AOS DESIGN OPTIMIZATION: RAPID HABITAT ASSESSMENT

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1 BACKGROUND AND GOALS

1.1 Description of sample design and available data

Rapid Habitat Assessments are conducted annually, during baseflow conditions, at stream sites as part of the Stream Morphology Map (DP4.00131.001) data product. The protocol consists of two components: a habitat survey and a pebble count.

The habitat survey is conducted along the full NEON aquatic reach, typically 1,000 m. During the survey, each habitat unit is identified and measured, and GPS coordinates are recorded at the downstream end (tail) of each unit. For each habitat unit, several attributes are measured, including width, depth, dominant substrate, and percent riparian cover. The pebble count survey is conducted at five pre-established cross-sectional transects along the reach. At each transect, 40 measurements are collected, for a total of 200 measurements per bout. At each point, substrate size is measured using a gravelometer.

Rapid Habitat Assessment data are available in three tables within the Stream Morphology Map data product:

- **geo_rapidHabitatAssessment** – Contains habitat survey data, with one record per habitat unit.
- **geo_pebbleCount** – Contains individual pebble count measurements (200 total per bout).
- **geo_pebbleFieldData** – Contains processed pebble count metrics, including D_5, D_{16}, D_{50}, and D_{84} values, with one record per bout.

1.2 Analytical Goals

The purpose of this analysis is to evaluate whether NEON should continue implementing the Rapid Habitat Assessment protocol. If continuation is warranted, the analysis will also identify the optimal frequency of assessments and determine whether the sampling effort within each assessment can be reduced while maintaining data quality and utility.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Reference Documents

RD[01]	NEON.DOC.001152	NEON Aquatic Sampling Strategy
RD[02]	NEON.DOC.003162	AOS Protocol and Procedure: Wadeable Stream Morphology

2.2 Acronyms

Acronym	Definition
NEON	National Ecological Observatory Network
AOS	Aquatic Observation System
m	Meter
GPS	Global positioning system
IQR	Interquartile range
CV	Coefficient of variation

3 METHODS AND RESULTS

3.1 Methods

The analysis was performed using the NEON Stream Morphology Map (DP4.00131.001) data from RELEASE-2026 (data collected through 2024) and provisional data collected in 2025. The data were downloaded using the neonUtilities R package.

3.1.1 Habitat composition and pebble count variability

The proportional habitat composition was calculated for each sampling event. Data were then transformed using a centered log-ratio transformation. Temporal changes in habitat composition were calculated within each site using Aitchison distance, where larger values indicate greater changes in habitat composition through time. Cumulative particle size distributions were constructed for each site and year. The median particle size (D_{50}) was estimated via linear interpolation of the cumulative frequency curve. Temporal site-level variability was quantified for both Aitchison distance and D_{50} using the robust coefficient of variation (CV).

3.1.2 Evaluation of sampling frequency

To evaluate whether sampling frequency could be reduced, a subsampling approach was used to compare annual and biennial sampling scenarios. For both habitat composition and pebble count data, year-to-year changes were calculated separately for odd- and even-year subsets. Absolute differences between odd- and even-year estimates were summarized across sites to quantify the potential error introduced by biennial sampling.

3.1.3 Evaluation of reduced sampling intensity

To assess whether sampling effort within pebble counts could be reduced by sampling fewer transects per bout, a Monte Carlo subsampling approach was implemented. Transects were repeatedly resampled from the full dataset to simulate surveys with fewer transects. This was done with subsets of both three and four transects. Relative error was computed as the absolute percent difference between the subsampled and full-sample D_{50} estimates.

3.2 Results

3.2.1 Temporal variability in habitat composition

Habitat composition exhibited substantial year-to-year variability across most sites (Figure 1). Stacked bar plots of habitat proportions showed noticeable shifts in dominant habitat types between years at many locations, while some sites remained relatively stable. This variability was quantified using Aitchison distance between consecutive years. Distributions of site-level Aitchison distances (Figure 2) indicated considerable temporal variability, with a median within-site robust coefficient of variation (CV) of 61%.

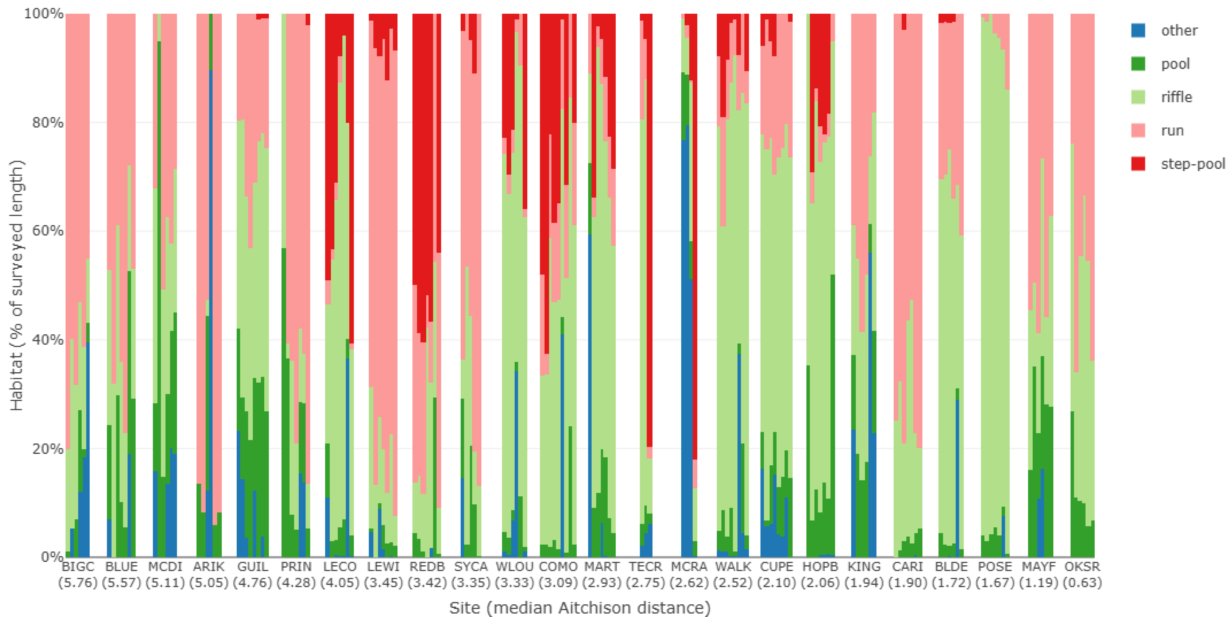

Figure 1: Habitat composition percentages at each site and bout. Within each site, the individual bars are ordered chronologically with the earliest bout on the left and most recent on the right. Sites are ordered by their median Aitchison distance, with the most temporal change on the left and least change on the right.

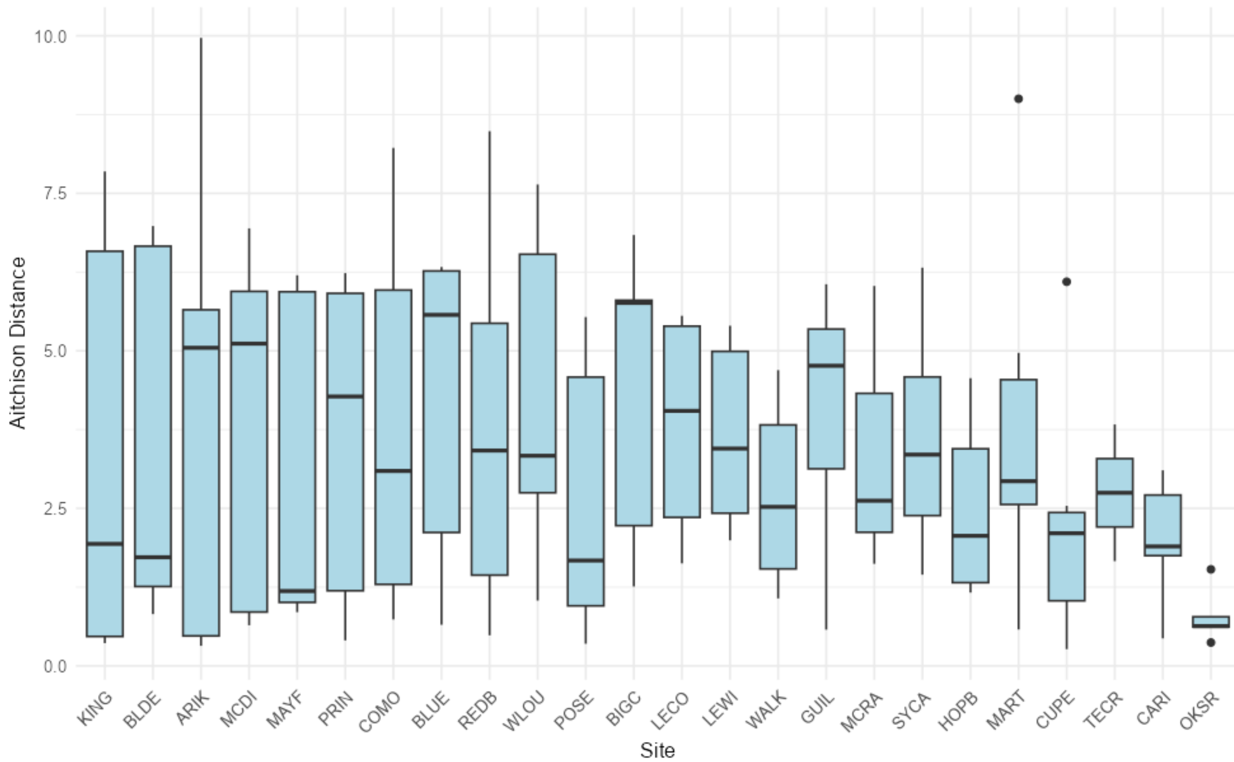

Figure 2: The distribution of Aitchison distance values at each site. Sites are ordered by descending IQR.

3.2.2 Temporal variability in substrate size distributions

Pebble count data also showed temporal variability, though generally less pronounced than habitat composition. Cumulative particle size distributions revealed visible differences among years at many sites (Figure 3), while some sites exhibited relatively consistent distributions over time.

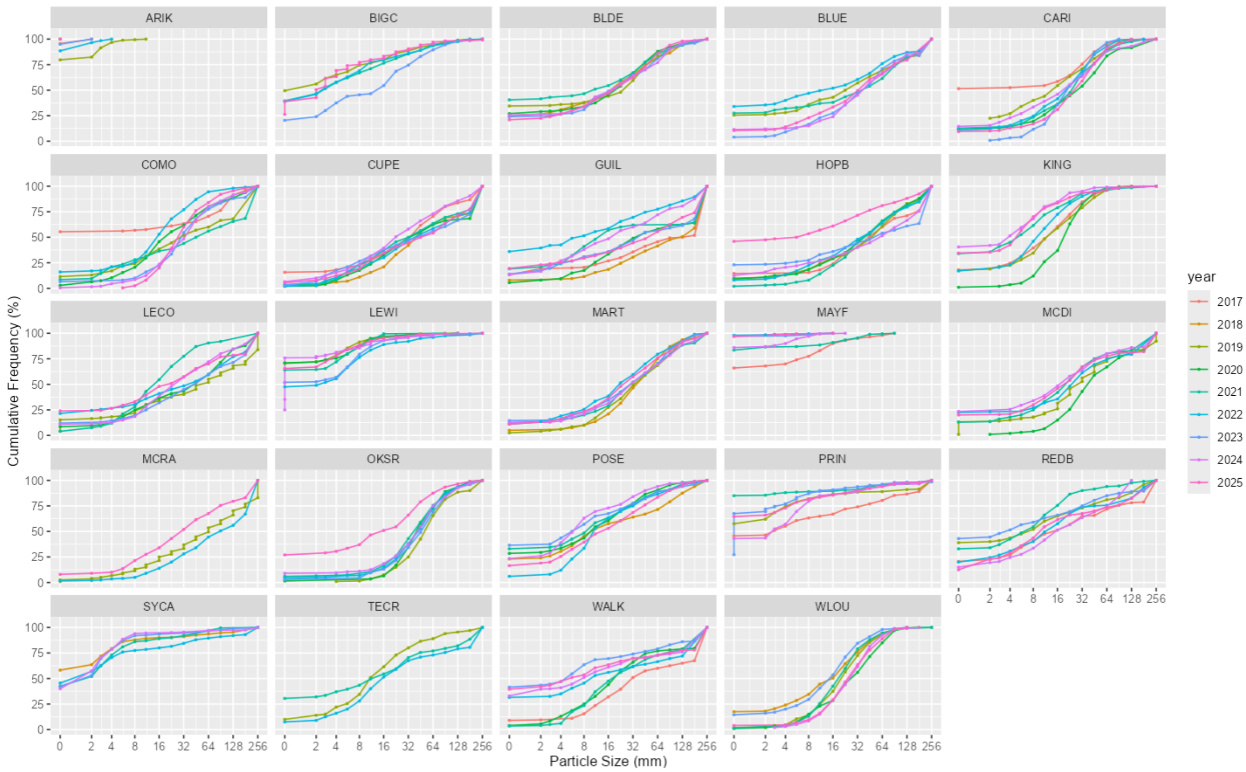

Figure 3: Cumulative particle size distributions at each site.

Site-level distributions of median particle size (D_{50}) (Figure 4) showed that the median within-site robust CV was 15%, indicating moderate variability in substrate size compared to habitat composition. Interquartile ranges (IQRs) further demonstrated that variability differed among sites, with some exhibiting stable sediment regimes and others showing substantial fluctuations.

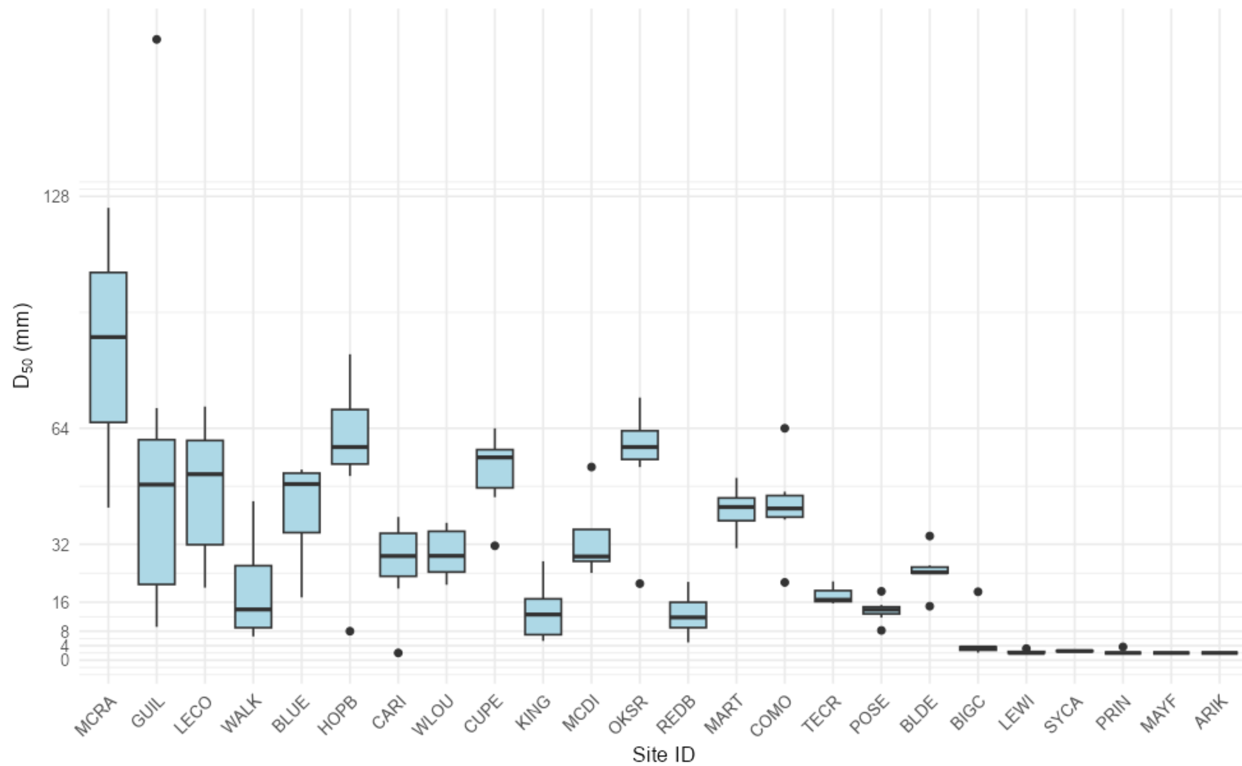

Figure 4: Distribution of the D_{50} (median particle size) values at each site. Sites are ordered by descending IQR.

3.2.3 Effects of reduced sampling frequency

Comparisons of annual versus biennial sampling indicated that reducing sampling frequency would substantially affect the ability to characterize temporal variability. For habitat composition, comparisons of median year-to-year Aitchison distance calculated from odd- versus even-year subsets showed substantial deviations from the 1:1 line (Figure 5). Absolute differences between subsets were large: half of the sites differed by more than 58 percentage points, and a quarter of the sites differed by more than 128 percentage points. These results indicate that estimates of temporal change are highly sensitive to sampling year.

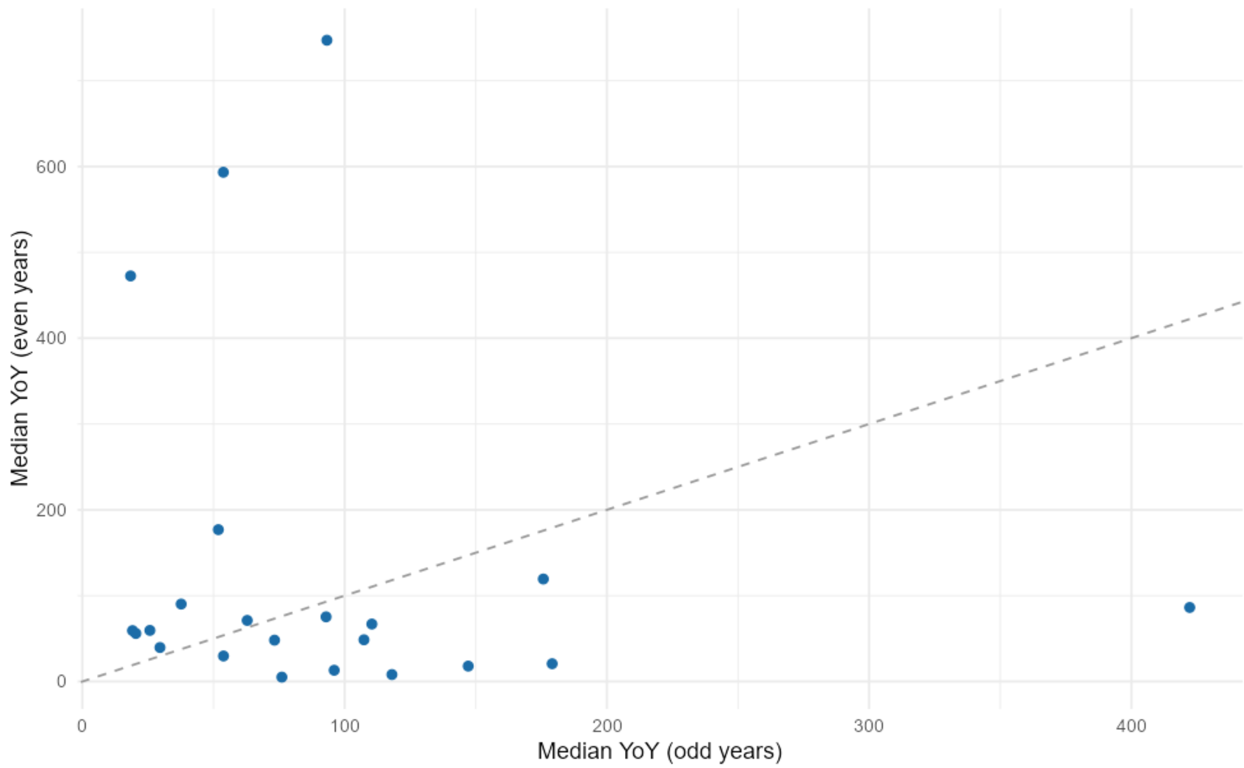

Figure 5: Median habitat year-over-year Aitchison Distances for odd- vs even-year subsamples at each site.

Similarly, for pebble count data, odd- versus even-year comparisons of D_{50} variability also deviated from the 1:1 relationship (Figure 6), although differences were smaller than for habitat composition. Half of sites showed differences greater than 19 percentage points, and a quarter exceeded approximately 30 percentage points. Together, these findings suggest that biennial sampling would introduce substantial uncertainty and could lead to inconsistent conclusions depending on the sampling years selected.

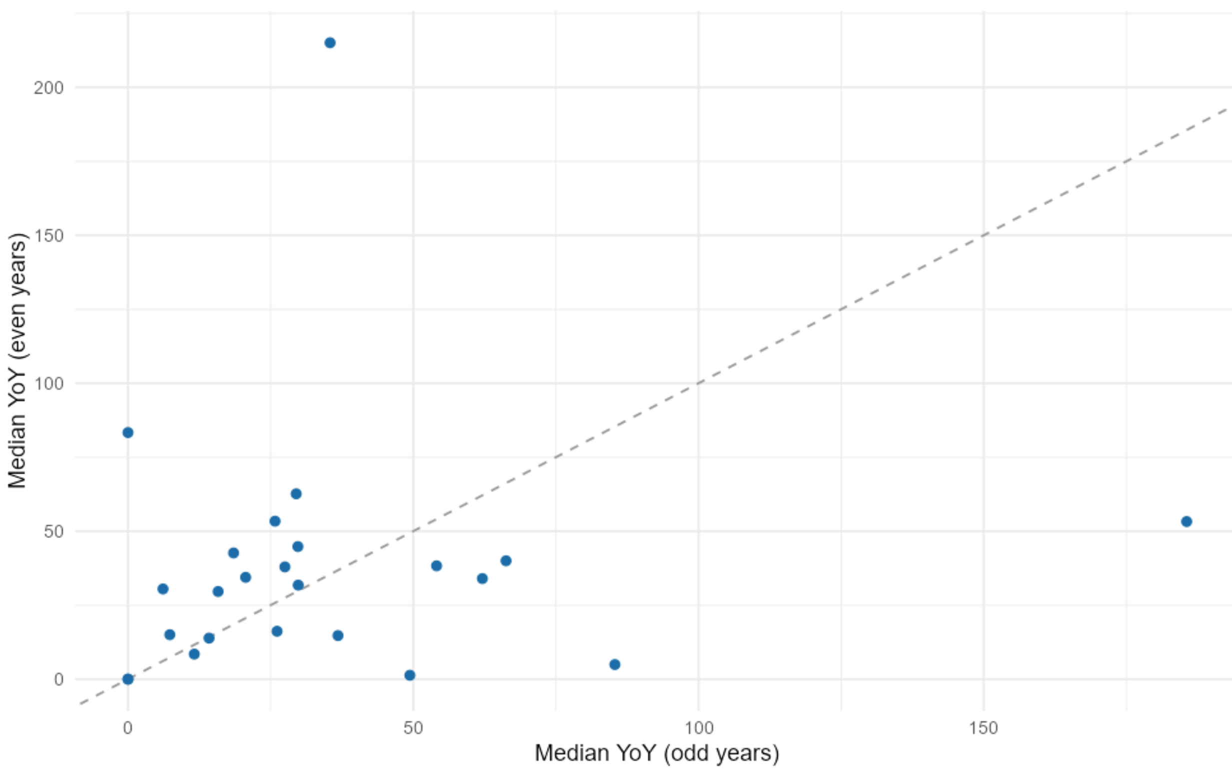

Figure 6: Median pebble count year-over-year D_{50} differences for odd- vs even-year subsamples at each site.

3.2.4 Effects of reduced sampling intensity

Monte Carlo subsampling analyses were used to evaluate the effects of reducing the number of pebble count transects per bout. Reducing sampling effort from five to three transects resulted in relatively small errors in D_{50} estimates for many sites (Figure 7). Across all sites, 25% had relative errors less than 2%, and 50% had less than 3.5%, although a minority of sites exhibited substantially larger errors. Reducing from five to four transects produced even smaller errors (Figure 8), with most sites showing less than 10% relative error and half showing less than 1.6% error. This suggests that four transects generally provide estimates of D_{50} close to those obtained from the full sampling design.

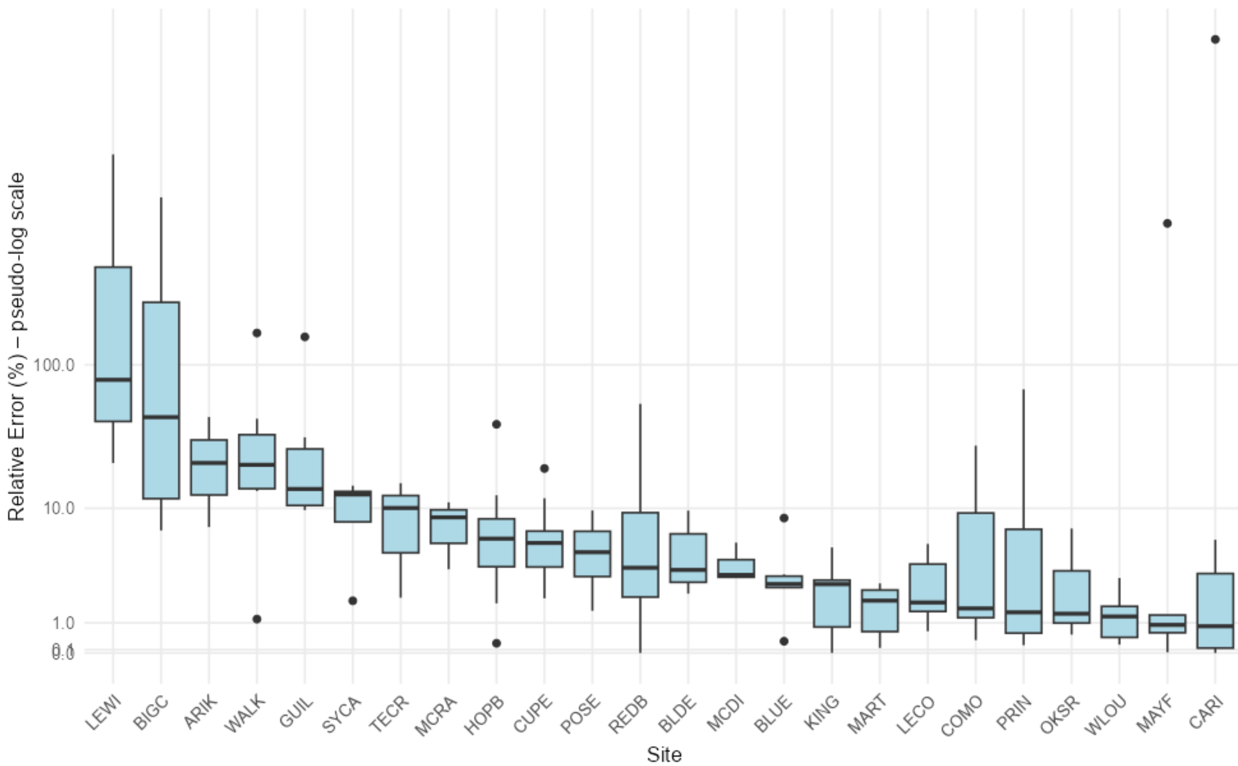

Figure 7: Relative error in estimates of D_{50} between subsets of 3 transects and all 5 transects. Sites are ordered by descending median relative error.

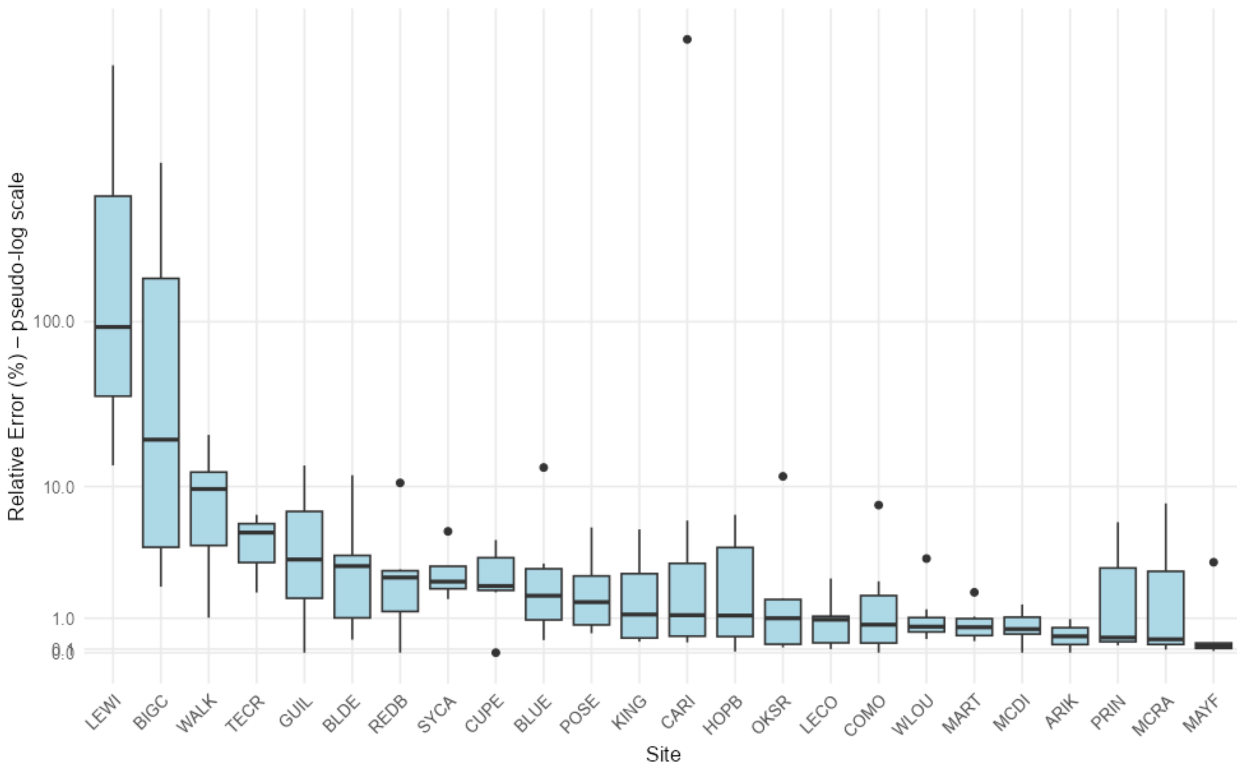

Figure 8: Relative error in estimates of D_{50} between subsets of 4 transects and all 5 transects. Sites are ordered by descending median relative error.

4 DISCUSSION

This study evaluated the temporal consistency and sampling design of NEON's Rapid Habitat Assessment protocol, with the goal of determining whether the protocol should be maintained and whether efficiencies could be achieved without compromising data quality. Overall, the results demonstrate that both habitat composition and substrate size exhibit meaningful temporal variability across sites, with important implications for sampling frequency and intensity.

4.1 Temporal variability and ecological interpretation

Habitat composition showed substantial year-to-year variability at most sites, as evidenced by high Aitchison distances and a median robust CV of approximately 60%. This level of variability suggests that stream habitat structure is dynamic over annual timescales. Such dynamics are likely driven, in part, by hydrologic variation, as changes in baseflow conditions and water level can shift habitat types (e.g., runs may transition to riffles at lower water levels), and alter their relative abundance. In addition, some degree of variability may reflect observer subjectivity inherent in field-based habitat classification.

Pebble count data exhibited lower, but still notable, temporal variability. Median particle size (D_{50}) was relatively stable at many sites resulting in a median robust CV of 15%. However, the presence of substantial variability at some sites indicates that sediment regimes can change meaningfully on annual timescales.

Together, these findings indicate that the Rapid Habitat Assessment captures ecologically relevant temporal dynamics in both channel structure and substrate composition. Importantly, the observed variability suggests that single-year measurements may not be representative of longer-term conditions, reinforcing the value of repeated observations.

4.2 Implications for sampling frequency

The comparison of annual and biennial sampling scenarios provides strong evidence that reducing sampling frequency would compromise the reliability of the dataset. For both habitat composition and pebble count metrics, estimates derived from odd- and even-year subsets differed substantially at many sites. In particular, habitat-based metrics showed very large discrepancies, with many sites exhibiting differences exceeding 50 percentage points. These results indicate that temporal variability is not reliably captured at a biennial interval. Thus, conclusions would depend heavily on which years happened to be sampled, which strongly supports the continuation of annual sampling. Maintaining annual observations allows for more accurate characterization of both short-term dynamics and longer-term trends, and reduces sensitivity to interannual variability. Additionally, the habitat survey may serve as an early indicator of system change, potentially informing decisions about when to conduct the full Wadeable Stream Morphology protocol.

4.3 Implications for sampling intensity

Opportunities for reducing habitat survey sampling intensity are limited. Most field effort is spent traversing the reach and delineating habitat units, which is fundamental to the protocol and cannot be reduced without altering its core purpose. Furthermore, collection of ancillary measurements within each habitat unit (such as wetted width, depth, and percent riparian cover) requires relatively little additional time. Eliminating or simplifying these measurements would provide minimal efficiency gains while reducing the overall value of the dataset.

A greater opportunity exists for reducing pebble count survey sampling effort. Monte Carlo subsampling analyses demonstrated that, for many sites, reducing from five transects to three or four resulted in relatively small errors in median particle size. However, these results should be interpreted with caution. First, the analysis focused on D_{50}, which is a central tendency metric and less sensitive to sample size than distribution tails. Lower-percentile metrics (e.g., D_5 and D_{16}) are more sensitive to sampling effort, and reductions in the number of measurements would likely increase uncertainty in these values (Rice and Church 1996). Second, while average errors were small, error distributions were skewed, with a subset of site-years exhibiting large deviations. These outliers may correspond to sites with uneven spatial distribution of sediment sizes, where reduced sampling could lead to biased estimates. Finally, the practical benefits of reducing pebble count sampling intensity appear limited. Field time associated with individual transects is relatively small (~30 minutes per transect), and reducing the number of transects would yield only modest time savings. Given the tradeoff between minor efficiency gains and potential increases in uncertainty, maintaining the current sampling design is preferable for consistency and data quality.

5 RECOMMENDATIONS

Recommendations are summarized as follows:

- Continue Rapid Habitat Assessment sampling without modification.
- Increase visibility by separating Rapid Habitat Assessment data from the Stream Morphology Mapping data product and creating a standalone data product.
- Create a standalone Rapid Habitat Assessment protocol by extracting relevant components from the Wadeable Stream Morphology protocol.

6 REFERENCES

Rice, S. and M. Church. 1996. Sampling surficial fluvial gravels; the precision of size distribution percentile sediments. Journal of Sedimentary Research 66(3):654-665.