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An assessment of long-term bluff recession rates in the Puget Sound and Salish Sea: implications for the prioritization and design of restoration projects

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Assessment of Bluff Recession Rates in Puget Sound

Implications for the Prioritization and Design of Restoration Projects

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Objectives

- Document the range of long-term bluff recession rates
- Explore potential drivers of long-term bluff recession using available data
- Expand foundation of bluff data at regional scale

Why?

- Limited regional data
- Shoreline development
- Perceived need for armor
- Regulations and setback distances
- Inform restoration and conservation planning
- Sea level rise

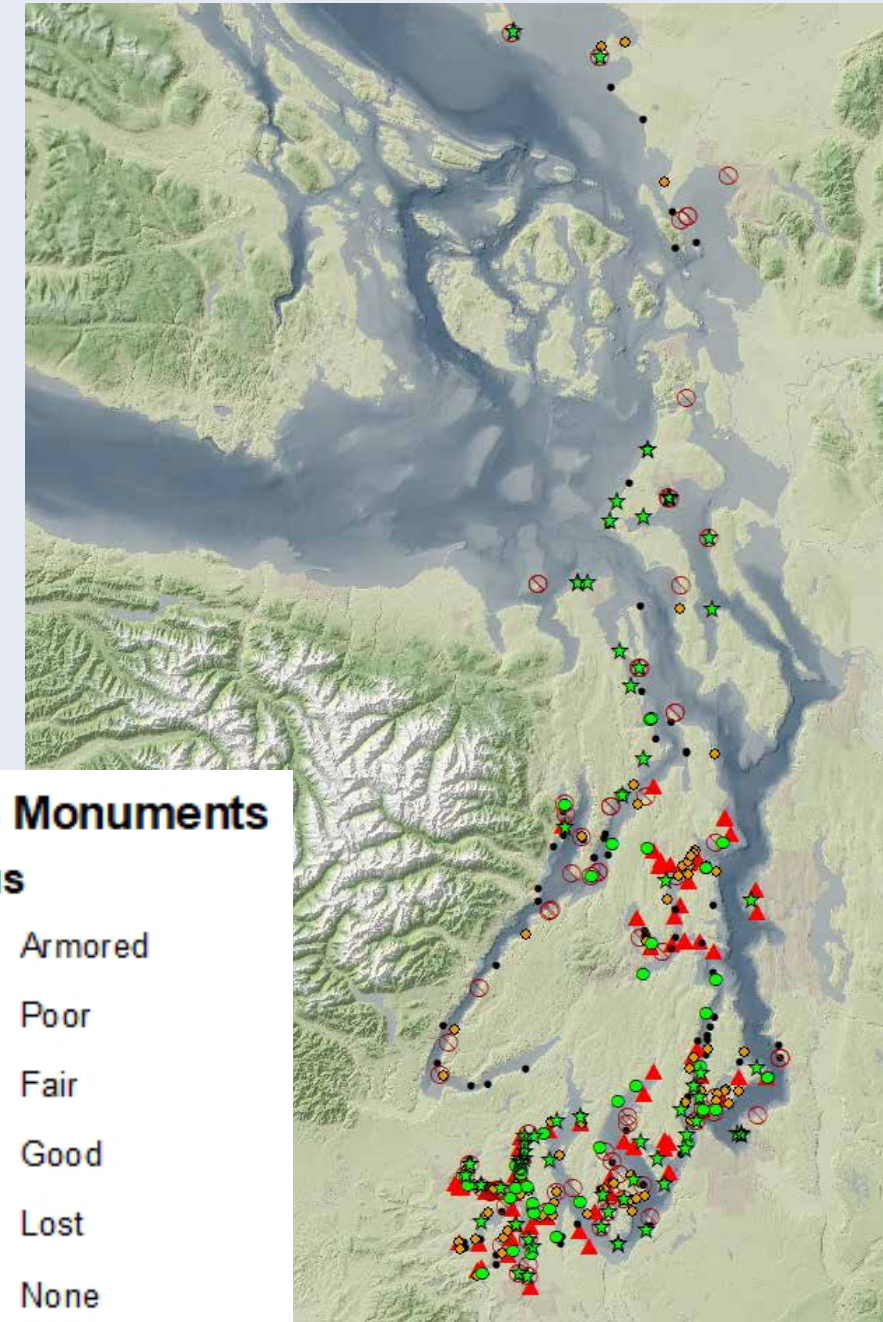
Field-based Measures (NGS)

Field-based Measures (79)

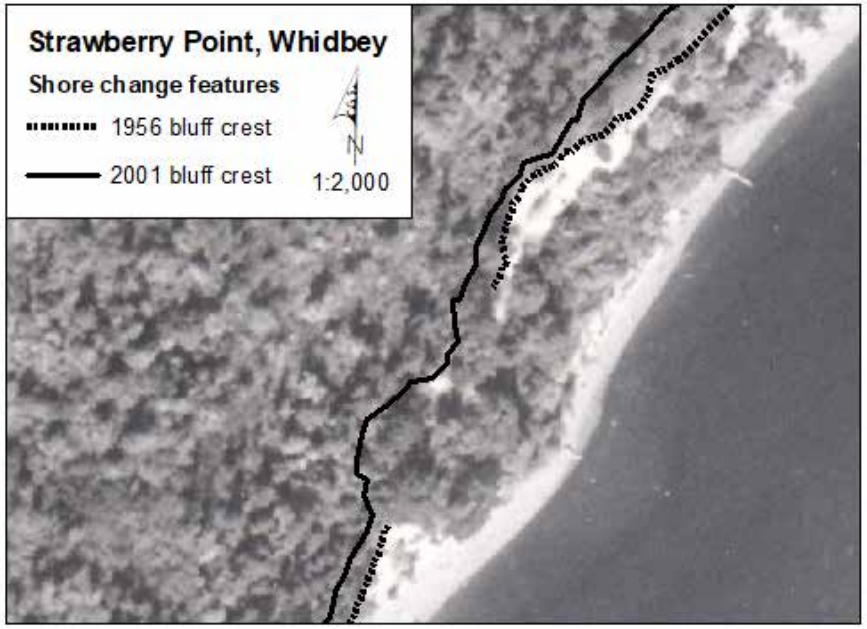
- Keuler 1979, 1988 (26)

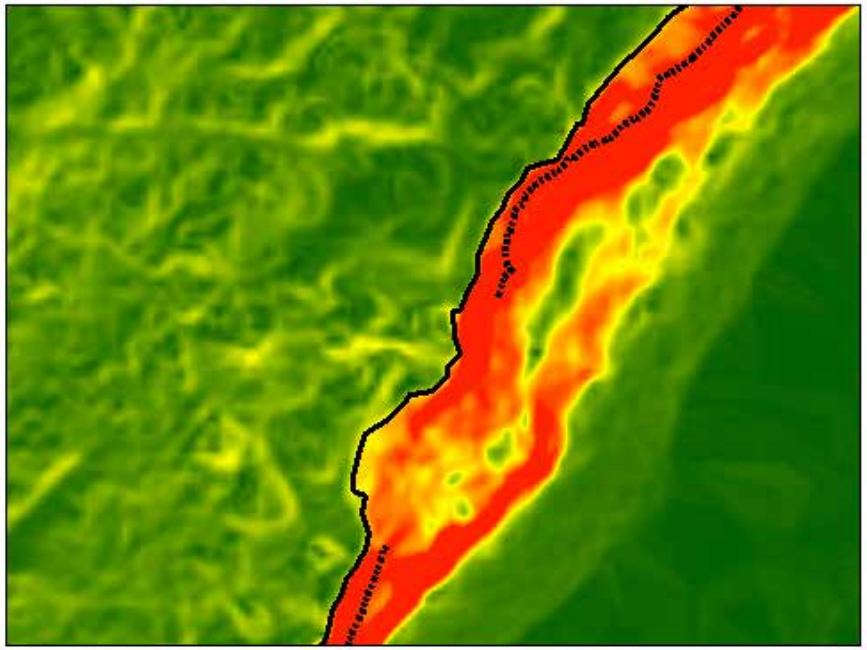
Field-based Measures (NGS)

- Explored NGS Benchmark Sheets
  - bluff or bank site
  - 1 + measured distance to feature
  - Unarmored
- Requested access



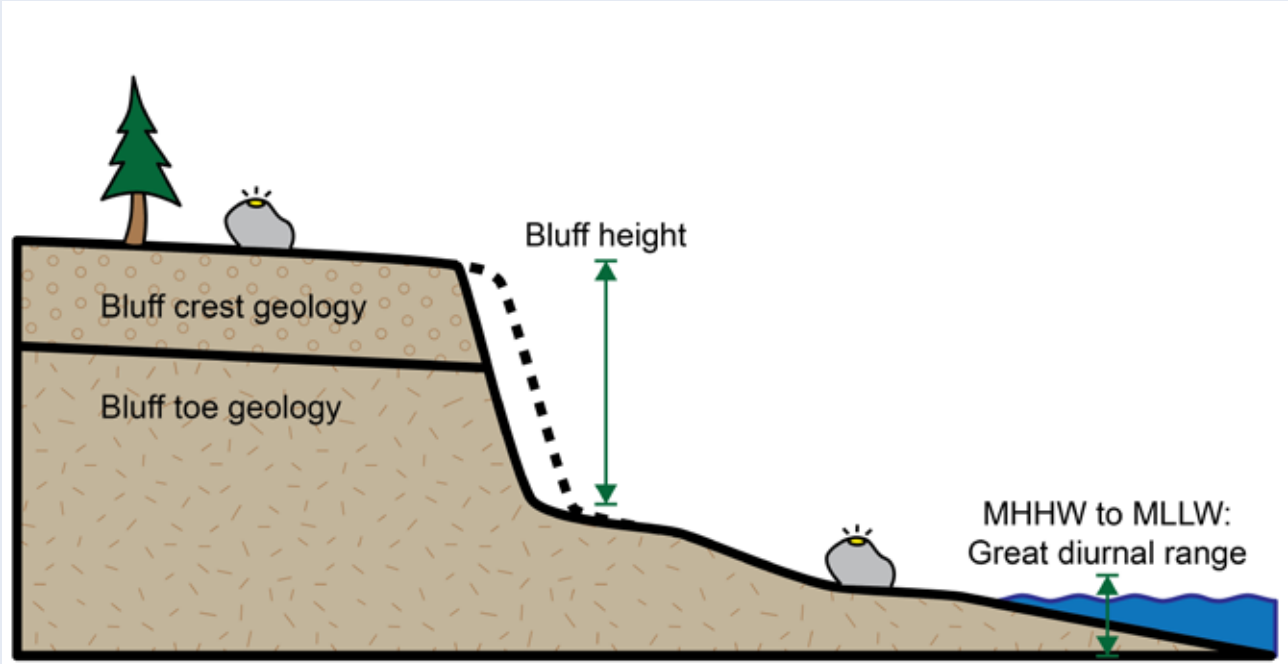
Historical Air Photo Analysis (DSAS)





- Total of 106 bluff recession sites
- Oldest, largest scale imagery
  - 6,000 - 12,000
- RMSE < 5 (average 3.3)
- Proxy with greatest certainty
- Referenced slope and DEMs
- Breaks in line where uncertain
- Digitized at 1:500 – 1:800 scale
- DSAS, 20 meter transect spacing
- Reported as EPR (negative #)

Supporting Data



- Shoretype (CGS)
- Maximum fetch
- Vertical bluff height
- Surface geology (bins)
- Toe geology (bins)
- Great diurnal (tidal) range
- Latitude
- Shore orientation (N vs S)
- Percent of drift cell downdrift of measurement location
- Beach substrate (ShoreZone)
- Vertical land movement

Puget Sound Feeder Bluff Mapping

a) Feeder bluff exceptional — Double Bluff, Island County

b) Feeder bluff — Anderson Island, Pierce County

c) Transport zone — Guemes Island, Skagit County

d) Pocket beach, San Juan County

Bluff Recession Results

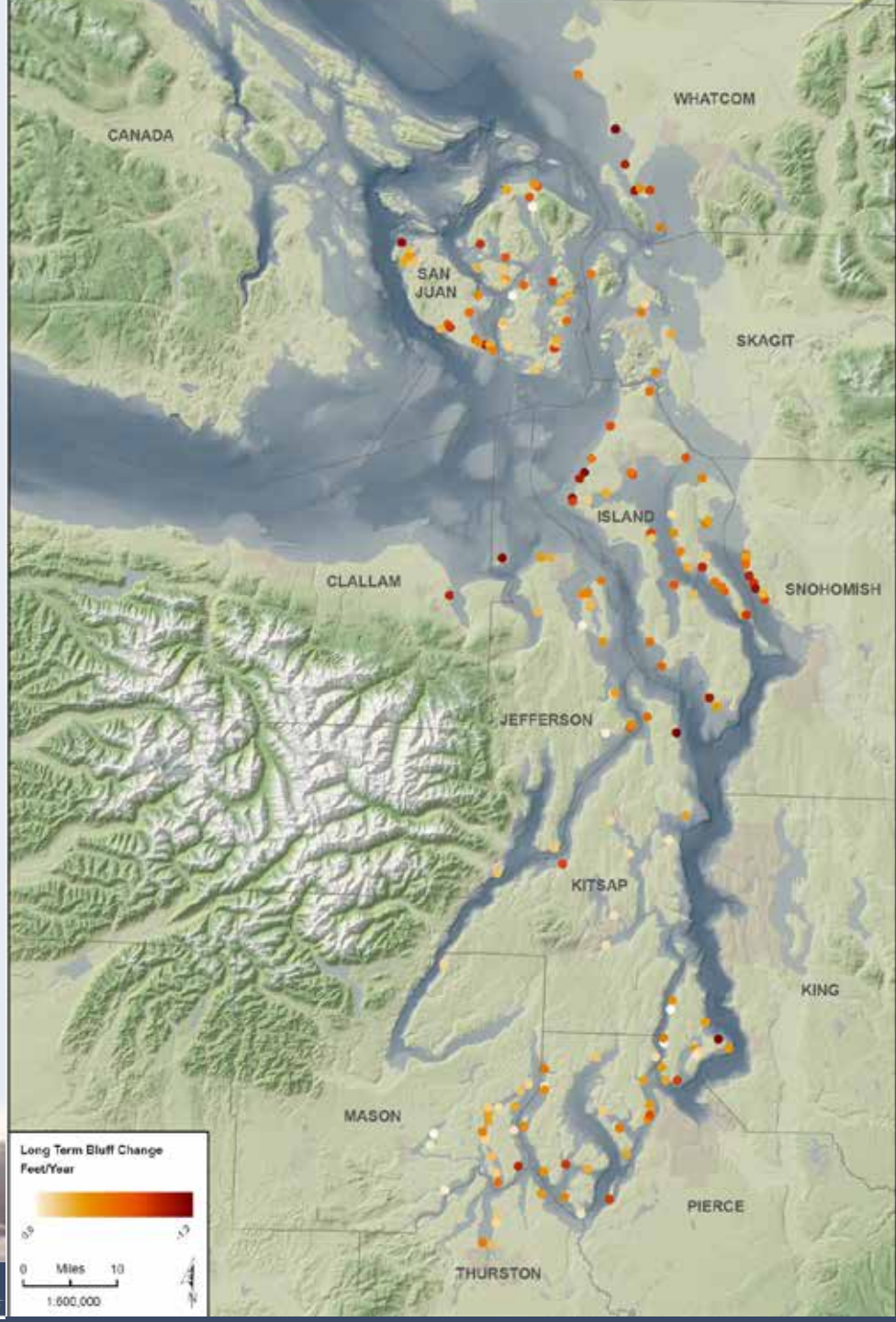
EPR = End Point Rate (average FT/year)

- Negative #s = erosion/recession
- Mean = -0.29 FT/yr
- Mode = -0.14
- Median = -0.24
- Standard deviation = 0.19
- Min = -0.98*
- Max = -0.03

Range of years = 23-101 years
Average = 44.2 years
Median = 49 years

*outliers removed

Bluff Recession in Puget Sound



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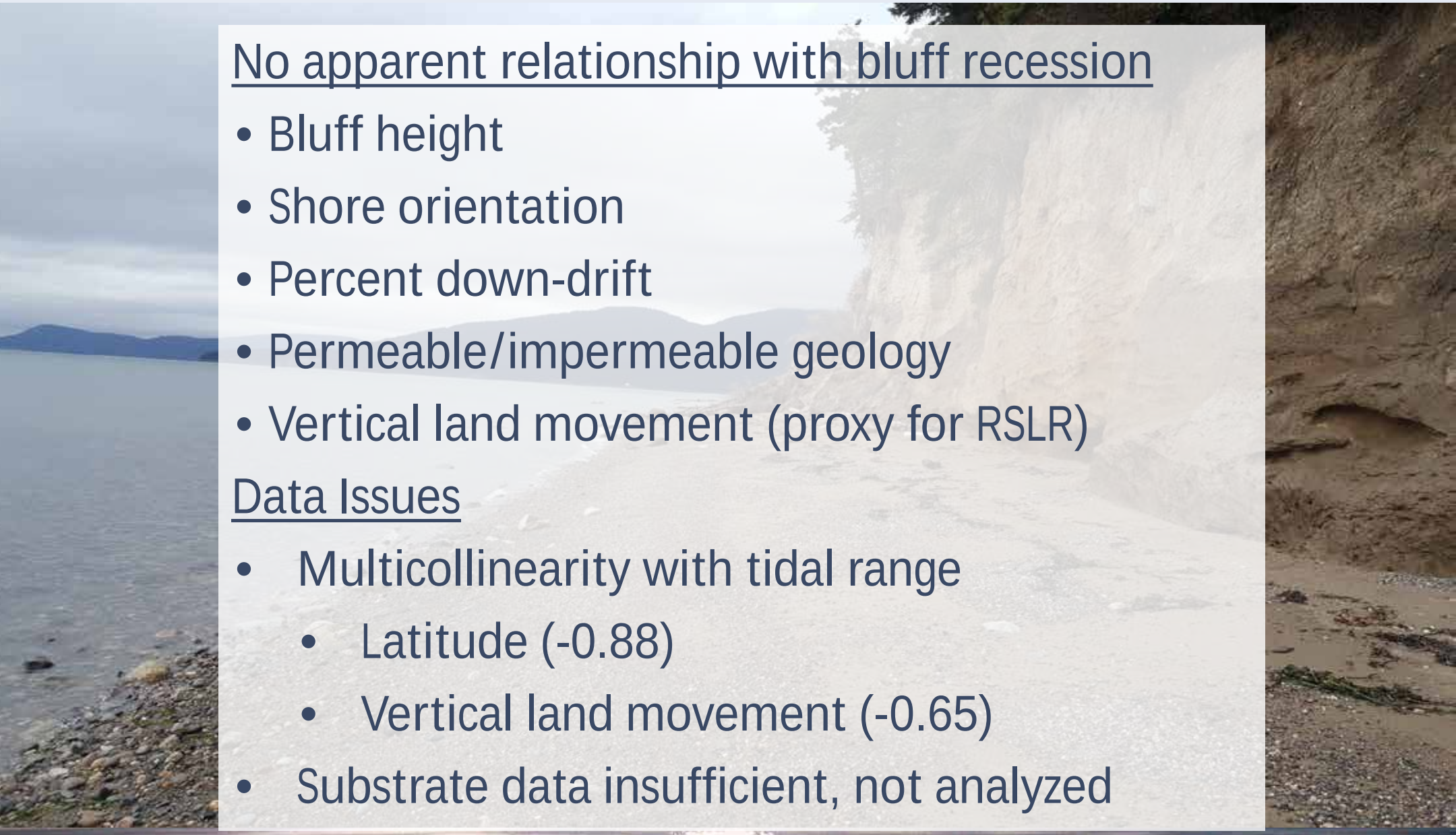
Bluff Analysis Results

The five most influential variables documented (together explaining 41.5% of variation in EPR):

- Shoretype
- Fetch
- Surface geology
- Tidal range
- Measurement feature (crest vs. toe)

EPR = End Point Rate, erosion is negative number

Bluff Analysis Results



No apparent relationship with bluff recession

- Bluff height
- Shore orientation
- Percent down-drift
- Permeable/impermeable geology
- Vertical land movement (proxy for RSLR)

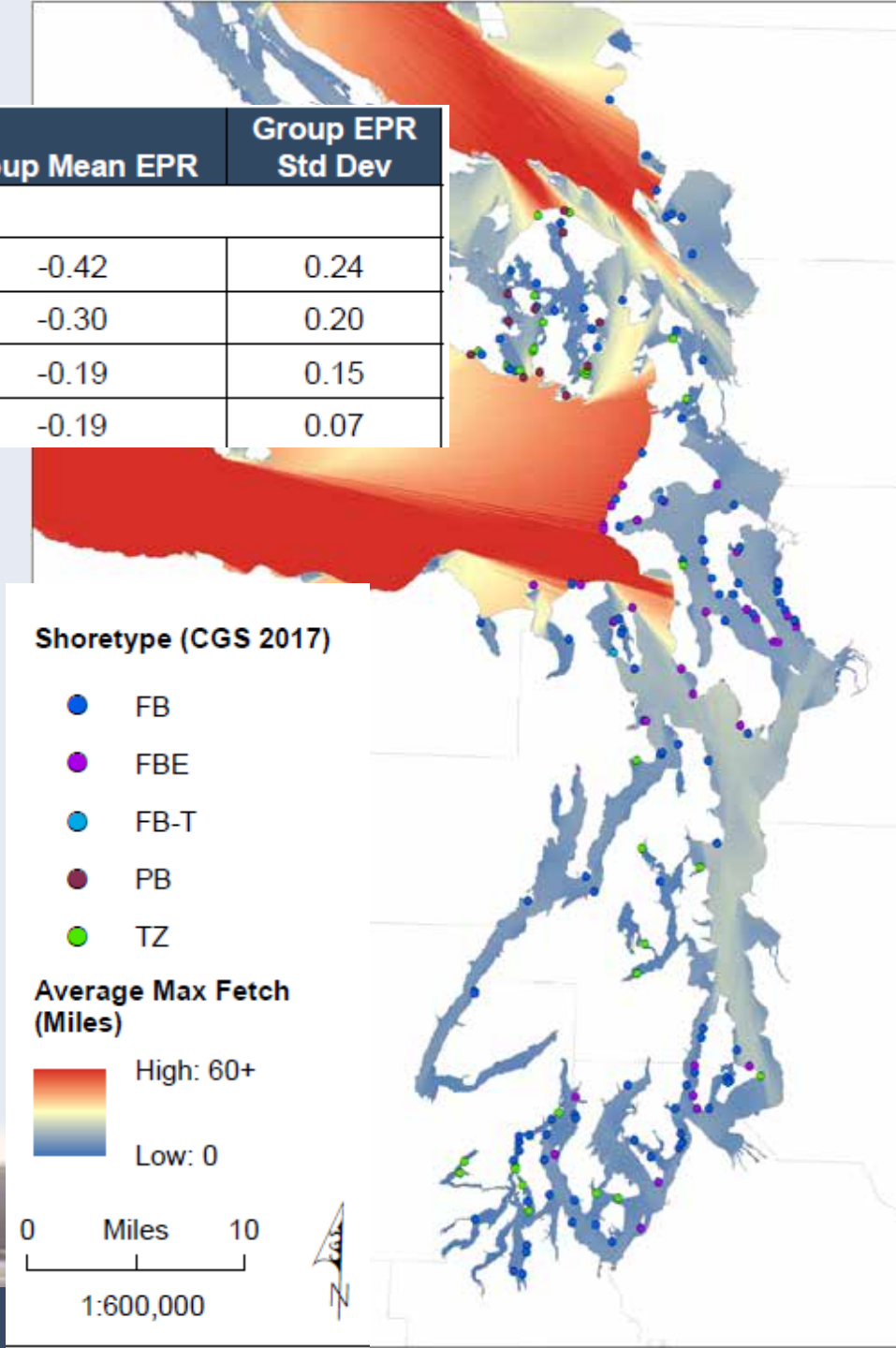
Data Issues

- Multicollinearity with tidal range
  - Latitude (-0.88)
  - Vertical land movement (-0.65)
- Substrate data insufficient, not analyzed

Bluff Analysis Results

Variable	Proportion	N	Group Mean EPR	Group EPR Std Dev
Shoretype(*)				
Feeder Bluff Exceptional	0.18	32	-0.42	0.24
Feeder Bluff	0.58	103	-0.30	0.20
Transport Zone	0.17	30	-0.19	0.15
Pocket Beach	0.08	14	-0.19	0.07

- Bluff recession rates of FBEs/FBs/TZs shoretypes area significantly different
- Transport zones and pocket beaches are not significantly different
- With every 2 mile increase in fetch bluff recession rates increase by 0.01 FT/Year (p=0.000)

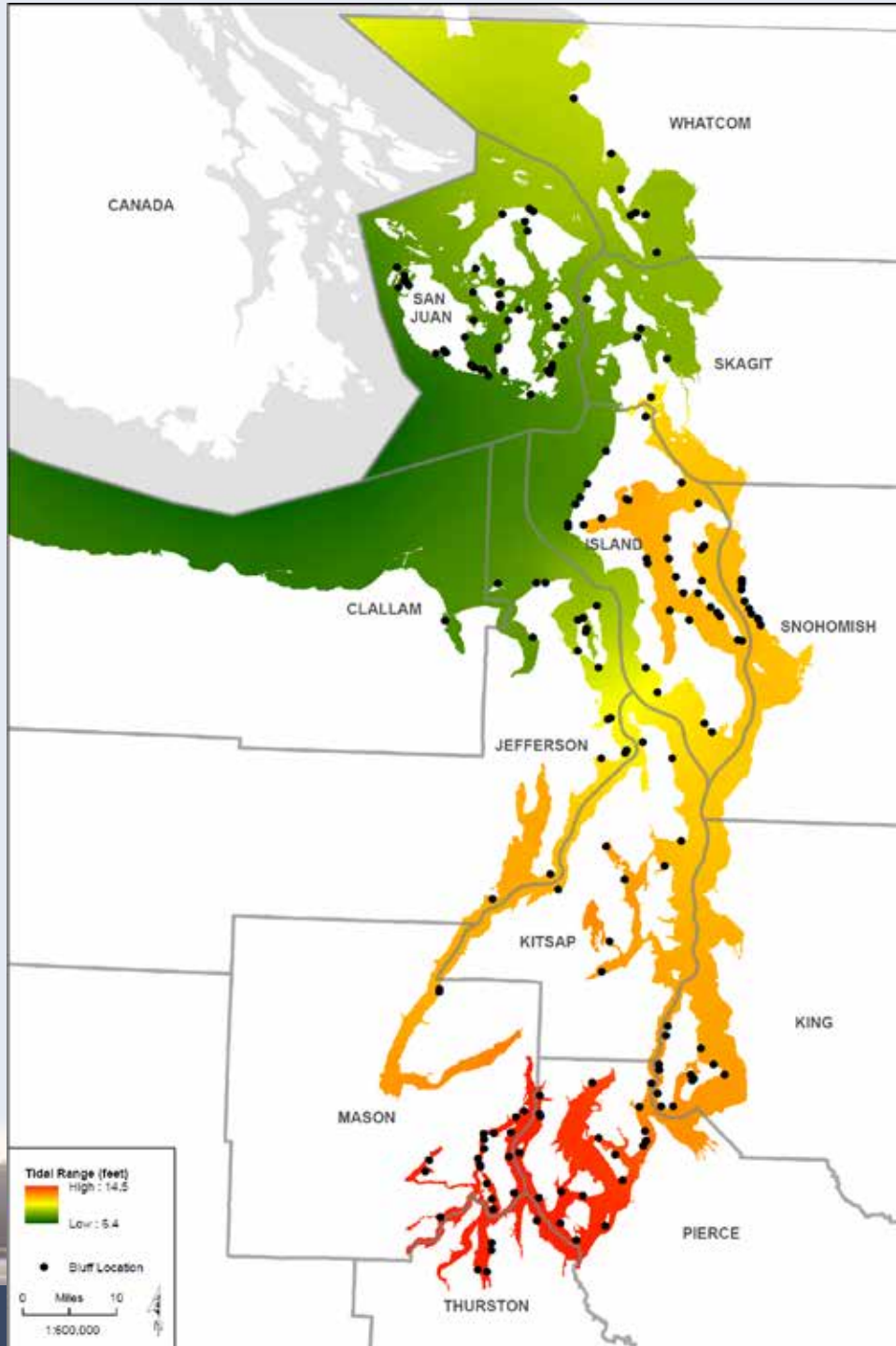


Bluff Analysis Results

- Till bluffs had more rapid recession than bluffs mapped as advance outwash sands
- No difference between bluffs with glaciomarine drift and Pre-Fraser deposits

Bluff Analysis Results

- Bluff recession is slower in areas with greater tidal range
- Average tidal range was 10.58 ft (ranged from 6.98-14.53 ft)
- With every 1 ft increase in tidal range is associated with an 0.02 FT/Year decrease in bluff recession



Bluff Recession in Puget Sound

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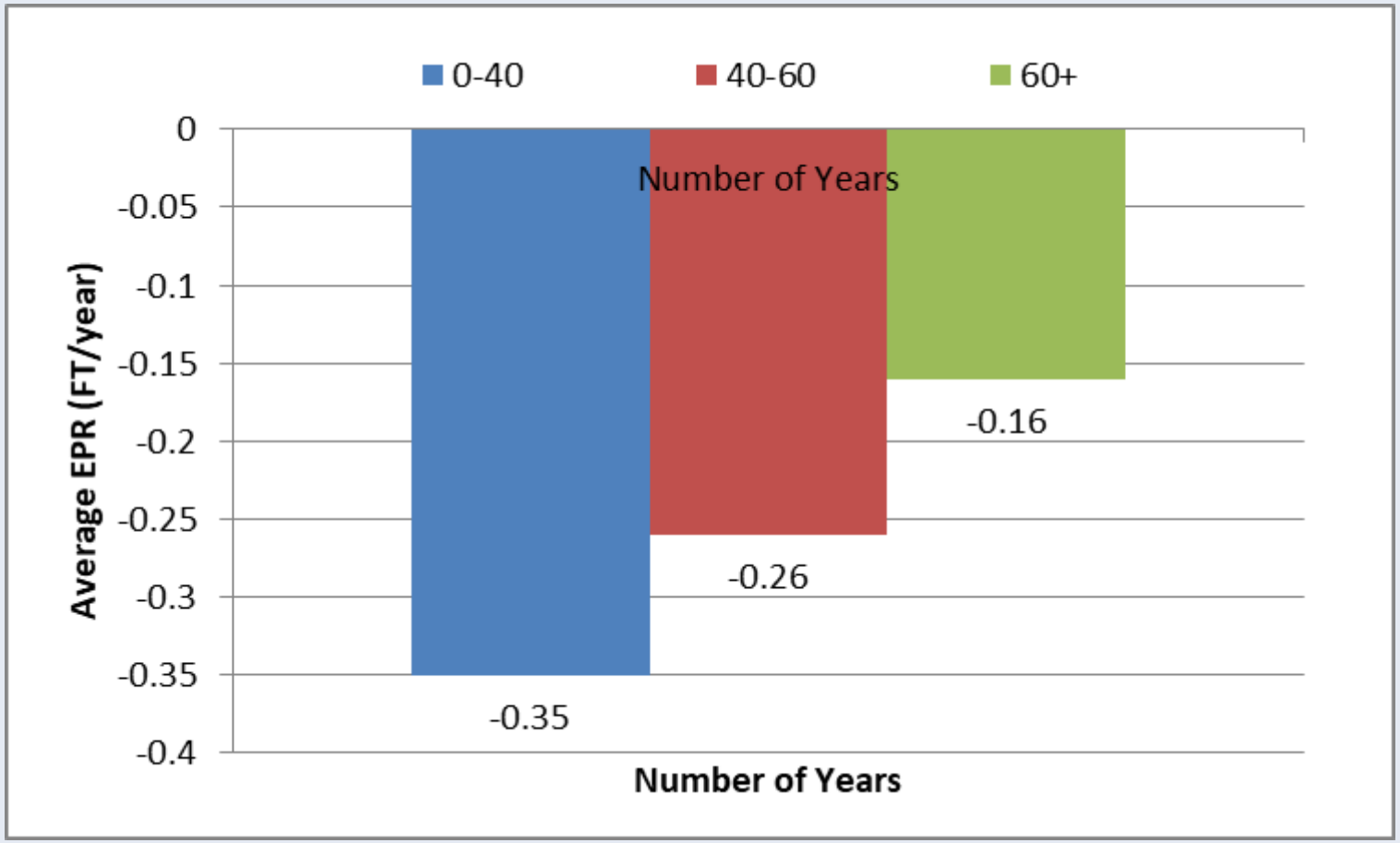
Bluff Recession Over Time



- The longer the measure the slower the long-term recession rate
- Are change events becoming more frequent?

Bias, Uncertainty, and Error

Together the inherent bias and uncertainty lead bluff recession estimates to be ***skewed toward more rapid erosion***

Cumulative Error Calculation

Types of error: image distortion (historic and current imagery), digitization errors, LiDAR resolution, georectification error (RMSE)

Mean annualized error range: 0.14 – 0.43 FT/year

Utility of Data

- Better understand range of long-term erosion rates
- Better management: better setback distances
- Restoration and Conservation planning
- SLR planning: accelerated bluff recession rates
- Geodatabase for spatial analysis

Next Steps

- Integrate additional measurements
- Pair with new data
  - USGS wave modeling
  - Beach topography (LIDAR)
  - Higher resolution substrate/stratigraphy
  - Storm event data
- Look at decadal trends from sample of sites
- Compare armored versus unarmored bluffs
- Causation and predictive modeling

Questions?

Final report available on Salish Sea Wiki