A hand-held, photogrammetric, approach to riparian and stream assessment and monitoring

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JOE DEHNERT
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A HAND-HELD PHOTOGRAMMETRIC APPROACH TO RIPARIAN AND STREAM ASSESSMENT AND MONITORING

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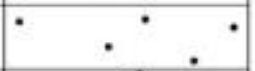
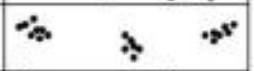
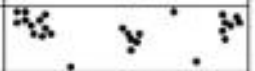
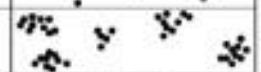
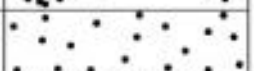
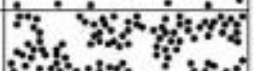
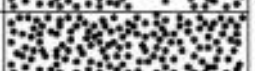
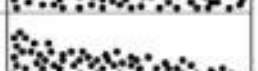
VISUAL ESTIMATION

CLASS	DESCRIPTION OF ABUNDANCE	DISTRIBUTION PATTERN
0	No invasive plants on the polygon	
1	Rare occurrence	
2	A few sporadically occurring individual plants	
3	A single patch	
4	A single patch plus a few sporadically occurring plants	
5	Several sporadically occurring plants	
6	A single patch plus several sporadically occurring plants	
7	A few patches	
8	A few patches plus several sporadically occurring plants	
9	Several well spaced patches	
10	Continuous uniform occurrence of well spaced plants	
11	Continuous occurrence of plants with a few gaps in the distribution	
12	Continuous dense occurrence of plants	
13	Continuous occurrence of plants associated with a wetter or drier zone within the polygon.	

RESOURCE EFFICIENCY

LOTIC WETLAND SURVEY HEALTH ASSESSMENT FOR STREAMS AND SMALL RIVERS
FIELD SCORE SHEET

1. Vegetative Cover of Floodplain and Streambanks. **Score:_____/ 6**

6 = More than 95% of the reach soil surface is covered by rooted plant material (live or dead).
4 = 85% to 95% of the reach soil surface is covered by rooted plant material (live or dead).
2 = 75% to 85% of the reach soil surface is covered by rooted plant material (live or dead).
0 = Less than 75% of the reach soil surface is covered by rooted plant material (live or dead).

2a. Total Canopy Cover of Invasive Plant Species (Weeds). **Score:_____/ 3**

3 = No invasive plant species (weeds) on the site.
2 = Invasive plants present with total canopy cover less than 1% of the polygon area.
1 = Invasive plants present with total canopy cover between 1% and 15% of the polygon area.
0 = Invasive plants present with total canopy cover more than 15% of the polygon area.

2b. Density/Distribution Pattern of Invasive Plant Species (Weeds). **Score:_____/ 3**

3 = No invasive plant species (weeds) on the site.
2 = Invasive plants present with density/distribution in categories 1, 2, or 3.
1 = Invasive plants present with density/distribution in categories 4, 5, 6, or 7.
0 = Invasive plants present with density/distribution in categories 8, or higher.

3. Disturbance-Increaser Undesirable Herbaceous Species. **Score:_____/ 3**

3 = Less than 5% of the site covered by disturbance-increaser undesirable herbaceous species.
2 = 5% to 25% of the site covered by disturbance-increaser undesirable herbaceous species.
1 = 25% to 50% of the site covered by disturbance-increaser undesirable herbaceous species.
0 = More than 50% of the site covered by disturbance-increaser undesirable herbaceous species.

4. Preferred Tree and Shrub Establishment and/or Regeneration. **Score:_____/ 6**

(*If the site has no woody vegetation [except for the species listed to be excluded], replace both Actual Score and Possible Score with NA.*)

6 = More than 15% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
4 = 5% to 15% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
2 = Less than 5% of the total canopy cover of preferred tree/shrubs is seedlings and saplings.
0 = Preferred tree/shrub seedlings or saplings absent.

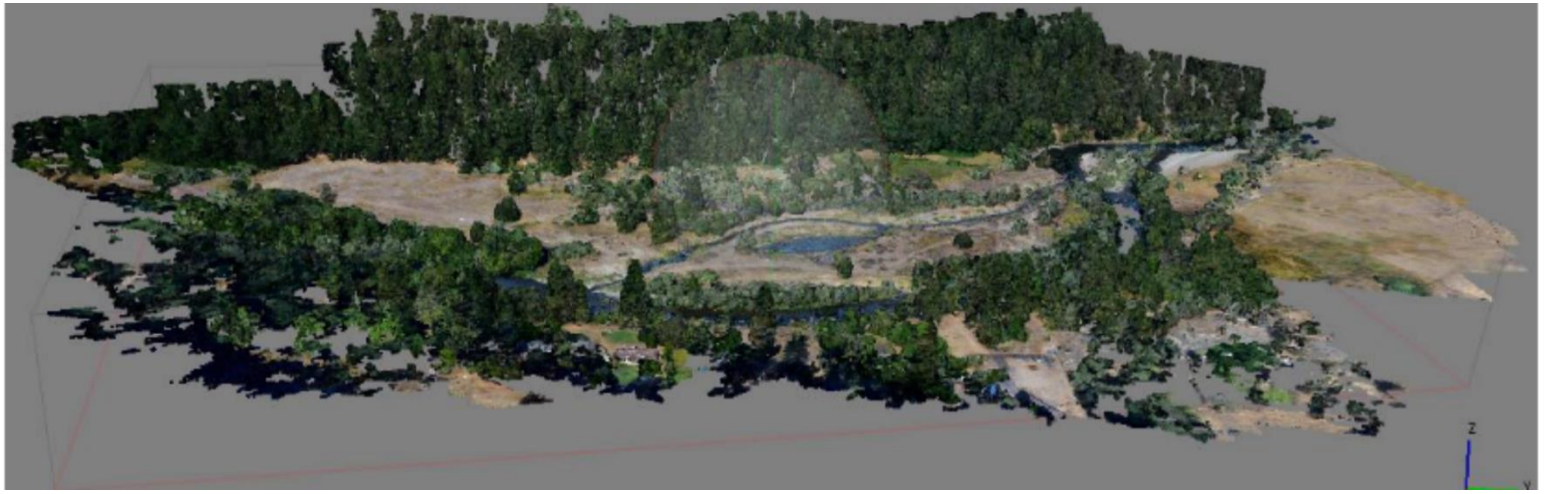
5a. Browse Utilization of Preferred Trees and Shrubs. **Score:_____/ 3**

(*If the site has no woody vegetation [except for the species listed to be excluded], replace both Actual Score and Possible Score with NA.*)

3 = None (0% to 5% of available second year and older leaders of preferred species are browsed).
2 = Light (5% to 25% of available second year and older leaders of preferred species are browsed).
1 = Moderate (25% to 50% of available second year and older leaders of preferred species are browsed).
0 = Heavy (More than 50% of available second year and older leaders of preferred species are browsed).

COMMON TERRAIN MODELING PROS AND CONS

- Satellite
  - Landscape Analysis
    - NDVI & MODIS scans
    - Spaceborn Image-Matching
    - Machine Learning Algorithms
  - Established Infrastructure
    - Public Access
    - <15m Panchromatic resolution
    - Future use limited only by application and access
  - Dynamic Environments
    - Low Light
    - Variable Vegetation
    - Dense Canopy Cover
- UAV
  - Time Efficient
    - Kilometers in a day
  - Landform Scale and beyond
    - RBG & NIR scans
  - Specialization
    - Prohibitively expensive equipment
    - Specialized skills
    - Extensive Permitting
  - Dynamic Environments
    - Low Light
    - Variable Vegetation
    - Dense Canopy Cover



PHOTOGRAMMETRY PROS AND CONS

- High-accuracy 3D point cloud data
- Comparison with historical data
- Comparable to AerialLiDARScan/TerrestrialLiDARScan in terms of accuracy
- Unspecialized, cost-effective acquisition of spatial data
- Quality data production in a variety of dynamic environments
- Relatively recent development
- Validation and standardization can be laborious with increase in Vegetation

PROBLEM STATEMENT & RESEARCH QUESTIONS

- Problem Statement
  - Two of the biggest weaknesses in stream restoration and monitoring are: 1) subjective estimation and subsequent comparison of changes in channel form, vegetative cover, and in-stream habitat; and 2) the high costs in terms of financing, human resources, and time necessary to make these estimates.
- Research Questions
  - What is the most suitable camera (cell phone, digital SLR, GoPro) and data acquisition method for hand-held photogrammetry in the field, considering minimum resolution, affordability, and repeatability?
  - What is the most suitable image processing workflow, considering computing power and time constraints?
  - What measurements can hand-held photogrammetry provide to stream and riparian restoration specialists and researchers?

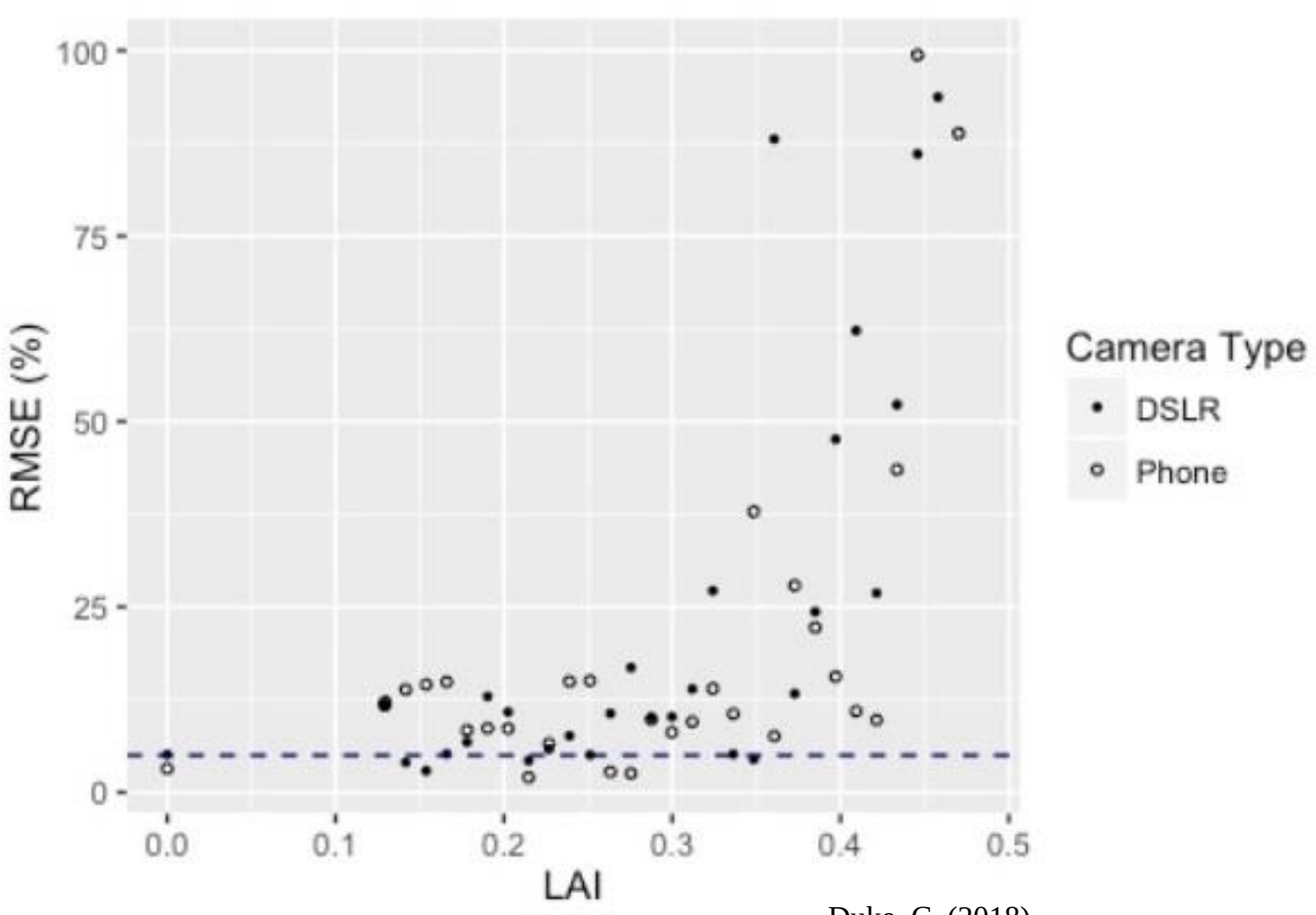
WHY DEER CREEK?

- Ideal location to test methodology
  - Heavily vegetated stream
  - Impossible to employ other remote sensing techniques
- Close to Missoula
- First-order stream feeding Fish Creek

WHY AGISOFT METASHAPE?

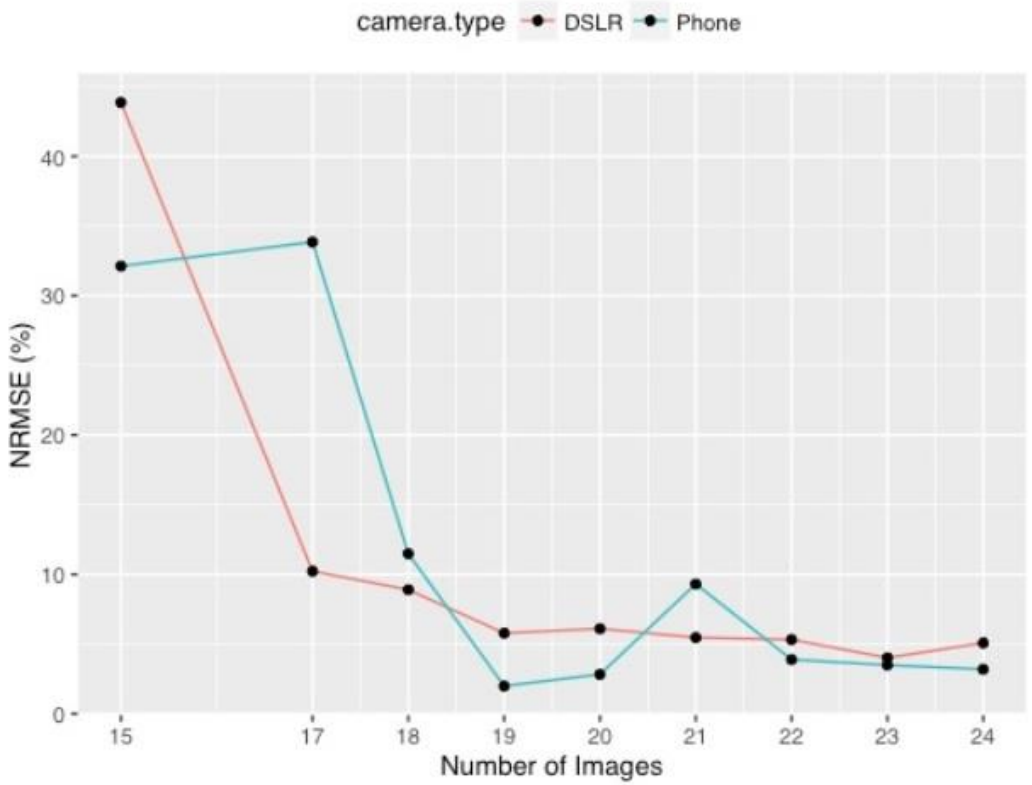
- ‘Best Practice’ workflows already established for UAV & ALS/TLS
- Intuitive ‘Graphic User Interface’ flattens software learning curve
- Capable of exporting multiple spatial products (orthomosaic, Digital Elevation Models, 3D mesh)

LEAF AREA INDEX CHALLENGE



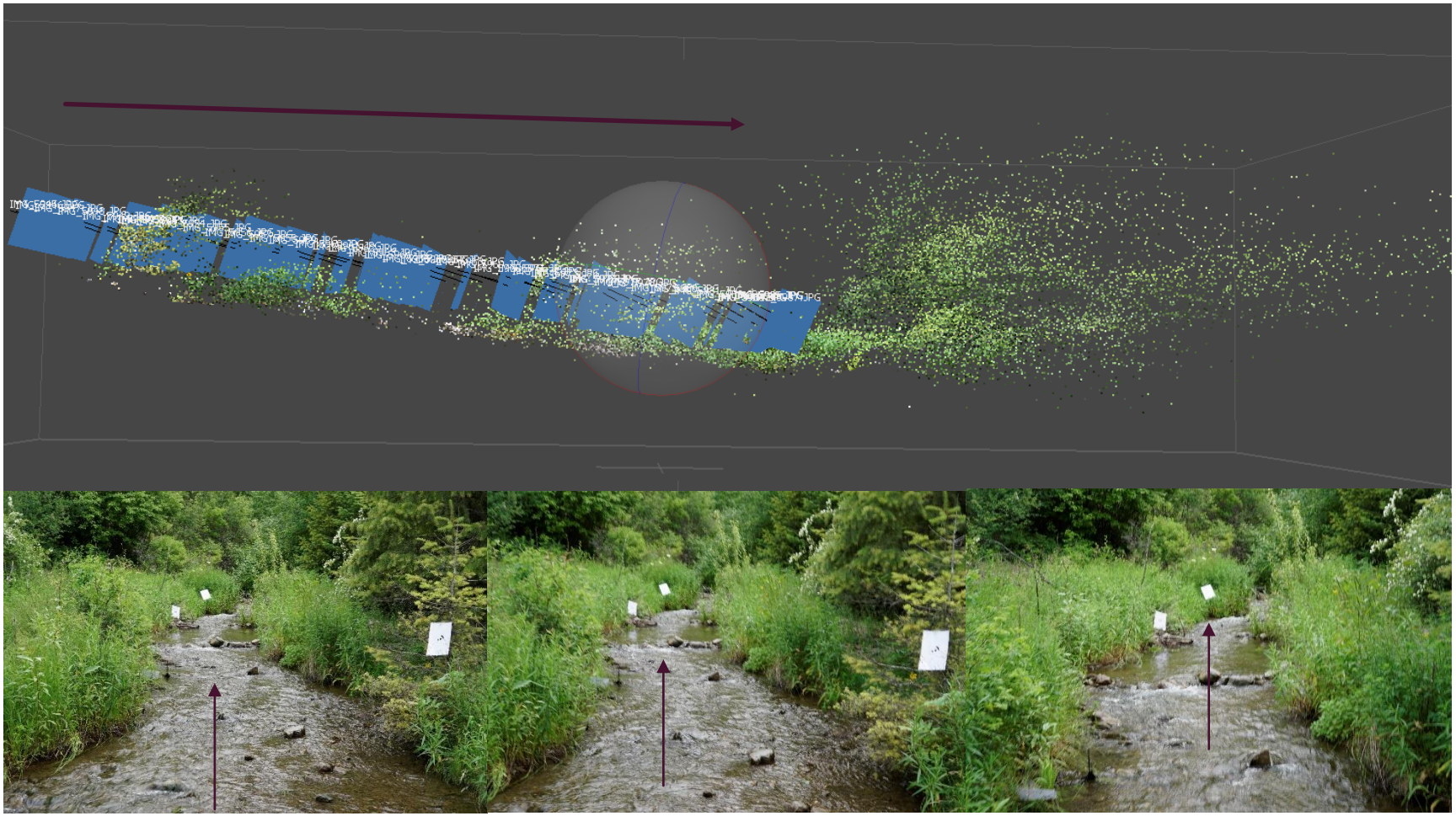
Duke, C. (2018)

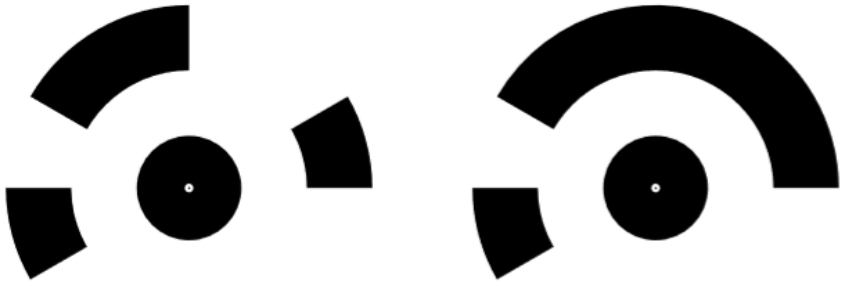
IMAGE NUMBER & ERROR CHALLENGE



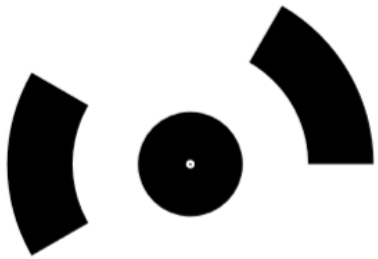
Duke, C. (2018)

STUDY DESIGN





6 7



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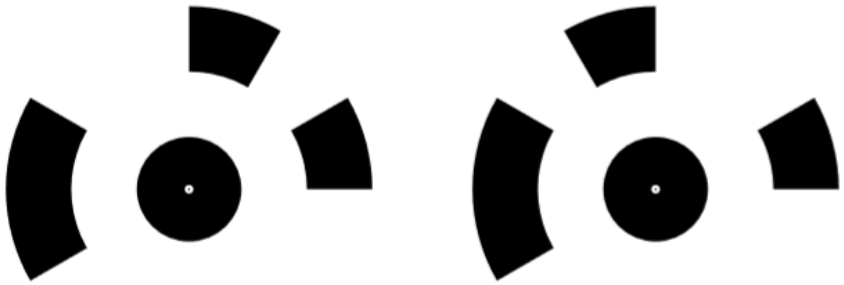


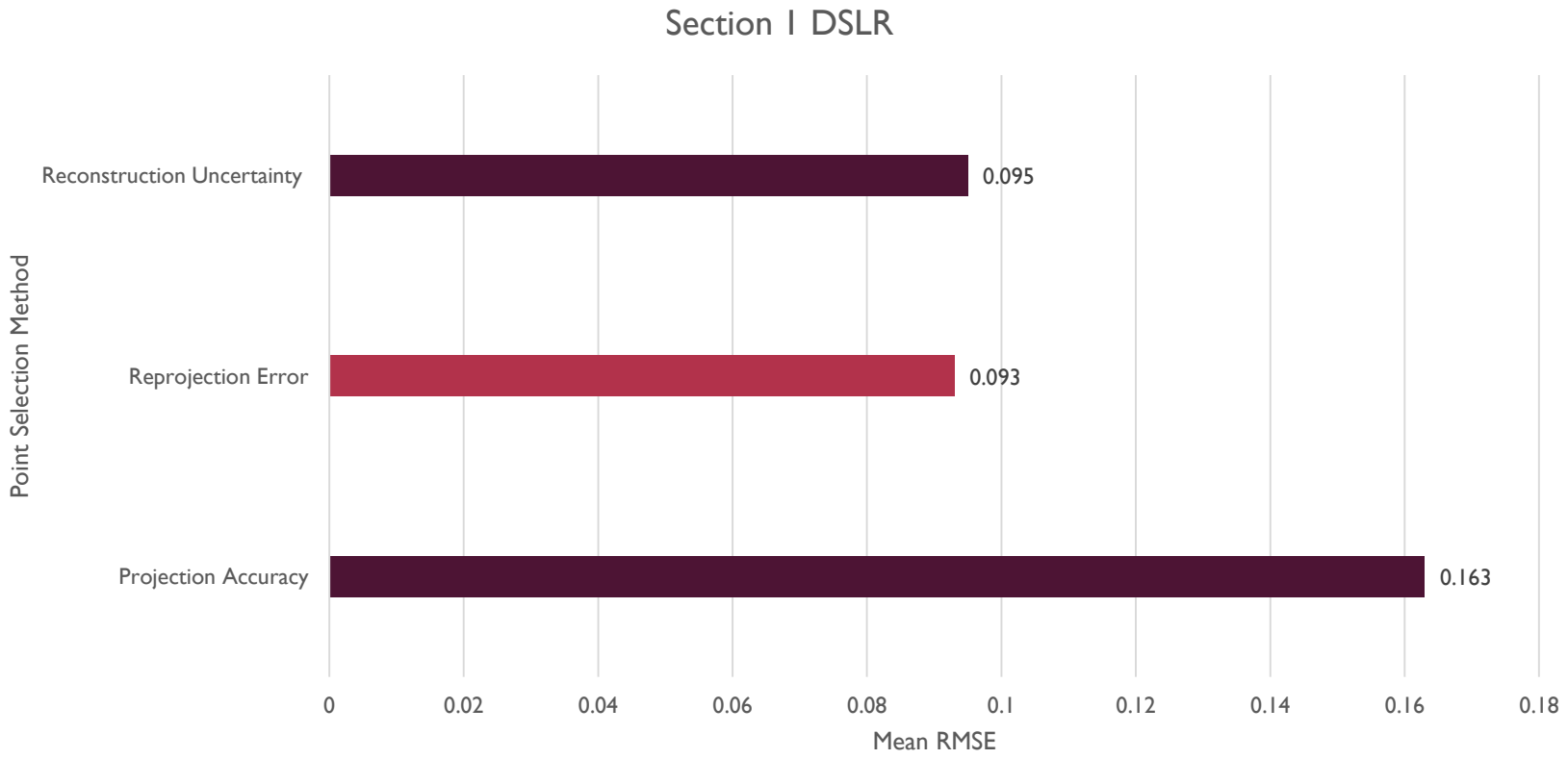
SENSORS


iPhone
SE

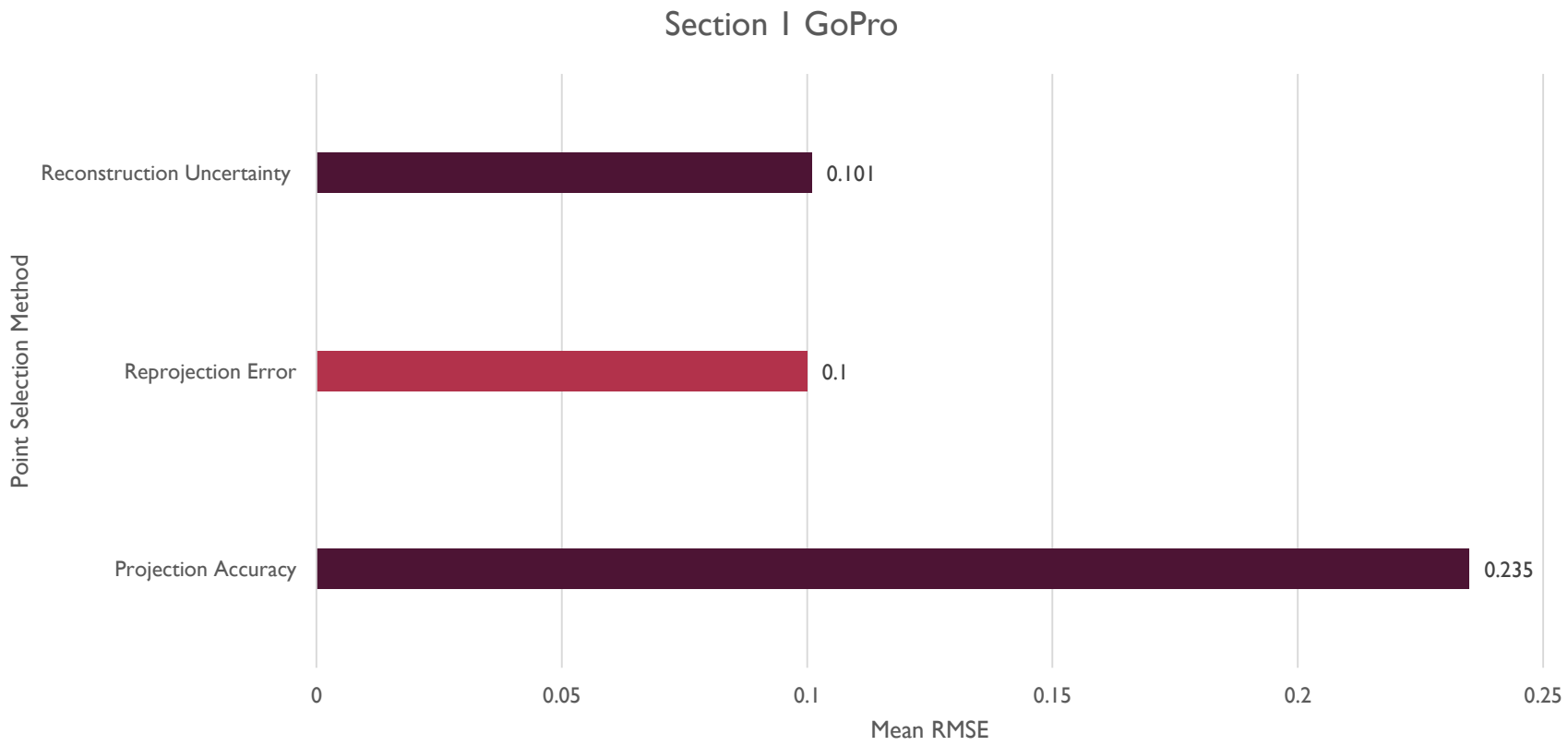

4K-30
00:01
1H:04
mode
HERO4


SONY
0.38m/1.3ft MACRO
ø55
DT 3.5-5.6/18-70

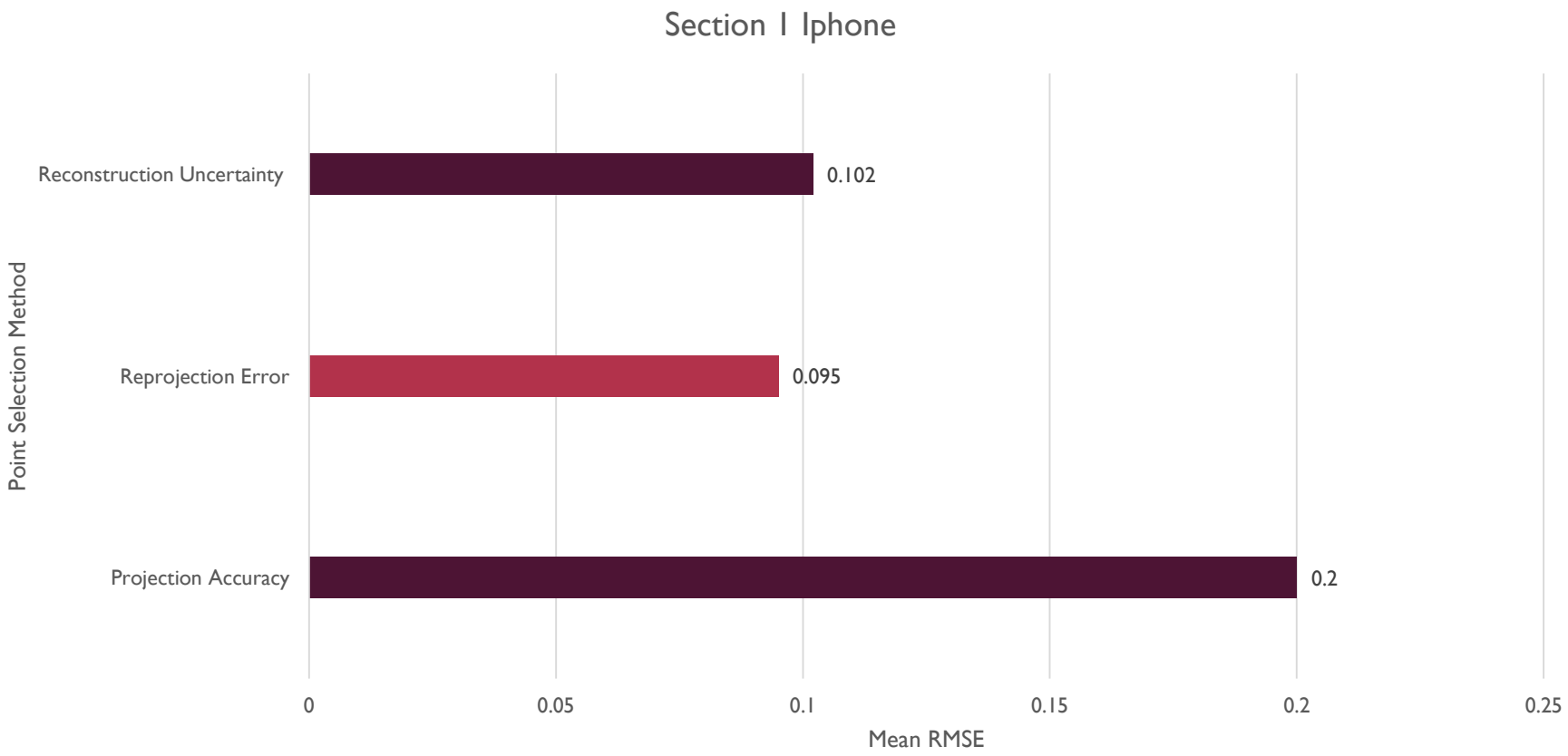
EVALUATING SENSORS – ROOT MEAN SQUARE ERROR (RMSE)



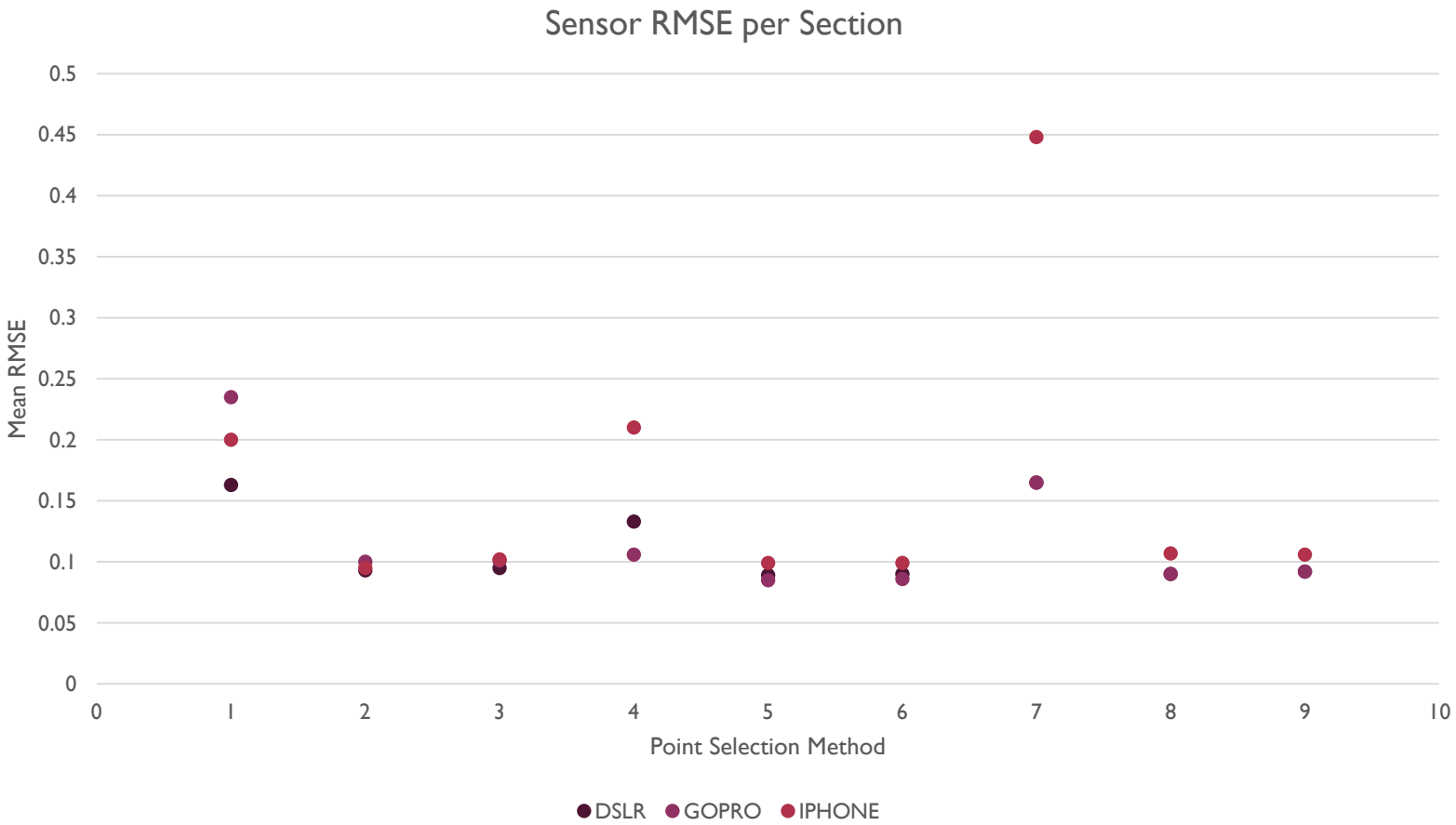
EVALUATING SENSORS - RMSE



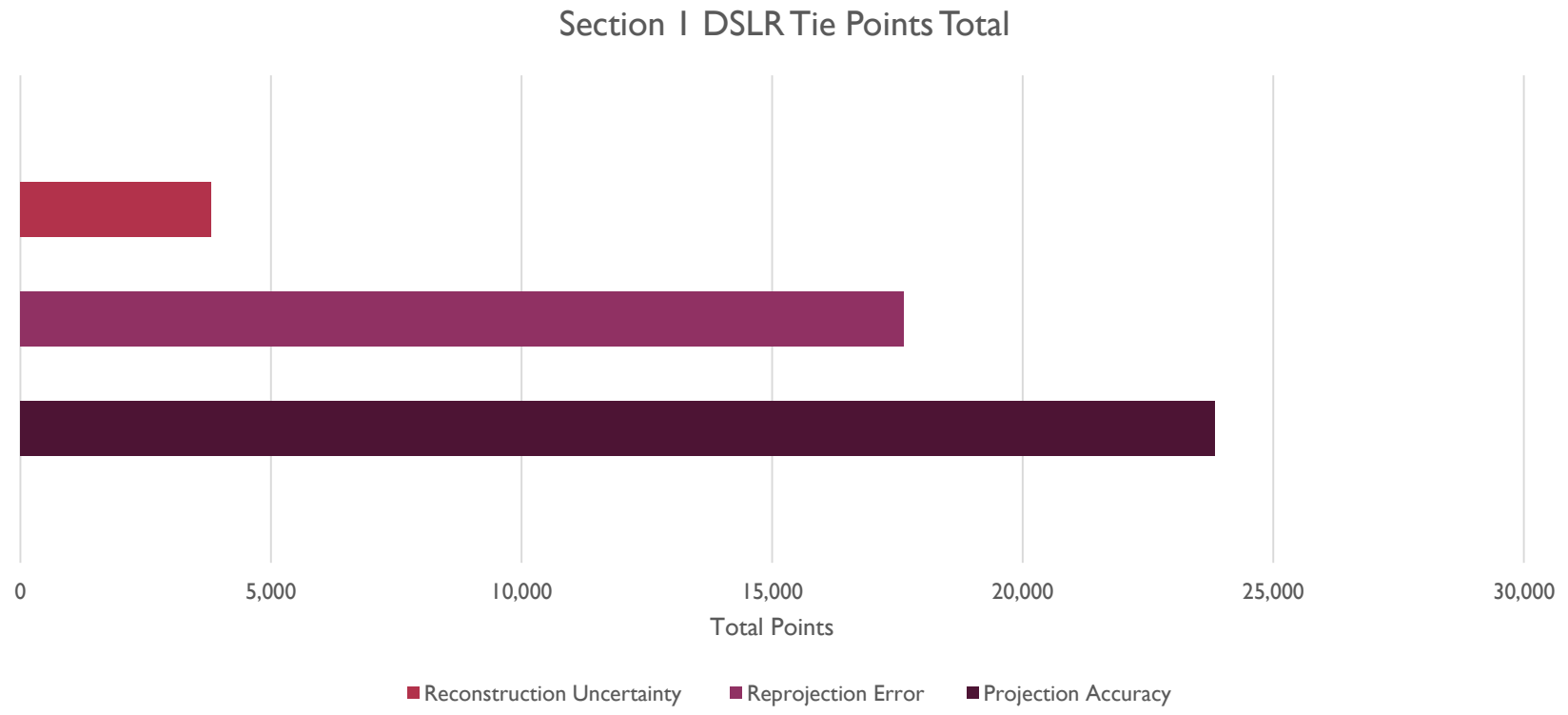
EVALUATING SENSORS - RMSE



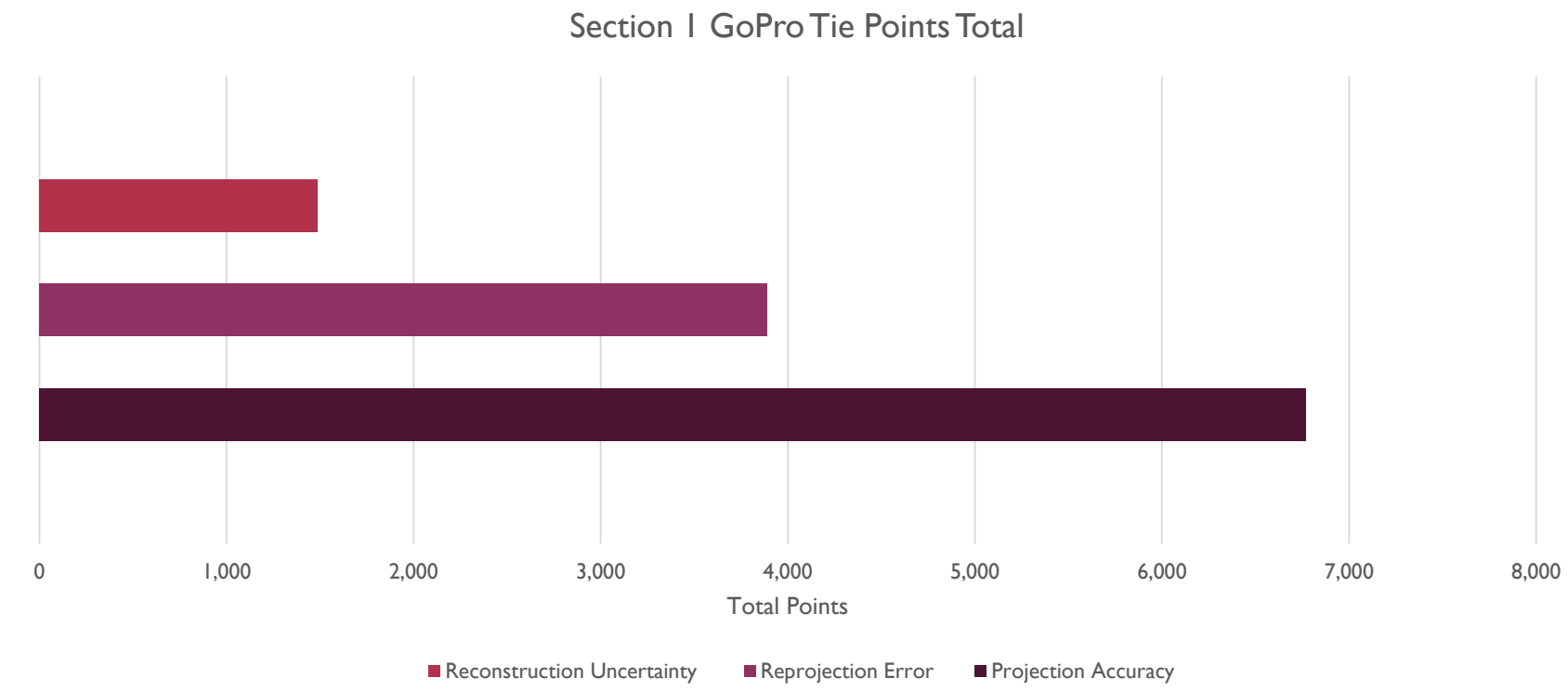
EVALUATING SENSORS - RMSE



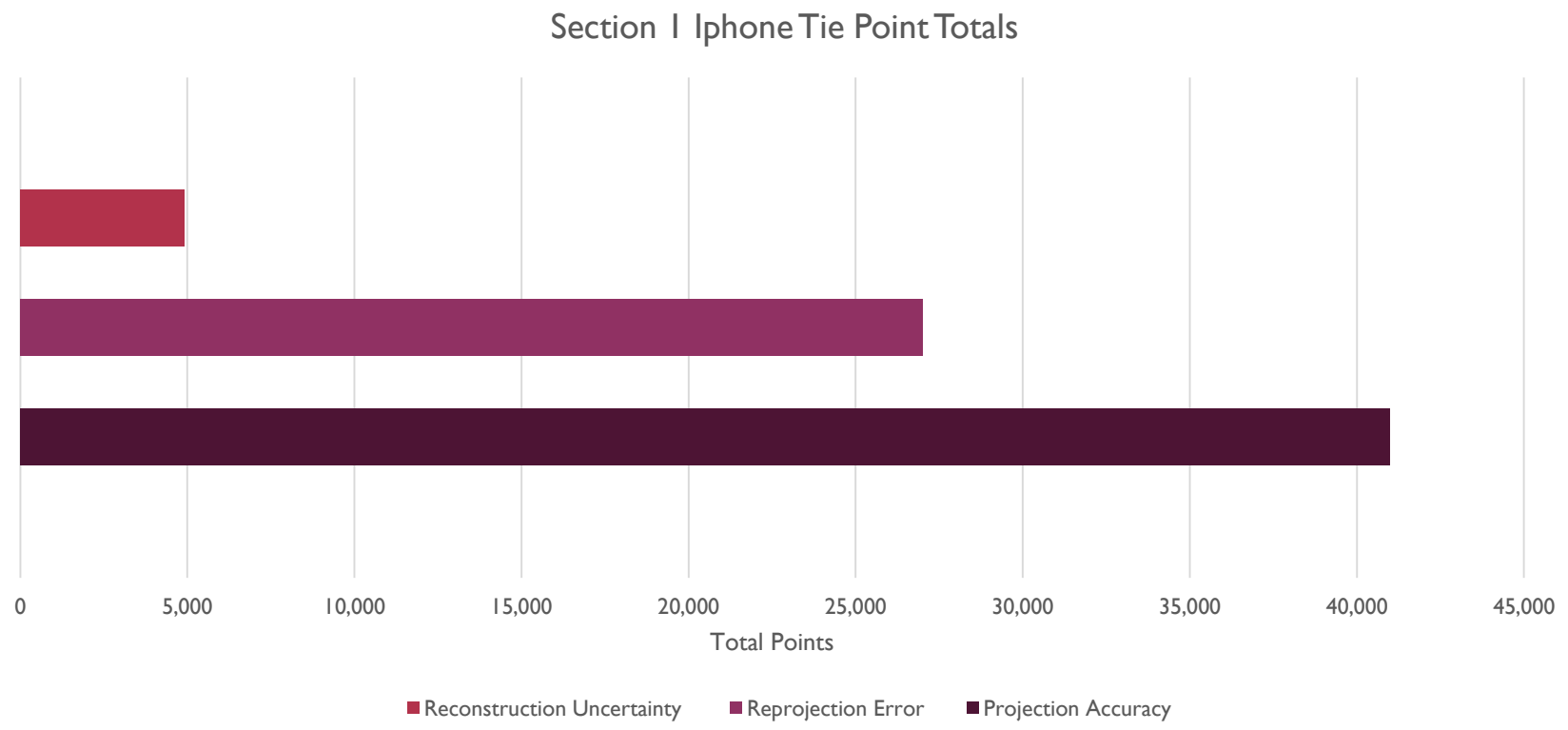
RMSE VS. POINT COUNTS REMOVED



RMSE VS. POINT COUNTS REMOVED

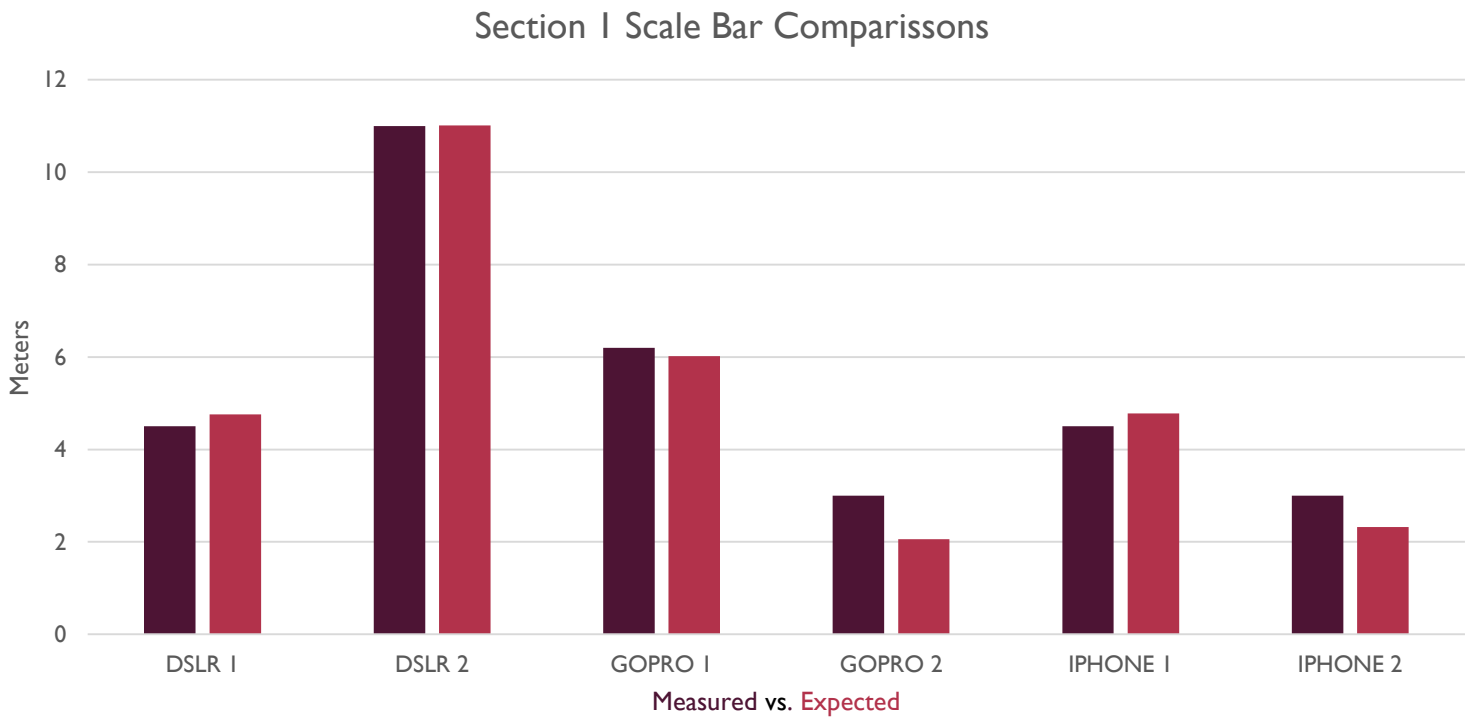


RMSE VS. POINT COUNTS REMOVED



MEASURED VS. EXPECTED

- How does Metashape create scale without coordinates?



RESEARCH QUESTION 1
REPEATABILITY & AFFORDABILITY

- What is the most suitable camera (cell phone, digital SLR, GoPro) and data acquisition method for hand-held photogrammetry in the field, considering minimum resolution, affordability, and repeatability?

- Results from RMSE error analysis and Expected vs. Measured Scale
  - RMSE Comparable
  - Expected vs. Measured Scale comparable
  - Winner goes to the most ubiquitous technology

RESEARCH QUESTION 2

- What is the most suitable image processing workflow, considering computing power and time constraints?

IPHONE SECTION 1

Product	Time	Memory
Dense Cloud	3 mins 6 secs	221.90 MB
DEM	6 secs	84.04 MB
Orthomosaic	3mins 36 secs	1.53 GB

GOPRO SECTION 1

Product	Time	Memory
Dense Cloud	50 secs	200.73 MB
DEM	2 secs	24.98 MB
Orthomosaic	29 secs	562.68

DSLR SECTION 1

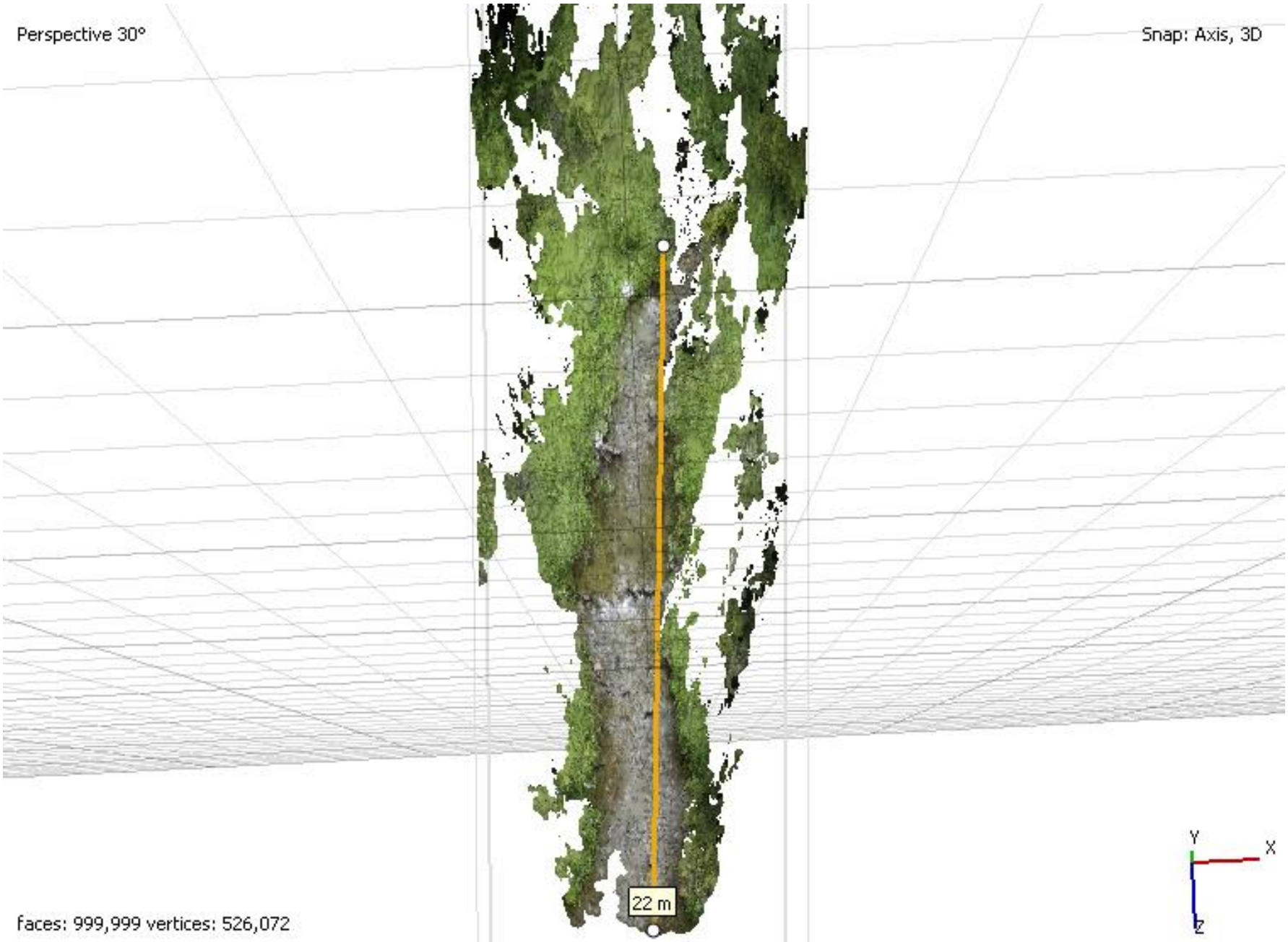
Product	Time	Memory
Dense Cloud	12 mins 24 secs	596.7 MB
DEM	16 sec	237.68 MB
Orthomosaic	9 mins 39 secs	3.93 GB

- Import -> Align -> Optimize -> Reduce Error (Projection Accuracy & Reconstruction Error Selections) -> Create Coordinate System and Scale -> Create Dense Point Cloud -> Create Mesh -> Create Texture -> Save Exports

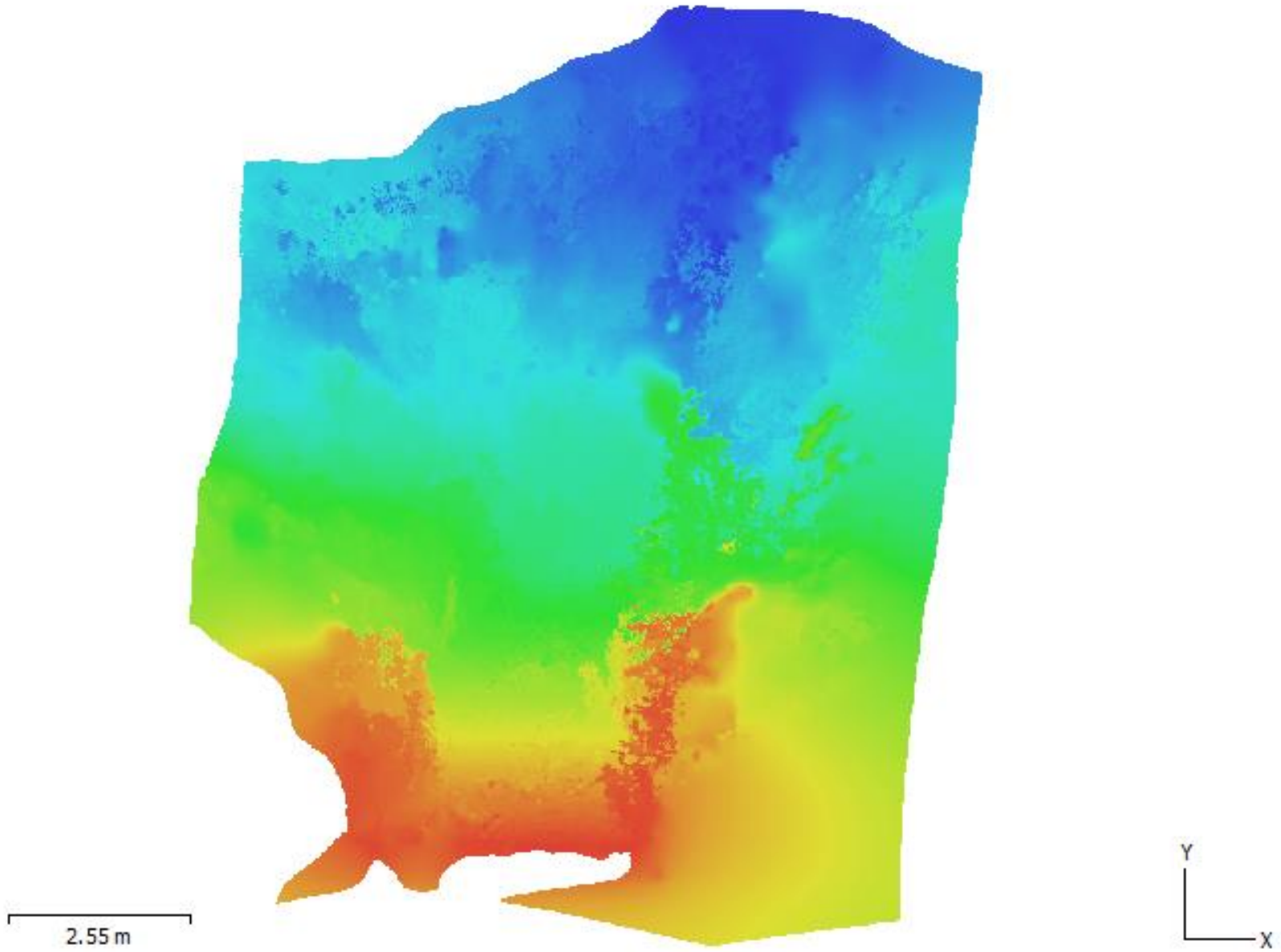
RESEARCH QUESTION 3 QUANTITATIVE MEASUREMENTS

- What measurements can hand-held photogrammetry provide to stream and riparian restoration specialists and researchers?

	Length	WettedWidth	Depth
Section1	22 meters	2.8 meters	9 inches


Perspective 30°
Snap: Axis, 3D
22 m
Y
X
Z
faces: 999,999 vertices: 526,072


1.61 m
Y
X


2.55 m
Y
X

RESULTS

- What is the most suitable camera (cell phone, digital SLR, GoPro) and data acquisition method for hand-held photogrammetry in the field, considering minimum resolution, affordability, and repeatability?
  - The ubiquitous nature of the cell phone camera combined with the lack of significance in error analysis for all three sensors puts the iPhone as the most suitable camera when considering minimum resolution, affordability, and repeatability.
- What is the most suitable image processing workflow, considering computing power and time constraints?
  - The most suitable image processing and model creation workflow within Agisoft Metashape is:
    - Import -> Align -> Optimize -> Reduce Error (Projection Accuracy & Reconstruction Error Selections) -> Create Coordinate System and Scale -> Create Dense Point Cloud -> Create Mesh -> Create Texture -> Save Exports
- What measurements can hand-held photogrammetry provide to stream and riparian restoration specialists and researchers?
  - In addition to the quantitative stream dimension measurements displayed above, Capture also provides qualitative information on instream habitat, presence of large debris, and evidence of bank erosion. These qualitative measurements on gathered at the time of stream survey and can be compared to future surveys by looking at the 3D model record created by Capture.

THANK YOU VERY MUCH