SIEN Merced Riverbank Study: Power Analysis

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Introduction

This study aims to estimate tradeoffs between site level measurement intensity and precision of site level and reach level metric estimation, for metrics included in the SIEN Merced Riverbank Study. Analysis of existing GRTS sample data from a reach of the Merced river suggests that when reach level estimates are of interest, there is very little improvement in precision of estimates when increasing sub-site sampling intensity beyond about 20 transects per bank per site, or beyond about 10 locations per transect. Changes in the total number of sites sampled will always have an effect on the precision of reach level estimates.

Thirteen metrics (see list, below) have been assessed for 24 sites along the Merced River as part of the SIEN Merced Riverbank Study. The 24 sites were selected by a GRTS sampling design, with two stratifications included in the design. Measurements at each site were conducted in 2010.

Within each site sampled, assessment of each metric at each site is made by taking a large number of transects, at both river banks, at each site; and assessing the metric at a large number of points within each transect. At the site level, the metric estimates describe the proportion of each site that falls into the metric category. At each point along each transect, each metric is evaluated as either present (1) or not-present (0). Site level estimates are obtained by averaging all present (0) and not-present (1) values within each site.

The R-package spsurvey, developed specifically for the analysis of data obtained from GRTS designs, is then used to make reach level estimates, based on site level estimates, along with reach level estimates of uncertainty (standard errors and confidence intervals).

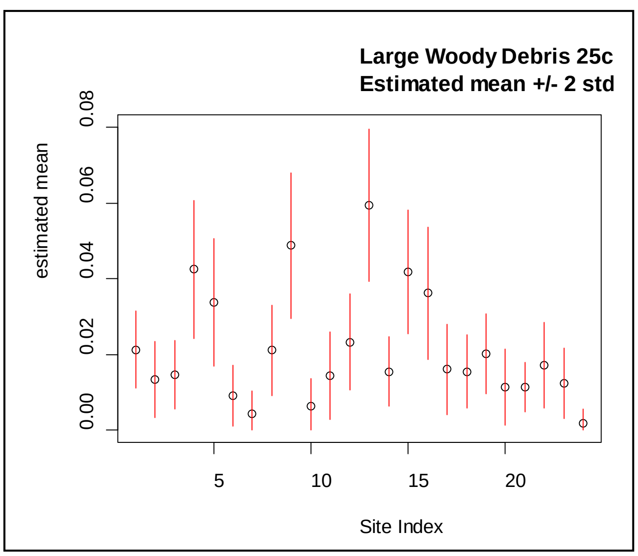
This paper investigates the effect of varying the total number of sites sampled, the number of transects per site, and the number of points assessed per transect, on the precision of both site-level and reach-level estimates for the various metrics assessed. “Reach level” estimates, in this case, are defined as estimates for the weighted average response across all sites included in the sampling frame (i.e. all possible sites in the reach, from which the sample of sites was obtained). For reach level estimates in particular, there is generally a point of sharply diminishing returns as the number of transects and/or points per transect is increased. Resource optimization requires determination of these trends and appropriate resource allocation based on these trends.

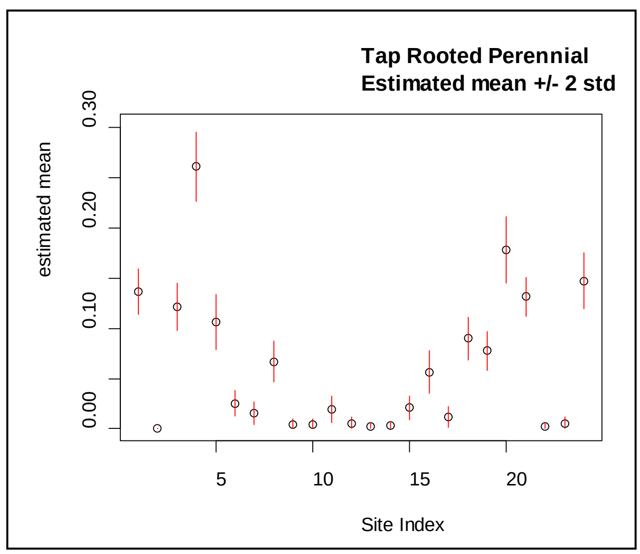
The following metrics are included in this analysis:

- Bare Ground
- Litter 25 cm diameter
- Large Woody Debris 25cm diameter
- Exposed Roots
- Non Vascular Plant
- Annual Biennial
- Fibrous Root Rhizomatous Perennial
- Tap Rooted Perennial
- Shrub
- Woody Seedling 0.5m tall
- Live Canopy Evergreen Tree
- Live Canopy Deciduous Tree
- Snag Dead Standing Trees

Background

In general, efficient spatial sampling maximizes sampling units over the spatial level that contains the highest level of variability. For a given metric, assuming site-site variability is high relative to within site variability, a high number of sites sampled are required to achieve high precision for reach level metric estimates. Figures 1 and 2 show examples of site-site variability for two metrics included this analysis: Large Woody Debris and Tap Rooted Perennial. Note the high level of site-site variability.





High site-site variability is common for spatially varying metrics, as points near each other are often more alike than points further apart in space. Hypothetically, if one were to increase the number of sites sampled (regardless of the number of points measured within each site), the estimated reach level mean would converge on the true reach level mean as the number of sites increased to infinity. However, if a fixed number of sites were sampled, the reach level estimated mean will not converge to the true reach level mean, even if the number of transects and/or points sampled per transect approached infinity. At some point, increasing the number of transects and/or points sampled per transect will result in little or no improvement in precision of reach level estimates.

Plots showing site-site variability for all 13 metrics considered in this analysis are included in Appendix A1.

Within Site Sampling Intensity: Simulation Methodology

Within sites, sampling at different numbers of transects per site, and different numbers of points per transect, was simulated using bootstrapping, where resampling, with replacement, was done using actual 2010 raw, sub-site level data.

For the purposes of this study, data from both banks of the river was used, for all sites that included data for both banks in the original dataset. The effect on precision of sampling only 1 bank versus sampling both banks was not considered, as bank-bank variability is always assumed large relative to transect-transect variability within a bank, or point-point variability within a transect. Sampling only one bank would not make sense from a resource optimization perspective, given that sampling transects from both banks does not entail much, if any, additional effort compared to sampling the same number of transects on only one bank. This appears to be the case for the Merced River, given the easy access to both banks of the river. For the remainder of this analysis and report, the number of transects sampled is always the number of transects *per bank*, unless otherwise noted. Thus the total site level effort, in terms of number of points sampled per site, is:

Sampling Intensity: Total Points/Site = Transects/Bank * Points/transect * 2 Banks/Site

Reach Level Sampling Intensity: Simulation Methodology

At the multi-site level, conventional bootstrap methods are not appropriate for estimating the change in standard errors at various numbers of total sites sampled. This is because a GRTS sample is an ordered list, and the ordering is necessary to preserve the spatially balanced properties. A bootstrap sampling of sites at the watershed level would result in a random sample that lacked the spatial balance of the original sample. Therefore, in lieu of bootstrapping, a different approach is necessary to estimate the effect of changes in total number of sites surveyed on reach level standard errors.

In simple random sampling, well established theory shoes that the standard error scales linearly with 1/sqrt(n), where n is the total sample size. A heuristic argument can be made that an appealing property of a GRTS sample is that, while the standard error isn't straightforward to calculate (as in a simple random sample of independent observations) the standard error should nevertheless retain the linear relationship with 1/sqrt(n). For a given sample size (where sample size is referring to number of sites), assume we have a known or estimated standard error (in this case based on analysis of the existing GRTS design using Spsurvey). The value of that standard error will be a function of the variance and spatial distribution of the metric across sites, and the sampling plan (stratifications, panels, etc.) Regardless of the spatial distribution and GRTS sampling design, adding additional sites to an existing design adds them in a continuously spatially balanced manner, across any known or unknown spatial variations, across the entire sampling frame – provided the additional sites added were sampled using the same GRTS design. This differs from, say, a block sample where n1 blocks are sampled and n2 sites are sampled within blocks. In this case, adding changing n1 or n2 would not necessarily cause the standard error to scale with 1/sqrt(n), because the increase in sampling intensity might not be linear at all spatial levels.

The above heuristic argument was tested empirically using a sampling frame and dataset obtained from the EPA aquatic resources monitoring homepage (http://www.epa.gov/nheerl/arm/index.htm). This dataset included spatial locations, and various measurements or other properties, covering all sites within a sampling frame covering the Luckiamute Watershed in the Willamette Valley of Oregon. Using the data frame, and treating various measurement or other properties as site level response measurements, multiple GRTS designs (Equal probability and 2 versions of stratified samples) were created, and repeatedly simulated and analyzed using cont.analysis from the spsurvey R package. The sampling design and analysis were repeated 1000's of times for each GRTS design, and at various total samples sizes for each GRTS design. The resulting standard errors, for each GRTS design, were plotted against 1/sqrt(n). In each case, over all metrics considered, the plots were consistent with a linear relationship. Two such plots are shown by the Figures 3 and 4:

Figure 3.

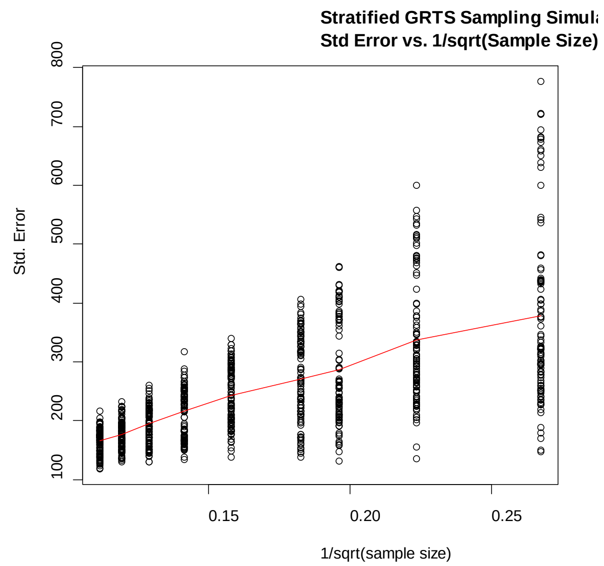
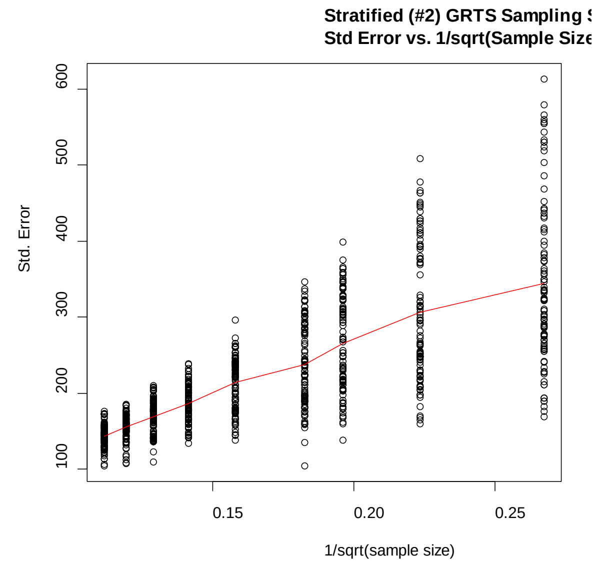


Figure 4.

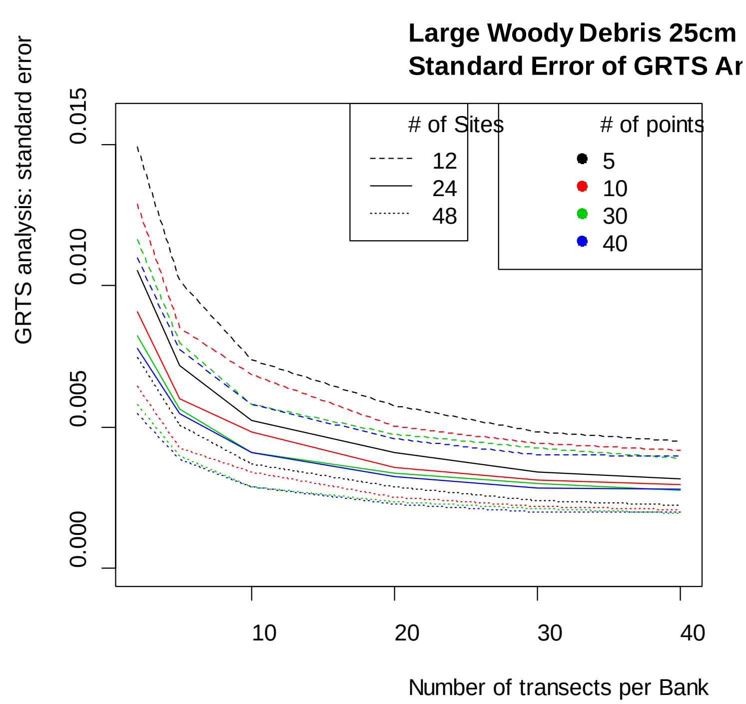


Figures 3 and 4 support the assertion that standard error from an analysis of GRTS sample data is at least approximately linear with 1/sqrt(n), within a given GRTS design. This assertion will be relied on for the results presented in the next section.

Results

For the Large Woody Debris metric, Figure 5 provides a set of curves where the response (along the vertical axis) is the standard error of the reach level proportion of Large Woody Debris. The x-axis is the number of transects per site per bank; the color of each line shows the number of points per transect observed, and the type of line (solid, dotted, dashed) corresponds to the total number of sites sampled within the reach of the Merced River. Figure 6 shows the same curves for the proportion of Tap Rooted Perennial.

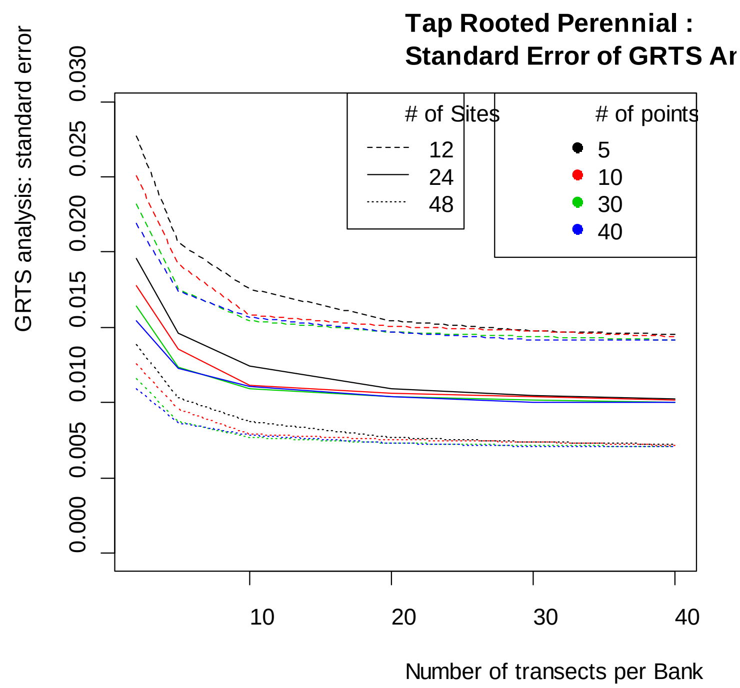
Figure 5.



Standard error is a measure of uncertainty in results. It is an inverse quantity to precision. Thus, in Figures 5 and 6, lower standard error indicates higher precision.

As would be expected, increasing the number of sites sampled always increases the precision of the estimates at the reach level.

Figure 6.



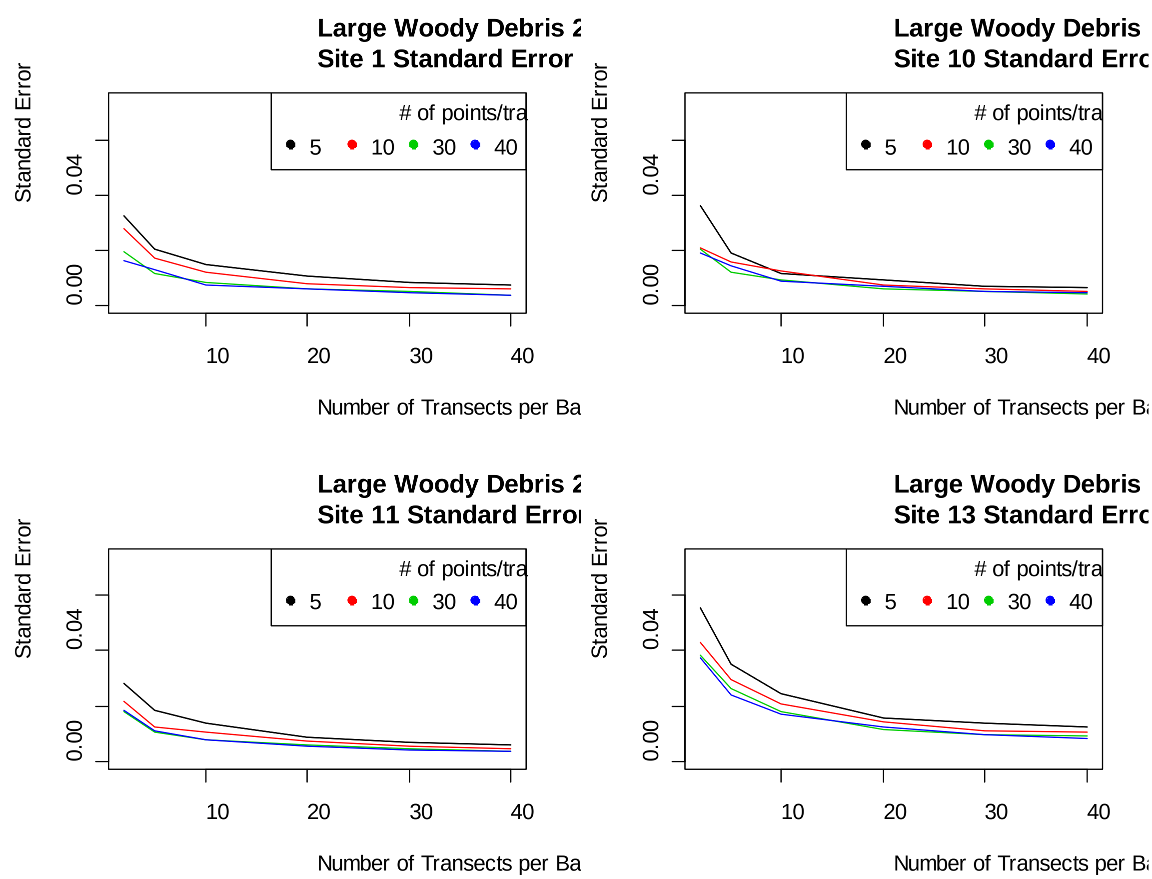
Increasing the number of transects per site per bank also increases the reach level precision (reduces the reach level standard error), but the improvement in precision drops considerably after roughly 30 transects per bank for Large Woody Debris, and after as few as 10 transects per site for Tap Rooted Perennial.

Increasing the number of points per transects results in only modest improvements in reach level estimate precision for Large Woody Debris. For Tap Rooted Perennial, increasing number of points per transect beyond 10 results in nearly no further improvement in reach level precision.

Plots of the reach spatial level standard errors versus number of sites, number of transects, and points per transect, analogous to figures 5 and 6, for all 13 metrics in this analysis are included in Appendix A2. All metrics show similar trends in that beyond 20 or so transects per site, and 10-30 sites points per transect, there is very limited improvement in precision of reach level estimates.

In some cases, interest may lie in estimating a metric at a specific site rather than across an entire GRTS sampling frame. In these cases, it may be important to achieve a desired precision within a site. Figure 7 and 8 show site level precision estimates for Large Woody Debris and Tap Rooted Perennial, by number of transects per banks and number of points per transect, for sites 1, 10, 11, and 13.

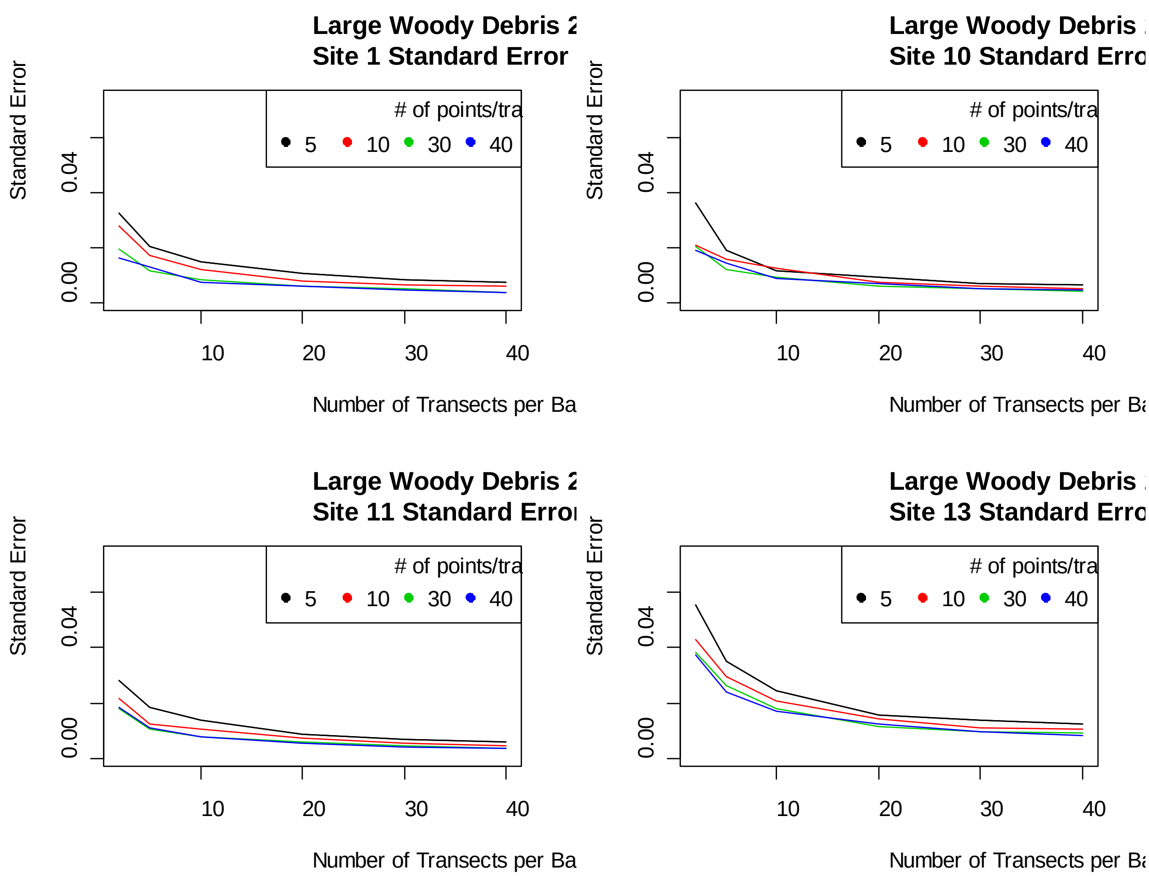
Figure 7.



Because the metrics included in this study are proportions, the variance of each response varies with the magnitude of the response, with highest site level variances occurring as the proportions approach 0.5. Therefore, the site level precision varies by site and metric, even when the same number of transects per banks and points per transect are used. A full set of site level curves showing the tradeoffs between sampling intensity and precision, for all 13 metrics, and all 24 sites included in the 2010 sample, are shown in Appendix A3.

Note that, unlike GRTS sampling frame level estimates, increasing the number of transects will always provide some level of improvement in site level precision estimates.

Figure 8.



Because of the nature of the responses (proportions) cause the variance of the response to vary by the level of the response, some investigation was done to determine whether there may be sampling efficiencies to be gained by optimizing sampling intensity for each site, so that sites likely to have high variability (based on prior estimates) are sampled with higher intensity. However, for a given metric, any potential improvements in efficiency were small. Also, even if there were significant improvements in efficiency to be had for a given metric, when considering multiple metrics there are not consistently high variance sites and low variance sites, but rather the variance tends to be high for some metrics and low for others within each site. Thus, varying sampling intensity by site seems to have little value at this point.

If, however, there is high interest in specific sites, there is certainly no harm to be done by increasing sampling intensity for a given site or sites. The integrity of the GRTS sampling design and resulting reach level estimate will not be negatively impacted by increasing sampling intensity at one or more sites, while keeping sampling intensity the same at all other sites.

Note on the Impact of Changing Sampling Intensities Mid-Study

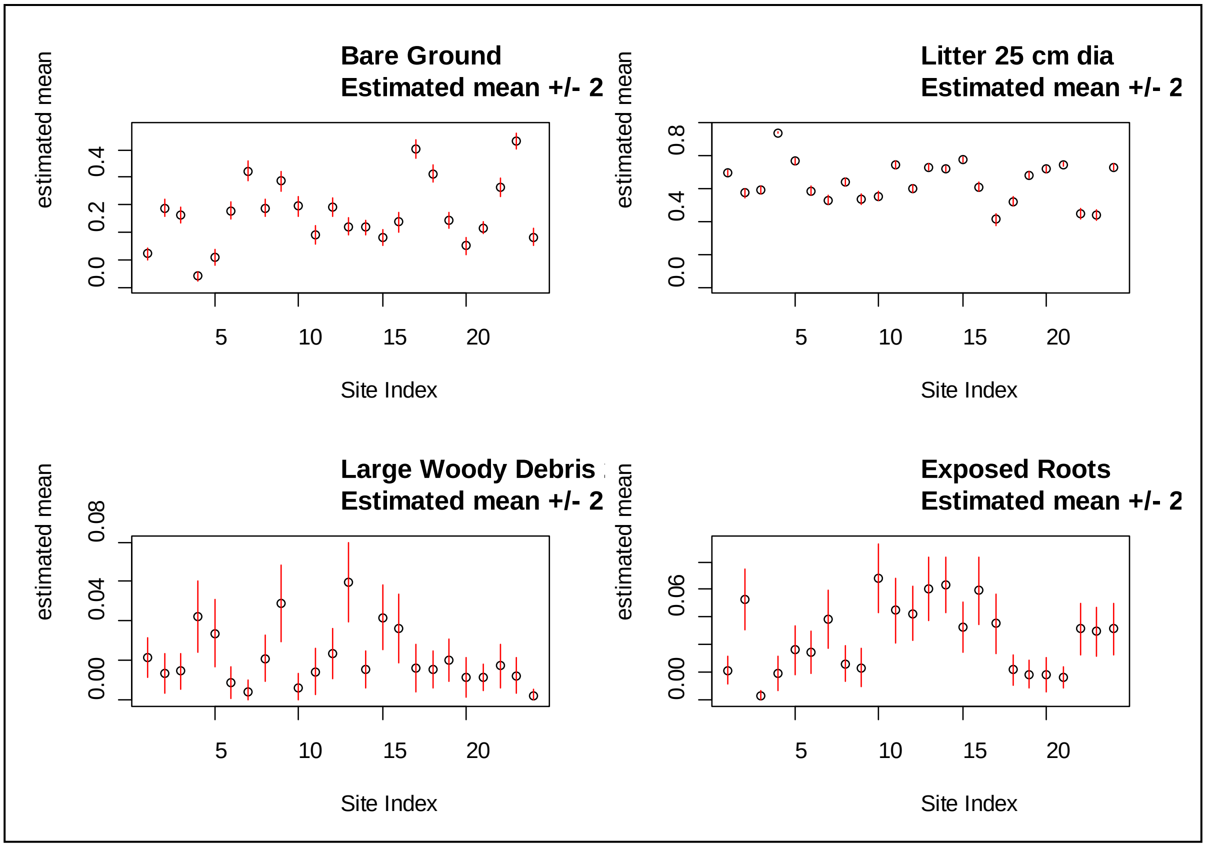
Given that this study applies to long term sampling, and for which sampling has already been completed at all sites for 2010, the question has also arisen as to whether or not changing sampling intensity in proceeding years will adversely affect the integrity of the GRTS design or otherwise bias results. In general, the GRTS design integrity will not be affected, and results will not be biased by changing sampling intensity year to year. In the GRTS analysis, a single response from each site is used. To track trends over time, this response may be, for example, a linear fit of site level response by year. While changing the precision of the estimated response will affect the precision of the linear fit, it will not bias the response, thus it will not bias the GRTS analysis results. If the response of interest is instead, for example, the mean response averaged over multiple years, the analysis will require that the within site level estimate are not biased towards years with more data if changes in sampling intensity are made; but again, as long as the site level response is estimated correctly (which can be done even if sampling intensity changes from one year to another by, for example, giving equal weight to each year), then the integrity of the GRTS analysis is maintained.

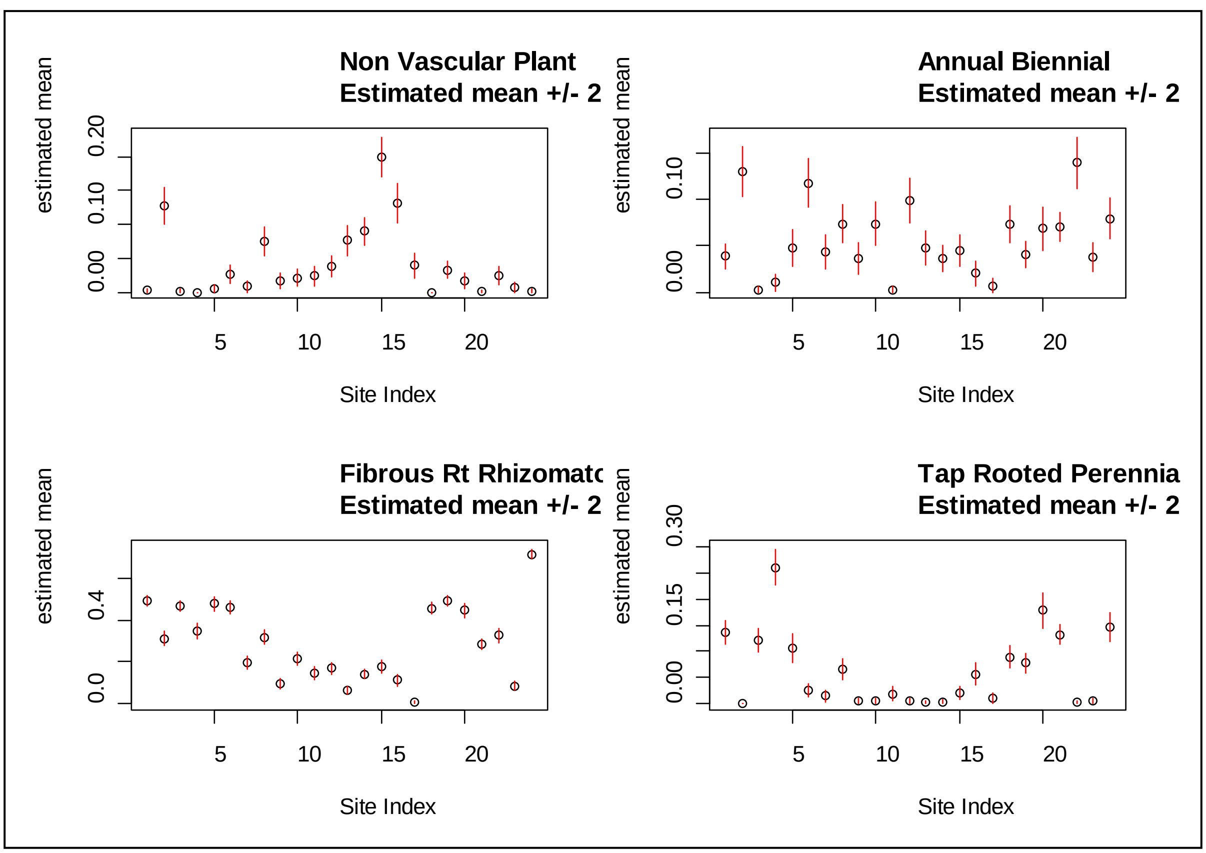
Conclusion

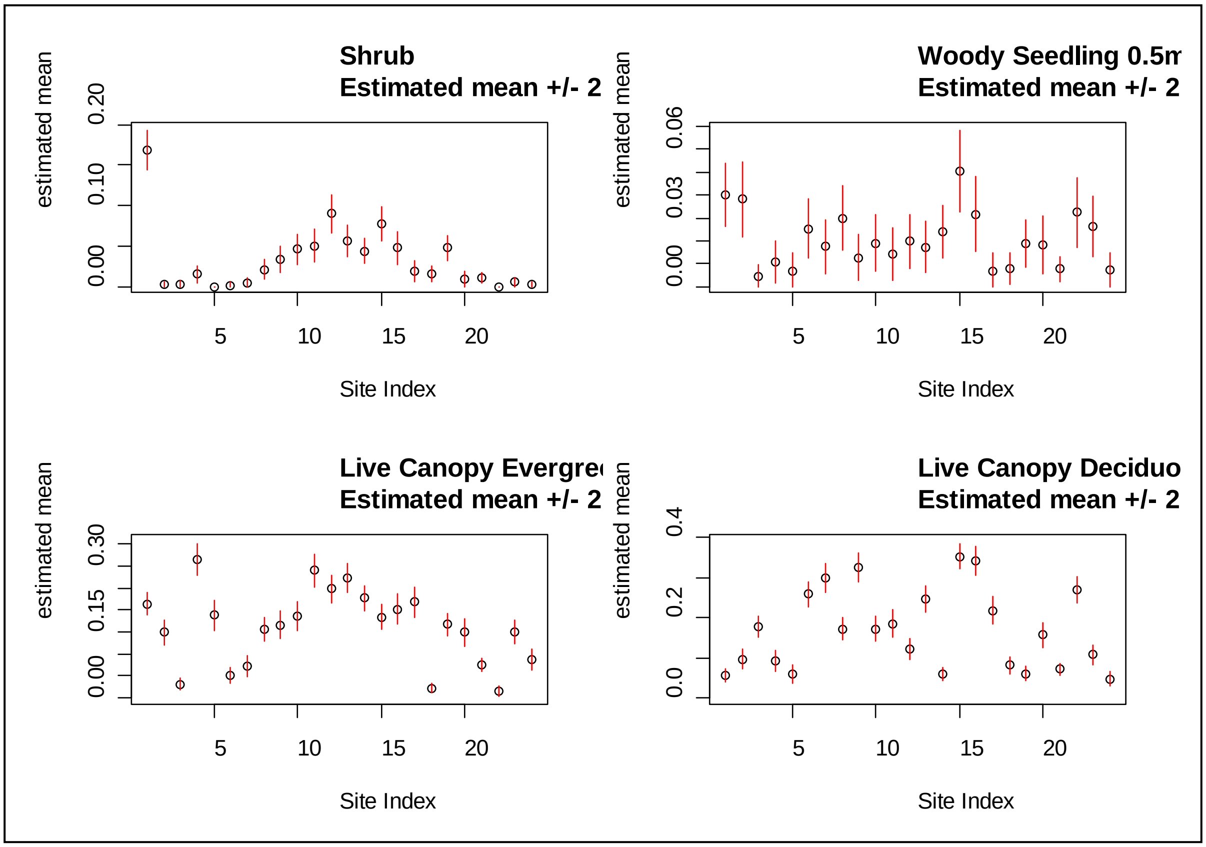
Analysis and simulation from 2010 Sien Merced Riverbank Study data demonstrate that, where reach level estimate are desired, there are within site sampling intensities beyond which increases in sampling intensity provide little additional benefit. Typically, obtaining measurements at more than 20 transects per bank, or more than 10 points per transect, yield little or no benefit in the precision of reach level estimates. Changes in the total number of sites sampled will always yield a change in precision of reach level estimates, with the standard error of reach level mean estimates at least approximately linear with 1/sqrt(N), where N is the number of sites sampled.

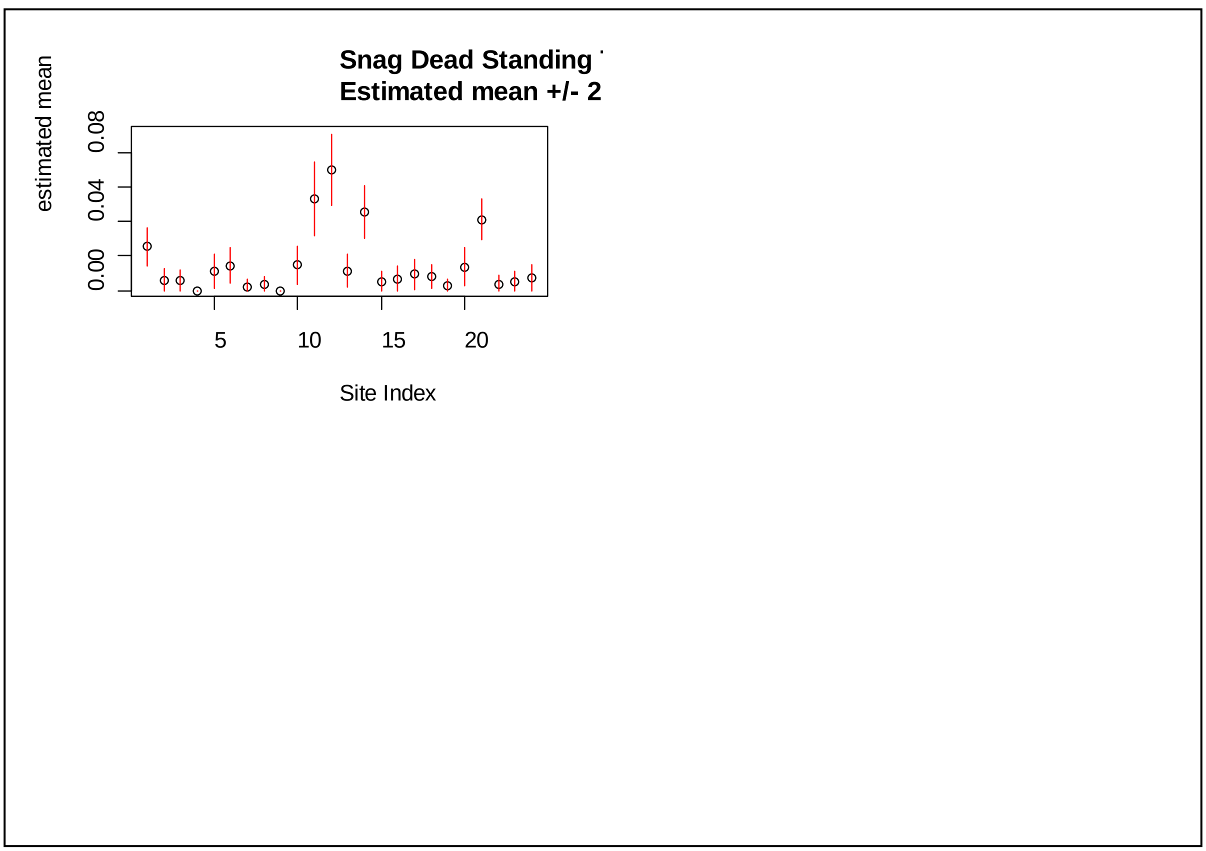
If specific site level estimates are of interest, the researcher may use the curves included to determine a sampling intensity that’s likely to achieve the desired precision.

Appendix A1: Estimated Response Average by Site for All Metrics

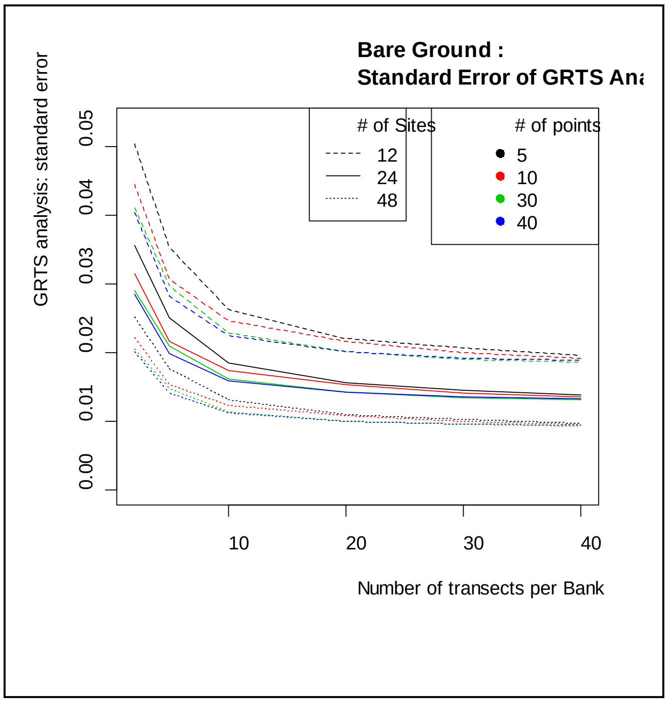


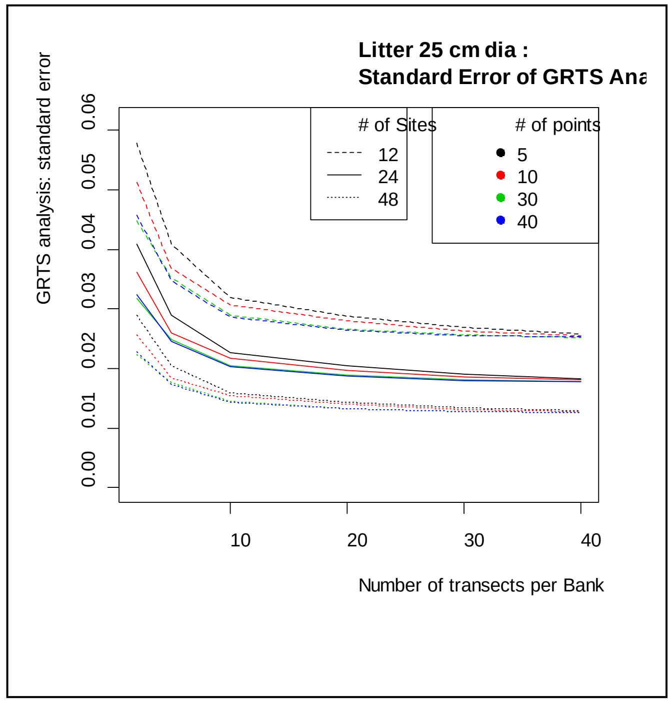


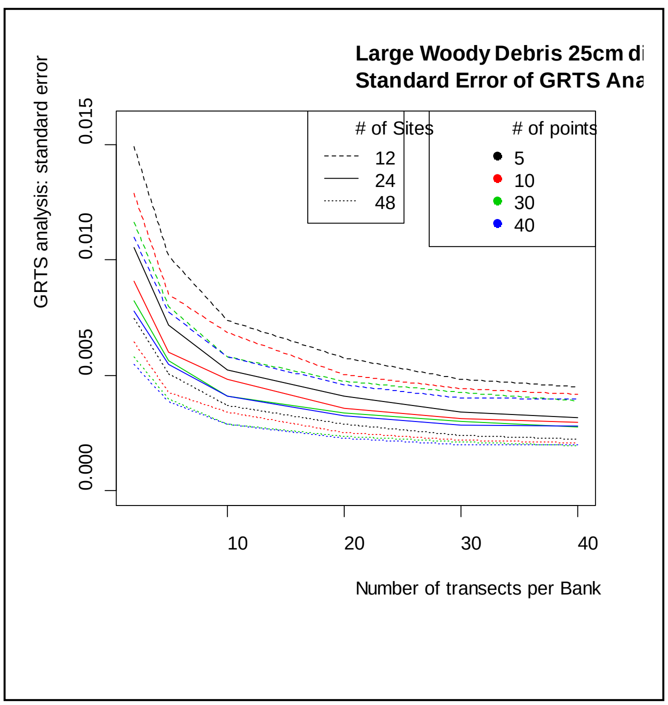

Shrub
Estimated mean +/- 2
Woody Seedling 0.5m
Estimated mean +/- 2
Live Canopy Evergre
Estimated mean +/- 2
Live Canopy Deciduo
Estimated mean +/- 2
estimated mean
Site Index

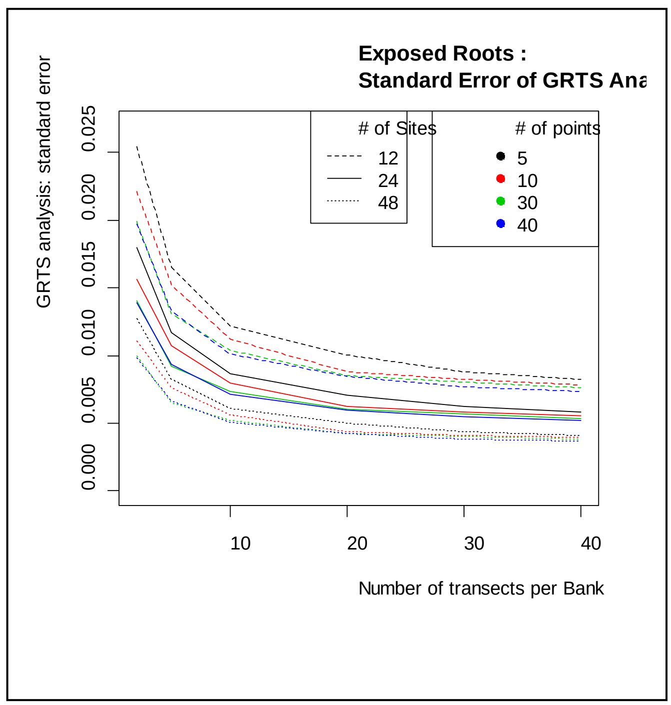

Snag Dead Standing
Estimated mean +/- 2
estimated mean
Site Index

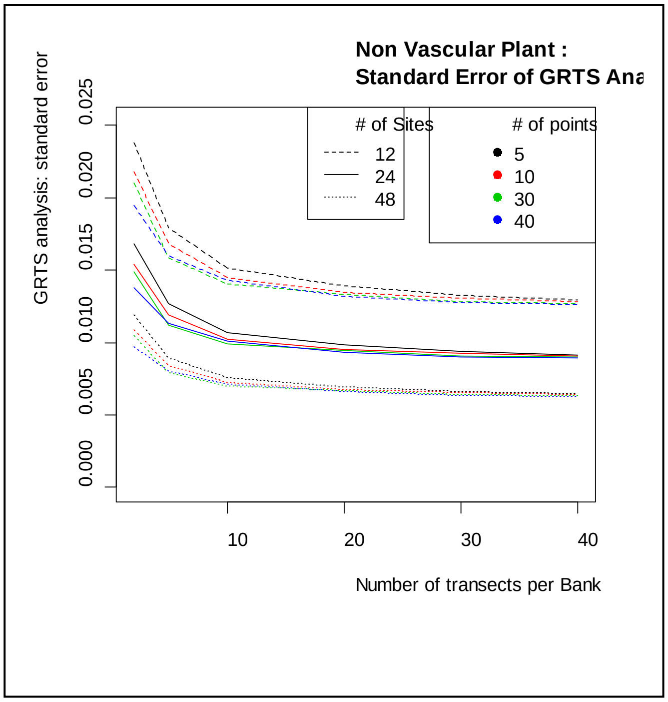
Appendix A2: Site Level Sampling Intensity versus GRTS Sampling Frame Standard Error, for All Metrics

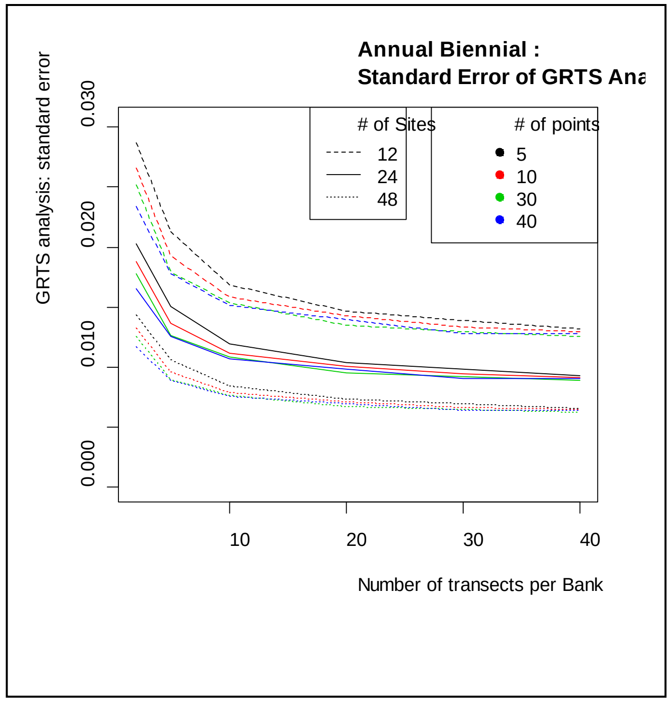


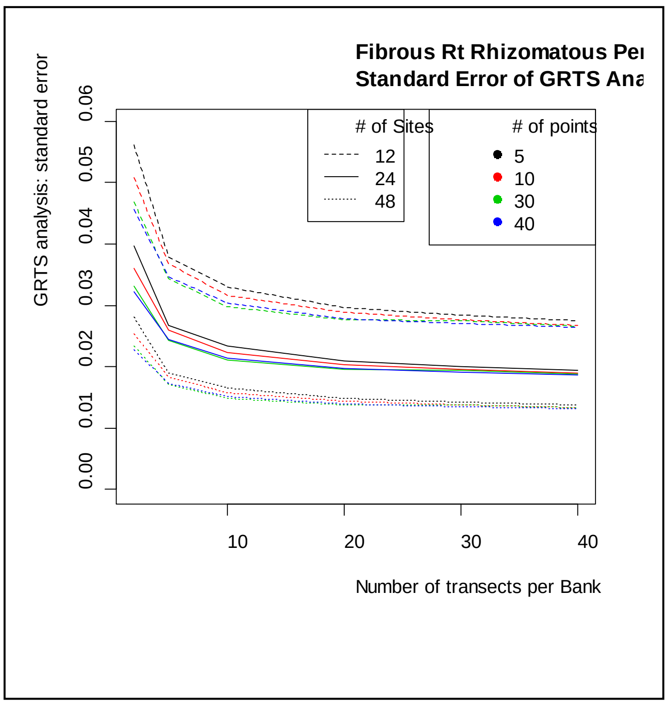


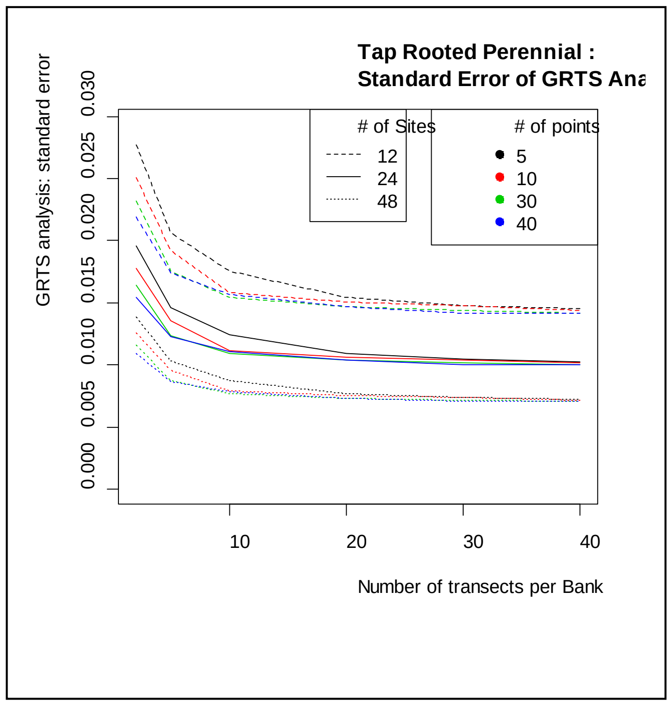


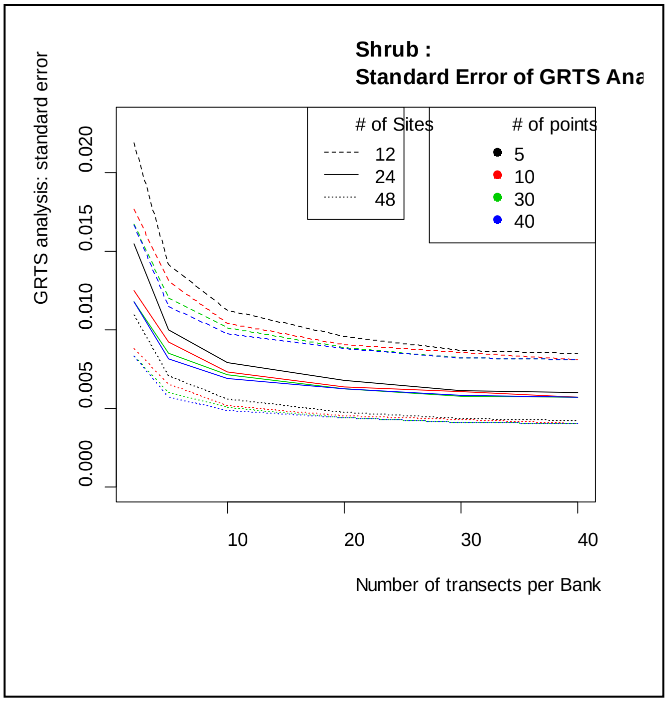


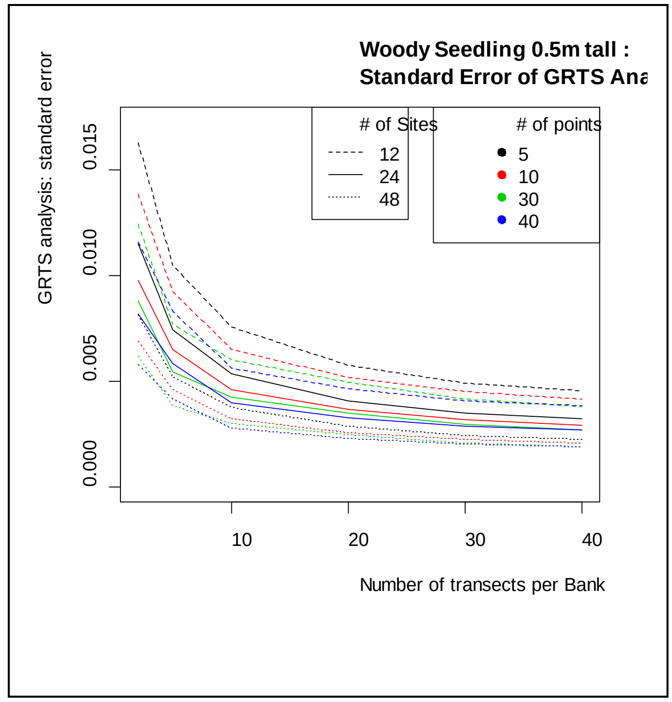

Non Vascular Plant :
Standard Error of GRTS Ana
GRTS analysis: standard error
0.000
0.005
0.010
0.015
0.020
0.025
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank

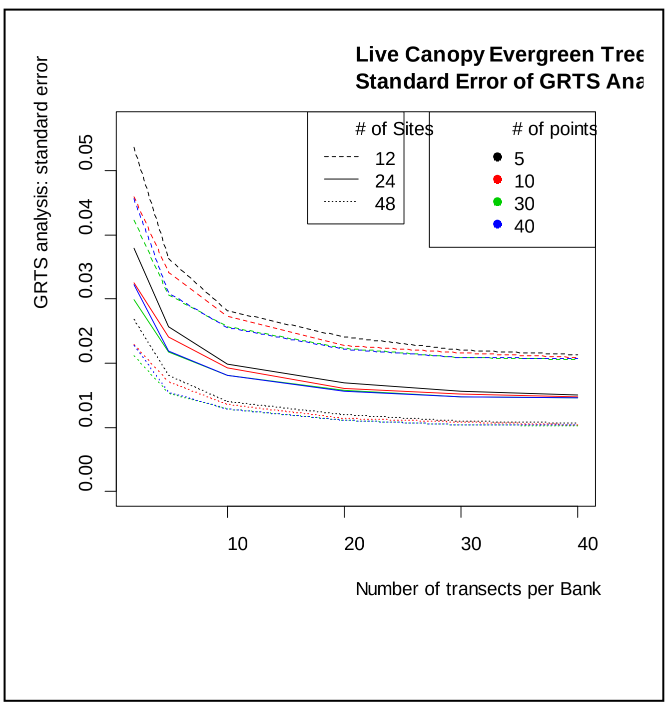

Annual Biennial :
Standard Error of GRTS Ana
GRTS analysis: standard error
0.000
0.010
0.020
0.030
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank

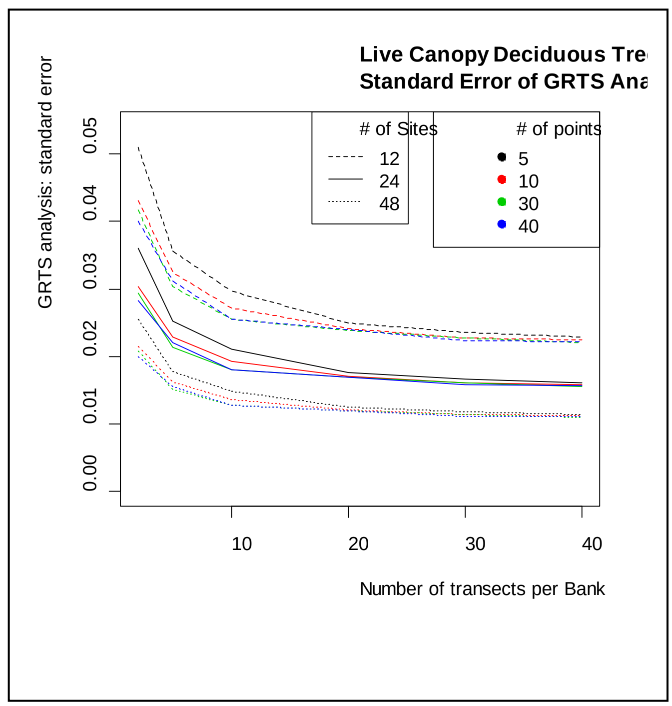

Fibrous Rt Rhizomatous Pe
Standard Error of GRTS Ana
GRTS analysis: standard error
0.00
0.01
0.02
0.03
0.04
0.05
0.06
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank

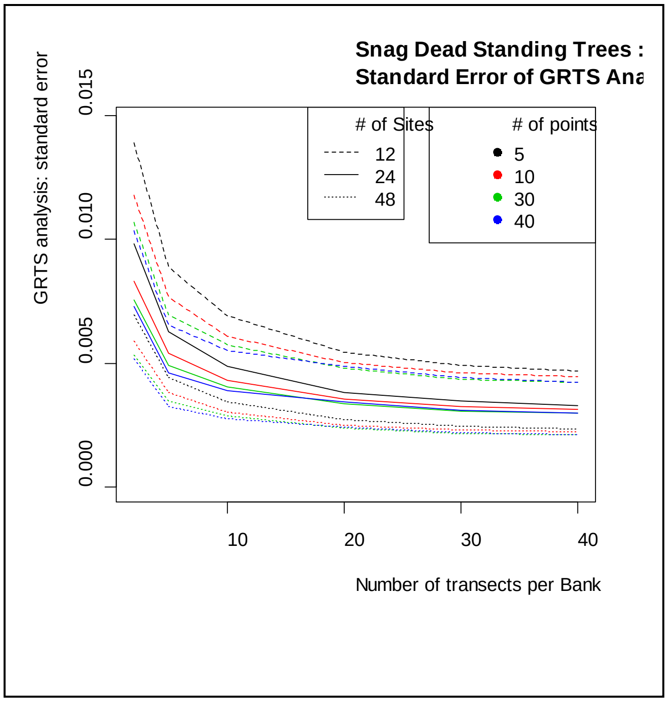

Tap Rooted Perennial :
Standard Error of GRTS Ana
GRTS analysis: standard error
0.000
0.005
0.010
0.015
0.020
0.025
0.030
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank


Shrub :
Standard Error of GRTS Ana
GRTS analysis: standard error
0.000
0.005
0.010
0.015
0.020
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank

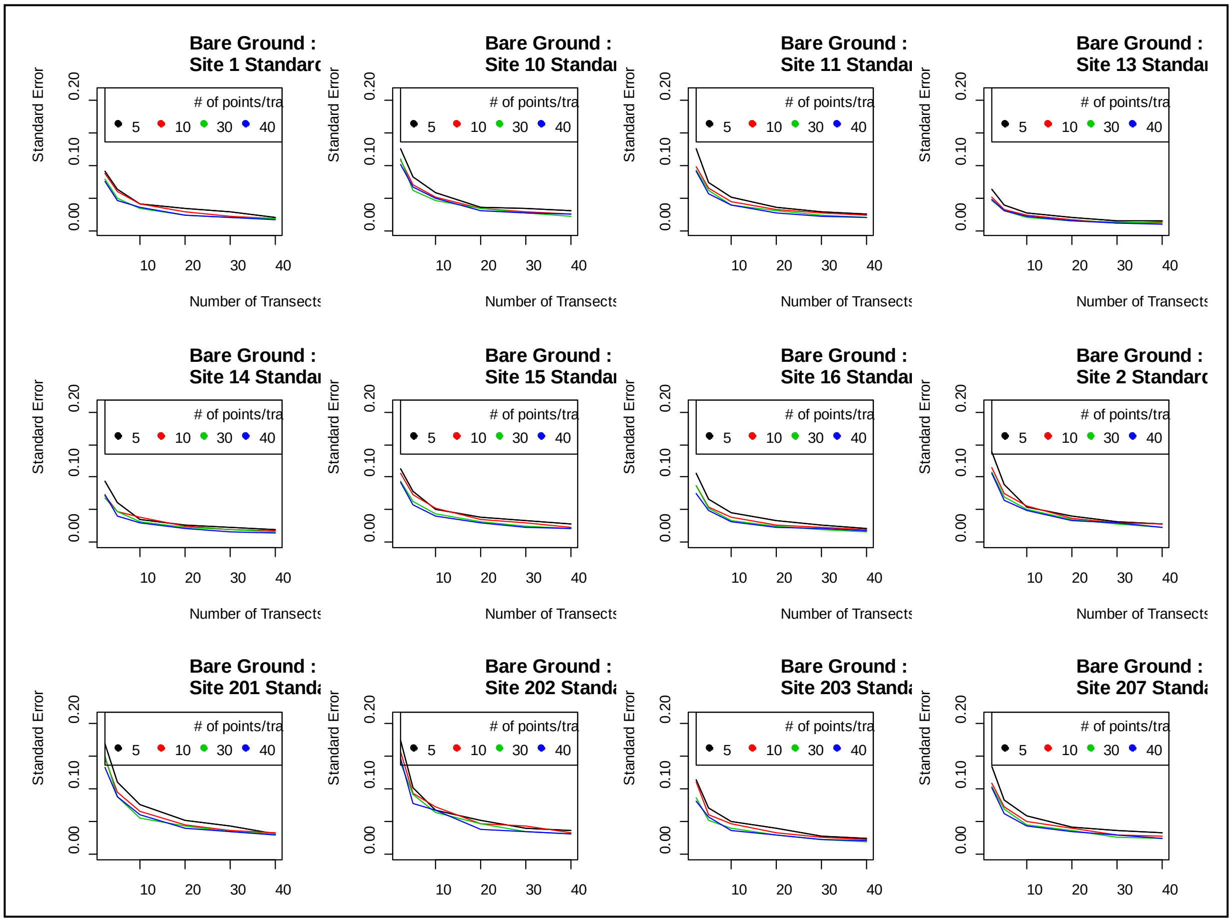

Woody Seedling 0.5m tall :
Standard Error of GRTS Ana
GRTS analysis: standard error
0.000
0.005
0.010
0.015
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank

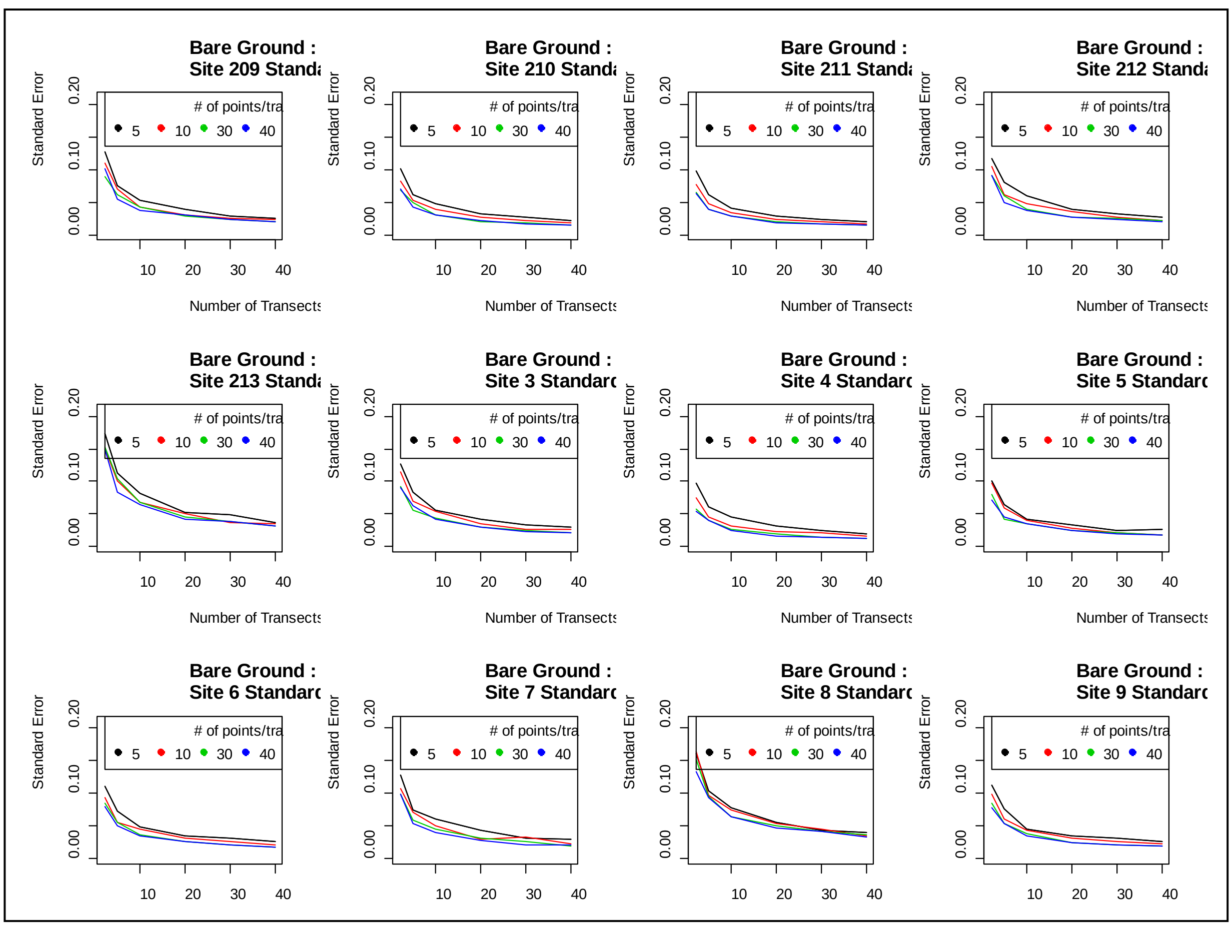

Live Canopy Evergreen Tree
Standard Error of GRTS Ana
GRTS analysis: standard error
0.00
0.01
0.02
0.03
0.04
0.05
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank

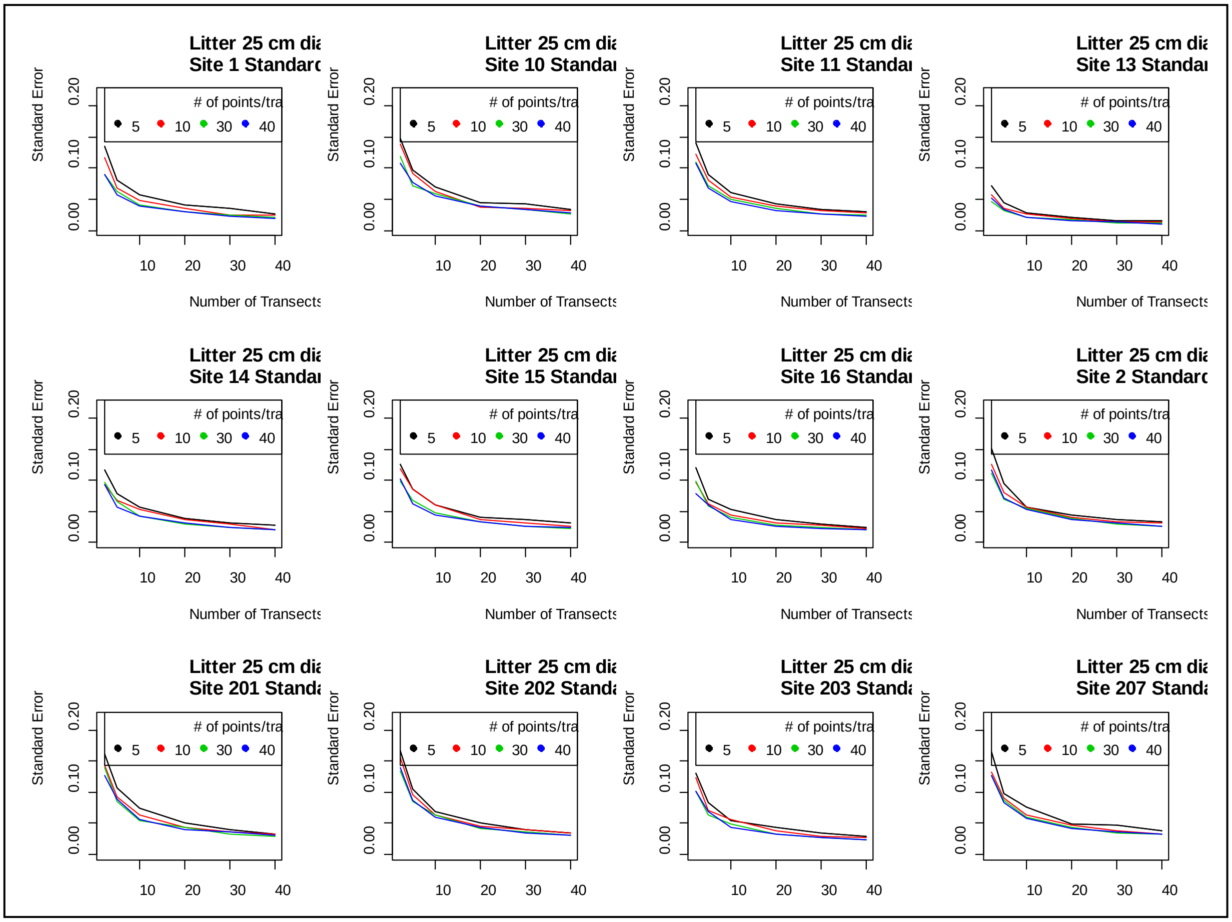

Live Canopy Deciduous Tre
Standard Error of GRTS Ana
GRTS analysis: standard error
0.00
0.01
0.02
0.03
0.04
0.05
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank

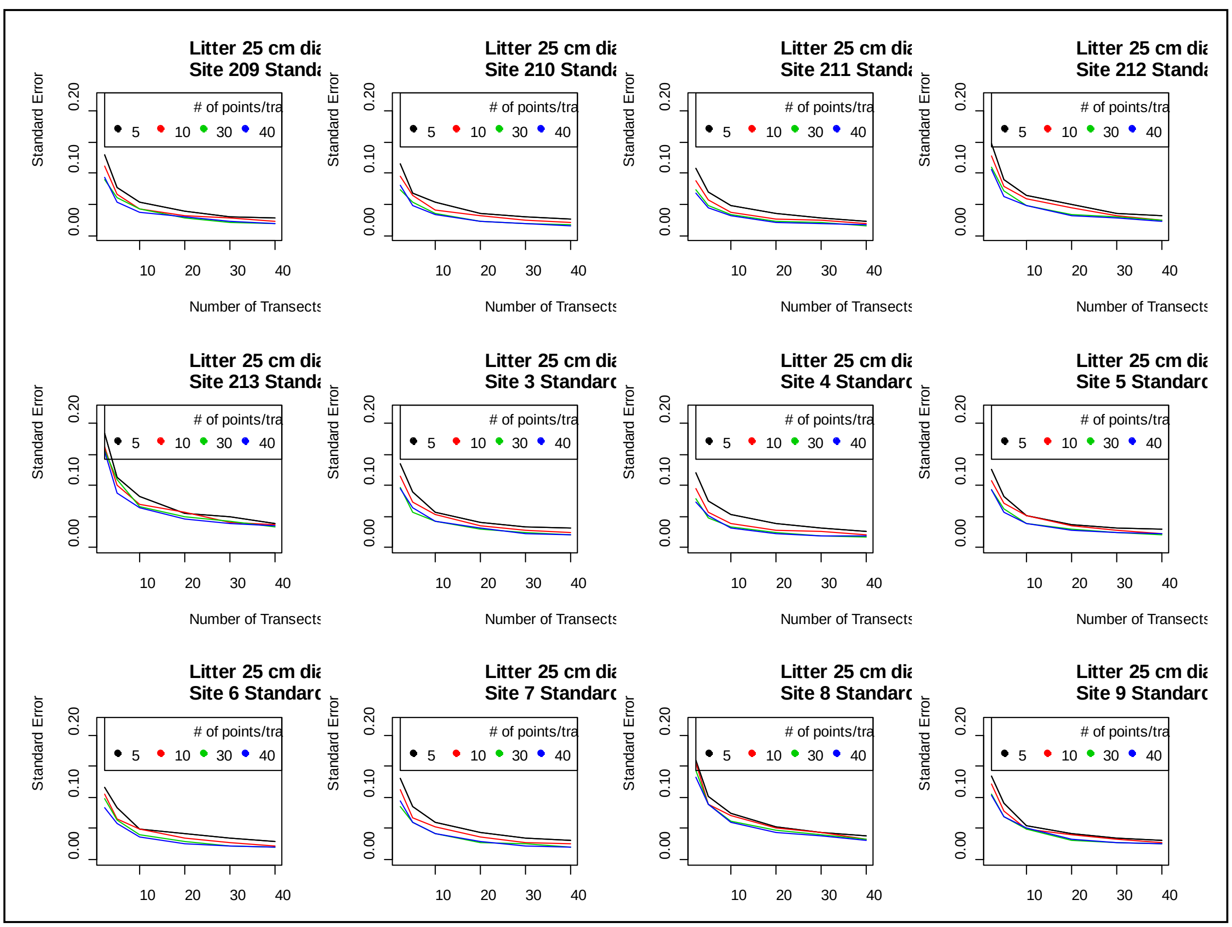

Snag Dead Standing Trees :
Standard Error of GRTS Ana
GRTS analysis: standard error
0.000
0.005
0.010
0.015
# of Sites
12
24
48
# of points
5
10
30
40
10
20
30
40
Number of transects per Bank

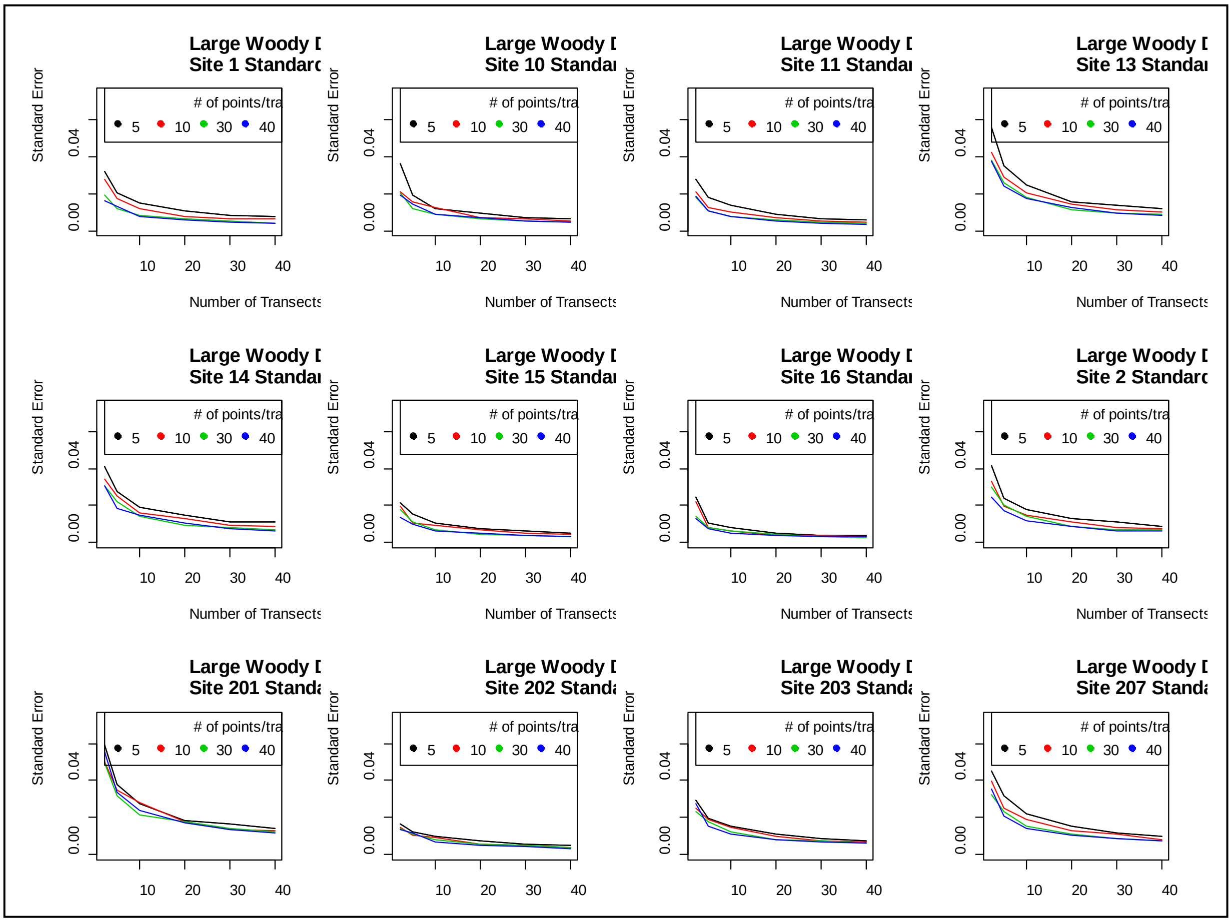
Appendix A3: Site Level Sampling Intensity vs. Site Level Standard Error, for All Metrics and All Sites

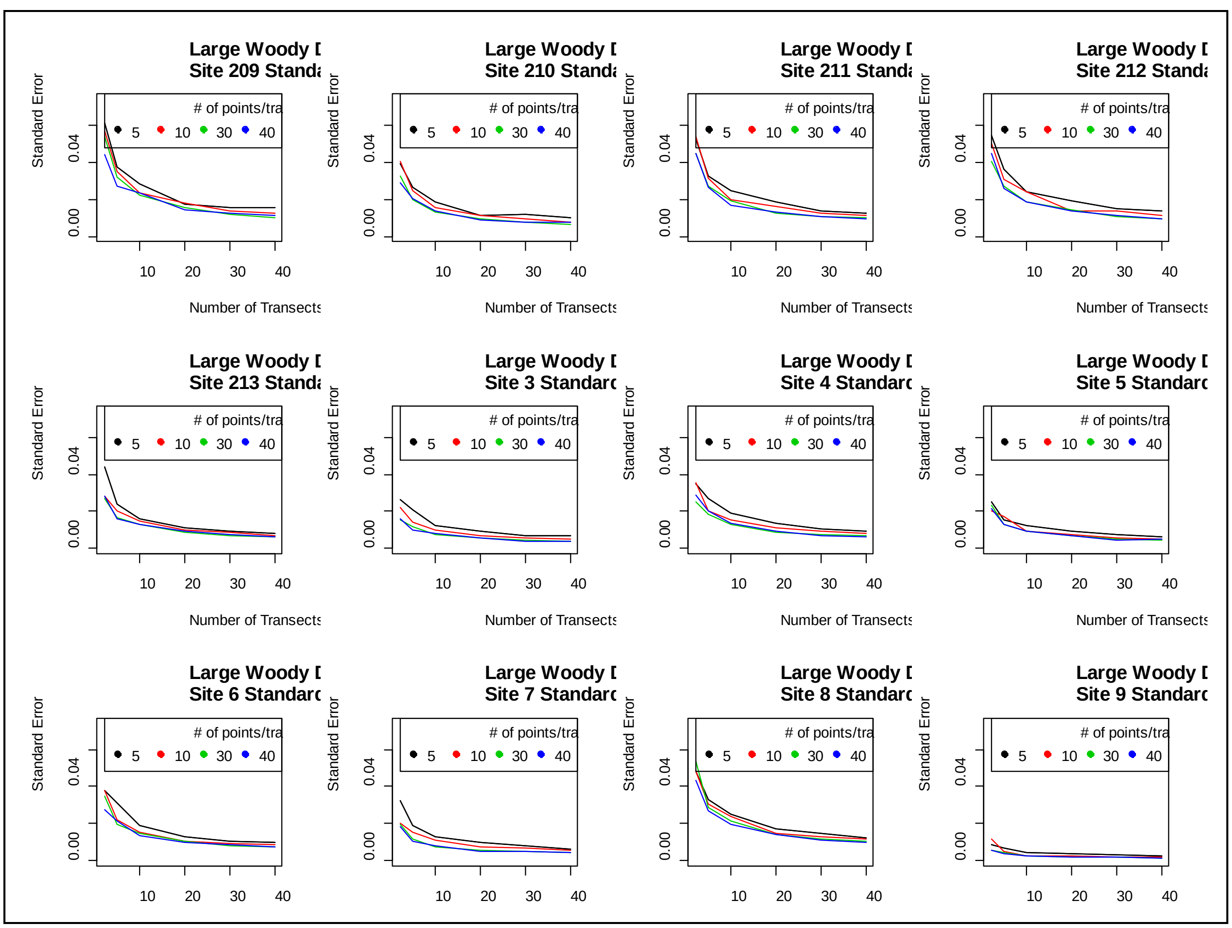


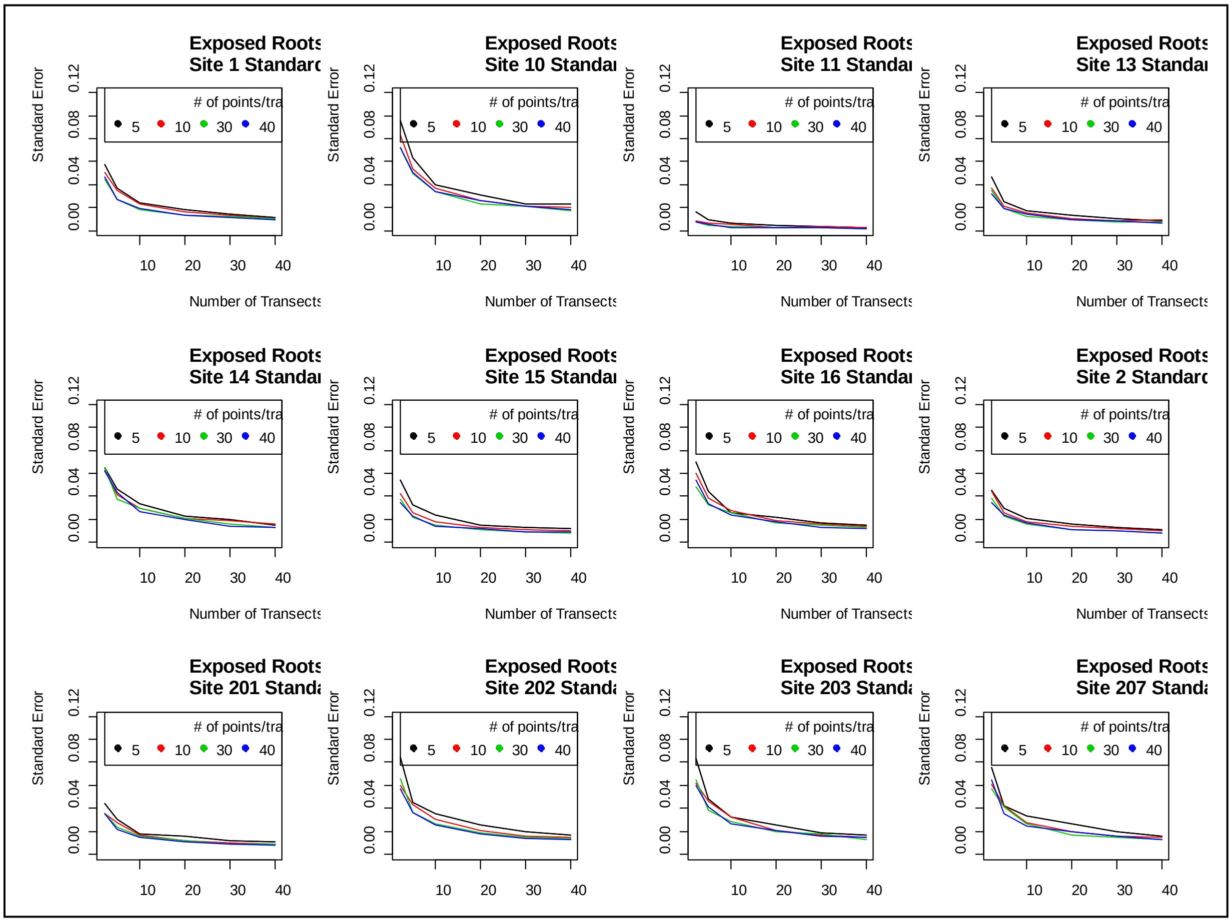


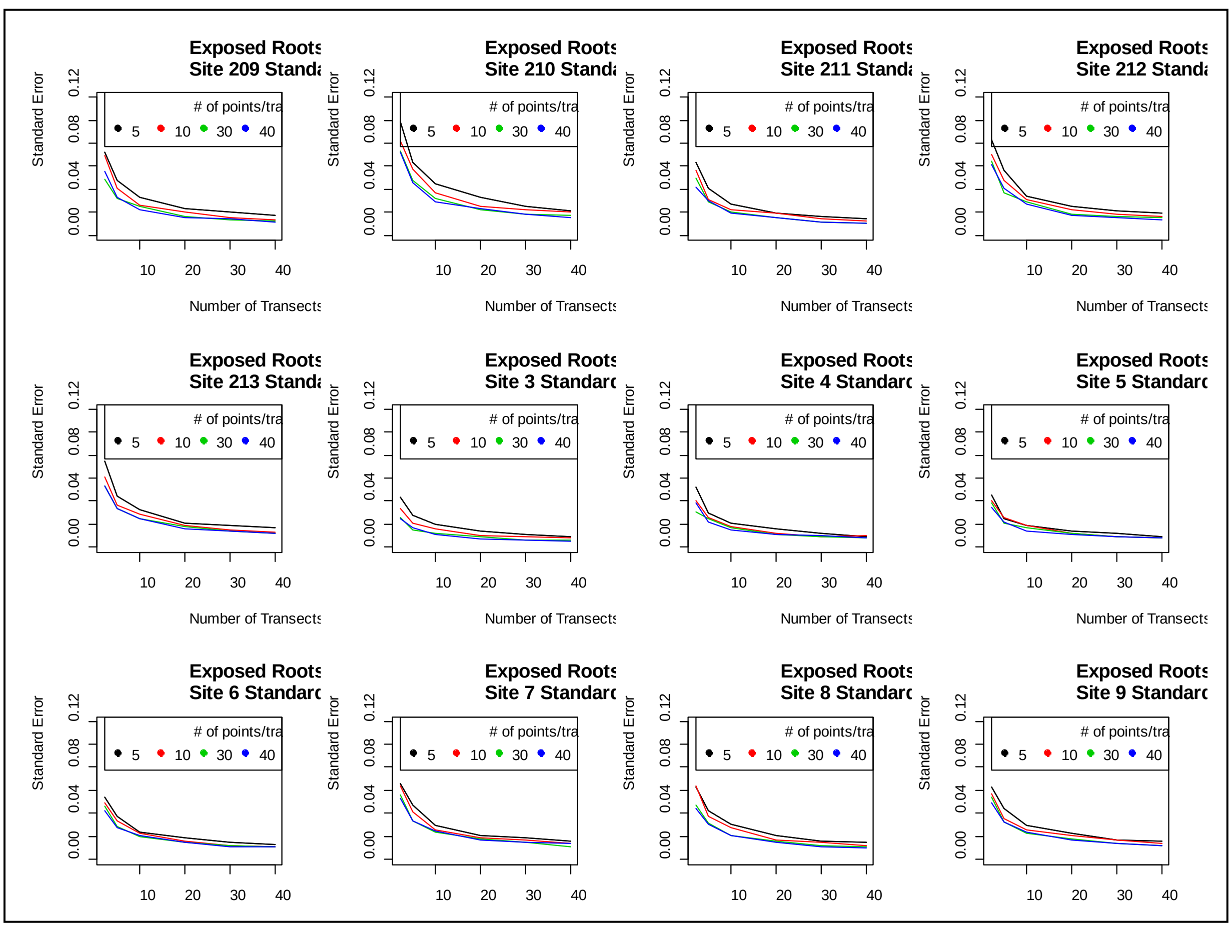

Litter 25 cm dia
Site 1 Standarc
Litter 25 cm dia
Site 10 Standa
Litter 25 cm dia
Site 11 Standa
Litter 25 cm dia
Site 13 Standa
Litter 25 cm dia
Site 14 Standa
Litter 25 cm dia
Site 15 Standa
Litter 25 cm dia
Site 16 Standa
Litter 25 cm dia
Site 2 Standarc
Litter 25 cm dia
Site 201 Standa
Litter 25 cm dia
Site 202 Standa
Litter 25 cm dia
Site 203 Standa
Litter 25 cm dia
Site 207 Standa
Standard Error
0.00
0.10
0.20
# of points/tra
5
10
30
40
10
20
30
40
Number of Transects

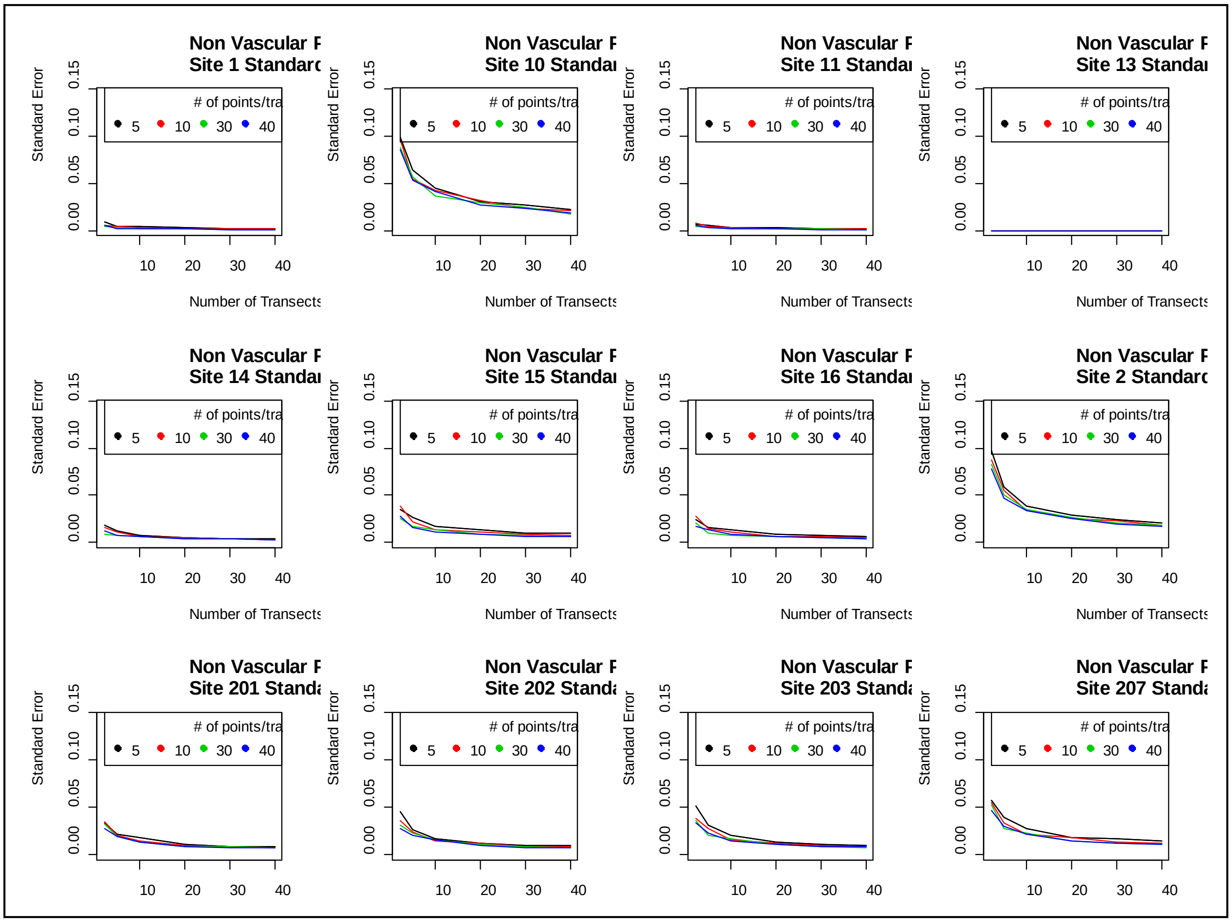

Litter 25 cm dia
Site 209 Standa
Litter 25 cm dia
Site 210 Standa
Litter 25 cm dia
Site 211 Standa
Litter 25 cm dia
Site 212 Standa
Litter 25 cm dia
Site 213 Standa
Litter 25 cm dia
Site 3 Standarc
Litter 25 cm dia
Site 4 Standarc
Litter 25 cm dia
Site 5 Standarc
Litter 25 cm dia
Site 6 Standarc
Litter 25 cm dia
Site 7 Standarc
Litter 25 cm dia
Site 8 Standarc
Litter 25 cm dia
Site 9 Standarc
Standard Error
0.00
0.10
0.20
# of points/tra
5
10
30
40
10
20
30
40
Number of Transects

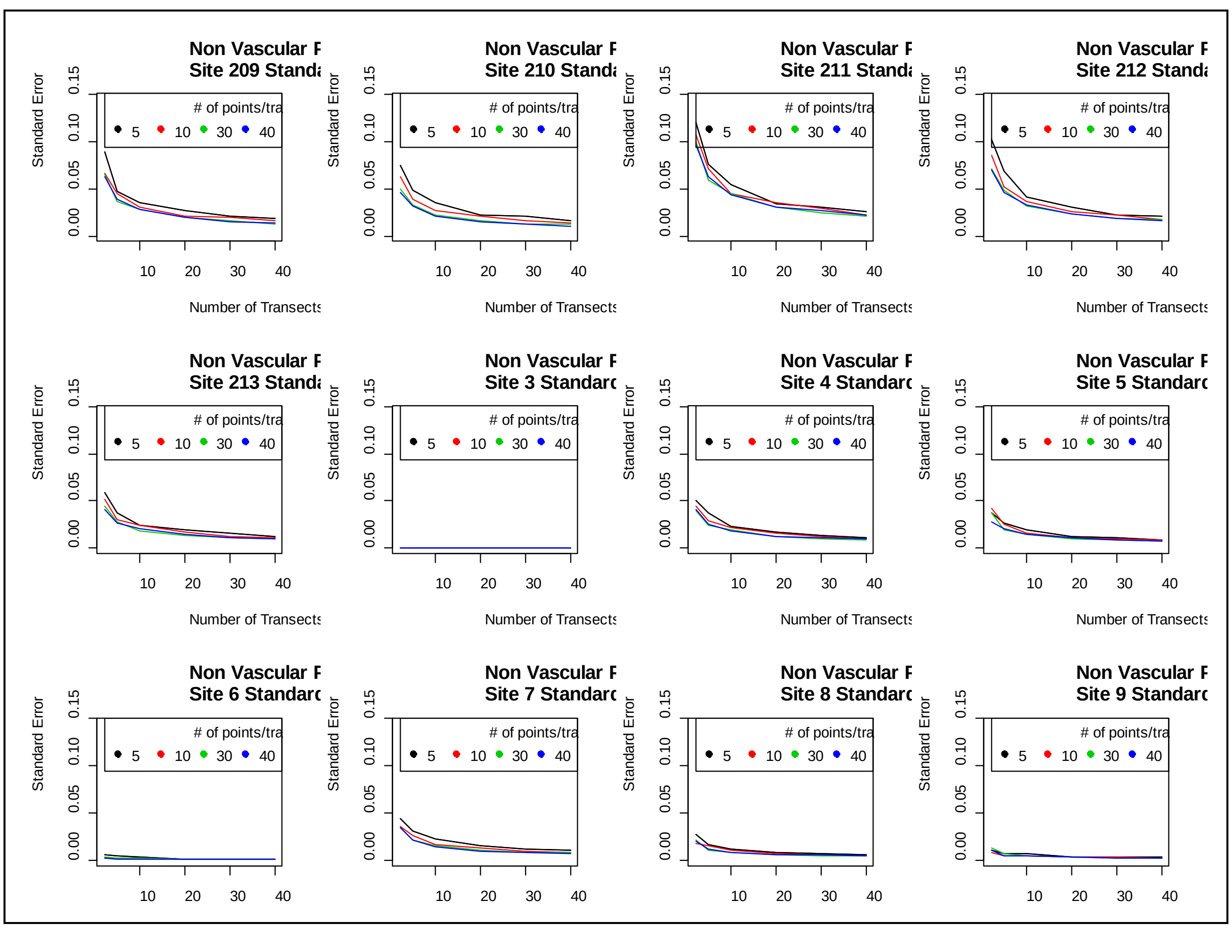

Large Woody I
Site 1 Standarc
Large Woody I
Site 10 Standai
Large Woody I
Site 11 Standai
Large Woody I
Site 13 Standai
Large Woody I
Site 14 Standai
Large Woody I
Site 15 Standai
Large Woody I
Site 16 Standai
Large Woody I
Site 2 Standarc
Large Woody I
Site 201 Standa
Large Woody I
Site 202 Standa
Large Woody I
Site 203 Standa
Large Woody I
Site 207 Standa
# of points/tra
5 10 30 40
Standard Error
0.00
0.04
10 20 30 40
Number of Transects

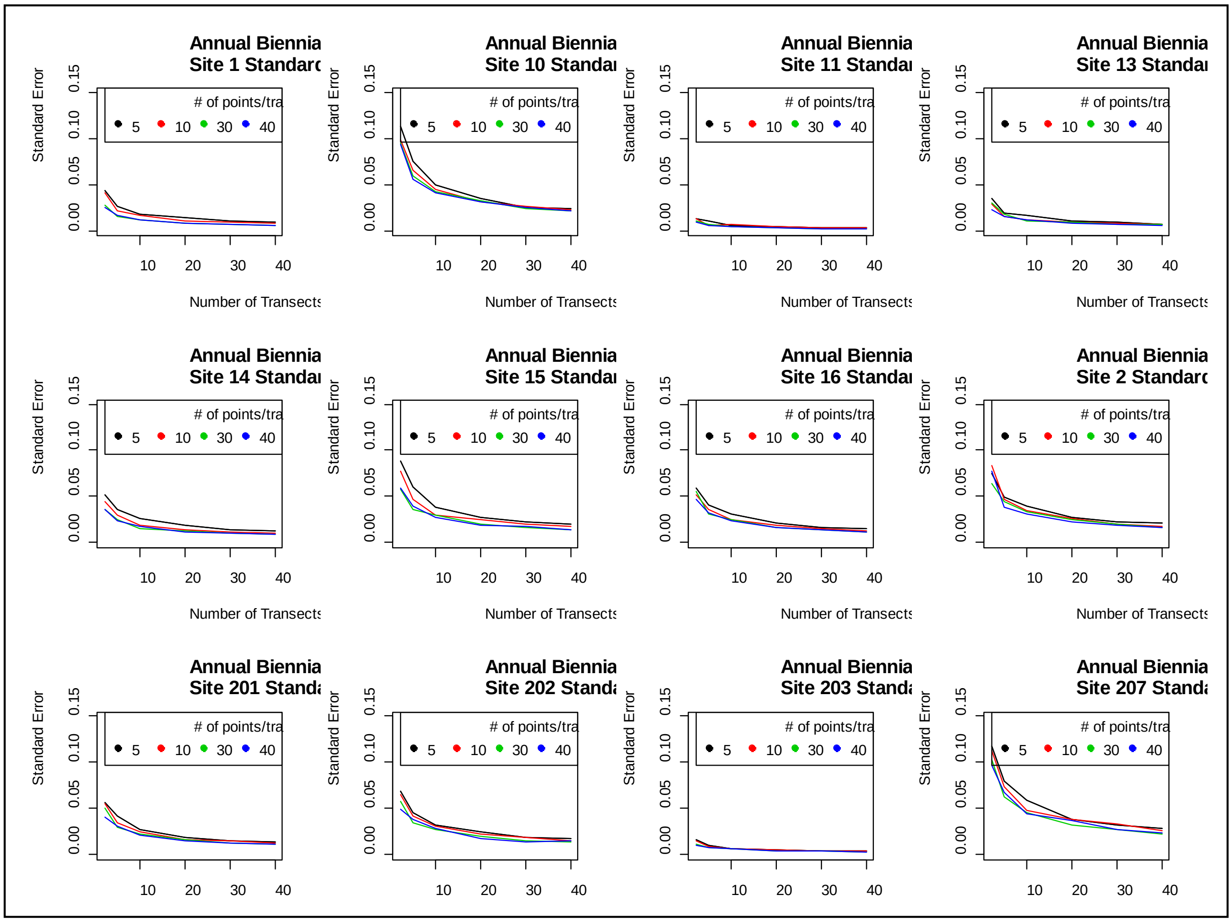

Large Woody I
Site 209 Standa
Large Woody I
Site 210 Standa
Large Woody I
Site 211 Standa
Large Woody I
Site 212 Standa
Large Woody I
Site 213 Standa
Large Woody I
Site 3 Standarc
Large Woody I
Site 4 Standarc
Large Woody I
Site 5 Standarc
Large Woody I
Site 6 Standarc
Large Woody I
Site 7 Standarc
Large Woody I
Site 8 Standarc
Large Woody I
Site 9 Standarc
# of points/tra
5 10 30 40
Standard Error
0.00
0.04
10 20 30 40
Number of Transects

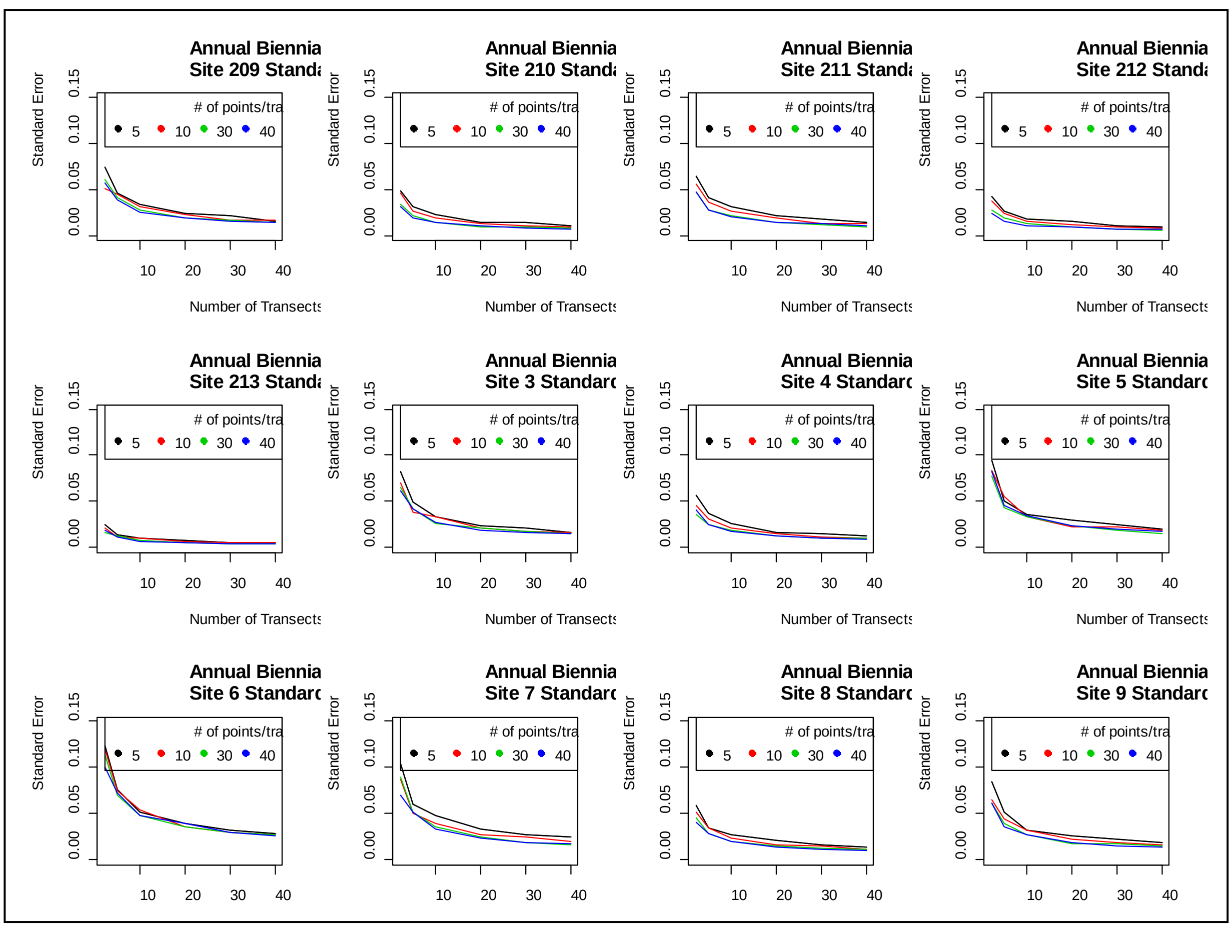

Exposed Roots Site 1 Standarc
Exposed Roots Site 10 Standai
Exposed Roots Site 11 Standai
Exposed Roots Site 13 Standai
Exposed Roots Site 14 Standai
Exposed Roots Site 15 Standai
Exposed Roots Site 16 Standai
Exposed Roots Site 2 Standarc
Exposed Roots Site 201 Standa
Exposed Roots Site 202 Standa
Exposed Roots Site 203 Standa
Exposed Roots Site 207 Standa
Standard Error
Number of Transects
# of points/tra
5 10 30 40
0.00 0.04 0.08 0.12
10 20 30 40

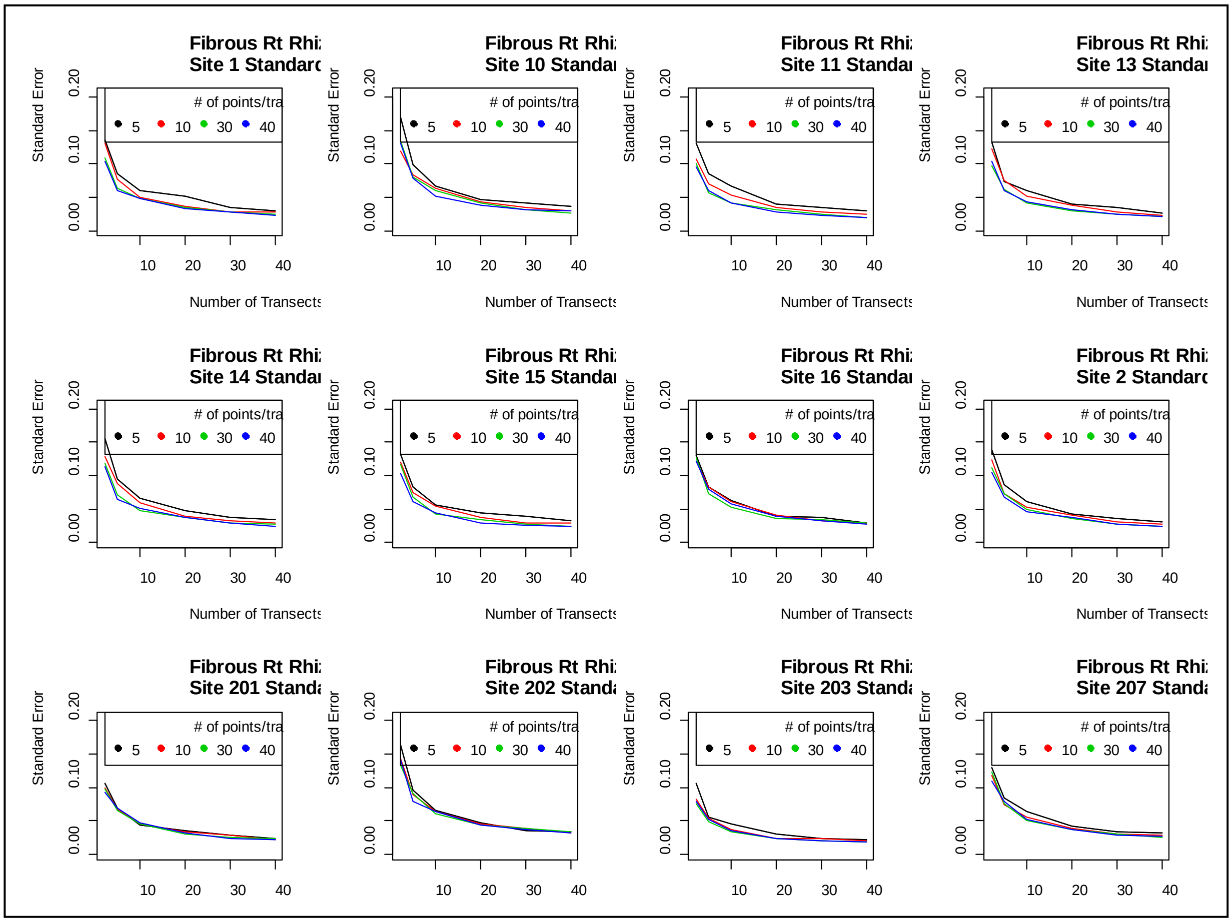

Exposed Roots Site 209 Standa
Exposed Roots Site 210 Standa
Exposed Roots Site 211 Standa
Exposed Roots Site 212 Standa
Exposed Roots Site 213 Standa
Exposed Roots Site 3 Standarc
Exposed Roots Site 4 Standarc
Exposed Roots Site 5 Standarc
Exposed Roots Site 6 Standarc
Exposed Roots Site 7 Standarc
Exposed Roots Site 8 Standarc
Exposed Roots Site 9 Standarc
Standard Error
Number of Transects
# of points/tra
5 10 30 40
0.00 0.04 0.08 0.12
10 20 30 40

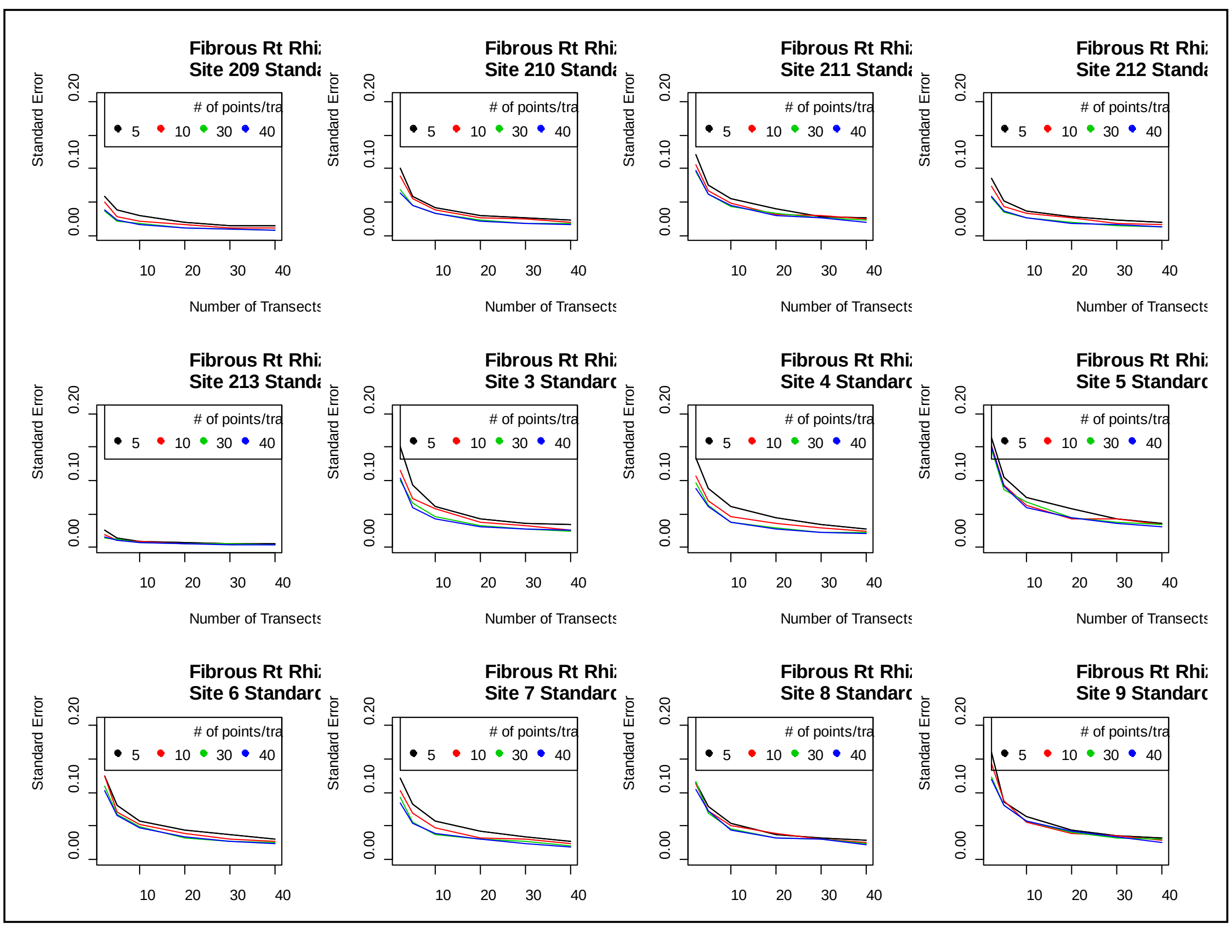

Non Vascular F
Site 1 Standarc
Site 10 Standaı
Site 11 Standaı
Site 13 Standaı
Site 14 Standaı
Site 15 Standaı
Site 16 Standaı
Site 2 Standarc
Site 201 Standa
Site 202 Standa
Site 203 Standa
Site 207 Standa
# of points/tra
5 10 30 40
Standard Error
0.00 0.05 0.10 0.15
10 20 30 40
Number of Transects

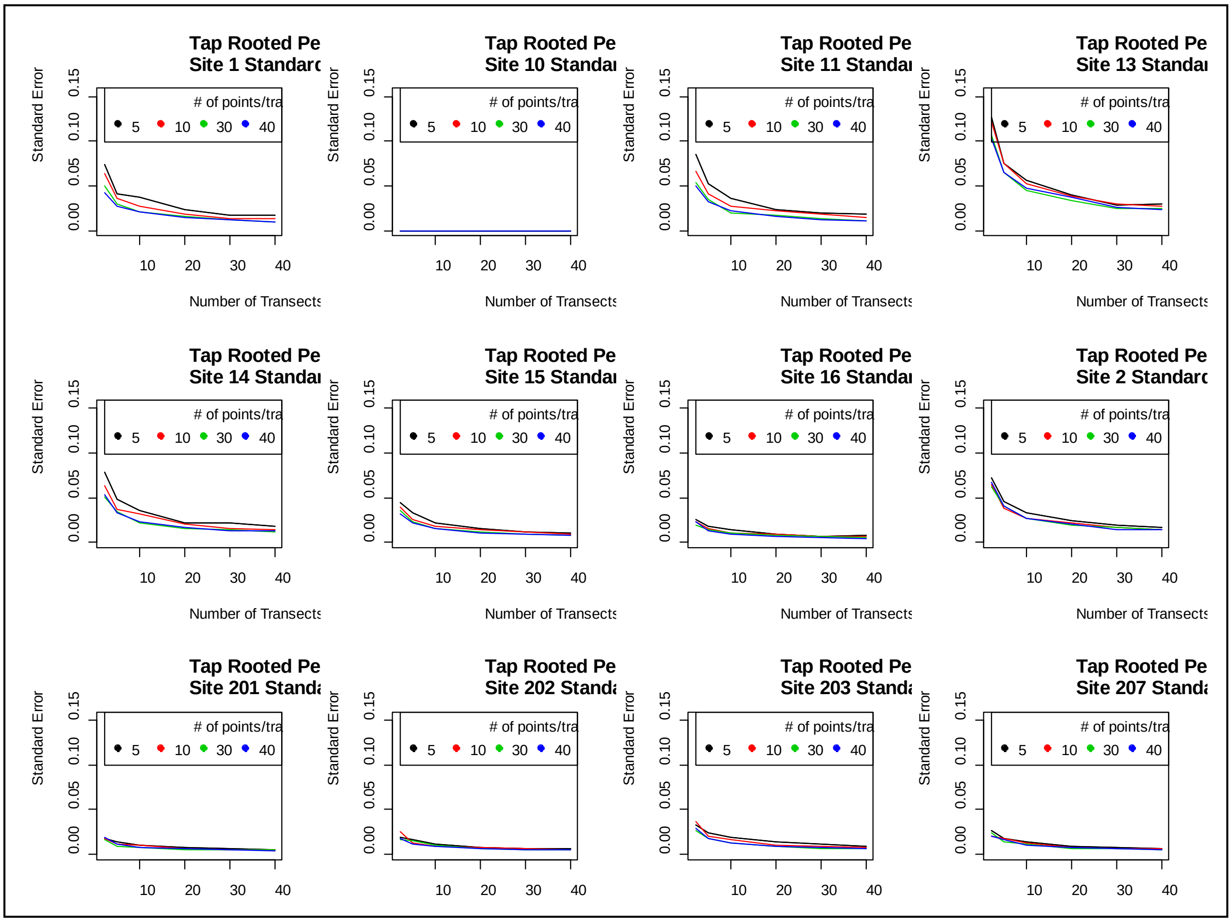

Non Vascular F
Site 209 Standa
Site 210 Standa
Site 211 Standa
Site 212 Standa
Site 213 Standa
Site 3 Standarc
Site 4 Standarc
Site 5 Standarc
Site 6 Standarc
Site 7 Standarc
Site 8 Standarc
Site 9 Standarc
# of points/tra
5 10 30 40
Standard Error
0.00 0.05 0.10 0.15
10 20 30 40
Number of Transects

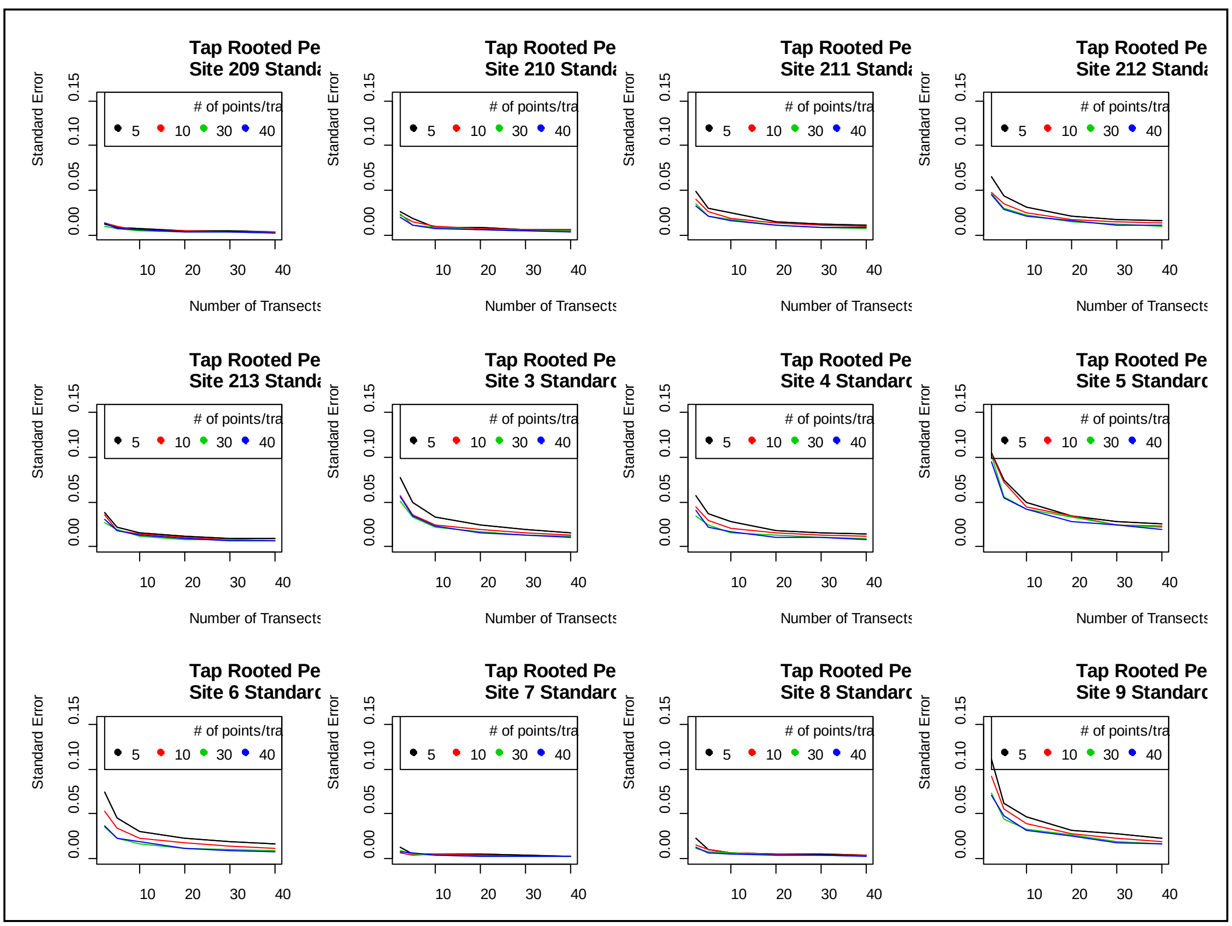

Annual Biennia
Site 1 Standarc
Annual Biennia
Site 10 Standa
Annual Biennia
Site 11 Standa
Annual Biennia
Site 13 Standa
Annual Biennia
Site 14 Standa
Annual Biennia
Site 15 Standa
Annual Biennia
Site 16 Standa
Annual Biennia
Site 2 Standarc
Annual Biennia
Site 201 Standa
Annual Biennia
Site 202 Standa
Annual Biennia
Site 203 Standa
Annual Biennia
Site 207 Standa
# of points/tra
5 10 30 40
Standard Error
0.00 0.05 0.10 0.15
10 20 30 40
Number of Transects

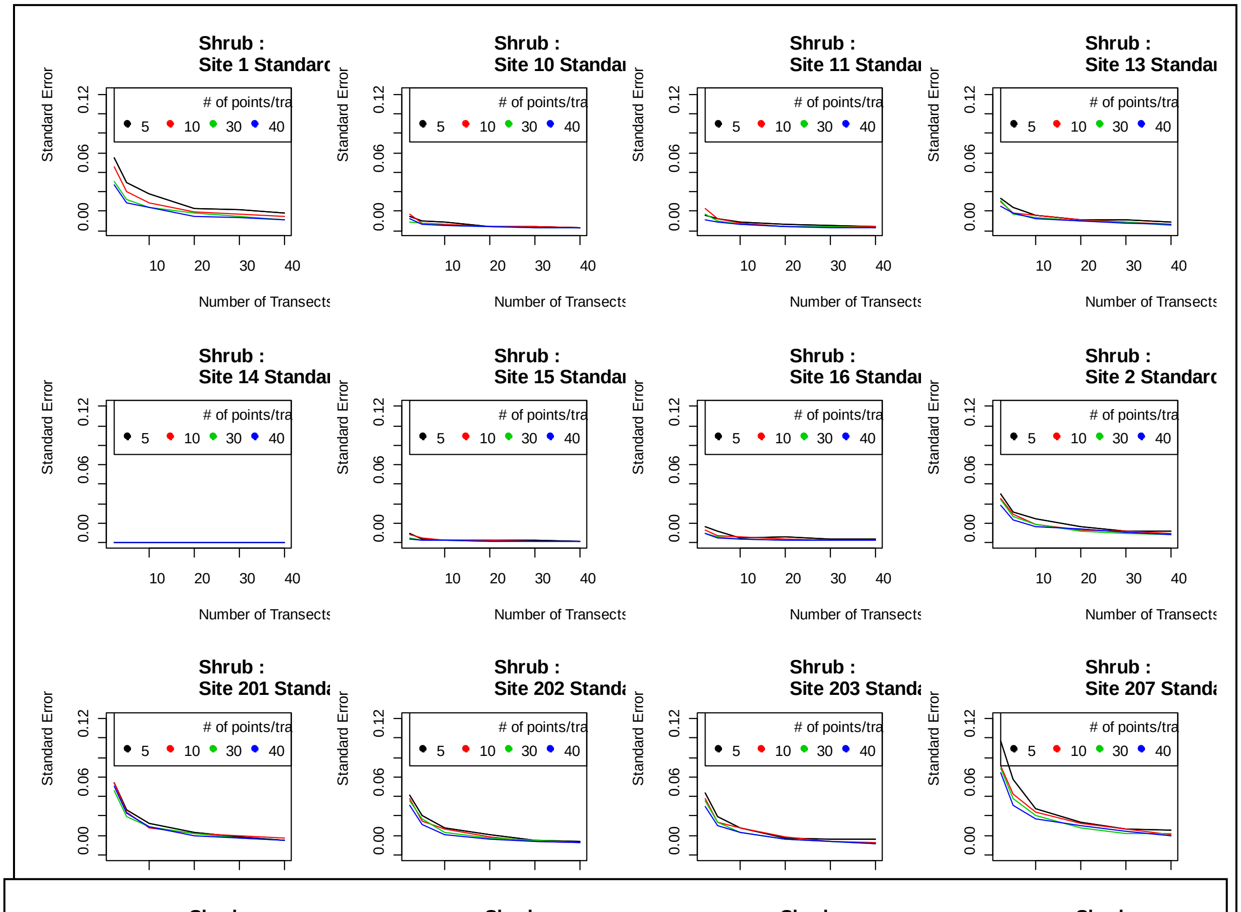

Annual Biennia
Site 209 Standa
Annual Biennia
Site 210 Standa
Annual Biennia
Site 211 Standa
Annual Biennia
Site 212 Standa
Annual Biennia
Site 213 Standa
Annual Biennia
Site 3 Standarc
Annual Biennia
Site 4 Standarc
Annual Biennia
Site 5 Standarc
Annual Biennia
Site 6 Standarc
Annual Biennia
Site 7 Standarc
Annual Biennia
Site 8 Standarc
Annual Biennia
Site 9 Standarc
# of points/tra
5 10 30 40
Standard Error
0.00 0.05 0.10 0.15
10 20 30 40
Number of Transects

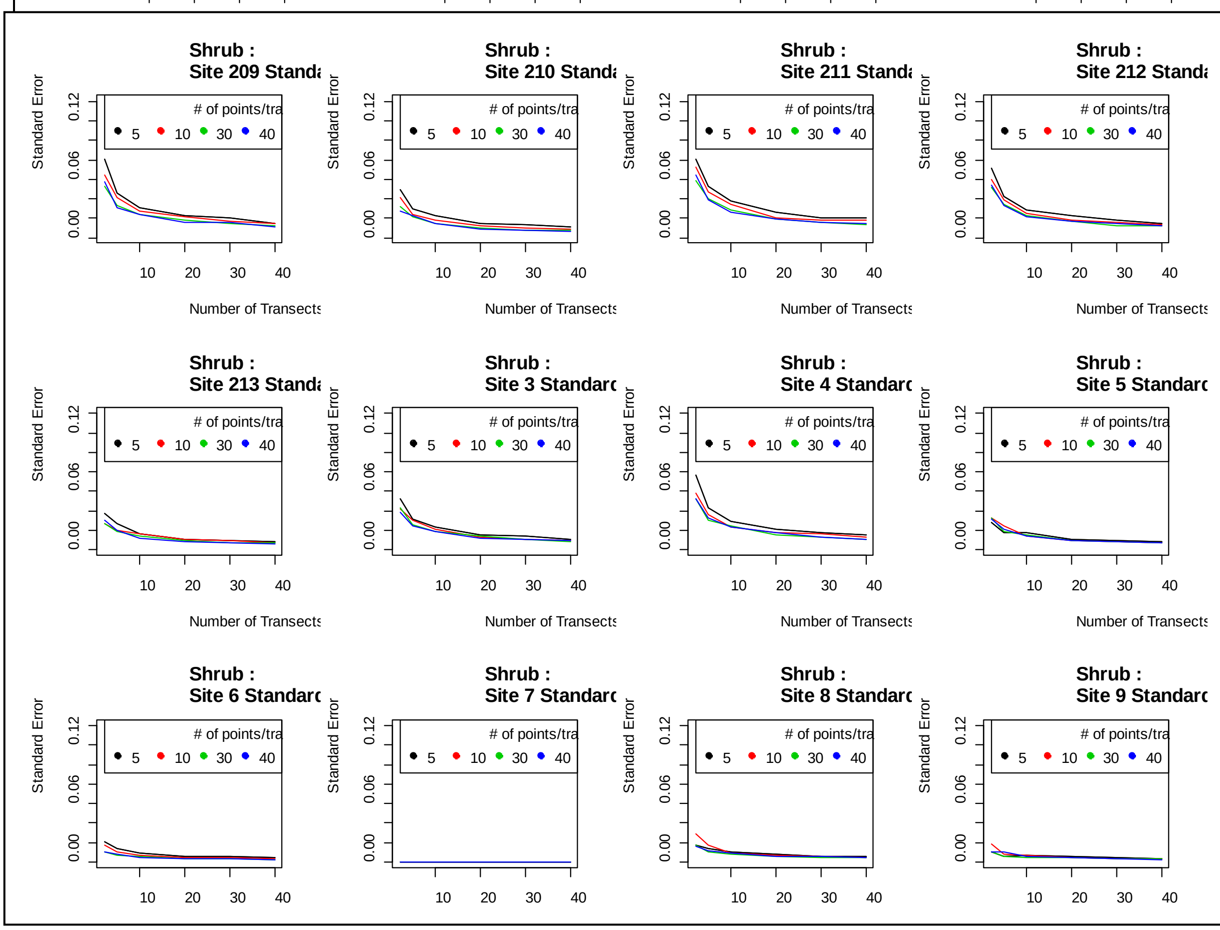

Fibrous Rt Rhi:
Site 1 Standarc
Fibrous Rt Rhi:
Site 10 Standai
Fibrous Rt Rhi:
Site 11 Standai
Fibrous Rt Rhi:
Site 13 Standai
Fibrous Rt Rhi:
Site 14 Standai
Fibrous Rt Rhi:
Site 15 Standai
Fibrous Rt Rhi:
Site 16 Standai
Fibrous Rt Rhi:
Site 2 Standarc
Fibrous Rt Rhi:
Site 201 Stand:
Fibrous Rt Rhi:
Site 202 Stand:
Fibrous Rt Rhi:
Site 203 Stand:
Fibrous Rt Rhi:
Site 207 Stand:
Standard Error
0.00
0.10
0.20
# of points/tra
5
10
30
40
Number of Transects

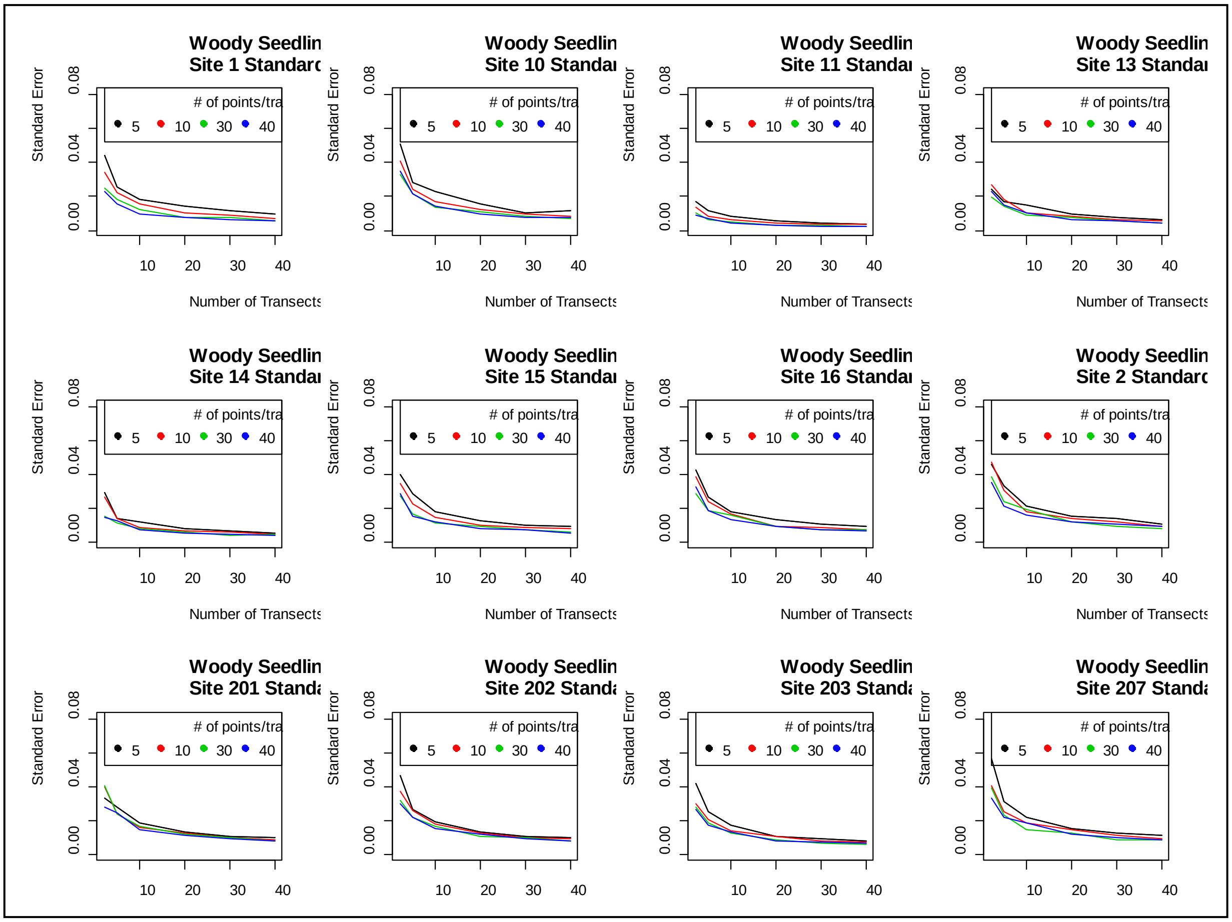

Fibrous Rt Rhi:
Site 209 Stand:
Fibrous Rt Rhi:
Site 210 Stand:
Fibrous Rt Rhi:
Site 211 Stand:
Fibrous Rt Rhi:
Site 212 Stand:
Fibrous Rt Rhi:
Site 213 Stand:
Fibrous Rt Rhi:
Site 3 Standarc
Fibrous Rt Rhi:
Site 4 Standarc
Fibrous Rt Rhi:
Site 5 Standarc
Fibrous Rt Rhi:
Site 6 Standarc
Fibrous Rt Rhi:
Site 7 Standarc
Fibrous Rt Rhi:
Site 8 Standarc
Fibrous Rt Rhi:
Site 9 Standarc
Standard Error
0.00
0.10
0.20
# of points/tra
5
10
30
40
Number of Transects

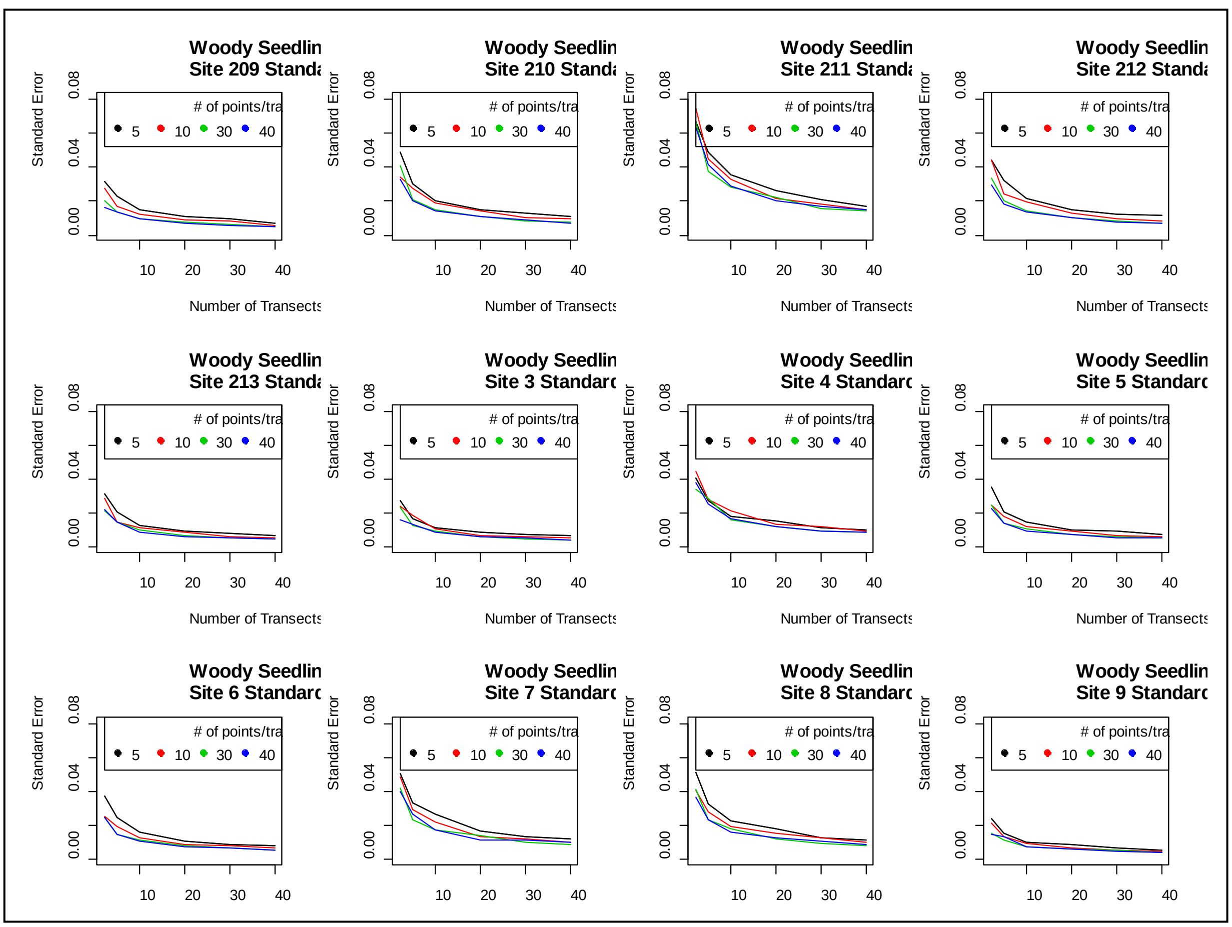

Tap Rooted Pe
Site 1 Standarc
Tap Rooted Pe
Site 10 Standaı
Tap Rooted Pe
Site 11 Standaı
Tap Rooted Pe
Site 13 Standaı
Tap Rooted Pe
Site 14 Standaı
Tap Rooted Pe
Site 15 Standaı
Tap Rooted Pe
Site 16 Standaı
Tap Rooted Pe
Site 2 Standarc
Tap Rooted Pe
Site 201 Standa
Tap Rooted Pe
Site 202 Standa
Tap Rooted Pe
Site 203 Standa
Tap Rooted Pe
Site 207 Standa
# of points/tra
5
10
30
40
Standard Error
0.00
0.05
0.10
0.15
10
20
30
40
Number of Transects

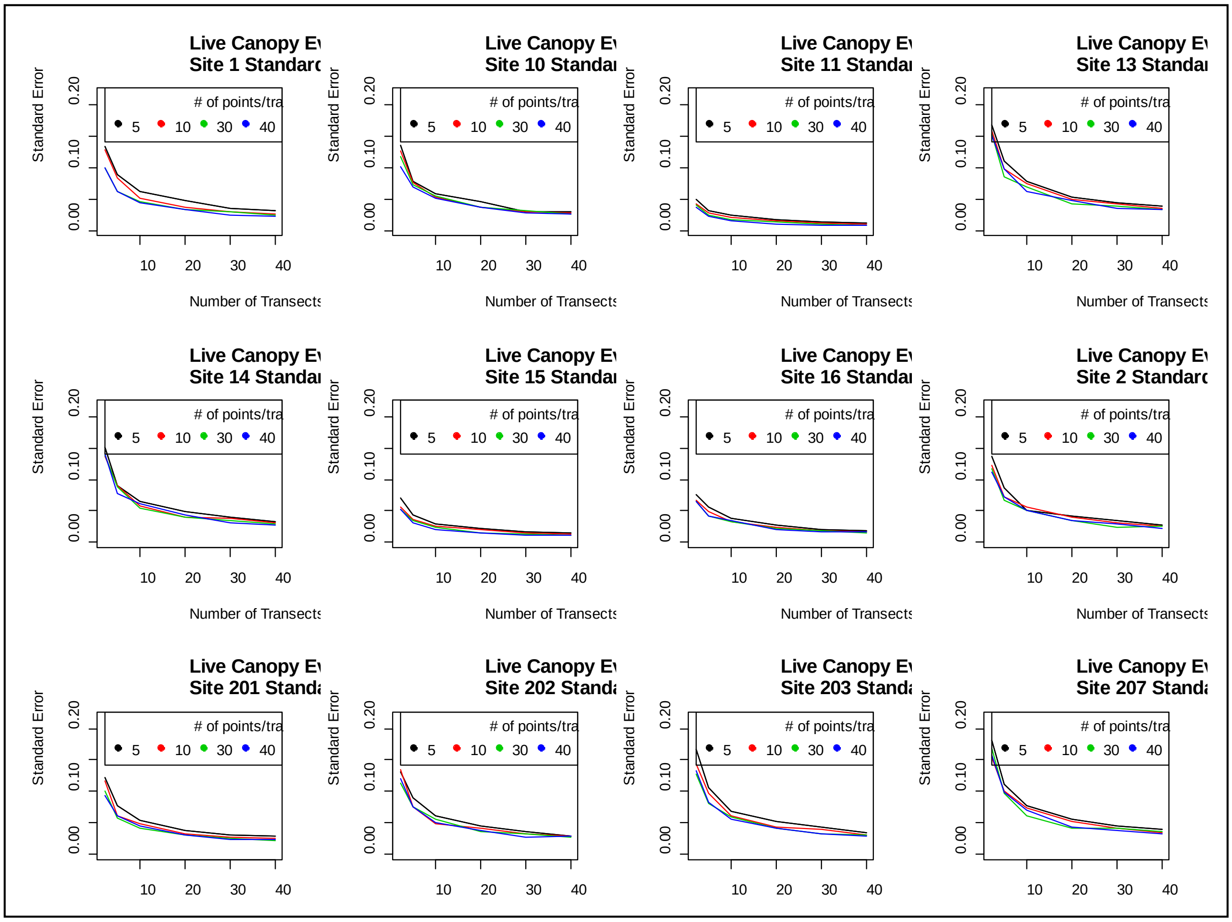

Tap Rooted Pe
Site 209 Standa
Tap Rooted Pe
Site 210 Standa
Tap Rooted Pe
Site 211 Standa
Tap Rooted Pe
Site 212 Standa
Tap Rooted Pe
Site 213 Standa
Tap Rooted Pe
Site 3 Standarc
Tap Rooted Pe
Site 4 Standarc
Tap Rooted Pe
Site 5 Standarc
Tap Rooted Pe
Site 6 Standarc
Tap Rooted Pe
Site 7 Standarc
Tap Rooted Pe
Site 8 Standarc
Tap Rooted Pe
Site 9 Standarc
# of points/tra
5
10
30
40
Standard Error
0.00
0.05
0.10
0.15
10
20
30
40
Number of Transects

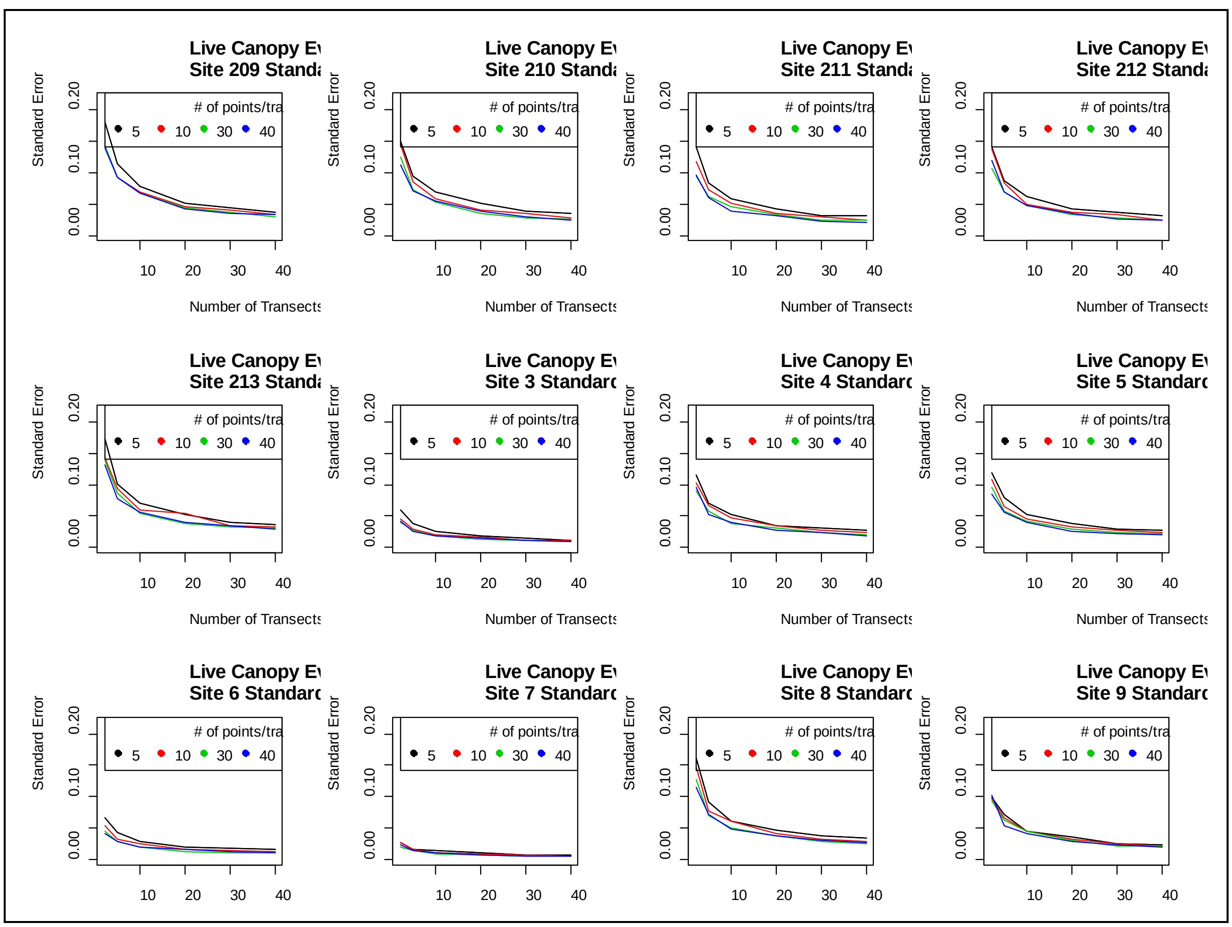

Shrub : Site 1 Standarc
Shrub : Site 10 Standai
Shrub : Site 11 Standai
Shrub : Site 13 Standai
Shrub : Site 14 Standai
Shrub : Site 15 Standai
Shrub : Site 16 Standai
Shrub : Site 2 Standarc
Shrub : Site 201 Standa
Shrub : Site 202 Standa
Shrub : Site 203 Standa
Shrub : Site 207 Standa
Standard Error
Number of Transects
# of points/tra
5 10 30 40


Shrub : Site 209 Standa
Shrub : Site 210 Standa
Shrub : Site 211 Standa
Shrub : Site 212 Standa
Shrub : Site 213 Standa
Shrub : Site 3 Standarc
Shrub : Site 4 Standarc
Shrub : Site 5 Standarc
Shrub : Site 6 Standarc
Shrub : Site 7 Standarc
Shrub : Site 8 Standarc
Shrub : Site 9 Standarc
Standard Error
Number of Transects
# of points/tra
5 10 30 40


Woody Seedlin
Site 1 Standard
Woody Seedlin
Site 10 Standar
Woody Seedlin
Site 11 Standar
Woody Seedlin
Site 13 Standar
Woody Seedlin
Site 14 Standar
Woody Seedlin
Site 15 Standar
Woody Seedlin
Site 16 Standar
Woody Seedlin
Site 2 Standard
Woody Seedlin
Site 201 Standa
Woody Seedlin
Site 202 Standa
Woody Seedlin
Site 203 Standa
Woody Seedlin
Site 207 Standa
# of points/tra
5 10 30 40
Standard Error
0.00 0.04 0.08
10 20 30 40
Number of Transects


Woody Seedlin
Site 209 Standa
Woody Seedlin
Site 210 Standa
Woody Seedlin
Site 211 Standa
Woody Seedlin
Site 212 Standa
Woody Seedlin
Site 213 Standa
Woody Seedlin
Site 3 Standard
Woody Seedlin
Site 4 Standard
Woody Seedlin
Site 5 Standard
Woody Seedlin
Site 6 Standard
Woody Seedlin
Site 7 Standard
Woody Seedlin
Site 8 Standard
Woody Seedlin
Site 9 Standard
# of points/tra
5 10 30 40
Standard Error
0.00 0.04 0.08
10 20 30 40
Number of Transects


Live Canopy E\
Site 1 Standarc
Live Canopy E\
Site 10 Standa
Live Canopy E\
Site 11 Standa
Live Canopy E\
Site 13 Standa
Live Canopy E\
Site 14 Standa
Live Canopy E\
Site 15 Standa
Live Canopy E\
Site 16 Standa
Live Canopy E\
Site 2 Standarc
Live Canopy E\
Site 201 Standa
Live Canopy E\
Site 202 Standa
Live Canopy E\
Site 203 Standa
Live Canopy E\
Site 207 Standa
# of points/tra
5 10 30 40
Standard Error
0.00 0.10 0.20
10 20 30 40
Number of Transects


Live Canopy E\
Site 209 Standa
Live Canopy E\
Site 210 Standa
Live Canopy E\
Site 211 Standa
Live Canopy E\
Site 212 Standa
Live Canopy E\
Site 213 Standa
Live Canopy E\
Site 3 Standarc
Live Canopy E\
Site 4 Standarc
Live Canopy E\
Site 5 Standarc
Live Canopy E\
Site 6 Standarc
Live Canopy E\
Site 7 Standarc
Live Canopy E\
Site 8 Standarc
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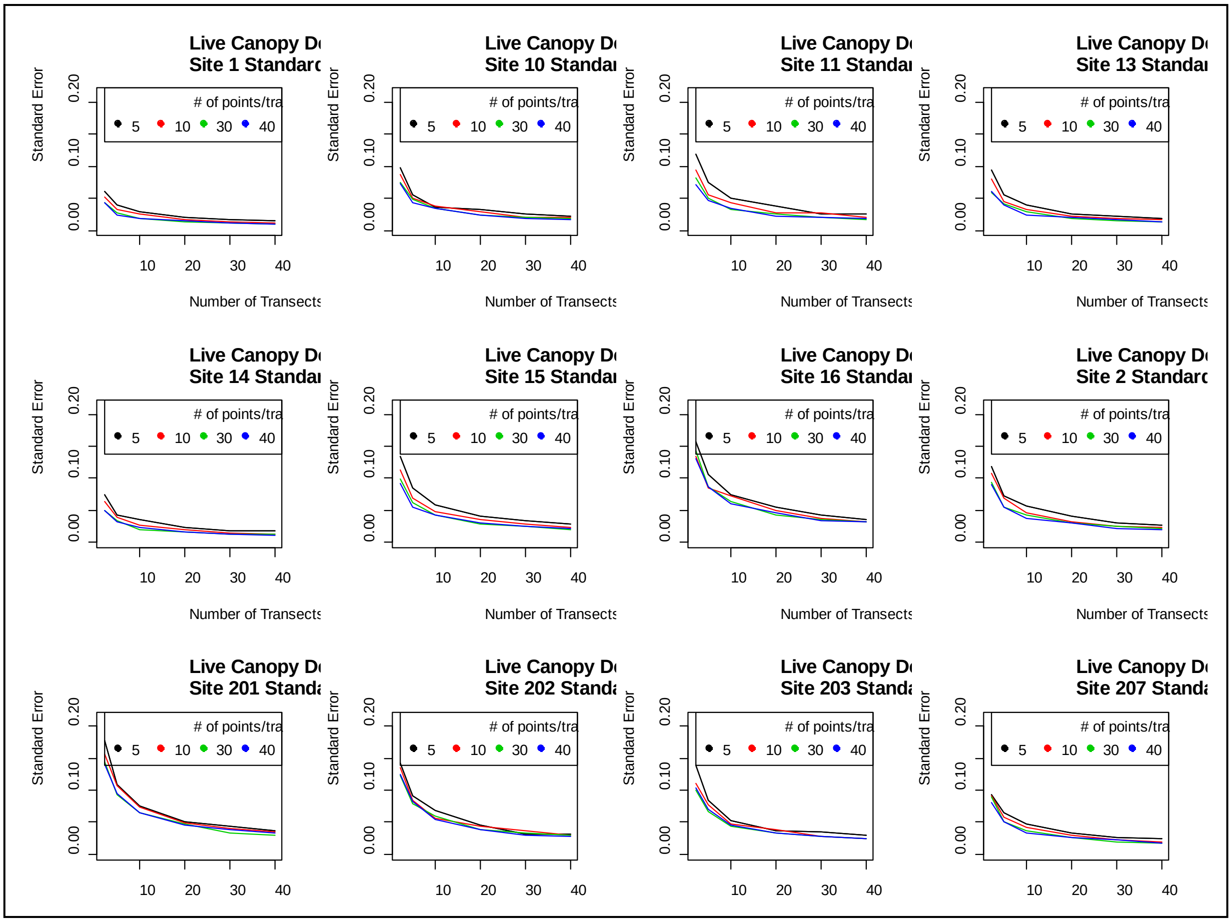
Site 9 Standarc
# of points/tra
5 10 30 40
Standard Error
0.00 0.10 0.20
10 20 30 40
Number of Transects


Live Canopy D
Site 1 Standar
Live Canopy D
Site 10 Standa
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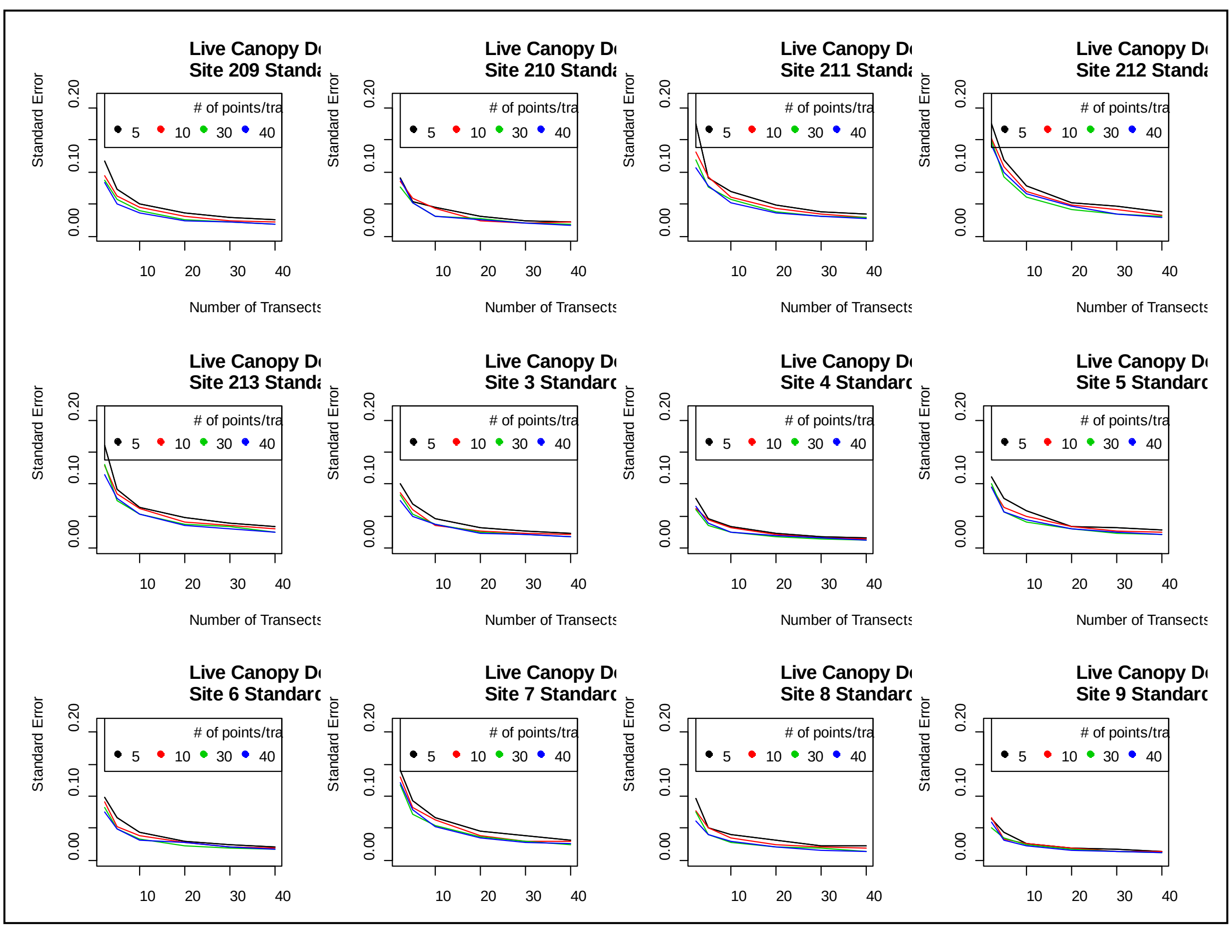
Site 11 Standa
Live Canopy D
Site 13 Standa
Live Canopy D
Site 14 Standa
Live Canopy D
Site 15 Standa
Live Canopy D
Site 16 Standa
Live Canopy D
Site 2 Standar
Live Canopy D
Site 201 Stand
Live Canopy D
Site 202 Stand
Live Canopy D
Site 203 Stand
Live Canopy D
Site 207 Stand
# of points/tra
5 10 30 40
Standard Error
0.00 0.10 0.20
10 20 30 40
Number of Transects


Live Canopy D
Site 209 Stand
Live Canopy D
Site 210 Stand
Live Canopy D
Site 211 Stand
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Site 212 Stand
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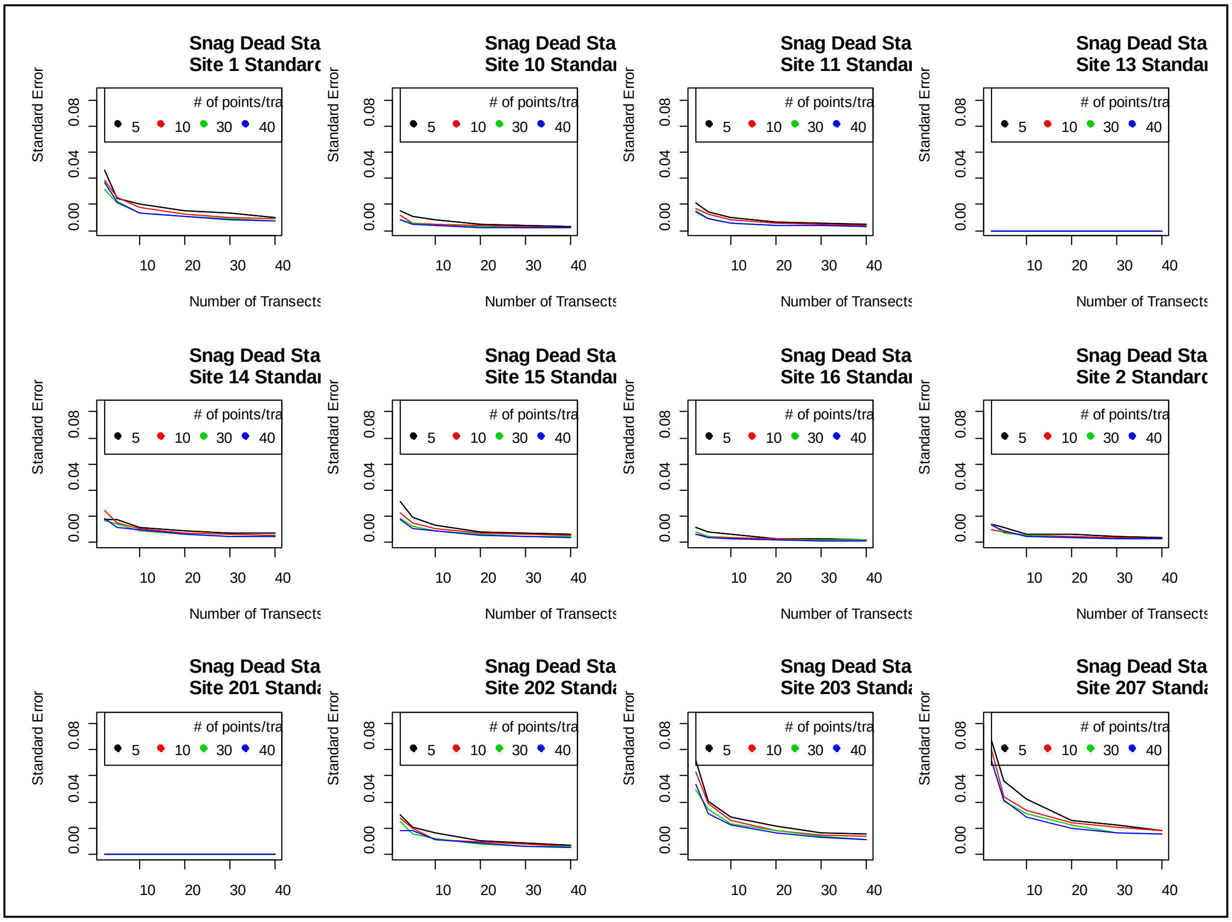
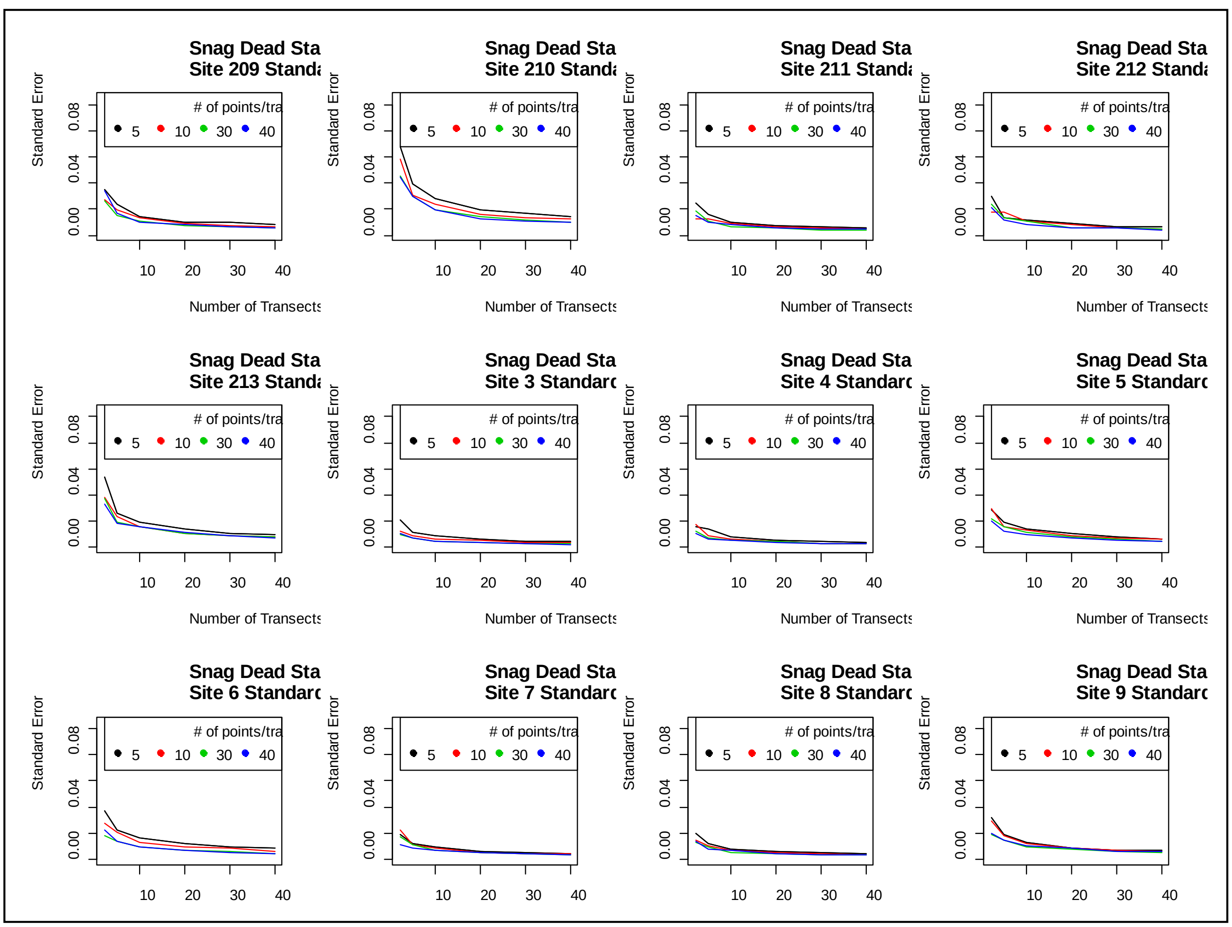
Site 213 Stand
Live Canopy D
Site 3 Standar
Live Canopy D
Site 4 Standar
Live Canopy D
Site 5 Standar
Live Canopy D
Site 6 Standar
Live Canopy D
Site 7 Standar
Live Canopy D
Site 8 Standar
Live Canopy D
Site 9 Standar
# of points/tra
5 10 30 40
Standard Error
0.00 0.10 0.20
10 20 30 40
Number of Transects


Snag Dead Sta
Site 1 Standarc
Snag Dead Sta
Site 10 Standaı
Snag Dead Sta
Site 11 Standaı
Snag Dead Sta
Site 13 Standaı
Snag Dead Sta
Site 14 Standaı
Snag Dead Sta
Site 15 Standaı
Snag Dead Sta
Site 16 Standaı
Snag Dead Sta
Site 2 Standarc
Snag Dead Sta
Site 201 Standa
Snag Dead Sta
Site 202 Standa
Snag Dead Sta
Site 203 Standa
Snag Dead Sta
Site 207 Standa
# of points/tra
5 10 30 40
Standard Error
0.00 0.04 0.08
10 20 30 40
Number of Transects


Snag Dead Sta
Site 209 Standa
Snag Dead Sta
Site 210 Standa
Snag Dead Sta
Site 211 Standa
Snag Dead Sta
Site 212 Standa
Snag Dead Sta
Site 213 Standa
Snag Dead Sta
Site 3 Standarc
Snag Dead Sta
Site 4 Standarc
Snag Dead Sta
Site 5 Standarc
Snag Dead Sta
Site 6 Standarc
Snag Dead Sta
Site 7 Standarc
Snag Dead Sta
Site 8 Standarc
Snag Dead Sta
Site 9 Standarc
# of points/tra
5 10 30 40
Standard Error
0.00 0.04 0.08
10 20 30 40
Number of Transects