

Incorporation of Digital Data into Rapid Geomorphic Assessments

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RAPID GEOMORPHIC ASSESSMENT (RGA)

- **On-site method to quickly rank stream reaches by streambank erosion potential**
- **Purpose**
 - **Target stream bank erosion remediation**
 - **Identify sediment contributions**
- **Current Study**
 - **Bank Erosion Hazard Index (BEHI)**
 - **Four Metrics + Two Adjustment Factors**
 - **Six Stability Rankings**
 - **Channel Stability Index (CSI)**
 - **Nine Metrics**
 - **Three Stability Rankings**



River/Creek _____ Station _____

Date _____ Crew _____

BEHI METRICS

- **Bank Height/Bankfull Height – Channel incision**
- **Root Depth/Bank Height – % of bank protected by roots**
- **Root Density – % of bank protected by roots**
- **Surface Protection – % of bank protected**
- **Bank Angle (Bank Height/Face Length) – Bank slope**

0. Preliminary Data (Left and Right Banks Looking Downstream):

BEHI		Bank Height/ Bankfull Height	Root Depth/Bank Height (%)	Root Density (%)	Surface Protection (%)	Bank Angle, Bank Height/Face Length	Aggregate Score
Very Low	Value	1.0-1.1	90-100	80-100	80-100	0.0-0.34 (0-20°)	7.25
	Score	1.45	1.45	1.45	1.45	1.45	
Low	Value	1.11-1.19	50-89	55-79	55-79	0.35-0.86 (21-60°)	14.75
	Score	2.95	2.95	2.95	2.95	2.95	
Moderate	Value	1.2-1.5	30-49	30-54	30-54	0.87-0.985 (61-80°)	24.75
	Score	4.95	4.95	4.95	4.95	4.95	
High	Value	1.6-2.0	15-29	15-29	15-29	0.985-1.0 (81-90°)	34.75
	Score	6.95	6.95	6.95	6.95	6.95	
Very High	Value	2.1-2.8	5-14	5-14	10-14	0.87-0.99 (91-119°)	42.50
	Score	8.5	8.5	8.5	8.5	8.5	
Extreme	Value	>2.8	<5.0	<5.0	<10.0	<0.87 (>119°)	50.00
	Score	10	10	10	10	10	
		1.45	2.95	4.95	6.95	8.5	10.0

Notes: _____

5. Bank Angle (°) – Circle One:

0-20°	21-60°	61-80°	81-90°	91-119°	>119°
BH/FL (= 0.00-0.34)	(=0.35-0.86)	(=0.87-0.985)	(=0.985-1.0)	(=0.87-0.99)	(<0.87)
1.45	2.95	4.95	6.95	8.5	10.0



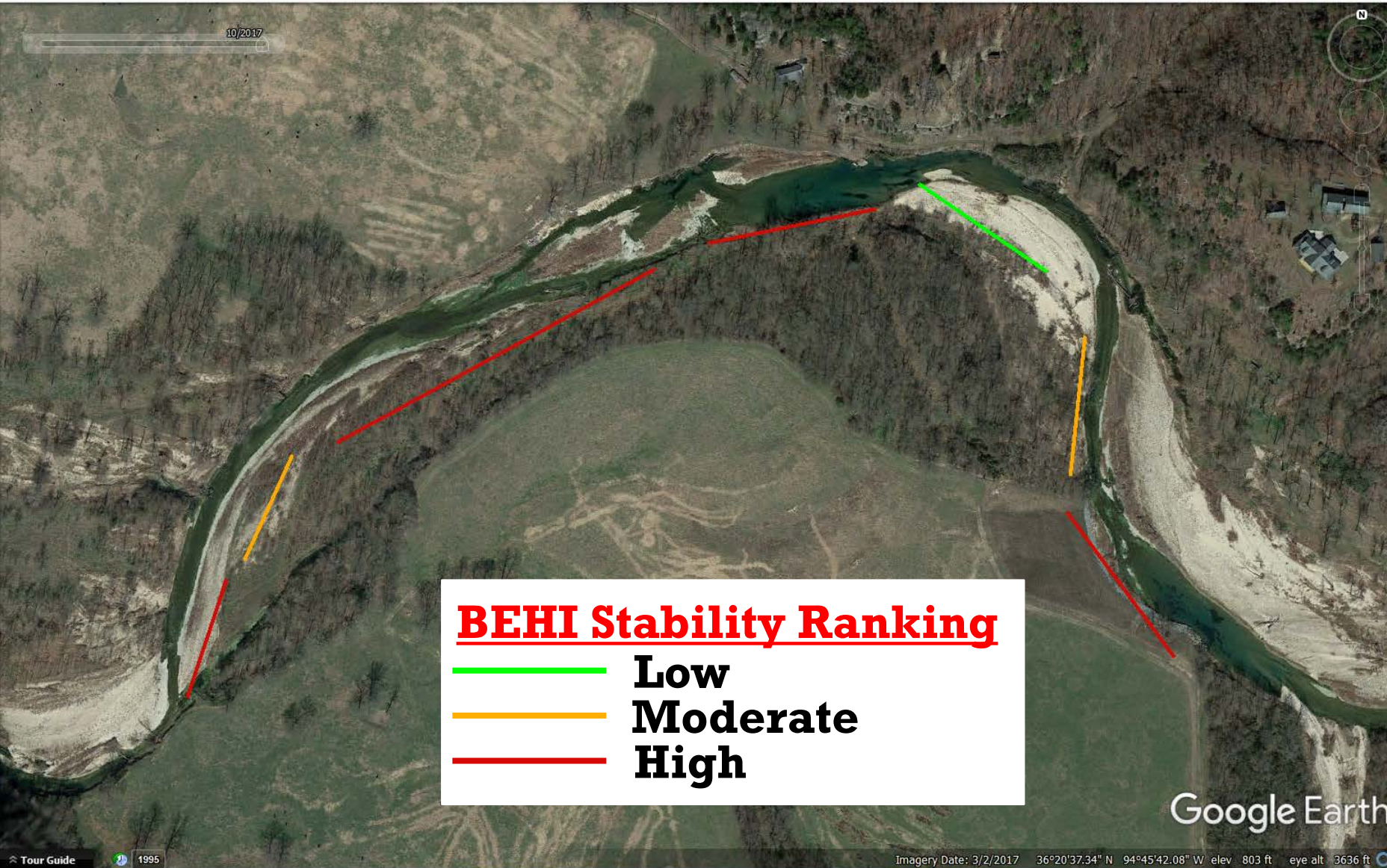
BEHI EXAMPLE

Metric	Value	Score	Stability Rank
Bank Height/ Bankfull Height	1.5	4.95	Very High
Root Depth/Bank Height (%)	73%	2.95	
Root Density (%)	66%	2.95	
Surface Protection (%)	55%	2.95	
Bank Angle, Bank Height/Face Length	0.59	2.95	
Primary Bank Material	Sand	+10	
Stratification	Multiple Layers	+10	
Cumulative Score		36.75	

BEHI		Bank Height/ Bankfull Height	Root Depth/Bank Height (%)	Root Density (%)	Surface Protection (%)	Bank Angle, Bank Height/Face Length	Aggregate Score
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BEHI RANKING - HISTORICAL REACHES



PROBLEM: CRITICISMS OF RGA'S

- **Property access**
- **Subjective measurements**
- **High uncertainty estimates**
- **Requires special training**
- **Teams recommended to reduce subjectivity**



PROPOSED SOLUTION: DIGITAL RGA

- **Digital RGA performed in office**
- **Uses readily available data and tools**
 - **USDA Web Soil Survey**
 - **USGS Stream Gages and StreamStats**
 - **LIDAR**
 - **Google Earth**



Google Earth



PROJECT OBJECTIVES

- **Develop RGA method using readily available off-site digital data and resources**
- **Quantify RGA sensitivity to replacement methods/values**
- **Determine metrics, if any, that must/should be measured on site**
- **Determine method limitations related to decreased data resolution or other issues**



METHODS & STUDY AREA

- **Developed Methodology → Digital RGA score**
- **Compared score to historical RGAs**
 - **2010 Barren Fork and Spavinaw**
 - **4th Order Stream**
 - **Ozark Ecoregion**
 - **2016 Fivemile and Willow**
 - **2nd Order Stream**
 - **Great Plains Ecoregion**
- **Success Rate**
 - **Did the overall stability ranking change?**
 - **No = Success**



CSI METHODS

CSI Metrics	Off-site Source
Degree of Incision	LIDAR
Degree of Constriction	LIDAR or Google Earth
Primary Bed Material	Stream Gages
Bed/Bank Protection	Stream Gages (bed) Web Soil Survey (Bank)
Streambank Erosion (Presence/Type)	Google Earth
Streambank Instability (%)	Google Earth
Established Riparian Woody Vegetative Cover (%)	Google Earth
Occurrence of Bank Accretion (%)	Google Earth
Stage of Channel Evolution	Google Earth

- **Mechanistic processes**
- **Uses both banks**
- **Reach-length estimates**
- **Metrics describe Stage of Channel Evolution**



BEHI METHODS

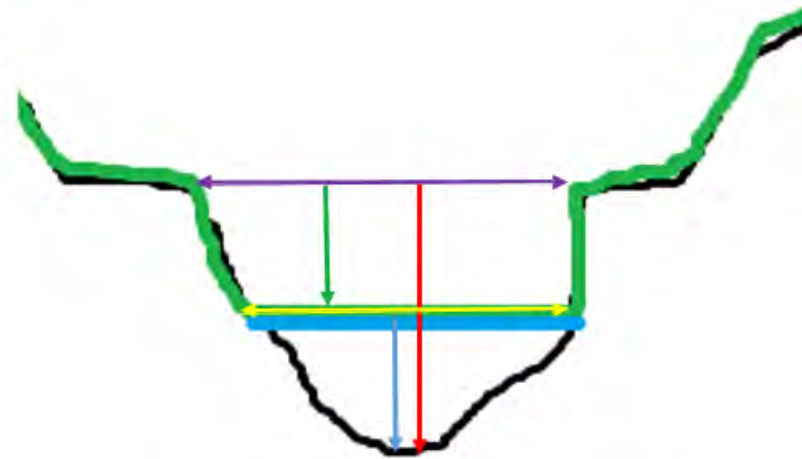
BEHI Metrics	Off-site Source
Bank Height/Bankfull	LIDAR
Bank Angle (Bankheight/Face length)	LIDAR
Root Depth (%)	LIDAR + Web Soil Survey + NRCS PLANTS Database
Root Density (%)	No direct method at this point
Surface Protection (%)	Root Depth (%) + LIDAR
Primary Bank Material	Web Soil Survey
Presence/number of Stratified Layers	Web Soil Survey

- **Dave Rosgen's Natural Channel Design**
- **Critical bank only**
- **3 of 5 metrics calculated using bank measurements**
- **Score adjustments**



BEHI METHODS – BANKFULL DEPTH

- On-site Measurement - recommend flow data validation
- Regional Equations
- USGS StreamStats-Q2
- USGS PeakFQ-Q1.5
- LIDAR
 - Bankfull Height
 - NAIP imagery



Bankfull Depth: $D_{Bf} = H_{Bf} + D_f$

Bankfull Width: W_{Bf}

Baseflow Depth: D_f

Bankfull Height: H_{Bf}

Base Flow Width: W_f



BEHI METHODS – BANKFULL WIDTH

LIDAR Data



NAIP Imagery



Final Bankfull Width



BEHI METHODS – BANKFULL DEPTH

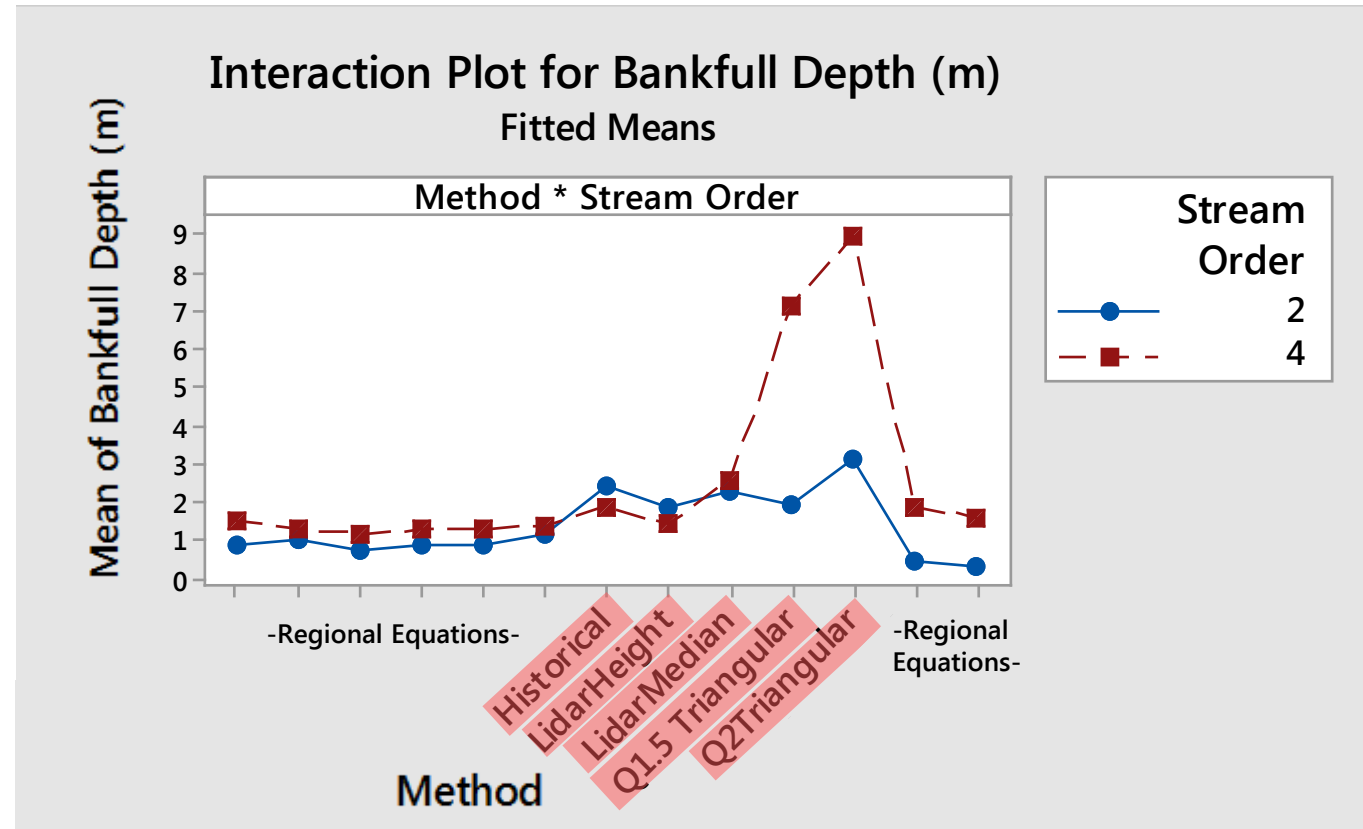
Statistically Similar to Historical Measurements (90% CI)

Two-Way ANOVA

- **RV: Bankfull Depth**
- **TRT: Method, Stream Order**
 - **LIDAR bankfull height**
 - **LIDAR bankfull depth**

One-Way ANOVA

- **RV: Bankfull Depth**
- **TRT: Method (2nd Order Only)**
 - **USGS StreamStats-Q2**
 - **USGS PeakFQ-Q1.5**
 - **LIDAR bankfull height**
 - **LIDAR bankfull depth**



RV: Response Variable
TRT: Treatment



BEHI METHODS - VEGETATION

- **Root Depth**
 - **Expected Woody and Grass Species**
 - **Web Soil Survey**
 - **NRCS PLANTS Database**
- **Root Density**
 - **Aerial imagery to determine vegetation presence/type**
 - **Historical measurements used for average root density by type**
- **Surface Protection**
 - **Surface Protection (%) = Root Depth (%)**



BEHI METHODS - ADJUSTMENTS

Web Soil Survey

- **Primary Bank Material**
 - **% Course Fragments**
 - **% Sand-Silt-Clay**
 - **Soil Horizons & thickness**
- **Stratification**
 - **Change in Erodibility Class**
 - **Order of Magnitude difference in k values**

BSTEM Erodibility Factor Calculator

Material Descriptors			Toe Model Input Data	
Bank material type	Description	Mean grain size, D_{50} (m)	τ_c (Pa)	k (cm ³ /Ns)
1	Boulders	0.512	498	0.004
2	Cobbles	0.128	124	0.009
3	Gravel	0.0113	11.0	0.030
4a and 4b	Angular sand	0.00035	Coarse (0.71 mm) or Fine (0.18 mm)	
5a and 5b	Rounded sand	0.00035		
6a, 6b and 6c	Silt	-	Erodible (0.100 Pa), Moderate (5.00 Pa), or Resistant (50.0 Pa)	
7a, 7b and 7c	Soft clay	-		
8a, 8b and 8c	Stiff clay	-		
9	Own data layer 1			
	Own data layer 2			
	Own data layer 3			
	Own data layer 4			
	Own data layer 5			
	Own data Bank Toe			



RESULTS – BEHI & CSI SUCCESS RATES

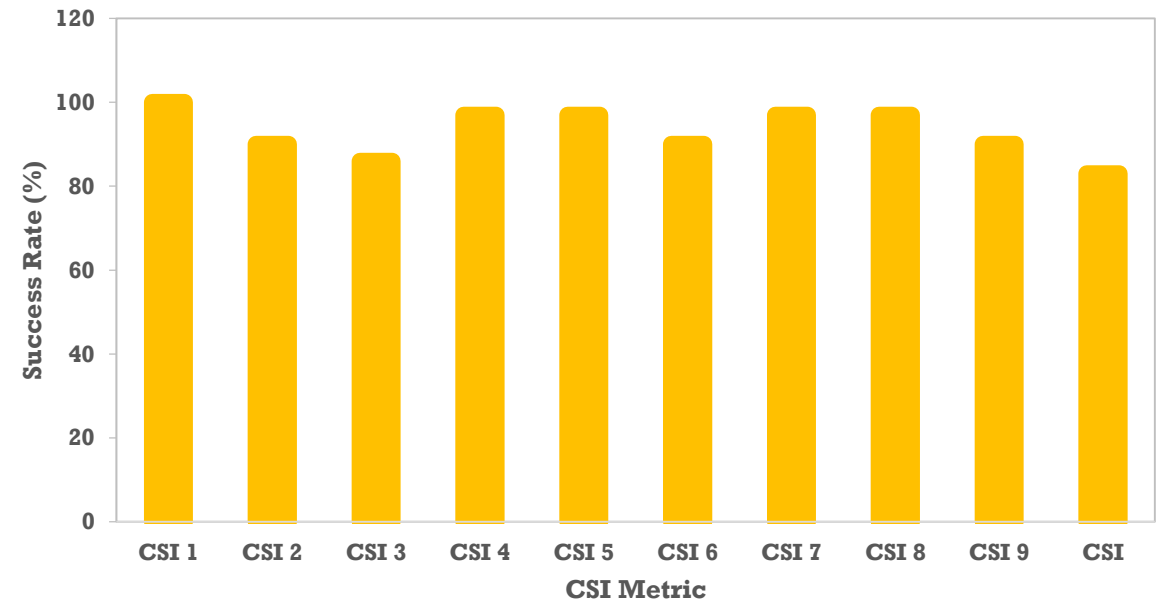
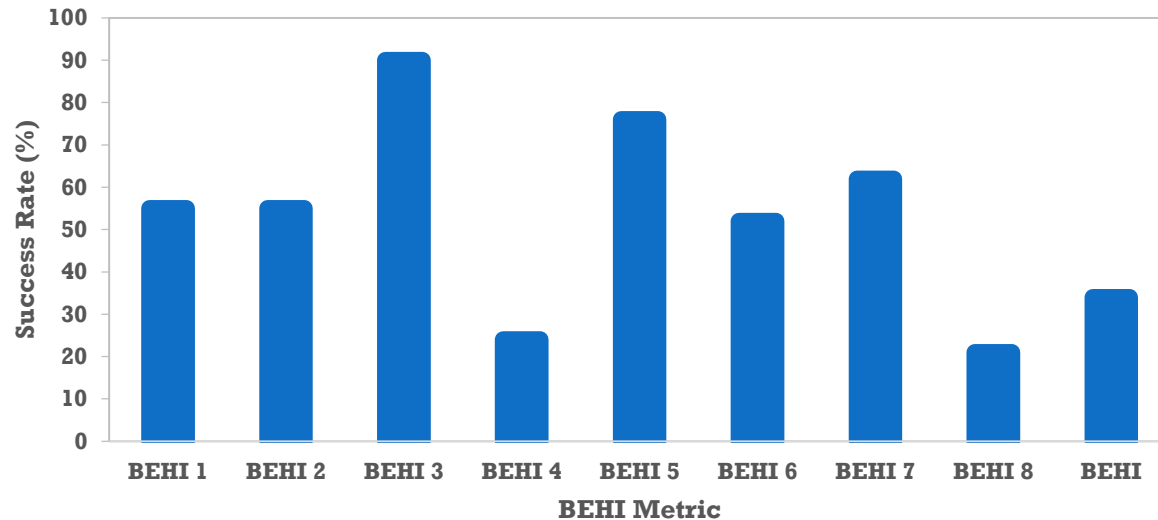
Evaluating Individual Metrics

- BEHI 1-7
- CSI 1-9

Evaluating Fully Digital RGA

- BEHI 8 – All but Adjustments
- BEHI
- CSI

$$\text{Success Rate} = \frac{\text{Correct Rankings}}{\text{Total Rankings}} * 100\%$$

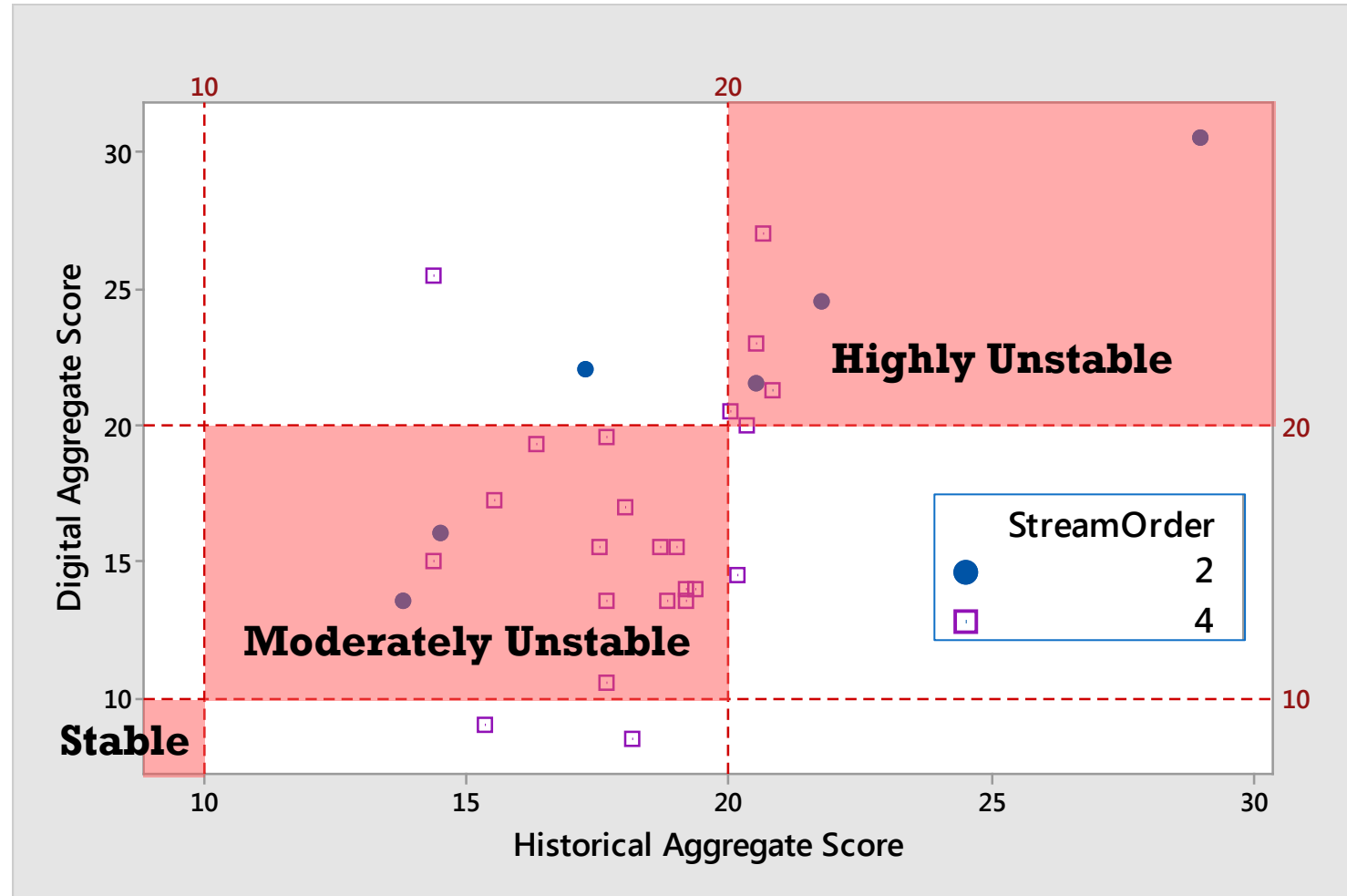


RESULTS – CSI DIGITAL VS HISTORICAL

Coefficient of Success (S^2)

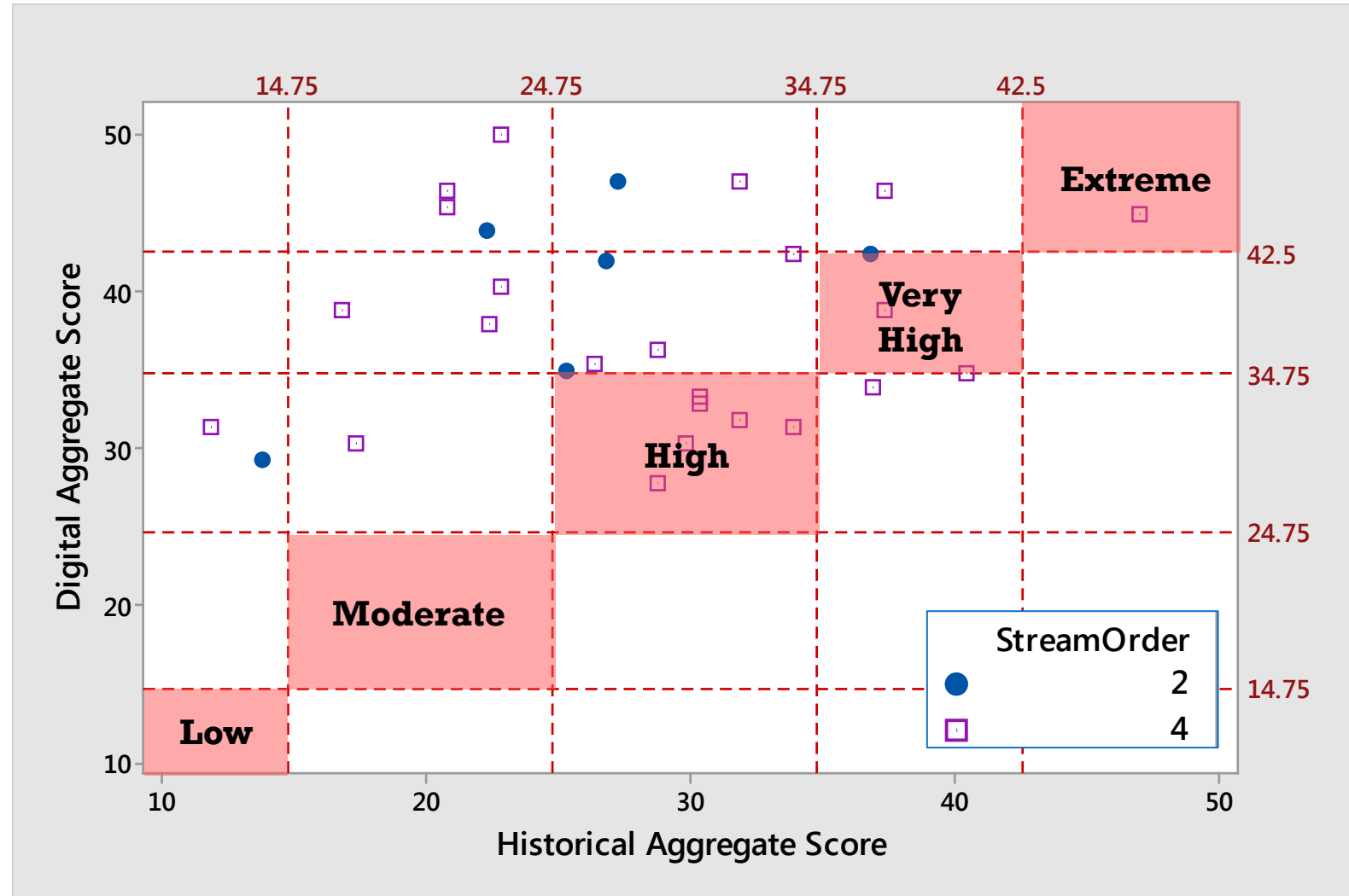
- Range 0 – 100%
- Similar to R^2
- Weighted Success Rate

Score	Success Rate (%)	Coefficient of Success - S^2 (%)
Moderately Unstable	80	88
Highly Unstable	89	82



RESULTS – BEHI DIGITAL VS HISTORICAL

Score	Success Rate (%)	Coefficient of Success - S^2 (%)
Low	0	0
Moderate	0	0
High	14	46
Very High	60	85
Extreme	100	N/A



VALIDATION-FEATHER CREEK

- **2nd Order Stream**
- **Central Great Plains Ecoregion**
- **RGAs Conducted by Different Person**

Method	On-site Score		Digital Score
BEHI	Moderate (22)		Extreme (43)
	Surface Protection	-3	
	Primary Bank Material	-20	
CSI	Highly Unstable (22)		Moderately Unstable (11)
	Stage	+4	
	%Woody Cover	+3	
	Streambank Erosion	+3	



DIGITAL VS ON-SITE RGA

■ Cost

- Digital – no travel costs and lost time in travel
- Time to do Digital vs RGA (less travel time)
 - Digital ~ 6 hours (Two sites+multiple bankfull calculations)
 - On-site ~1 hour (One site)

DIGITAL RGA

■ Advantages

- Not dependent on land access
- Alternative bankfull depth methods
- Simple reach-length measurements

■ Disadvantages, Limitations

- Areal imagery data gaps
- LIDAR availability and quality
- USGS Stream Gage availability

Google Earth Reach



Validation Reach



CONCLUSIONS & RECOMMENDATIONS

1. **Proposed Digital RGA method: feasible replacement for onsite RGAs**
2. **Improve Digital RGA accuracy: measure sensitive parameters on site**
 - **BEHI** (Primary Bank Material, Surface Protection, Root Density)
 - **CSI** (Stage of Channel Evolution, % Woody Cover, Streambank Erosion, Primary Bed Material, % Accretion, % Instability, Incision, and Bed/Bank protection)
3. **Method Limitation**
 - **Root Density** – development data may not be applicable to other ecoregions
4. **Data Resolution Limitations**
 - **Primary Bank Material** (Web Soil Survey scale)
 - **Bed Material** (available stream gage data)
 - **% Woody Cover/Streambank Erosion/Stage** (channel size & imagery)



QUESTIONS?

Thank You!

- **Dr. Dan Storm and Dr. Garey Fox**
- **Dr. Paul Weckler**
- **Dr. Jason Vogel**
- **Adrian Saenz & Keima Kamara**
- **Jean Lemmon (Blue Thumb)**
- **Steve Nechero & Lori Etheridge (NRCS)**

