Kerber Creek Restoration Project

Case study employing statistical techniques to analyze effects of restoration activities, Saguache, CO

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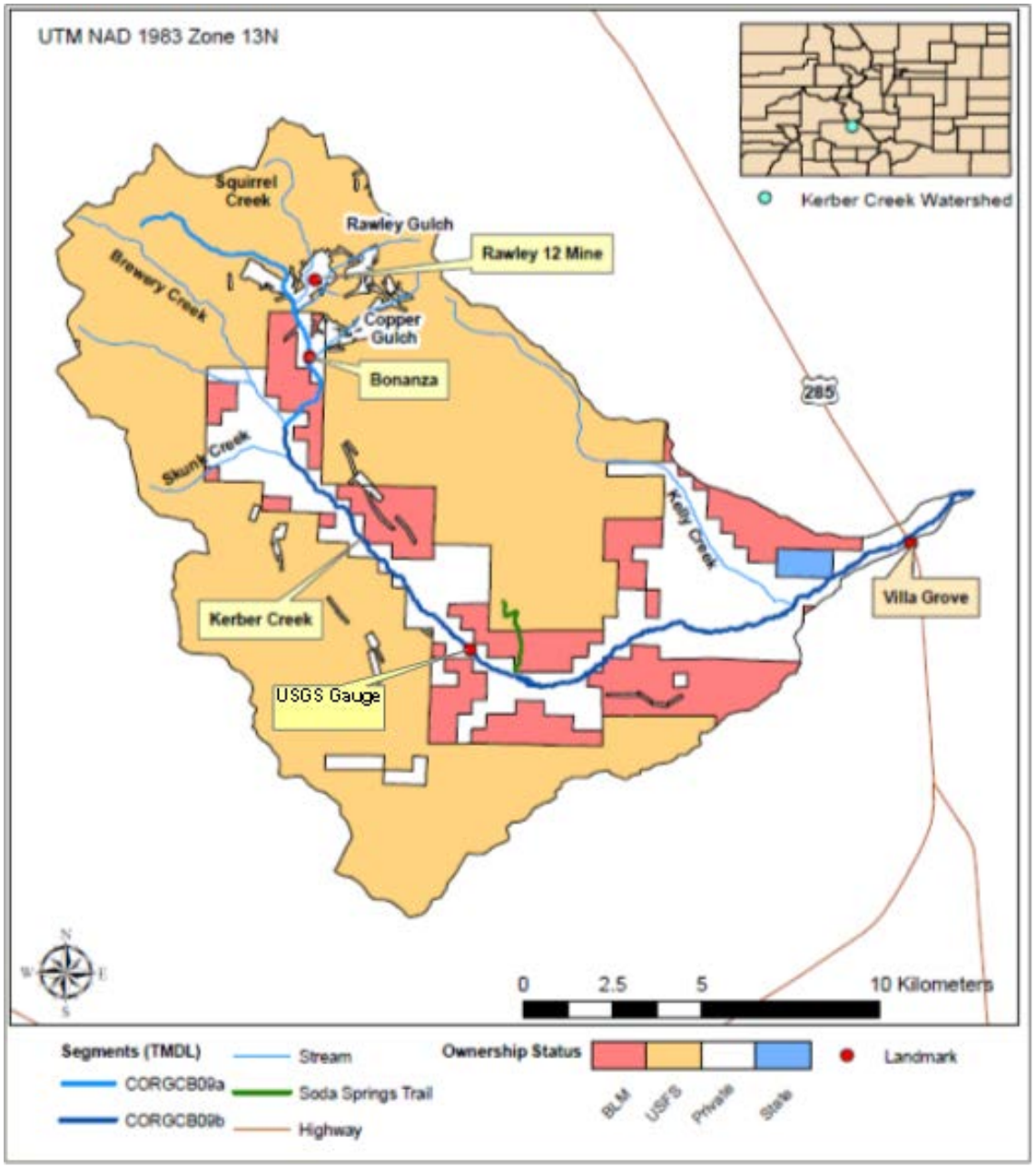
Presentation Overview

1) Introduction: Site History & Study Objectives
2) Methods: Site Description & Study Design
3) Results: Presentation of Data
4) Discussion: Results & Study Errors
5) Conclusions

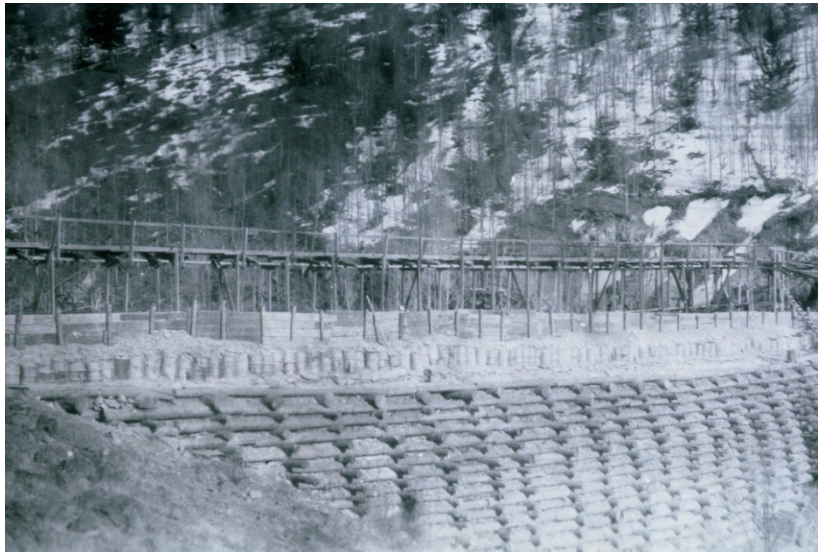
Site Location

- Northernmost end of Saguache County, CO in the northern San Luis Valley
- Tributary to San Luis Creek in the Rio Grande Closed Basin
- Kerber Creek watershed is approximately 260 km^2
- Includes private and BLM-owned rangeland and Rio Grande National Forest



Bonanza Mining District: A History

- 1880s – 1970s (largely ceased by 1930s)
- Dozens of silver, lead, zinc, copper mines (largest: Rawley 12)
- Tailings originally collected and consolidated in streams and behind dams
- Dams destroyed by flood events that carried tailings downstream and deposited them along the stream bank (mid-20th century)



Restoration Efforts, I

- 1994–1999: Restoration projects implemented (upper watershed)
- 2002: ASARCO, Inc. declares bankruptcy, halting restoration projects

Squirrel Creek, 2012

Squirrel Creek, pre-1992

- 1991: USFS & CDPHE investigate for Superfund designation
- 1994: Bonanza Group (ASARCO, Inc., USFS, BLM, Local Landowners) approved to pursue Voluntary Cleanup

Ramsey, 2012

Ramsey, pre-1996

Restoration Efforts, II

Kerber Creek Restoration Project

Mission: To sustain the health of the Kerber Creek watershed through collaborative restoration projects and community education

Methods

Phytostabilization: In-situ treatment of mine waste deposits

Stream Bank Stabilization: Installation of in-stream rock structures, re-gradation of stream banks

Restoration Project Objectives

Improve water quality

Increase vegetation cover

Increase fish density

Increase macroinvertebrate density

Reduce width/depth ratio

Increase sinuosity

Case Study: Problem and Objectives

- Systematic, rigorous data analyses rarely conducted for restoration projects

- ***Needs***
  - Comprehensive understanding of project results using easily monitored/derived variables
  - Further knowledge of stream restoration processes

1. Evaluate effects of extent of phytostabilization & time on sinuosity

2. Identify functional relationship between extent of phytostabilization & sinuosity

3. Assess validity & feasibility of statistical techniques employed

Problem

Objectives

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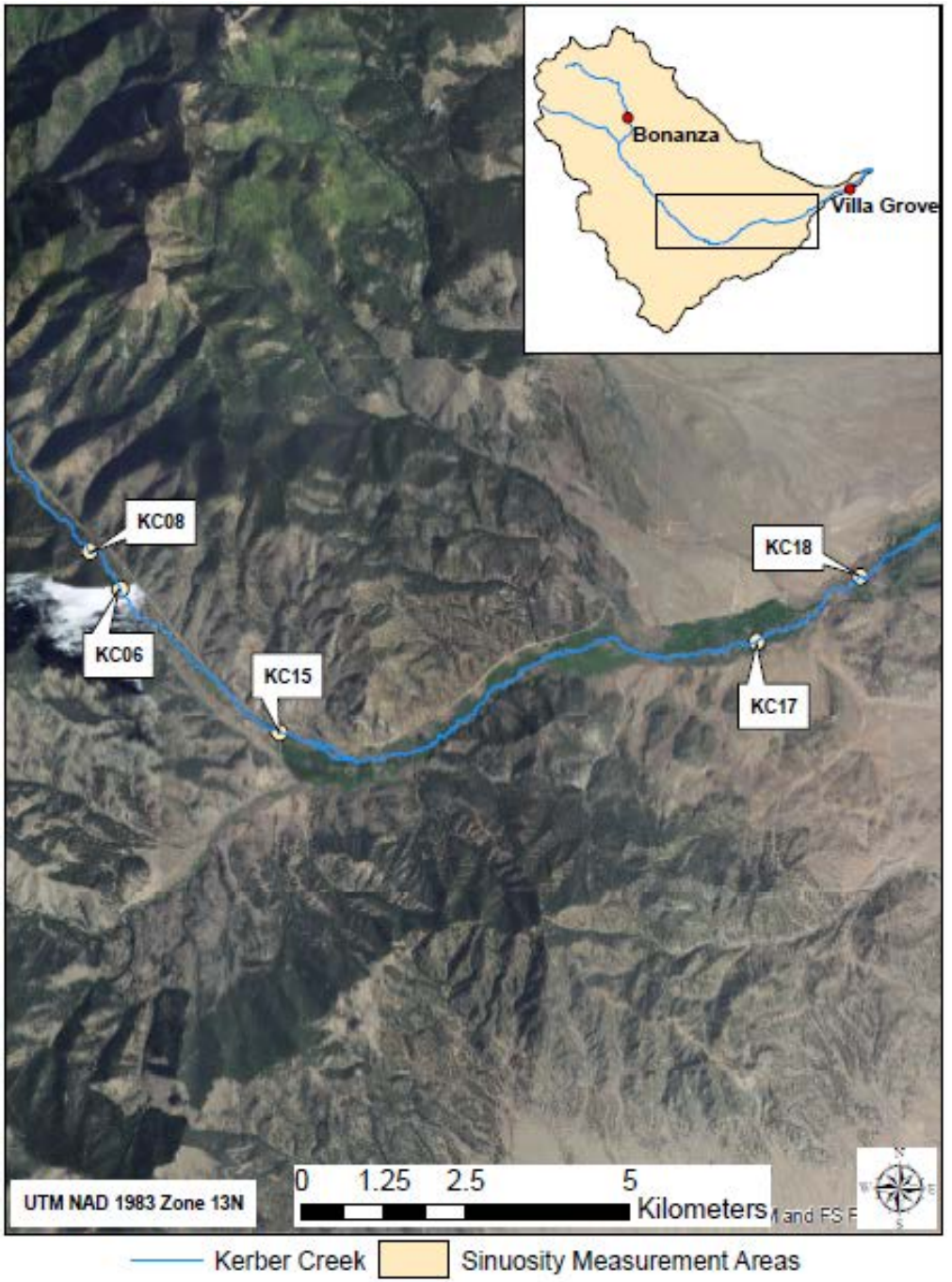
Site Description

- Geology: Dominated by tertiary igneous rock (latite)
- Precipitation: Low elevation, 25.4 cm; High elevation, 76.2 cm
- Ecology
  - Vegetation: grasses, willows, sedges
  - Fishery: brook trout, some brown trout & longnose dace
- Hydrology
  - Avg. high flow: 60 cfs
  - Avg. base flow: 4 cfs
  - 100-yr flood: 464 cfs
- Geomorphology
  - Avg. bankfull width: 4.3 – 4.9 m
  - Avg. bankfull depth: < 0.3 m
  - Avg. gradient: 3%
  - Medium-to-large cobble substrate



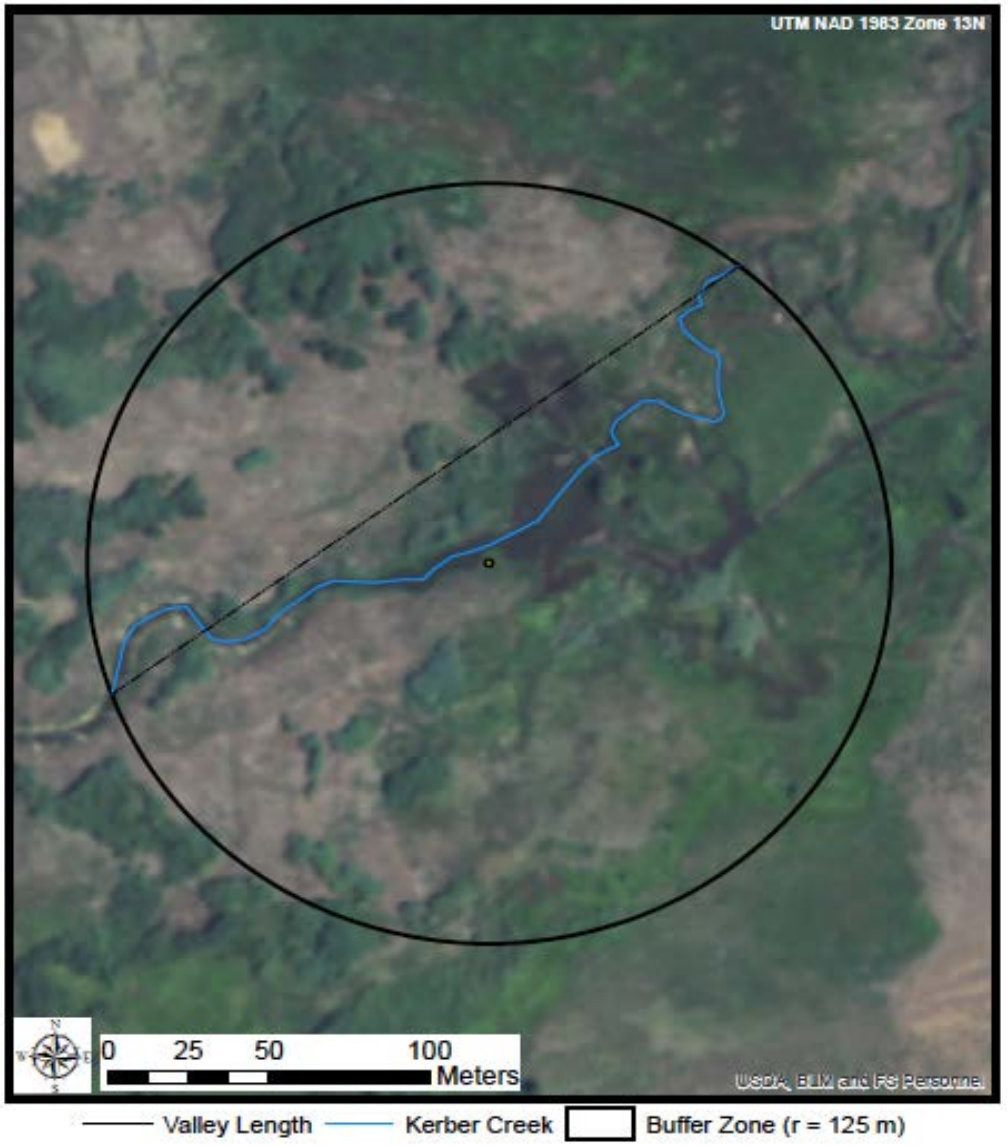
Measuring Variables, I: Sinuosity

Measured remotely using 2005, 2009, 2011 1-m resolution NAIP imagery

$$Sinuosity = \frac{Stream\ Length}{Valley\ Length}$$

Table 1. Stream length, valley length, and sinuosity for each site.

Site	Year	Stream length (m)	Valley length (m)	Sinuosity
KC18	2005	396.2	230	1.723
	2009	409.9		1.782
	2011	399.0		1.735
KC17	2005	306.7	240	1.278
	2009	319.5		1.331
	2011	316.2		1.320
KC15	2005	293.9	250	1.176
	2009	296.3		1.185
	2011	294.2		1.177
KC08	2005	298.1	250	1.192
	2009	289.4		1.157
	2011	281.6		1.126
KC06	2005	283.3	220	1.288
	2009	298.5		1.357
	2011	291.2		1.324



Measuring Variables, II: Extent of Phytostabilization

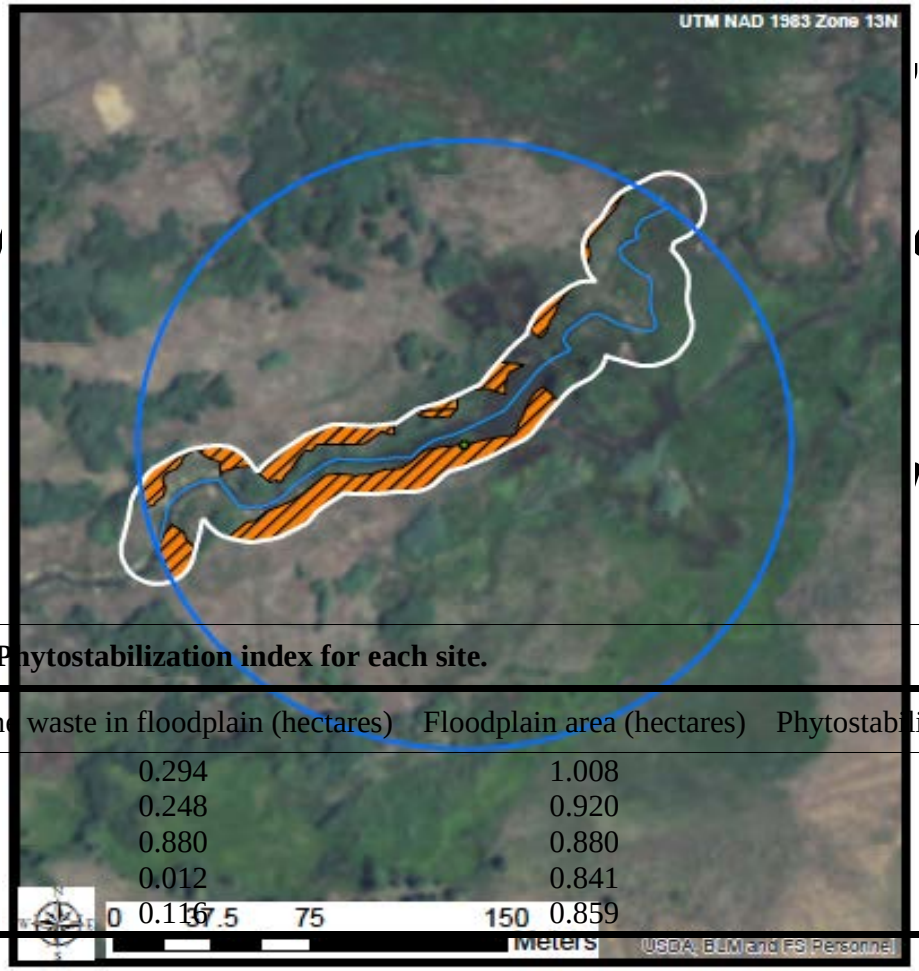


Table 2. Phytostabilization index for each site.

Site	Mine waste in floodplain (hectares)	Floodplain area (hectares)	Phytostabilization index (%)
KC18	0.294	1.008	29.2
KC17	0.248	0.920	27.0
KC05	0.880	0.880	100
KC08	0.012	0.841	1.4
KC06	0.116	0.859	13.5

Statistical Analysis, I: ANOVA

- Used to investigate Objective 1
- Repeated measures analysis of variance
  - Time: Effect of natural channel evolution
  - Independent Variable: Phytostabilization index treatment levels

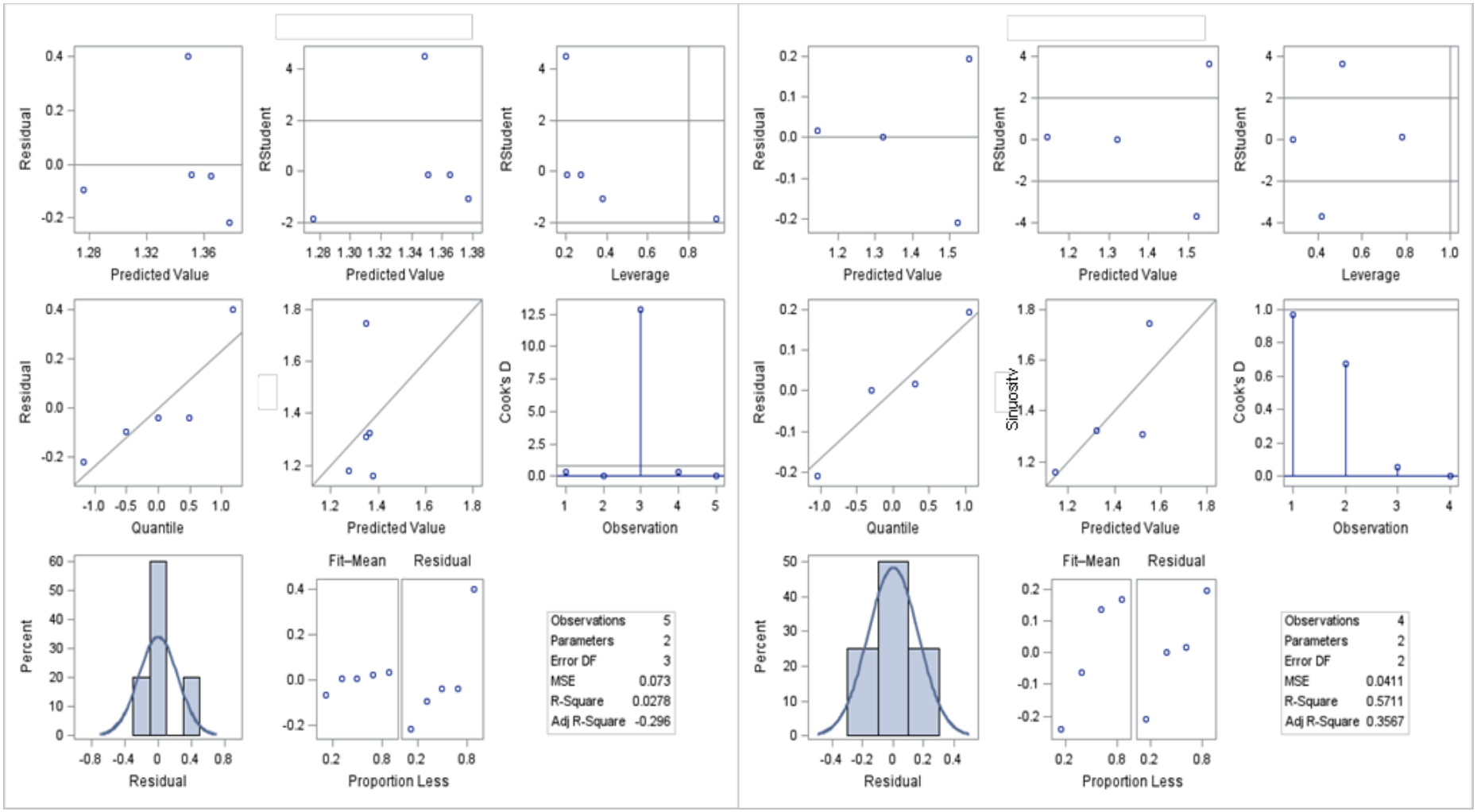
Table 3. Restoration index treatment levels assigned to each site for repeated measures ANOVA.

Sites	Phytostabilization Level
KC15	1
KC18, KC17	2
KC08, KC06	3

  - Interaction Term: Time BY Phytostabilization index
  - Dependent Variable: Sinuosity

Statistical Analysis, II: Linear Regression

- Used to investigate Objective 2
- Independent Variable: Phytostabilization index
- Dependent Variable: Average within sites sinuosity values
- No transformations required
- Outlier removed: KC15
- Regression Model: $S = \beta + P\alpha + \varepsilon$



Regression Diagnostics With and Without Outlier

Note differences in graphs of Cook's D statistic vs. observation, studentized residual vs. leverage, sinuosity vs. predicted value, and measures of normality

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Results, I: ANOVA

Table 4. Results of repeated measures ANOVAs considering the effects of phytostabilization and time on sinuosity in Kerber Creek.

Independent variable	Numerator DF	Denominator DF	F-value	P-value
Phytostabilization index	2	2	1.13	0.470
Time	2	4	1.94	0.258
Interaction term	4	4	0.41	0.793

- No statistically significant differences; all null hypotheses could not be rejected

Results, II: Linear Regression

- Regression coefficient not significant
- Adjusted correlation coefficient = 0.357
- No final regression model

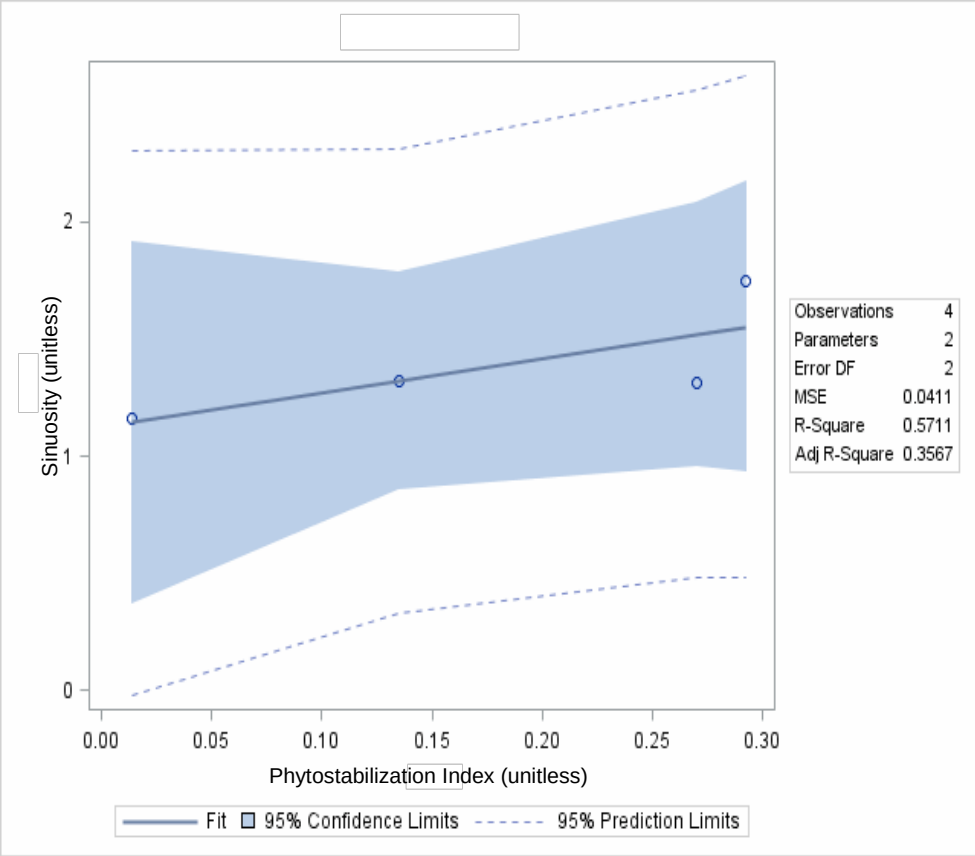

Table 5. Results of linear regression analysis: Estimates of regression coefficients for sinuosity vs. phytostabilization index.

Variable	Estimate	Standard Error	T-value	P-value
Y-Intercept	1.122	0.190	5.90	0.028
Slope	1.476	0.904	1.63	0.244

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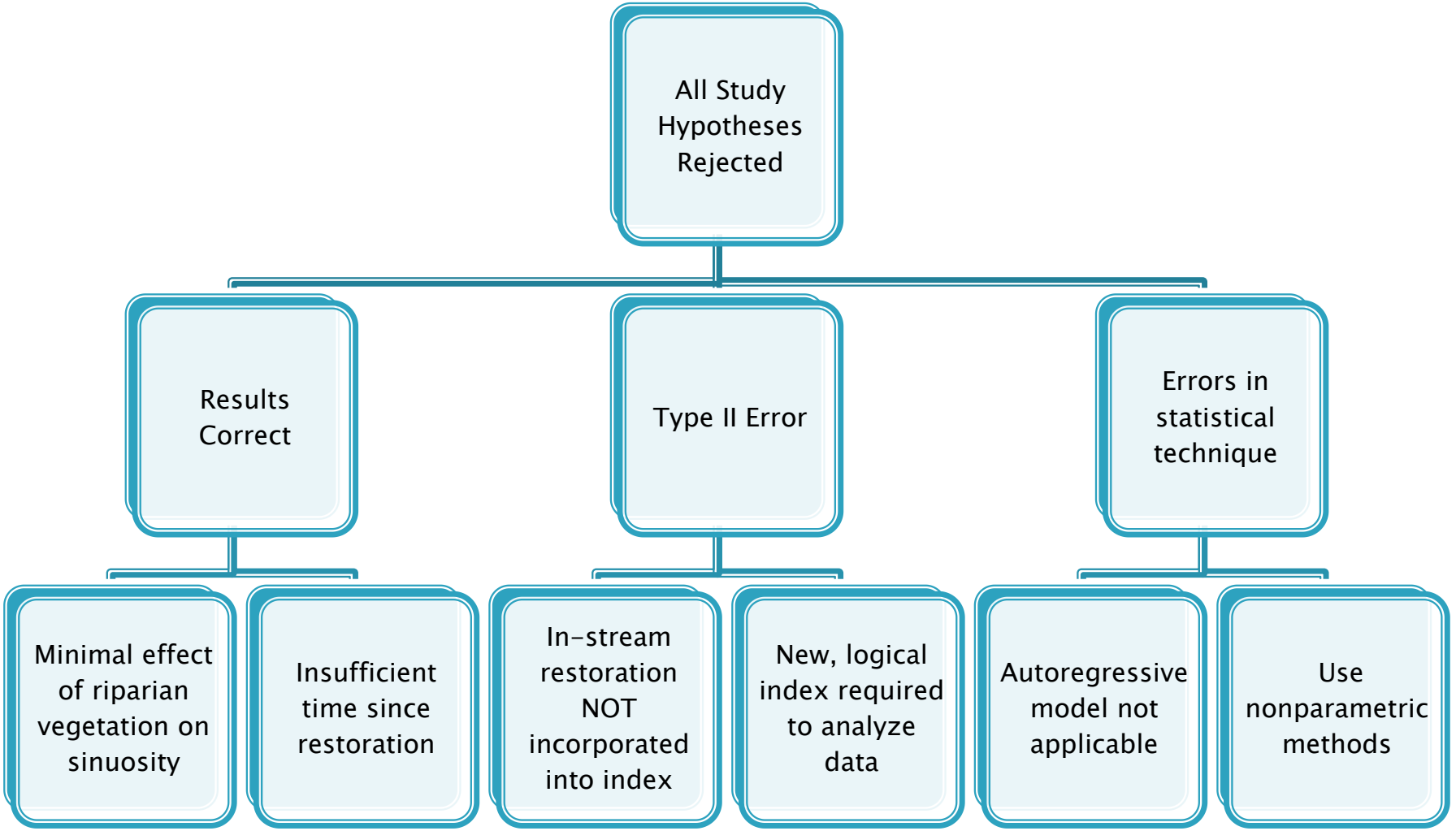
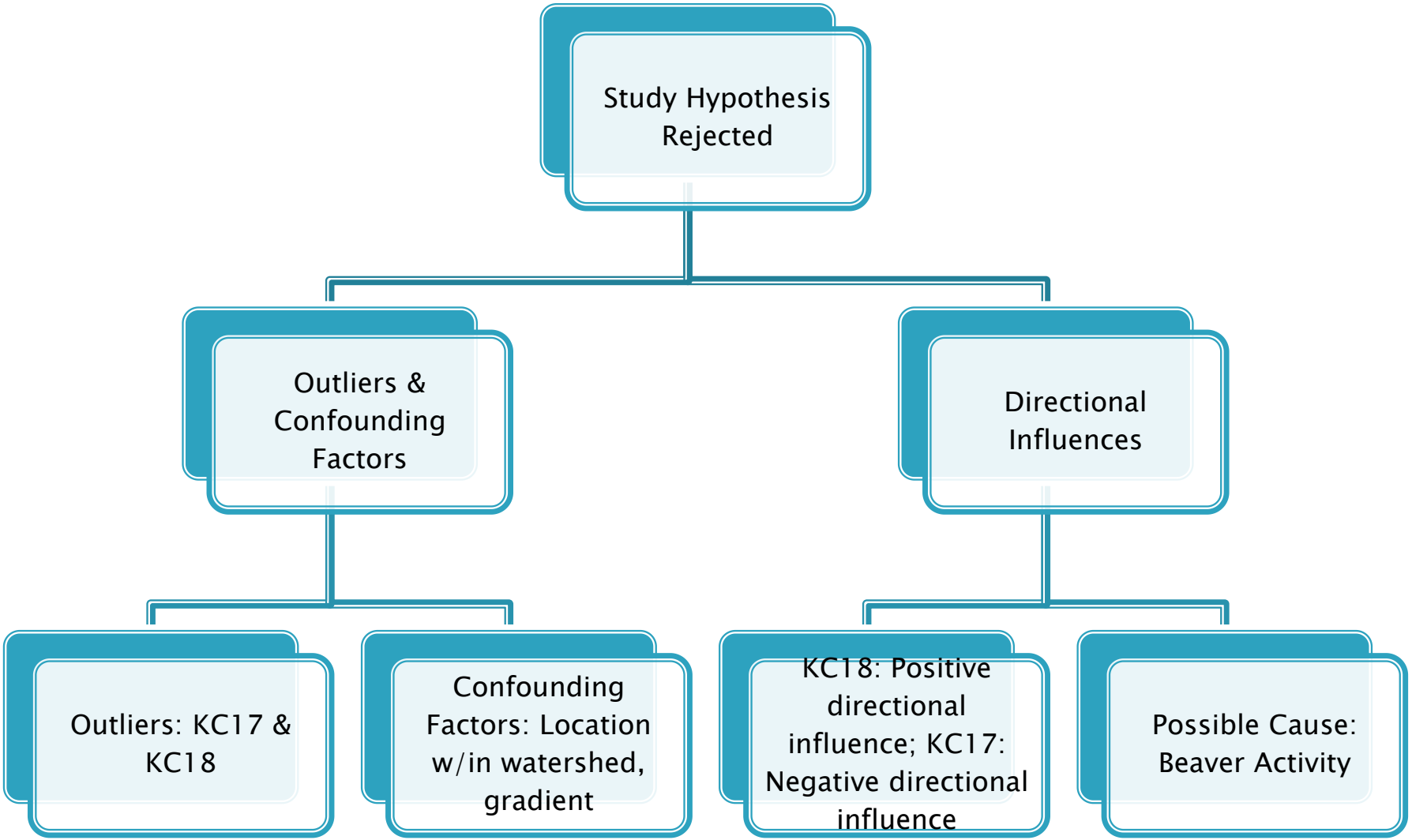
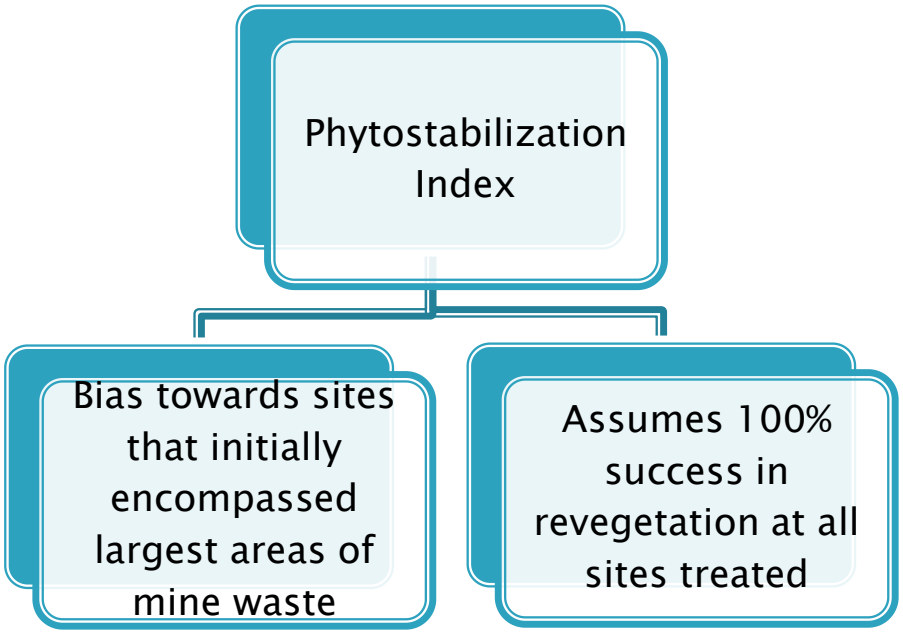
Discussion, I: ANOVA

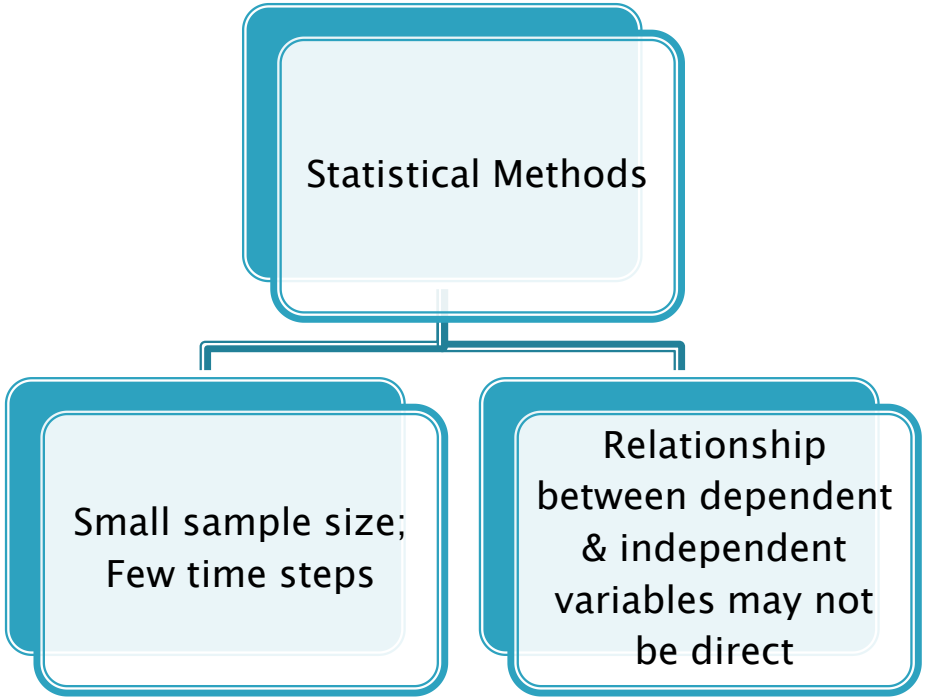


Discussion, II: Linear Regression



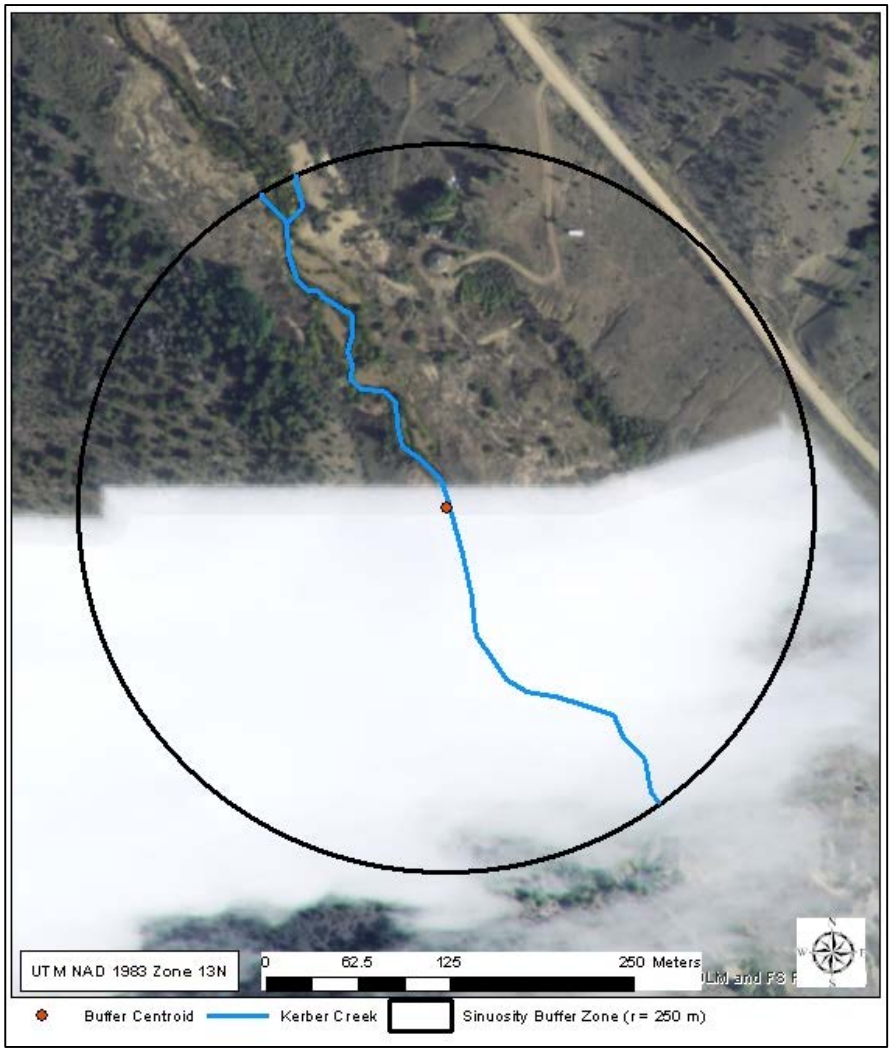
Discussion, III: Validity & Feasibility of the Study





Discussion, IV: Other Considerations

- Variable time periods since completion of restoration at each site
- Remote sensing-induced errors at KC08



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Conclusions

- Findings generally inconclusive
- Further, more rigorous data collection required
- Need to develop more accurate, quantitative measures of extent of restoration
- Need to identify appropriate statistical techniques

Squirrel Creek, 1990s

Squirrel Creek, 2013

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