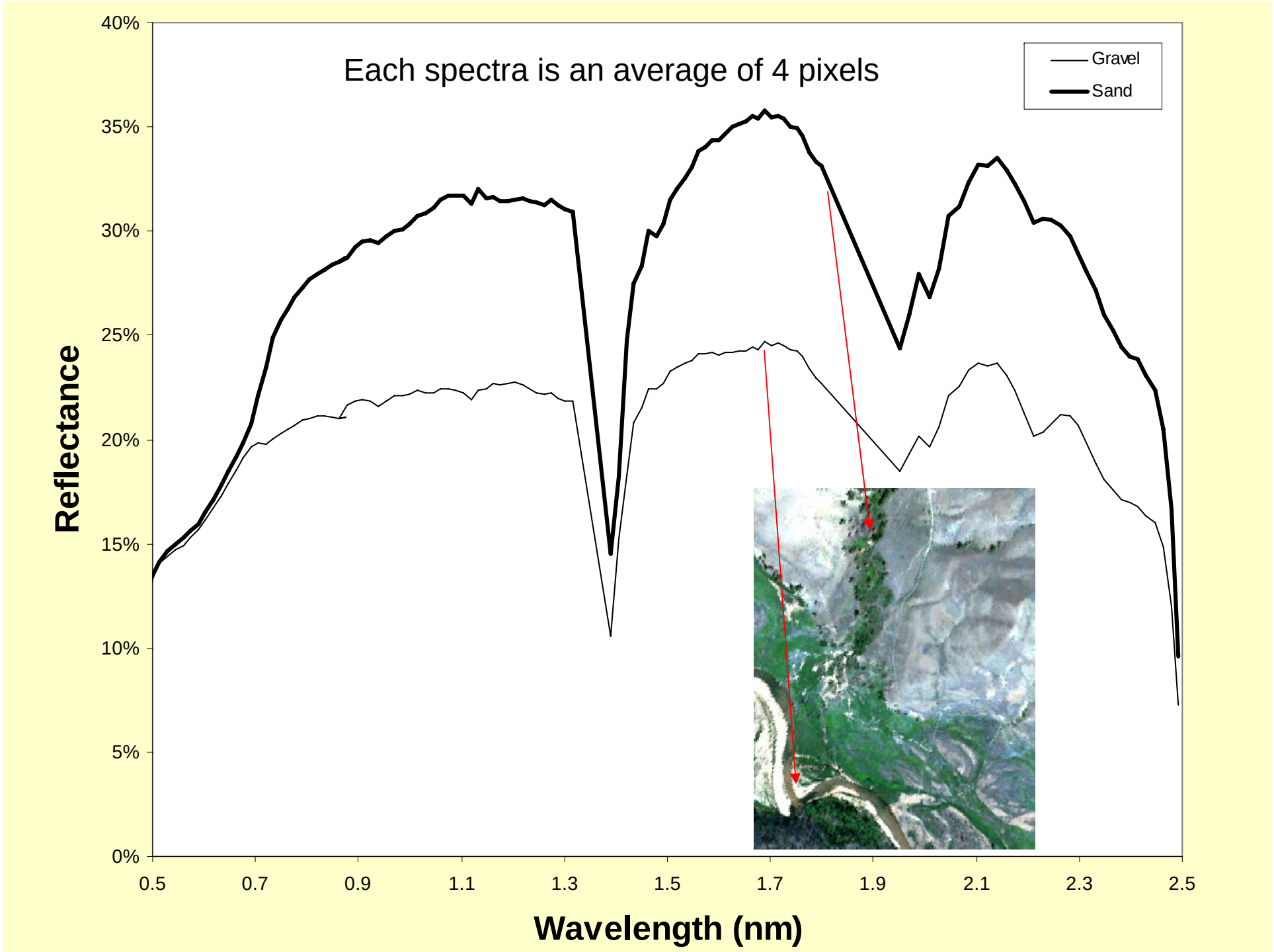
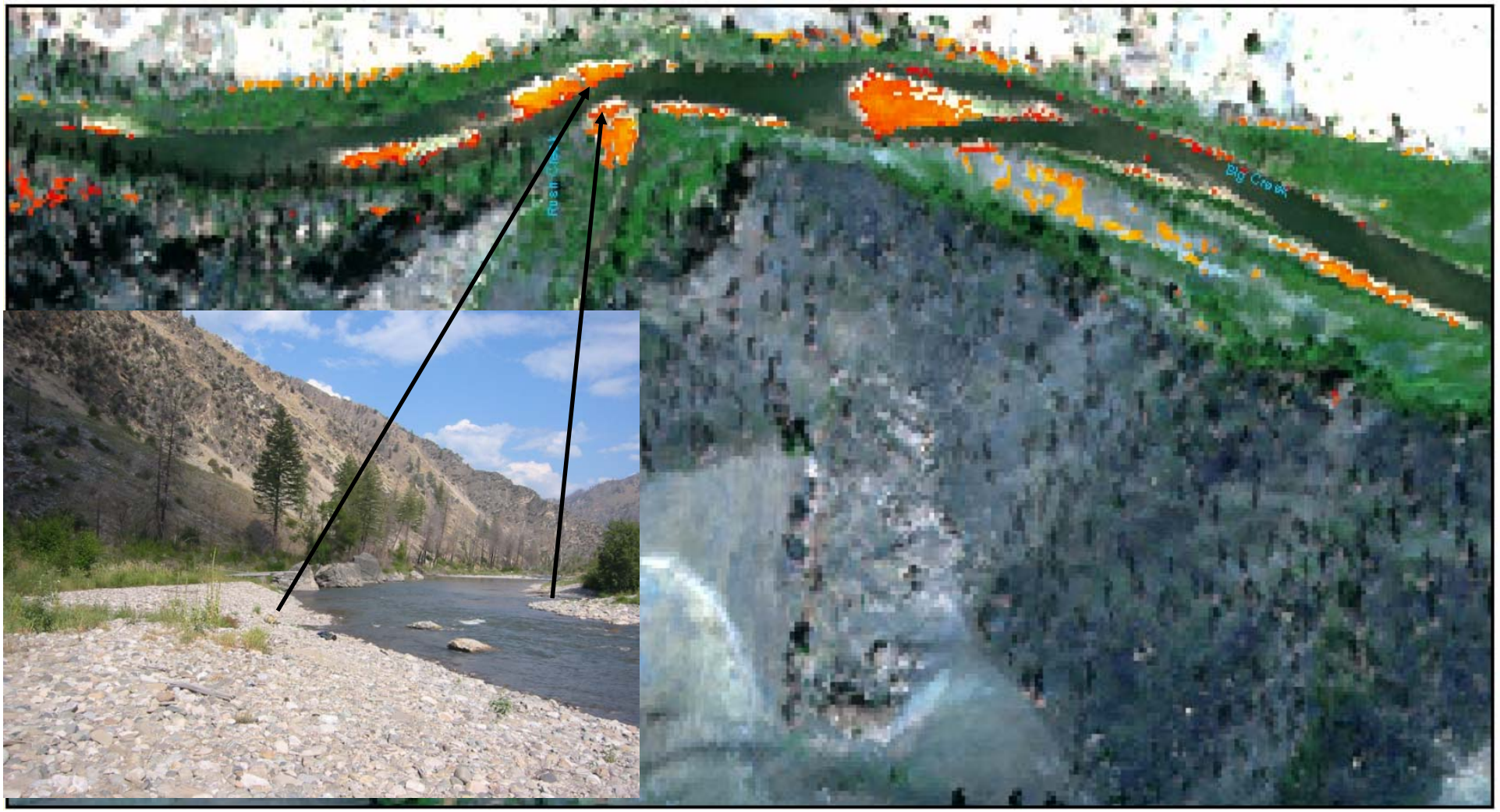


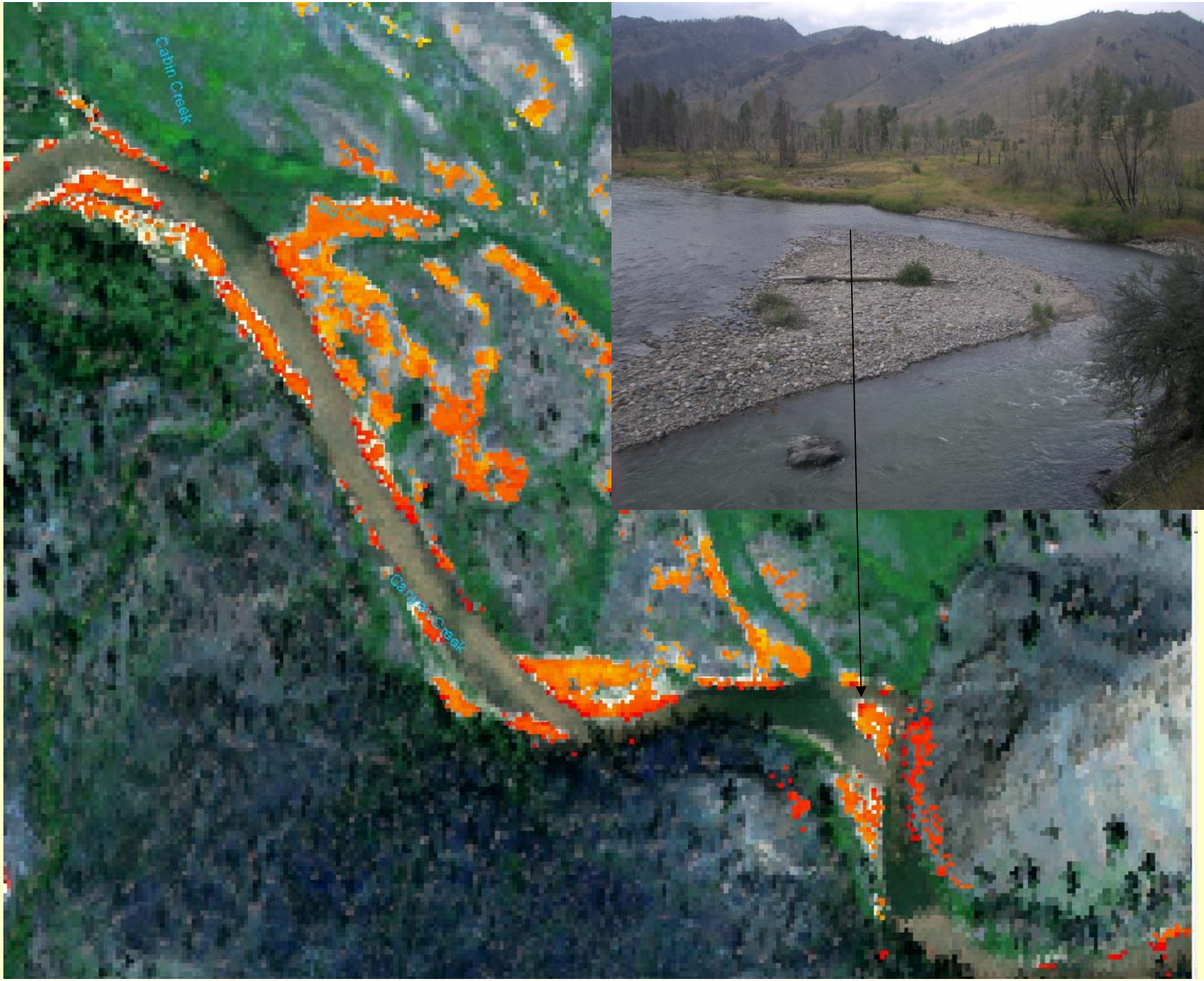
Image Processing - Bars

- Hypothesis that finer material will have a higher reflectance than coarser material
- Endmembers collected for fine grain material in Cabin Creek and coarse grain material in Big Creek
- Masked exposed bars were then used to map relative reflectance in HyMap Band 103 (2.1 µm)


Each spectra is an average of 4 pixels
Gravel
Sand
Reflectance
40%
35%
30%
25%
20%
15%
10%
5%
0%
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
2.3
2.5
Wavelength (nm)


N
W
E
S
Inferred Clast Size
Fine
Course
Big Creek


N
W
E
S
Inferred Clast Size
Fine
Course
Big Creek


Cabin Creek
Big Creek
Cabin Creek

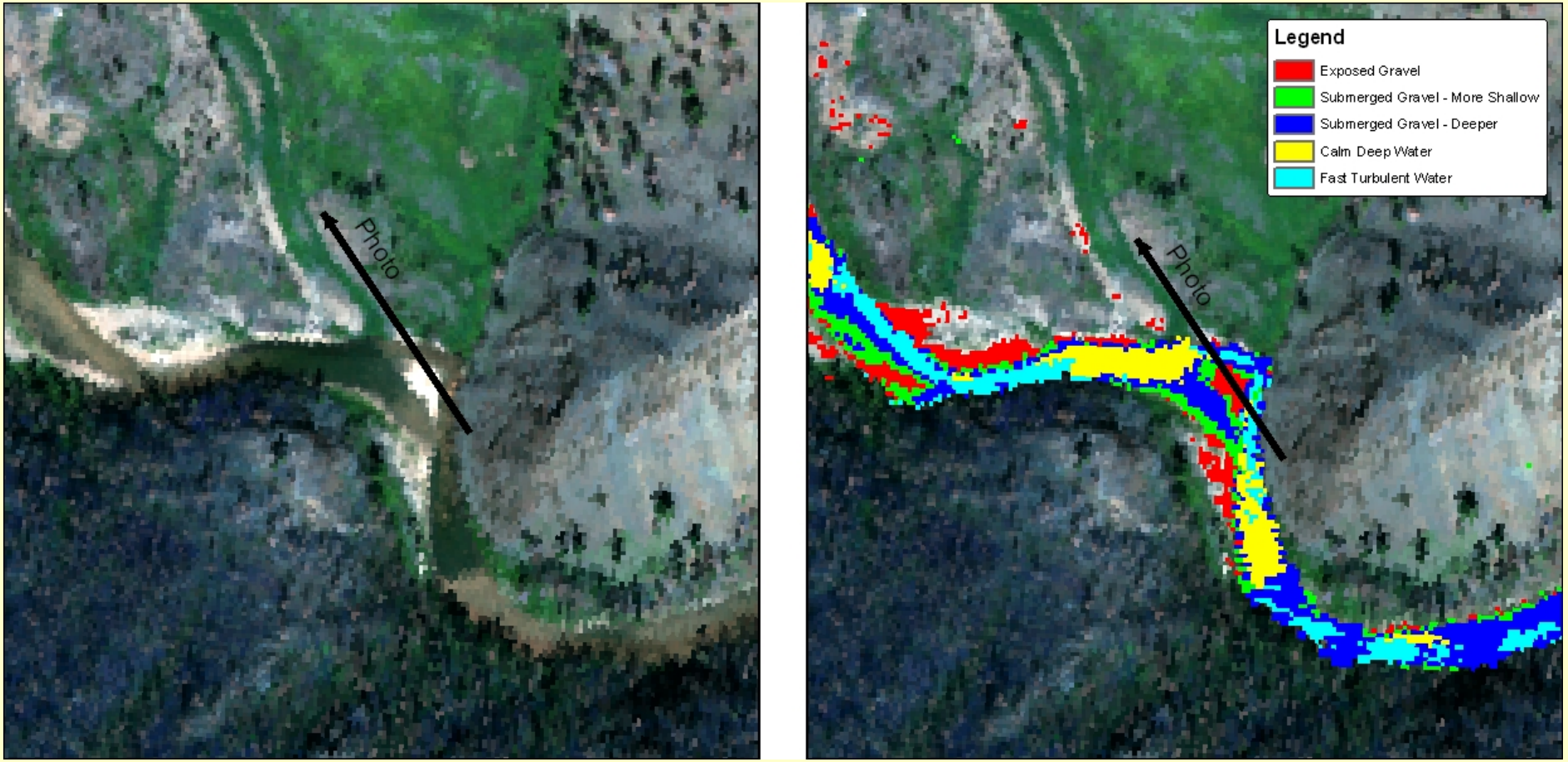
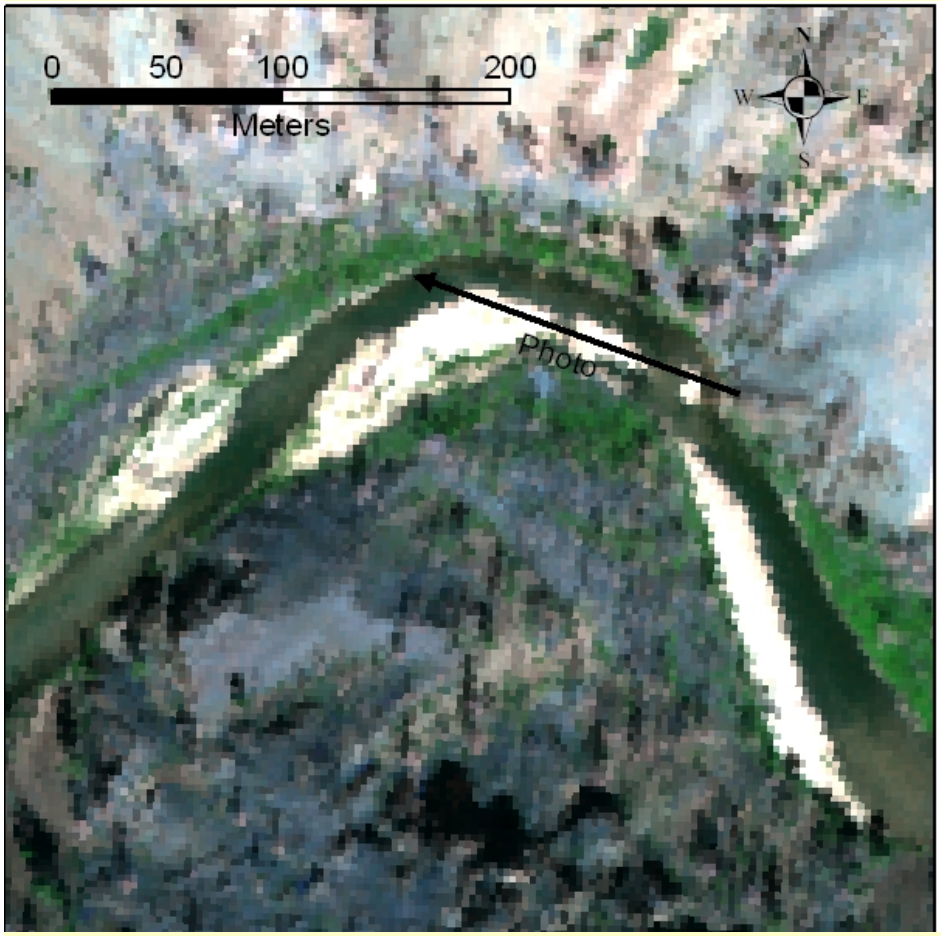
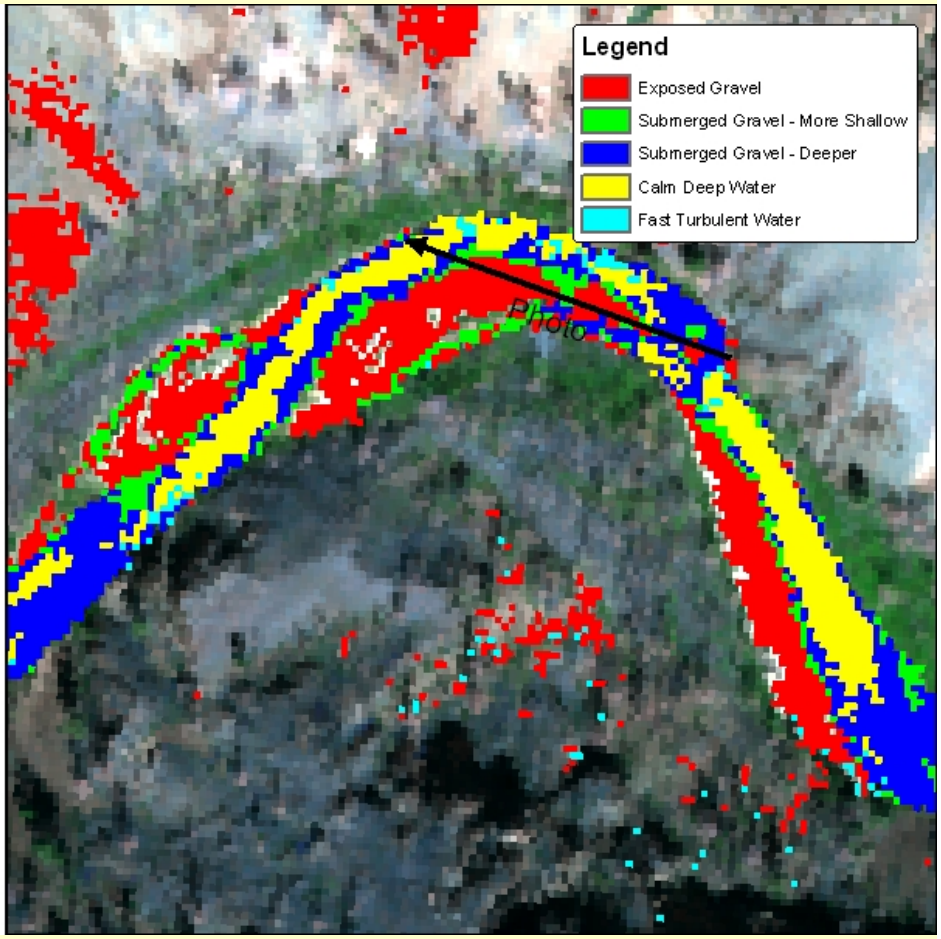


Photo
Legend
Exposed Gravel
Submerged Gravel - More Shallow
Submerged Gravel - Deeper
Calm Deep Water
Fast Turbulent Water
Photo


0
50
100
200
Meters
N
W
E
S
Photo


Legend
Exposed Gravel
Submerged Gravel - More Shallow
Submerged Gravel - Deeper
Calm Deep Water
Fast Turbulent Water
Photo

Next Steps

- Validation of relative grain size classification
- Validation of pools & rifle classification
- Change detection with 2002 HyMap hyperspectral data set