GULLY EROSION OF CULTURAL SITES

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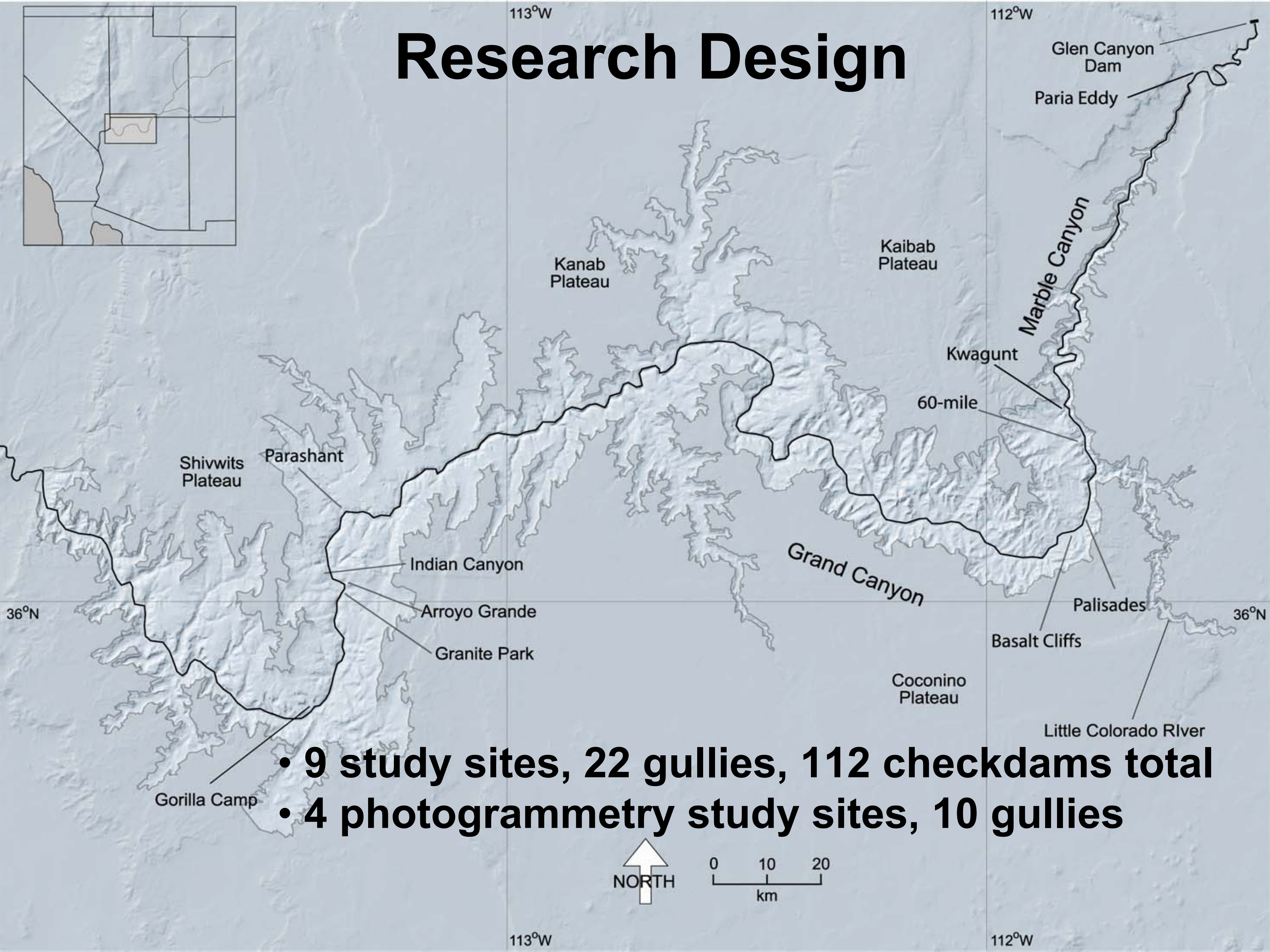
How do we mitigate it?

How do we monitor it?

Why is it happening?

Research Design



- 9 study sites, 22 gullies, 112 checkdams total
- 4 photogrammetry study sites, 10 gullies

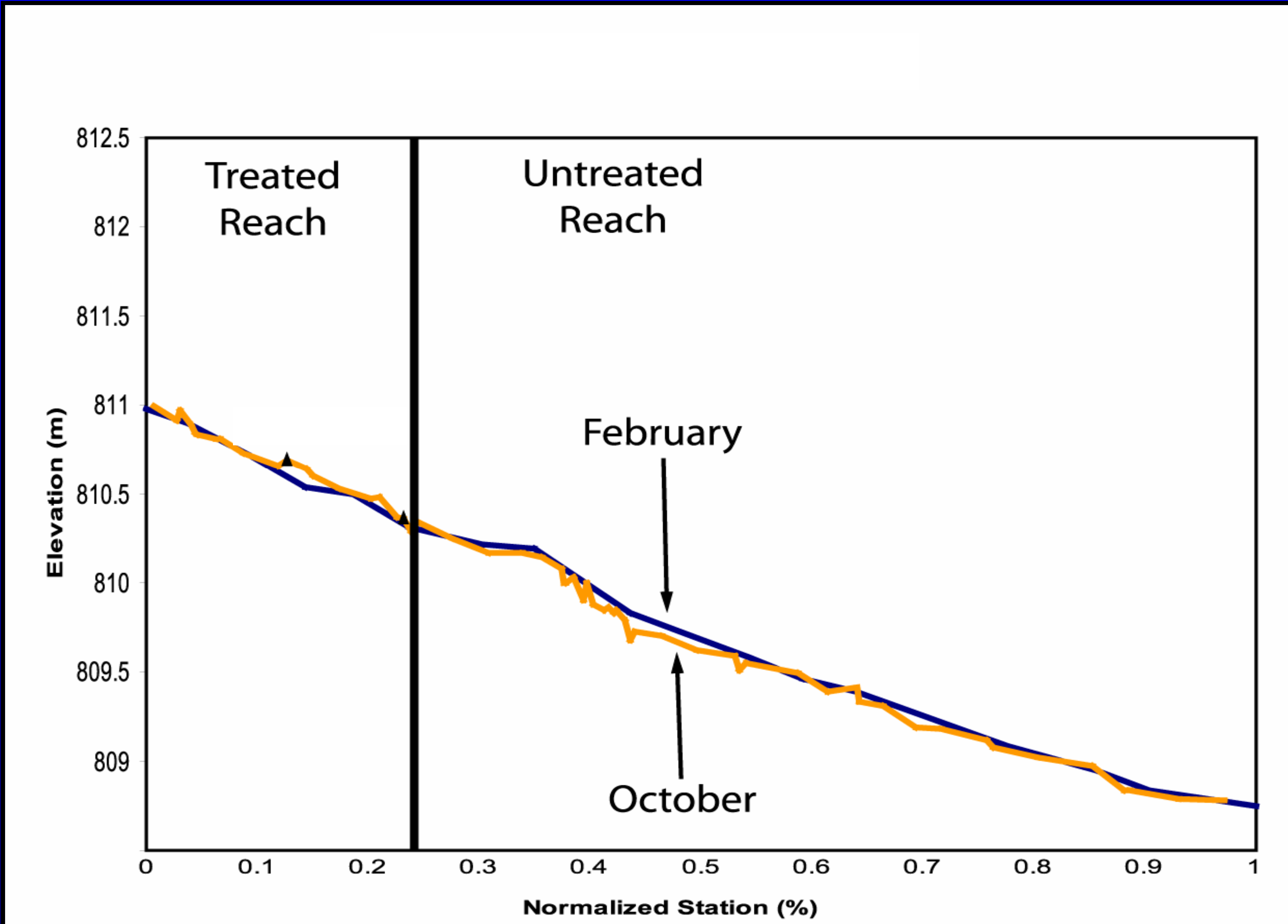

Research Design
•comparison of data gathered before and after the 2002 monsoon
- success of checkdams
- compare photogrammetry to ground survey "truth"

I. Erosion-Control Structures

- Increase roughness, slow flow velocity
- Trap sediment, reduce upchannel gradient

Are they effective?

Results

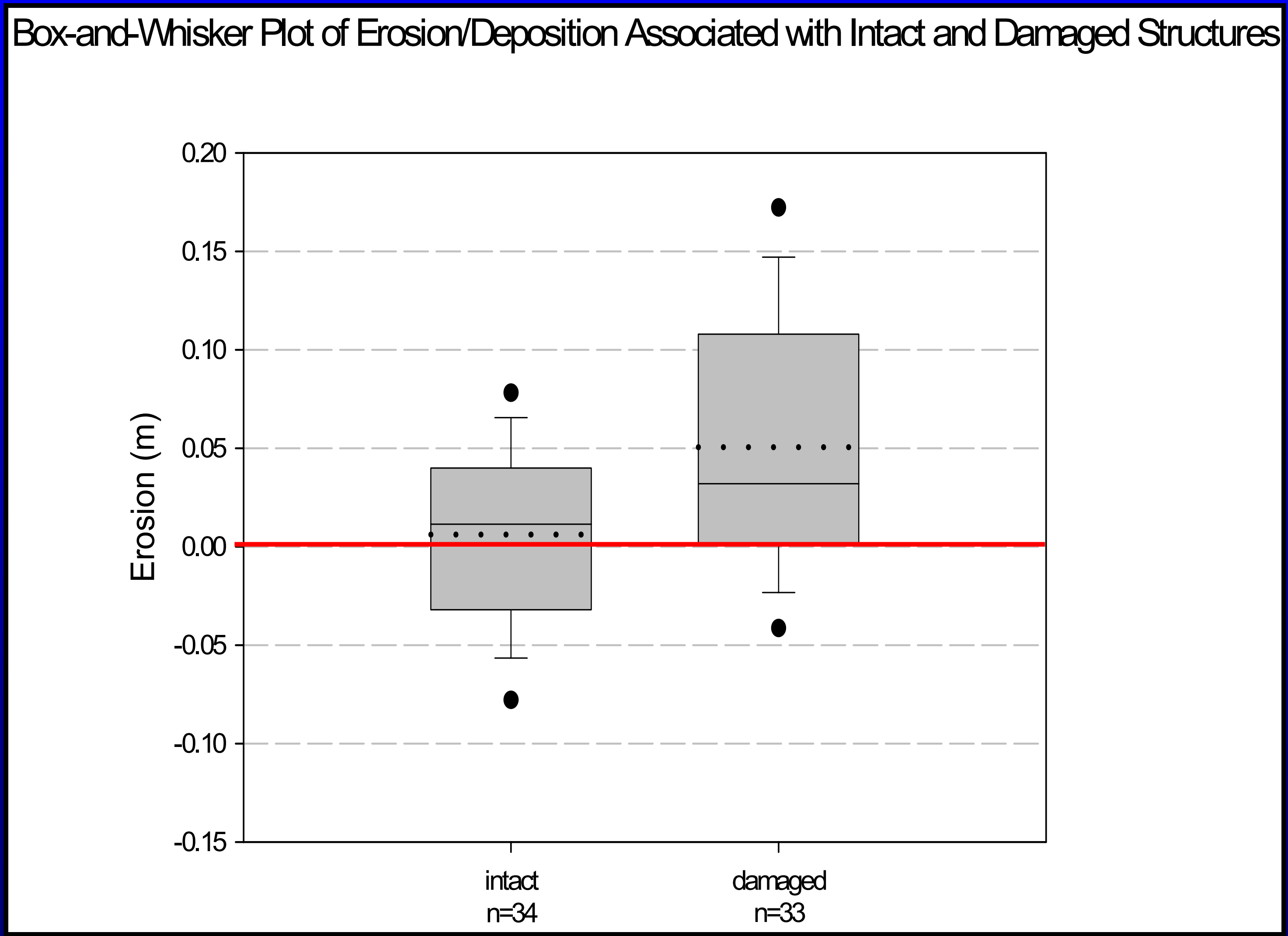


Treated Reach
Untreated Reach
February
October
812.5
812
811.5
811
810.5
810
809.5
809
Elevation (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Normalized Station (%)

Results

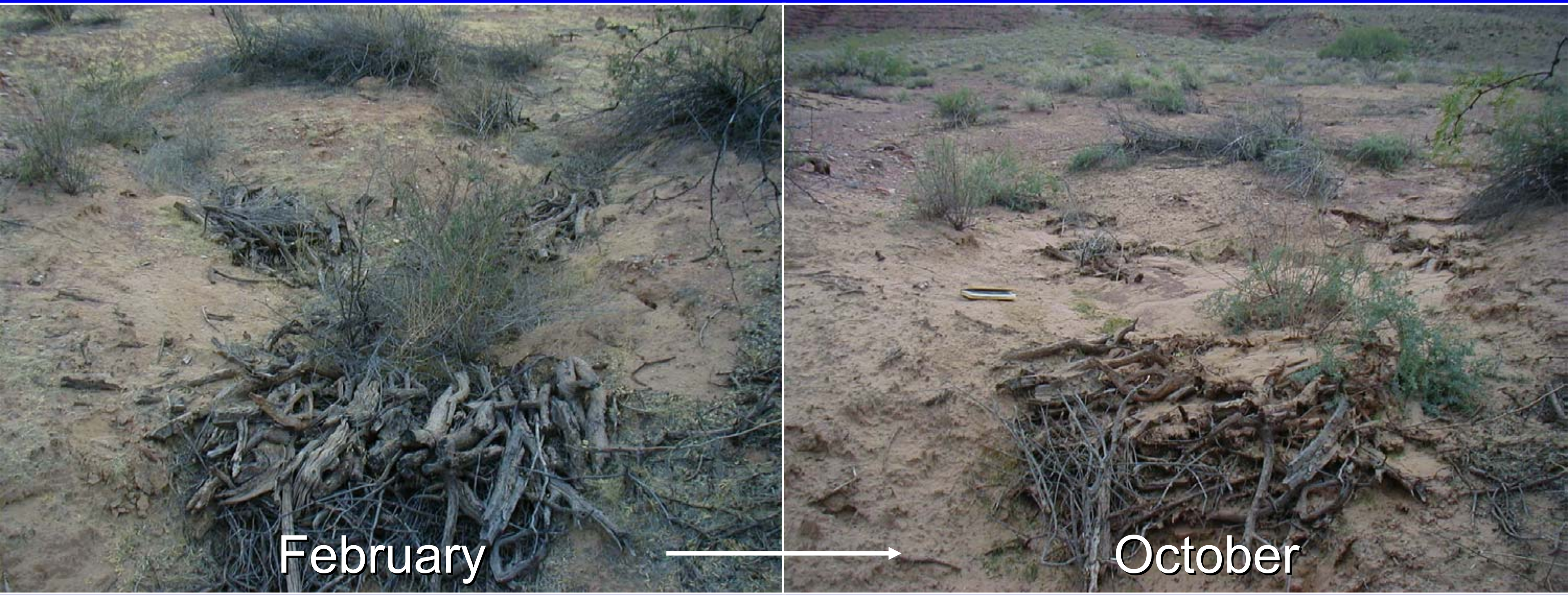
<u>Mean Local Gradient</u>

intact: 0.12
damaged: 0.17



brush checkdams superior to rock linings

- may stay intact better
- retain sediment
- encourage less scour (permeable)



dataset needs to be larger

Recommendations

- Increase dataset
- Continue using erosion treatments, especially brush-debris
- Maintain and repair structures to prevent erosion feedbacks

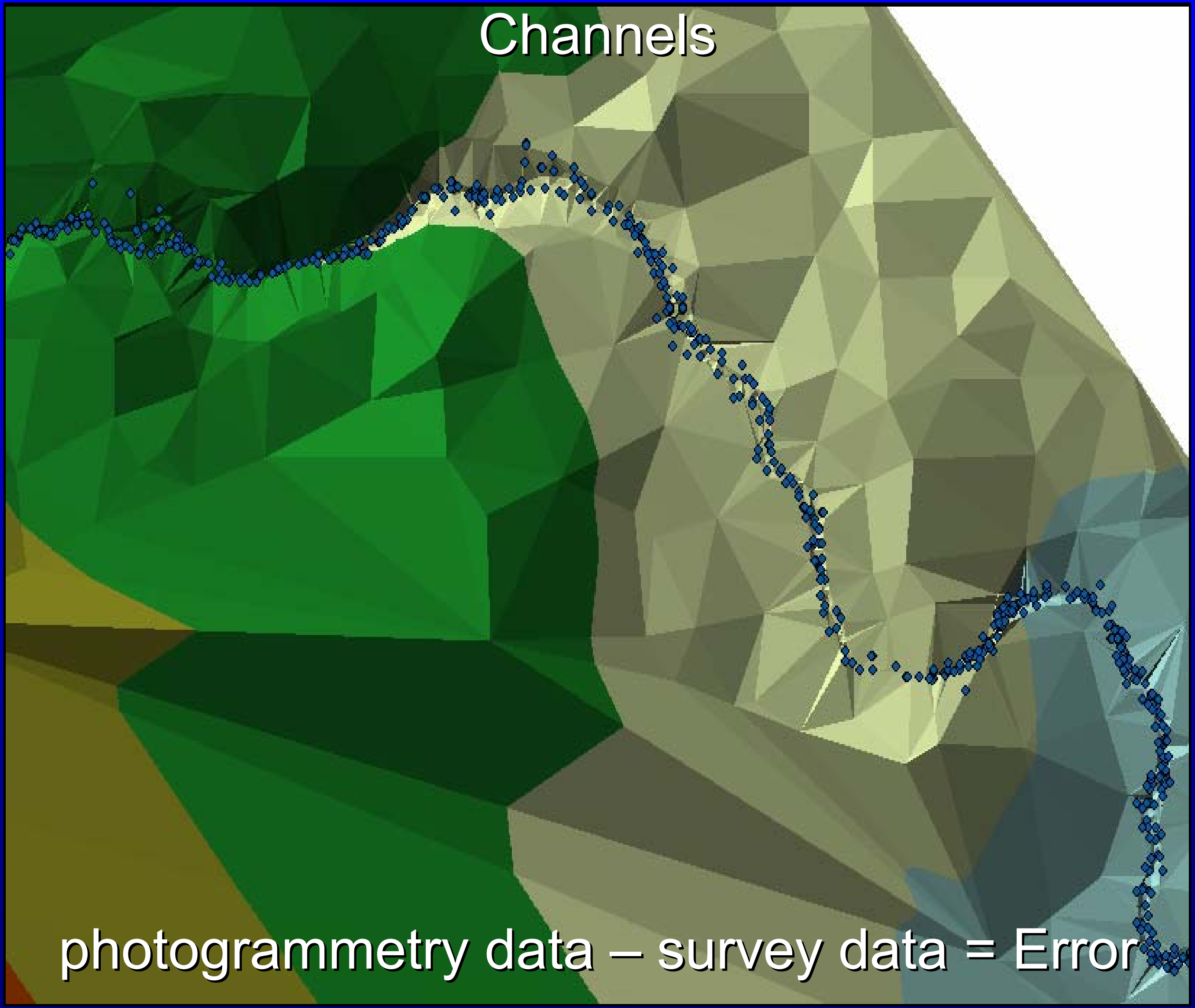
QUESTIONS?

II. Photogrammetric Monitoring

produces topography from photo stereopairs

ours = highest resolution aerial photogrammetry

Methods



Results—Photogrammetric Vertical Accuracy

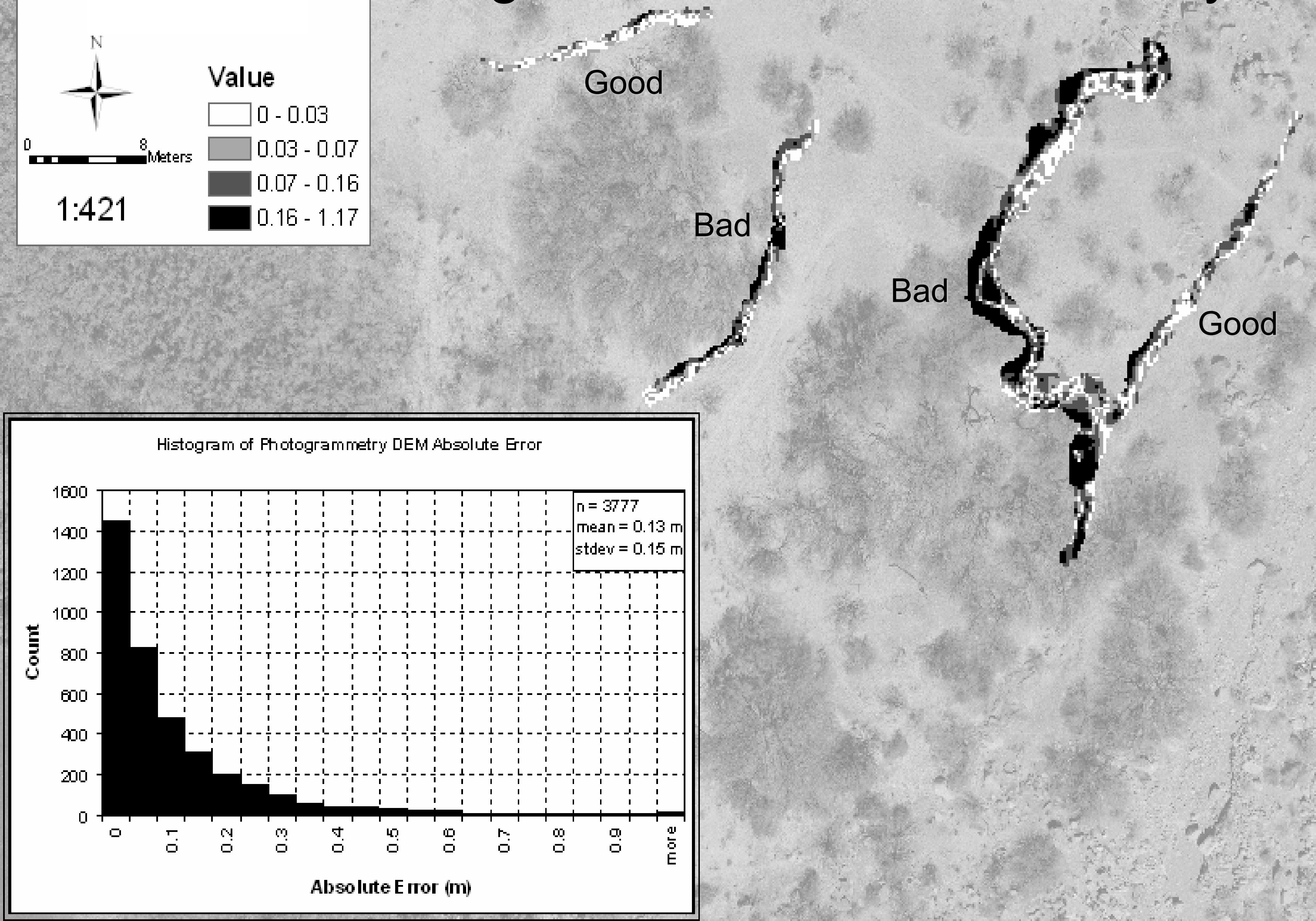
- Interpolation +

Summary of February photogrammetry accuracy assessment for combined sites (m)								
Site	n	**mean**	**stdev**	min (q_0)	q_1	median (q_2)	q_3	max (q_4)
Points	84	**0.07**	**0.07**	0.00	0.03	0.04	0.08	0.48
Profiles	983	**0.06**	**0.06**	0.00	0.02	0.04	0.09	0.45
Cross sections	207	**0.09**	**0.09**	0.00	0.04	0.07	0.13	0.44
Semi-auto TINs	4936	**0.08**	**0.11**	0.00	0.02	0.05	0.10	1.22
Manual TINs	5444	**0.09**	**0.10**	0.00	0.03	0.06	0.11	0.97
DEMs	20230	**0.10**	**0.10**	0.00	0.03	0.07	0.13	2.49

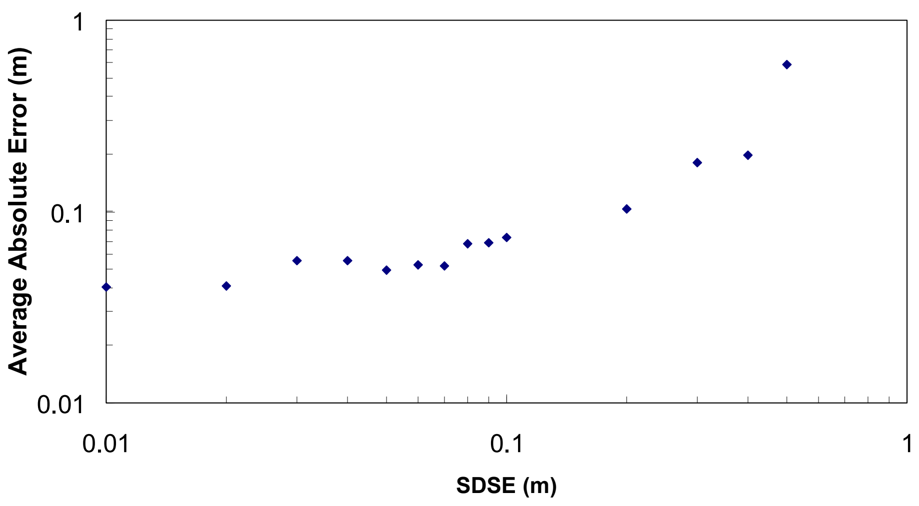
- Interpolation +

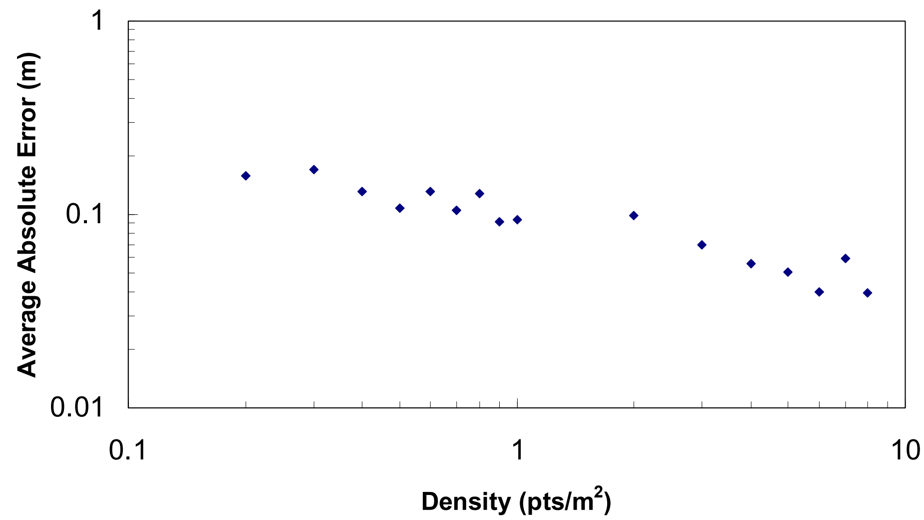
Summary of October photogrammetry accuracy assessment for combined sites (m)								
Site	n	**mean**	**stdev**	min (q_0)	q_1	median (q_2)	q_3	max (q_4)
Points	77	**0.08**	**0.08**	0.00	0.02	0.05	0.11	0.45
Profiles	983	**0.09**	**0.07**	0.00	0.04	0.07	0.12	0.59
Cross sections	207	**0.09**	**0.07**	0.00	0.03	0.06	0.14	0.35
Semi-auto TINs	3636	**0.10**	**0.10**	0.00	0.03	0.08	0.13	1.33
Manual TINs	207	**0.10**	**0.10**	0.00	0.03	0.07	0.12	0.77
DEMs	19424	**0.10**	**0.11**	0.00	0.03	0.07	0.13	2.16

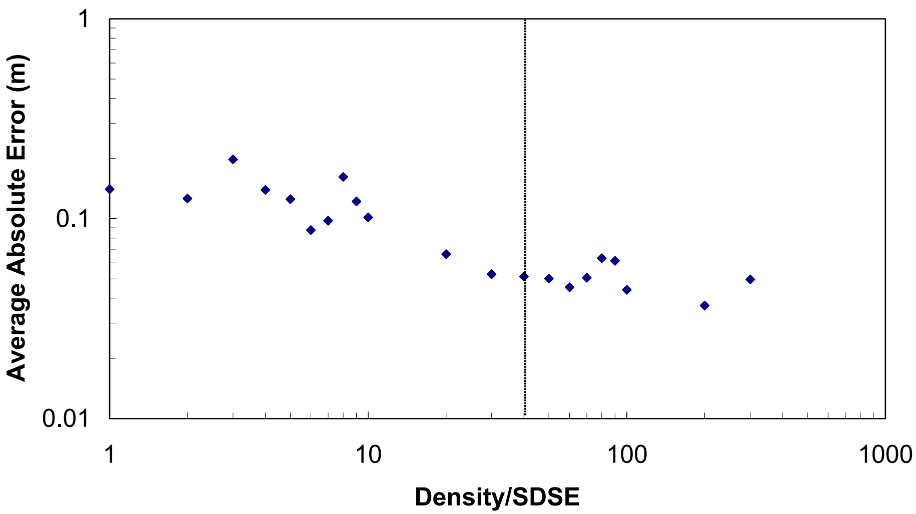
Results—Photogrammetric VerticalAccuracy



Results—GIS Error Analysis



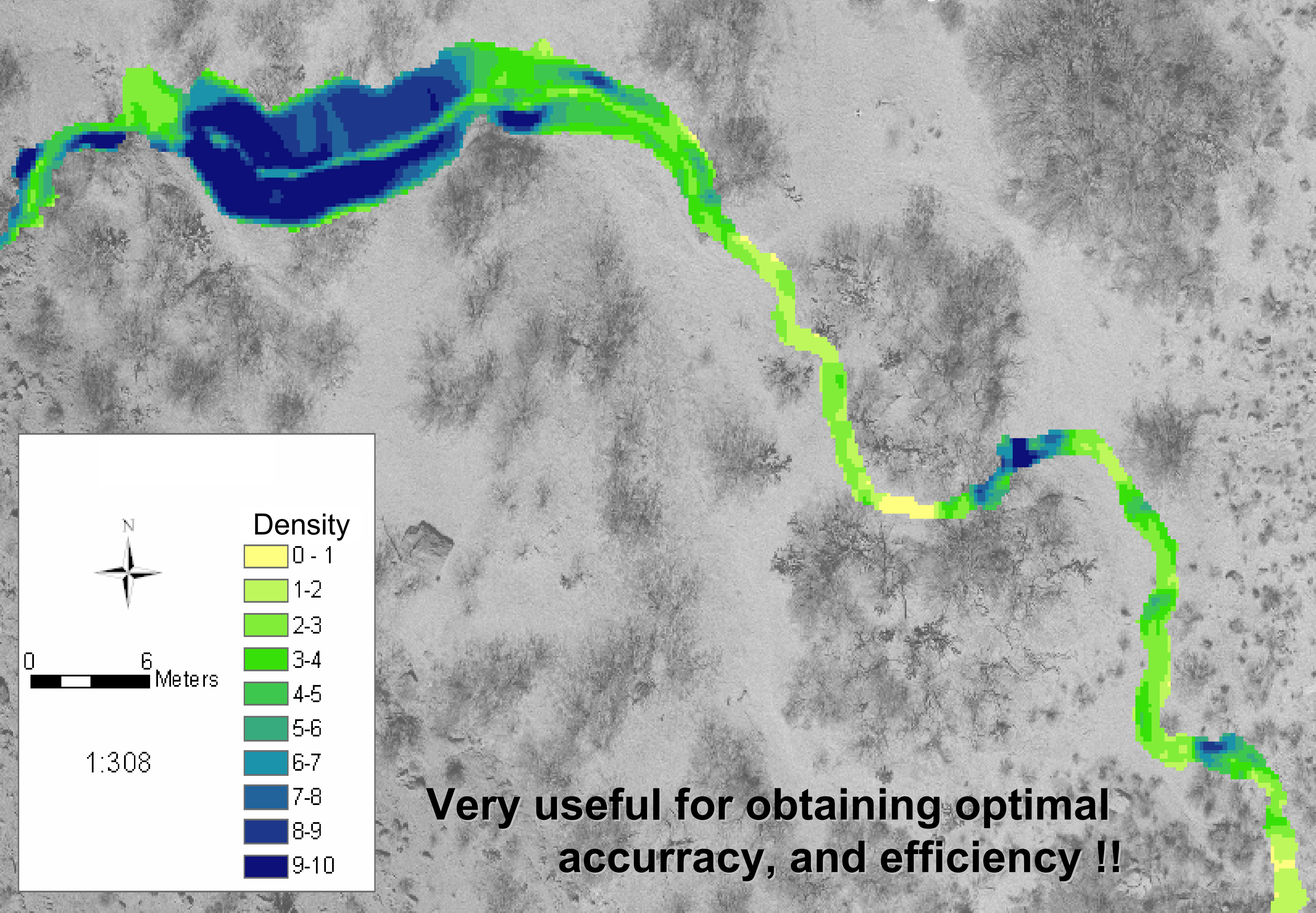




Accuracy of photogrammetry varies with:
1) Photogrammetric point density
2) Topographic ruggedness (SDSE)

when density/SDSE = ~40, average error = ~5-7 cm

Results—GIS Error Analysis



Very useful for obtaining optimal accurracy, and efficiency !!

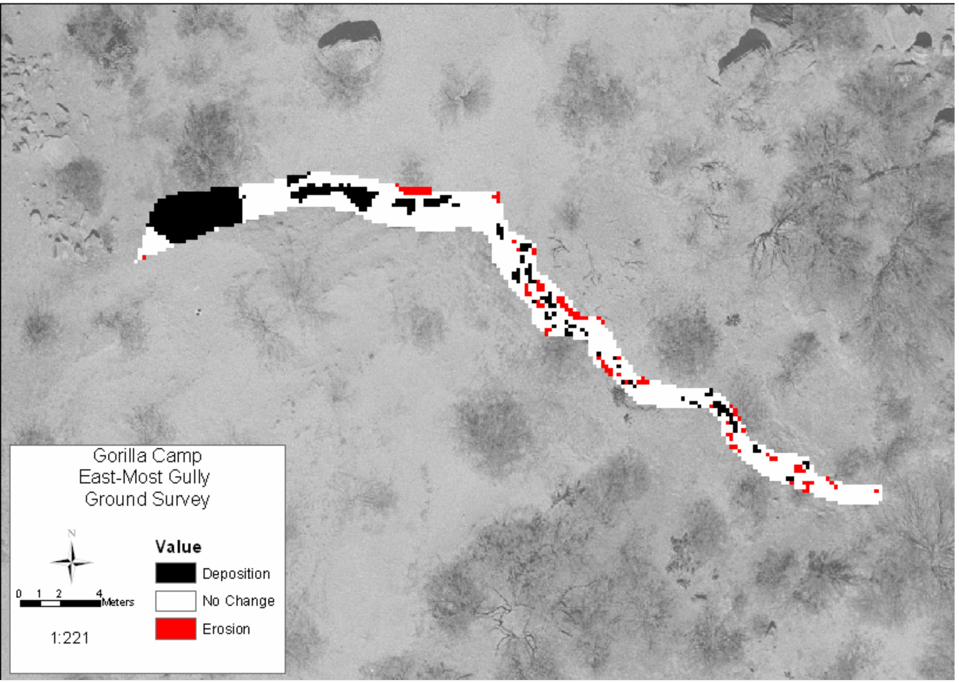
Results—Change Detection

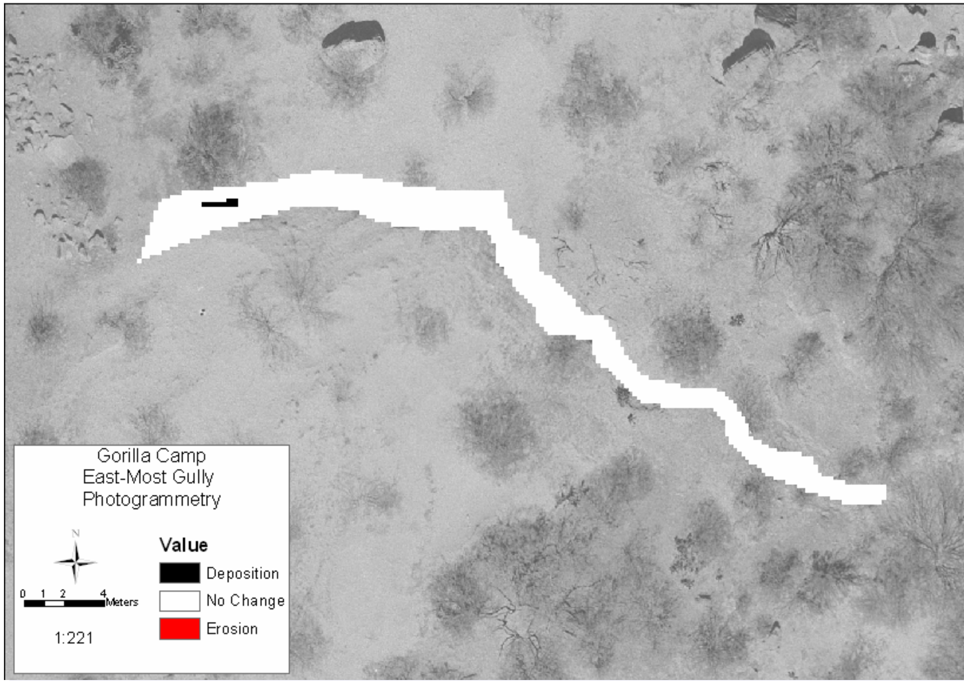
10-20 cm of observed change during study period

Results—Change Detection

Combined error between Feb and Oct = 20-40 cm
problem is propagating error

Best likely at this photographic scale = ~20 cm

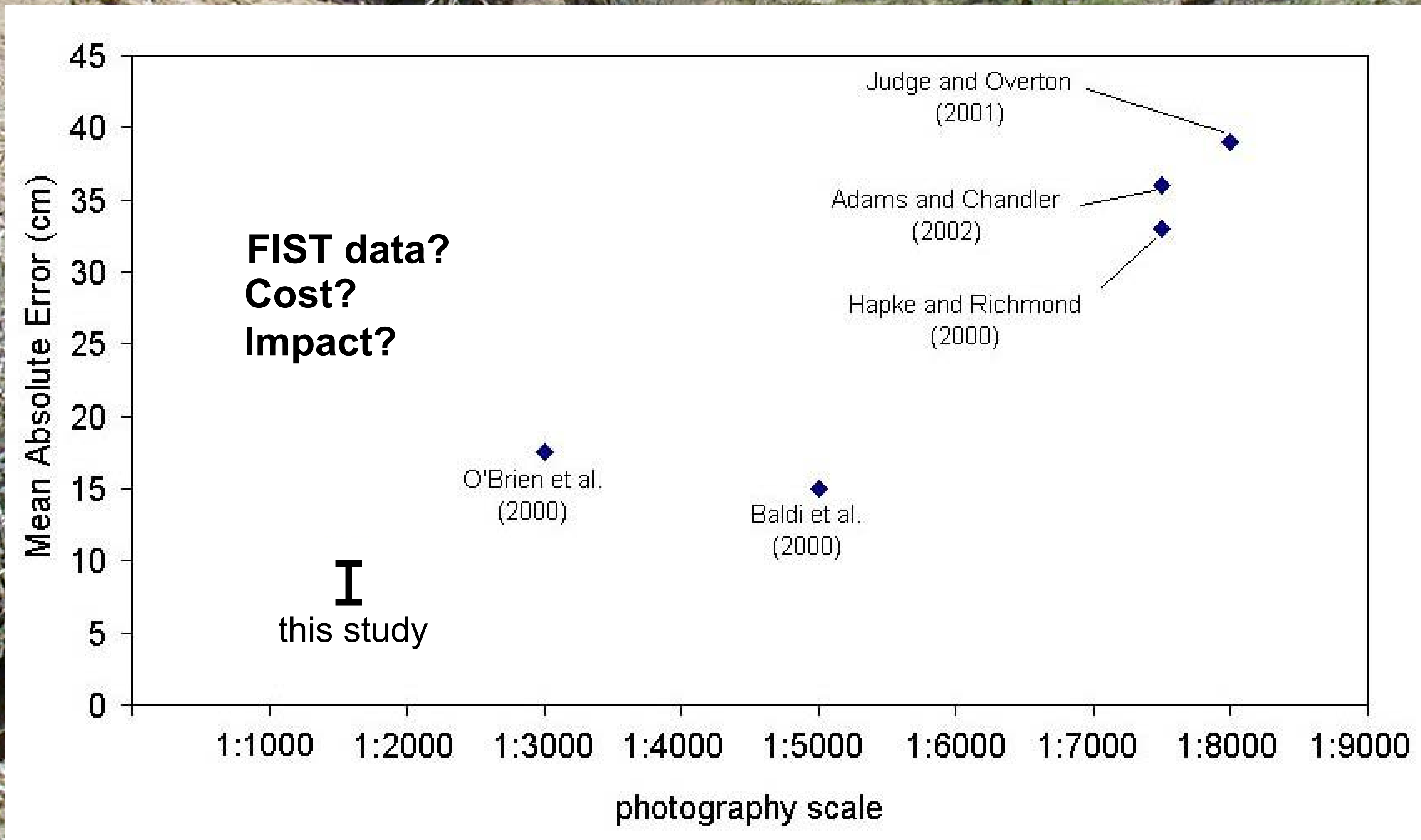




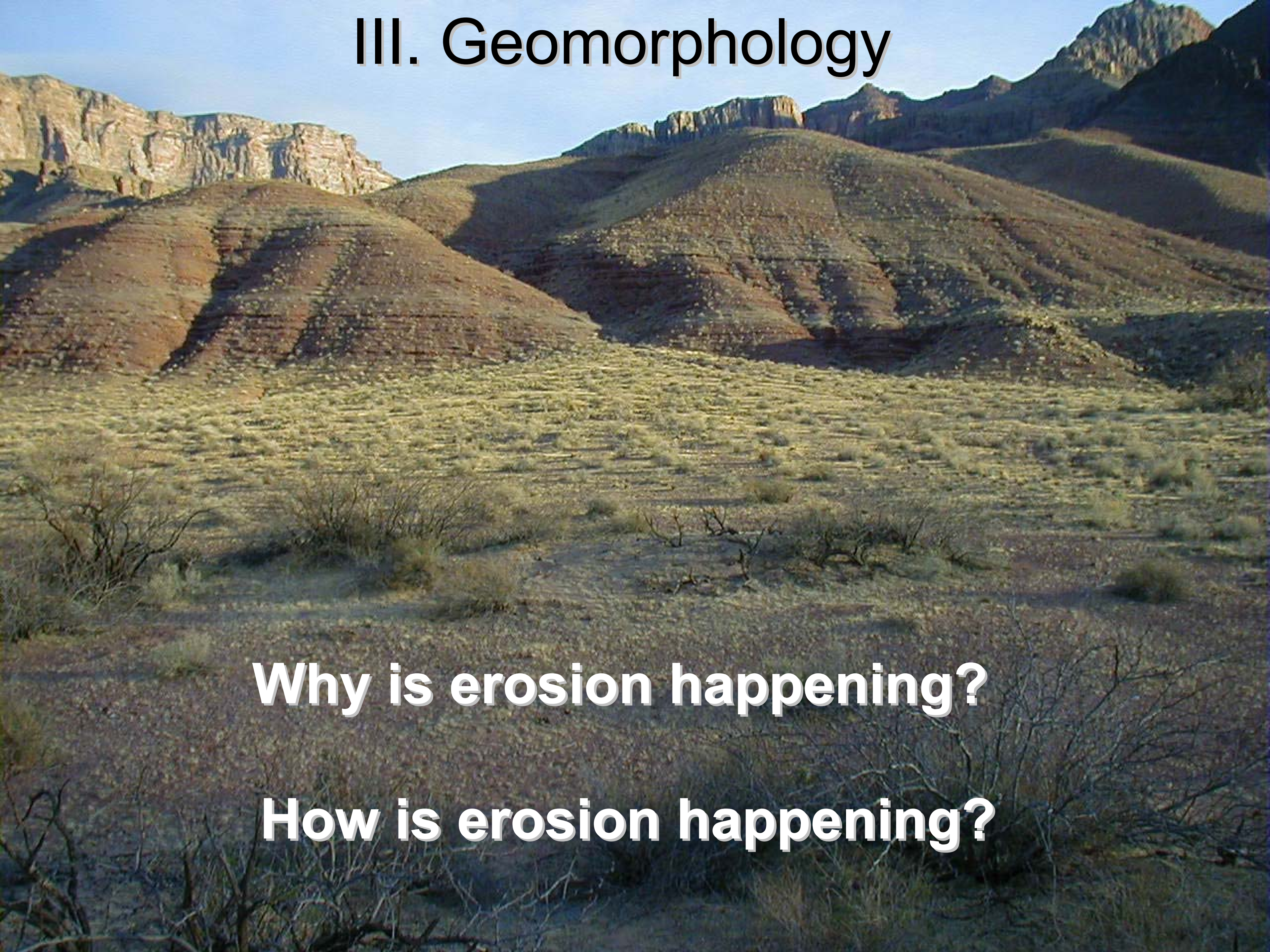
Photogrammetry could not detect small-scale channel change

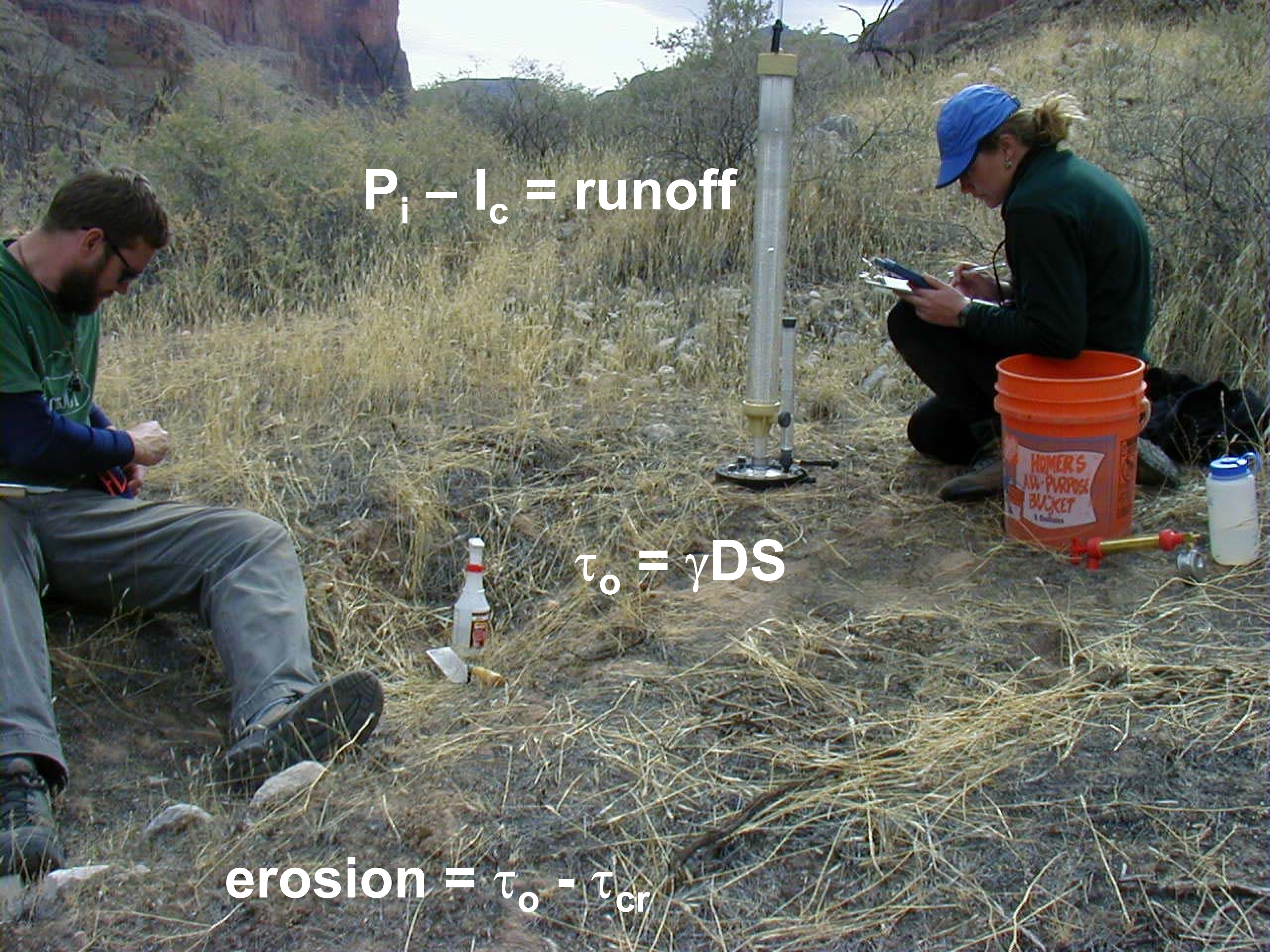
Recommendations

- <u>Not</u> yet useful for monitoring erosion < ~20 cm
- useful in larger gullies with larger erosion problems



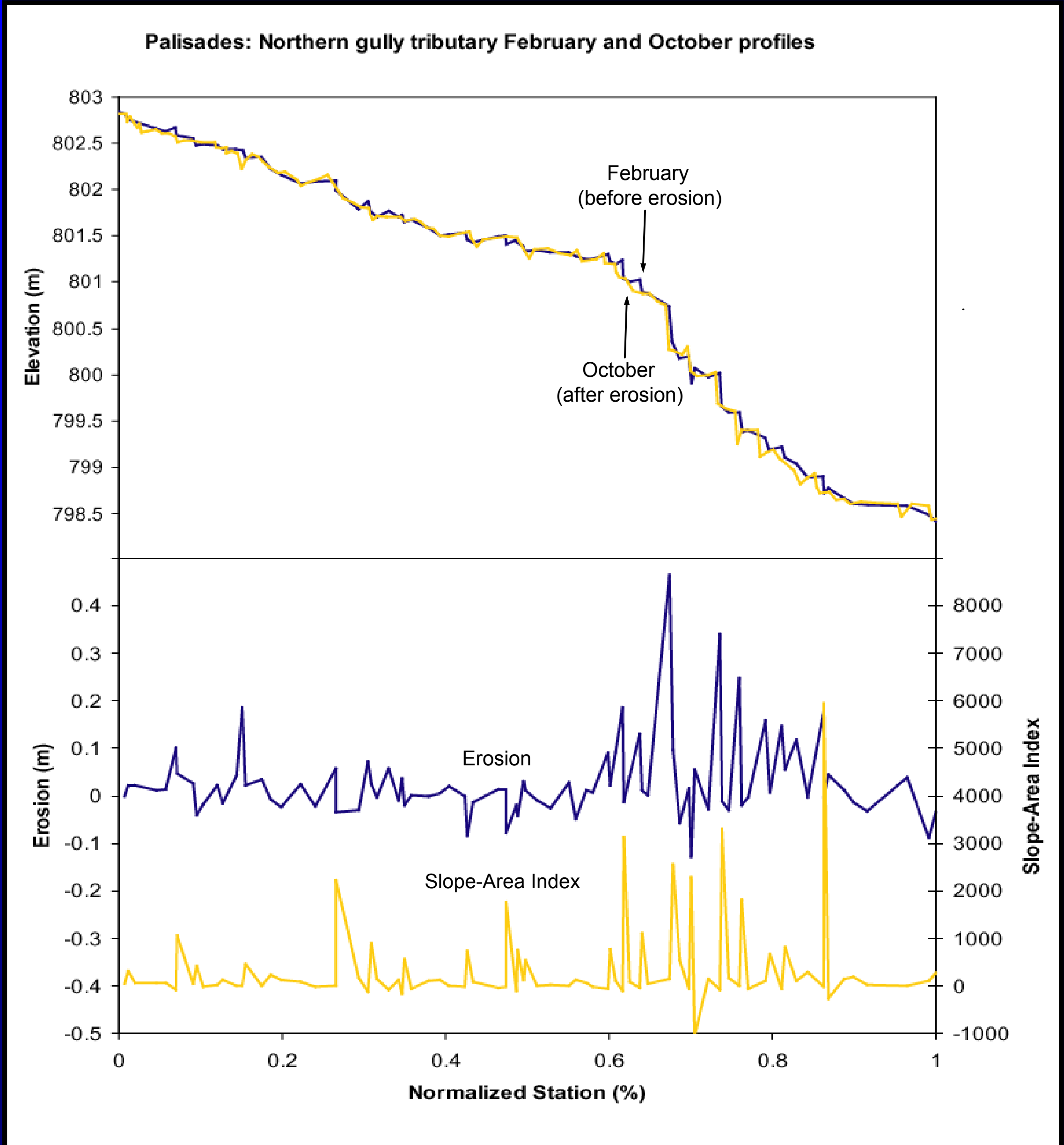
III. Geomorphology



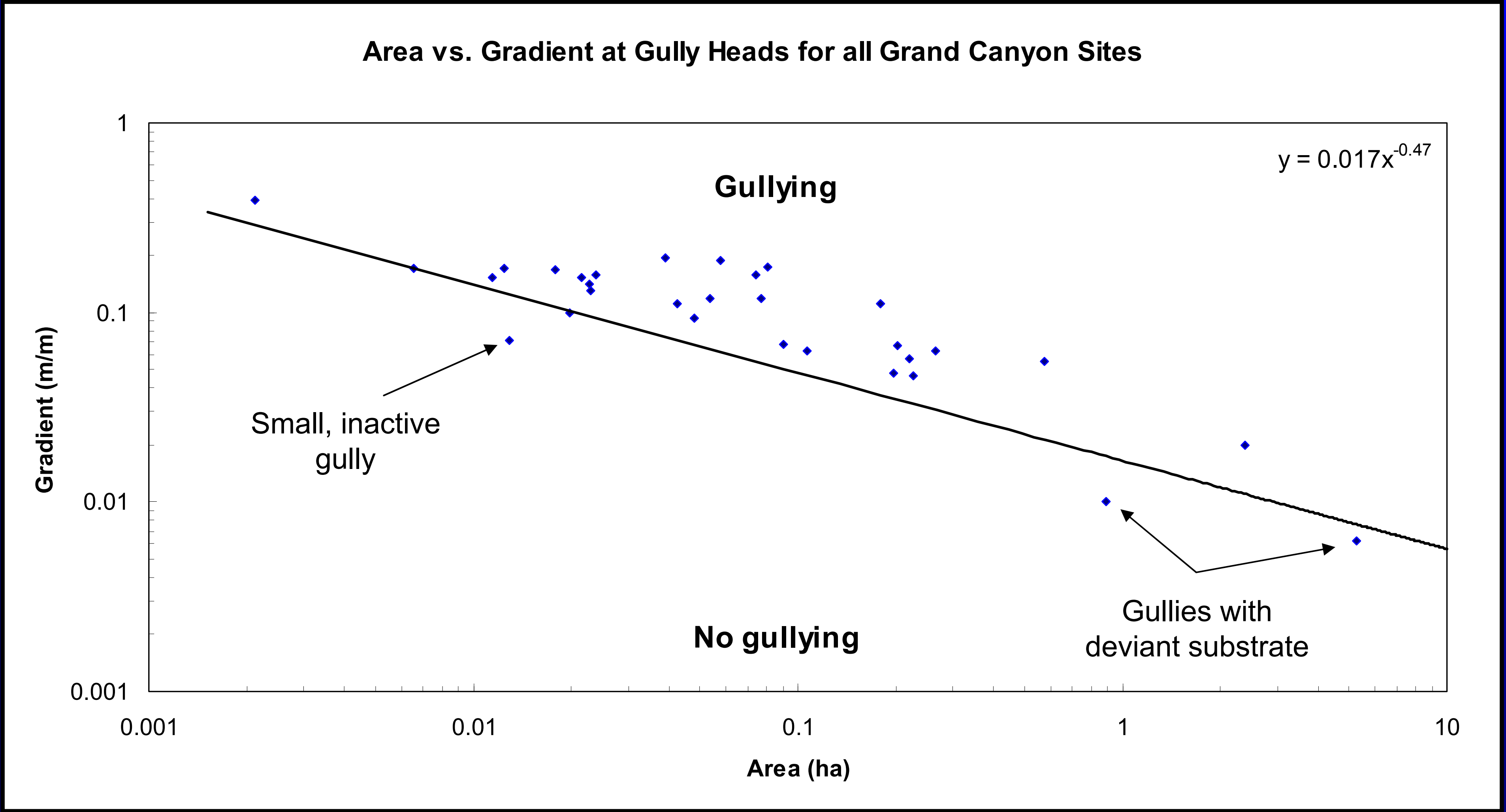

$P_i - I_c$ = runoff
$\tau_o = \gamma DS$
erosion = $\tau_o - \tau_{cr}$
HOMER'S
ALL-PURPOSE
BUCKET

Results

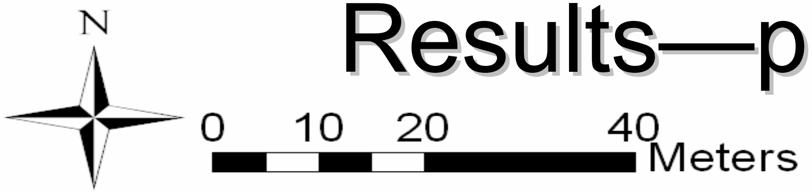
erosion and new knickpoints tend to correspond with high gradient



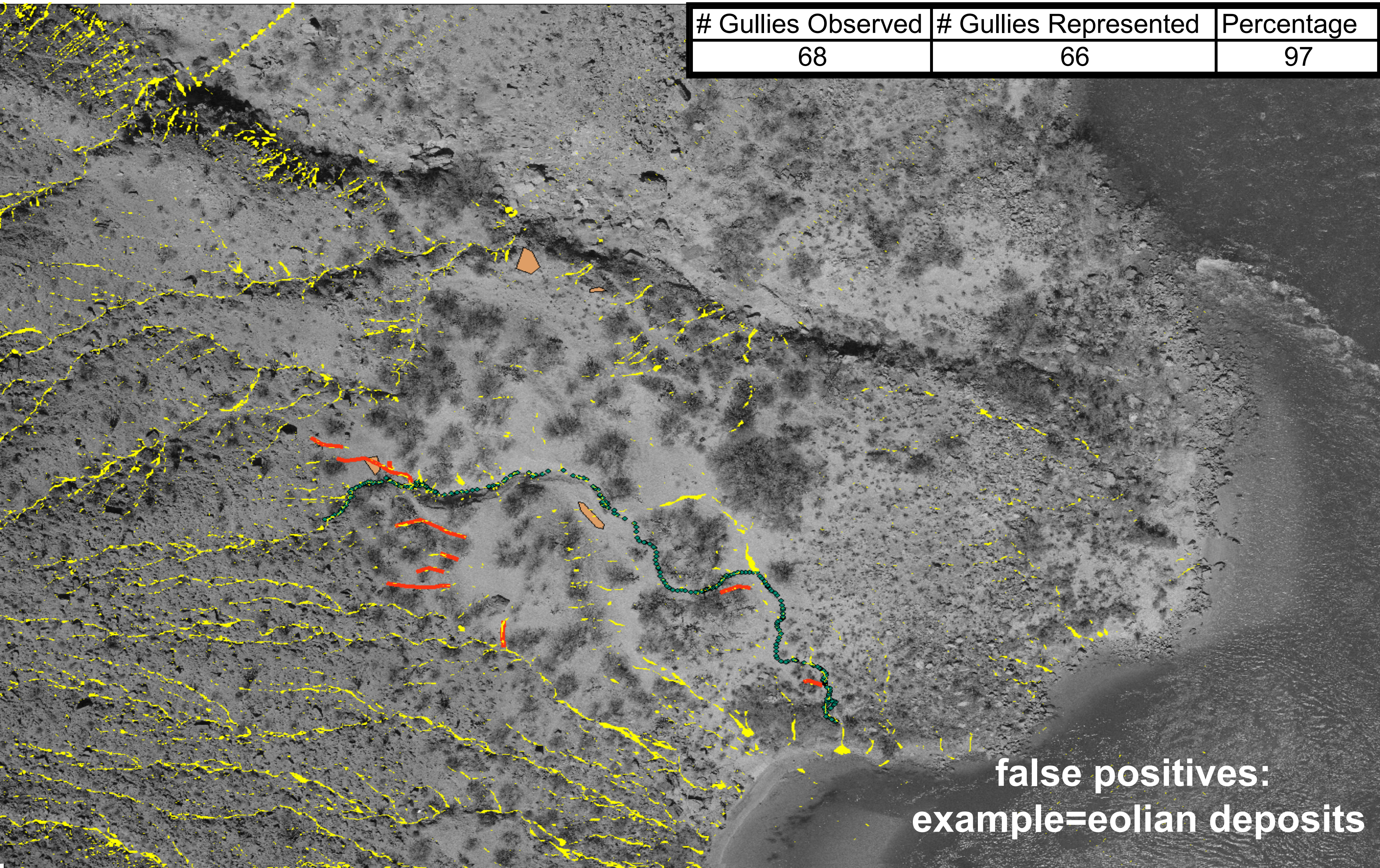
Results—Slope-Area Erosion Threshold



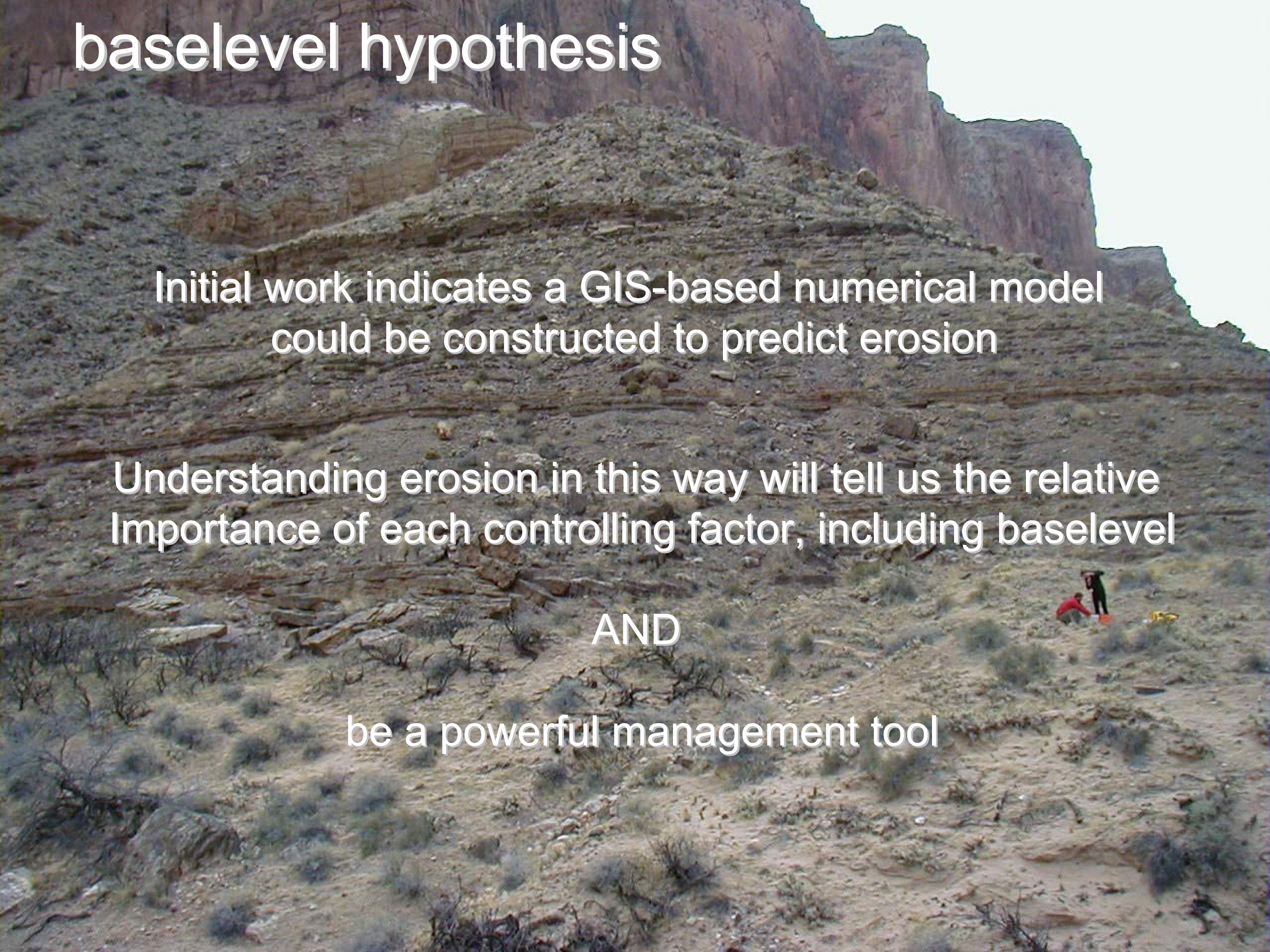
Results—predictive modeling



# Gullies Observed	# Gullies Represented	Percentage
68	66	97



baselevel hypothesis



Initial work indicates a GIS-based numerical model could be constructed to predict erosion

Understanding erosion in this way will tell us the relative Importance of each controlling factor, including baselevel

AND

be a powerful management tool

Recommendations

- increase and complete field and lab dataset, including linking precipitation events to resultant erosion

- take the next step in predictive modeling
  - vulnerable sites and precipitation-erosion relation

- understand eolian system

- the baselevel hypothesis can be tested

Conclusions

I. **Initial data indicate erosion-control structures, particularly brush checkdams, work if maintained**

II. **Repeat photogrammetry error is ~20 cm, *at this scale*, which is not good enough for monitoring many gullies**

III. **A GIS-based numerical model can likely predict gully erosion and the next step in research has great potential for cultural resource management**

Other impacts of research: -topical contribution to science
-training of students