Merced Riverbank Monitoring Analysis Report for Status, Trend, and Power to Detect Trend

Natural Resource Report NPS/XXXX/NRR—20XX/XXX

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February 2012

In Partial Fulfillment of
Task Agreement Number J8W07110005
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Introduction

Riverbank condition on the Merced River will be monitored over time as a measure of riparian ecosystem health. Accelerated riverbank erosion from visitor use is a major concern and can affect vegetation communities, water quality, and cultural value of the riverbank if archeological sites are affected. In this report, analyses of vegetation and substrate metrics provide estimates of annual status, trend over time, a power analysis for trend detection, and an investigation of the relationship between these metrics and visitor use.

Data

A generalized random tessellation stratified (GRTS) sample (Stevens and Olsen, 2003) was selected in 2008 with strata defined by sites occurring in stretches of river with gradients less than 0.005 (stratum 0) and greater than 0.005 degrees (stratum 1). Fifteen sites were surveyed in stratum 0 and 9 were surveyed in stratum 1 for a total sample of 24 sites, roughly in proportion to their relative linear extent. For each randomly-selected site in 2008, point-intercept sampling was used within transects spaced every 10m along a 100m-long baseline along on both banks. In the 2009 and 2010 surveys, baselines could exceed 100m if needed to obtain a minimum of 200 points and transects were located 4 to 5m apart along the baseline. In addition to the GRTS sample, four sites were deliberately chosen from sites with known levels of visitor use. Two sites were subjectively chosen from high-use areas and two sites were selected in low-use areas. Visitor use surveys were conducted in these sites as well as in four subjectively-selected GRTS sites with the goal of relating visitor use to metrics of riverbank condition.

The metrics analyzed in this report include functional groups related to understory community composition (nonvascular plants, annual biennials, tap-rooted perennials, fibrous-rooted perennials, woody seedlings, and shrubs), physical riverbank characteristics (litter cover, bare ground cover, large woody debris, green understory cover, substrate size classes, and exposed roots), and canopy characteristics (deciduous trees, evergreen trees, and snags). Green understory cover is calculated as the mean of indicators of the presence of nonvascular plants, annual biennials, tap-rooted perennials, fibrous-rooted perennials, woody seedlings, and shrubs. With the exception of substrate class size which is measured on a scale of 1 to 6, each of the measurements is a binary outcome taking the value of 1 if the outcome was observed at the plot level and 0 otherwise. In some cases, a value of "NI" was assigned to the point which indicated that the observer was concerned that the point was located too near another point and could not be treated as independent. Data summaries conducted with and without these points indicated very little difference in means at the site level, so these points were omitted. Means of all variables were computed at the site level. This results in a non-integer value for substrate class size and an estimate of percent cover for vegetation variables.

Bare ground and litter metrics were collected as a single field in 2008 but separately in 2009 and 2010. To maximize the replication over time, for this analysis the two fields are combined. However, as the monitoring period increases, the two metrics will be able to be analyzed over time separately.

Status Estimation

Status estimates from GRTS samples and subjectively-chosen sites are obtained. The ranges of metrics exhibiting significant differences between low- and high use subjectively-chosen sites are obtained to provide information on threshold values.

Status estimates

Status estimates are computed for each year from the GRTS sample sites only (Tables 1 to 15). Within-stratum and across-stratum estimates are calculated from site-level means with the *total.est* function from the R package, *spsurvey* (see Appendix A for example R code). The tables also provide the means, standard errors, and confidence intervals on the means for the two high-use and two low-use sites by year. Recall that the deliberately-chosen sites are not statistically representative of a larger population of sites, and confidence intervals are based on only two sites.

Table 1: Estimates of mean substrate size class by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	1.3438	0.0449	1.2699	1.4176
2008	1	GRTS	1.9800	0.2493	1.5700	2.3900
2008	ALL	GRTS	1.5460	0.0850	1.4063	1.6857
2009	0	GRTS	1.0971	0.0458	1.0218	1.1725
2009	1	GRTS	1.9760	0.1432	1.7404	2.2116
2009	ALL	GRTS	1.4484	0.0635	1.3439	1.5528
2010	0	GRTS	1.2633	0.0481	1.1842	1.3425
2010	1	GRTS	1.7909	0.1380	1.5639	2.0179
2010	ALL	GRTS	1.4775	0.0629	1.3741	1.5810
2008	Low use	Index	1.6650	0.3500	1.0893	2.2407
2008	High use	Index	1.3950	0.1662	1.1217	1.6683
2010	Low use	Index	1.7750	0.2722	1.3272	2.2228
2010	High use	Index	1.7100	0.0778	1.5821	1.8379

Table 2: Percent cover estimates of large woody debris by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.0129	0.0026	0.0086	0.0172
2008	1	GRTS	0.0175	0.0053	0.0088	0.0262
2008	ALL	GRTS	0.0144	0.0025	0.0103	0.0184
2009	0	GRTS	0.0129	0.0026	0.0086	0.0171
2009	1	GRTS	0.0299	0.0135	0.0077	0.0520
2009	ALL	GRTS	0.0197	0.0056	0.0104	0.0289
2010	0	GRTS	0.0164	0.0025	0.0123	0.0205
2010	1	GRTS	0.0255	0.0061	0.0154	0.0355
2010	ALL	GRTS	0.0201	0.0029	0.0153	0.0248
2008	Low use	Index	0.0300	0.0071	0.0184	0.0416
2008	High use	Index	0.0012	0.0008	-0.0002	0.0026
2010	Low use	Index	0.0500	0.0141	0.0267	0.0733
2010	High use	Index	0.0061	0.0027	0.0016	0.0106

Table 3: Percent cover estimates of exposed roots by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.0114	0.0016	0.0088	0.0141
2008	1	GRTS	0.0325	0.0041	0.0257	0.0393
2008	ALL	GRTS	0.0181	0.0017	0.0153	0.0209
2009	0	GRTS	0.0157	0.0044	0.0085	0.0229
2009	1	GRTS	0.0280	0.0052	0.0195	0.0365
2009	ALL	GRTS	0.0206	0.0033	0.0151	0.0261
2010	0	GRTS	0.0236	0.0028	0.0190	0.0281
2010	1	GRTS	0.0455	0.0068	0.0342	0.0567
2010	ALL	GRTS	0.0325	0.0032	0.0272	0.0378
2008	Low use	Index	0.0100	0.0000	0.0100	0.0100
2008	High use	Index	0.0108	0.0060	0.0010	0.0207
2010	Low use	Index	0.0400	0.0141	0.0167	0.0633
2010	High use	Index	0.0122	0.0055	0.0031	0.0213

Table 4: Percent cover estimates of nonvascular plants by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.0065	0.0042	-0.0004	0.0134
2008	1	GRTS	0.0306	0.0101	0.0140	0.0471
2008	ALL	GRTS	0.0141	0.0043	0.0071	0.0212
2009	0	GRTS	0.0082	0.0029	0.0034	0.0130
2009	1	GRTS	0.0587	0.0156	0.0331	0.0843
2009	ALL	GRTS	0.0284	0.0065	0.0178	0.0390
2010	0	GRTS	0.0185	0.0065	0.0079	0.0291
2010	1	GRTS	0.0555	0.0108	0.0376	0.0733
2010	ALL	GRTS	0.0335	0.0058	0.0239	0.0431
2008	Low use	Index	0.0500	0.0212	0.0151	0.0849
2008	High use	Index	0.0000	0.0000	0.0000	0.0000
2010	Low use	Index	0.0600	0.0212	0.0251	0.0949
2010	High use	Index	0.0100	0.0071	-0.0016	0.0216

Table 5: Percent cover estimates of annuals and biennials by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.0453	0.0172	0.0170	0.0735
2008	1	GRTS	0.0022	0.0007	0.0011	0.0032
2008	ALL	GRTS	0.0316	0.0117	0.0123	0.0508
2009	0	GRTS	0.0448	0.0114	0.0259	0.0636
2009	1	GRTS	0.0047	0.0034	-0.0009	0.0103
2009	ALL	GRTS	0.0287	0.0070	0.0172	0.0403
2010	0	GRTS	0.0631	0.0097	0.0472	0.0790
2010	1	GRTS	0.0355	0.0101	0.0189	0.0520
2010	ALL	GRTS	0.0519	0.0070	0.0403	0.0635
2008	Low use	Index	0.0200	0.0071	0.0084	0.0316
2008	High use	Index	0.0061	0.0028	0.0015	0.0106
2010	Low use	Index	0.0400	0.0000	0.0400	0.0400
2010	High use	Index	0.0700	0.0212	0.0351	0.1049

Table 6: Percent cover estimates of fibrous rooted/rhizomatous perennials by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.2600	0.0279	0.2141	0.3059
2008	1	GRTS	0.1150	0.0206	0.0811	0.1489
2008	ALL	GRTS	0.2139	0.0201	0.1808	0.2470
2009	0	GRTS	0.4386	0.0552	0.3478	0.5294
2009	1	GRTS	0.1300	0.0299	0.0808	0.1792
2009	ALL	GRTS	0.3153	0.0352	0.2573	0.3732
2010	0	GRTS	0.3847	0.0280	0.3386	0.4307
2010	1	GRTS	0.1064	0.0183	0.0763	0.1365
2010	ALL	GRTS	0.2717	0.0182	0.2417	0.3017
2008	Low use	Index	0.2700	0.0919	0.1188	0.4212
2008	High use	Index	0.2176	0.0795	0.0868	0.3483
2010	Low use	Index	0.2000	0.0495	0.1186	0.2814
2010	High use	Index	0.2400	0.0707	0.1237	0.3563

Table 7: Percent cover estimates of tap-rooted perennials by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.0627	0.0223	0.0261	0.0994
2008	1	GRTS	0.0058	0.0020	0.0025	0.0091
2008	ALL	GRTS	0.0446	0.0152	0.0196	0.0697
2009	0	GRTS	0.0629	0.0378	0.0007	0.1250
2009	1	GRTS	0.0150	0.0057	0.0055	0.0244
2009	ALL	GRTS	0.0437	0.0228	0.0062	0.0812
2010	0	GRTS	0.0960	0.0153	0.0708	0.1212
2010	1	GRTS	0.0104	0.0021	0.0069	0.0139
2010	ALL	GRTS	0.0613	0.0091	0.0462	0.0763
2008	Low use	Index	0.0012	0.0009	-0.0002	0.0026
2008	High use	Index	0.0000	0.0000	0.0000	0.0000
2010	Low use	Index	0.0622	0.0409	-0.0050	0.1294
2010	High use	Index	0.0106	0.0067	-0.0004	0.0215

Table 8: Percent cover estimates of shrubs by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.0425	0.0092	0.0273	0.0577
2008	1	GRTS	0.0350	0.0071	0.0233	0.0467
2008	ALL	GRTS	0.0401	0.0067	0.0291	0.0511
2009	0	GRTS	0.0062	0.0025	0.0020	0.0103
2009	1	GRTS	0.0520	0.0142	0.0287	0.0753
2009	ALL	GRTS	0.0245	0.0059	0.0149	0.0341
2010	0	GRTS	0.0185	0.0088	0.0040	0.0329
2010	1	GRTS	0.0400	0.0057	0.0306	0.0494
2010	ALL	GRTS	0.0272	0.0057	0.0178	0.0366
2008	Low use	Index	0.0850	0.0389	0.0210	0.1490
2008	High use	Index	0.0522	0.0298	0.0031	0.1013
2010	Low use	Index	0.0350	0.0106	0.0176	0.0524
2010	High use	Index	0.0033	0.0008	0.0021	0.0046

Table 9: Percent cover estimates of woody seedlings by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.0031	0.0014	0.0007	0.0054
2008	1	GRTS	0.0090	0.0034	0.0034	0.0145
2008	ALL	GRTS	0.0049	0.0014	0.0026	0.0073
2009	0	GRTS	0.0090	0.0025	0.0049	0.0132
2009	1	GRTS	0.0127	0.0027	0.0083	0.0171
2009	ALL	GRTS	0.0105	0.0018	0.0075	0.0135
2010	0	GRTS	0.0172	0.0025	0.0132	0.0213
2010	1	GRTS	0.0185	0.0026	0.0142	0.0229
2010	ALL	GRTS	0.0178	0.0018	0.0148	0.0207
2008	Low use	Index	0.0150	0.0035	0.0092	0.0208
2008	High use	Index	0.0012	0.0008	-0.0002	0.0026
2010	Low use	Index	0.0350	0.0106	0.0176	0.0524
2010	High use	Index	0.0150	0.0035	0.0092	0.0208

Table 10: Percent cover estimates of evergreen trees by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.2125	0.0300	0.1631	0.2619
2008	1	GRTS	0.4375	0.0680	0.3256	0.5494
2008	ALL	GRTS	0.2840	0.0298	0.2350	0.3330
2009	0	GRTS	0.1943	0.0590	0.0973	0.2913
2009	1	GRTS	0.3600	0.0221	0.3236	0.3964
2009	ALL	GRTS	0.2605	0.0365	0.2005	0.3205
2010	0	GRTS	0.1480	0.0213	0.1130	0.1830
2010	1	GRTS	0.3155	0.0591	0.2183	0.4126
2010	ALL	GRTS	0.2160	0.0271	0.1714	0.2606
2008	Low use	Index	0.3550	0.0601	0.2561	0.4539
2008	High use	Index	0.1505	0.0074	0.1383	0.1627
2010	Low use	Index	0.3100	0.0778	0.1821	0.4379
2010	High use	Index	0.0700	0.0071	0.0584	0.0816

Table 11: Percent cover estimates of deciduous trees by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.2250	0.0343	0.1686	0.2814
2008	1	GRTS	0.2950	0.0417	0.2264	0.3636
2008	ALL	GRTS	0.2472	0.0269	0.2030	0.2915
2009	0	GRTS	0.2057	0.0406	0.1389	0.2725
2009	1	GRTS	0.2820	0.0514	0.1975	0.3665
2009	ALL	GRTS	0.2362	0.0319	0.1838	0.2886
2010	0	GRTS	0.1553	0.0166	0.1281	0.1826
2010	1	GRTS	0.3145	0.0632	0.2105	0.4185
2010	ALL	GRTS	0.2200	0.0275	0.1747	0.2652
2008	Low use	Index	0.3750	0.0247	0.3343	0.4157
2008	High use	Index	0.2223	0.0370	0.1615	0.2832
2010	Low use	Index	0.3000	0.0778	0.1721	0.4279
2010	High use	Index	0.1500	0.0071	0.1384	0.1616

Table 12: Percent cover estimates of snags by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.0618	0.0375	0.0001	0.1234
2008	1	GRTS	0.0150	0.0052	0.0064	0.0236
2008	ALL	GRTS	0.0469	0.0256	0.0048	0.0891
2009	0	GRTS	0.0032	0.0012	0.0013	0.0051
2009	1	GRTS	0.0160	0.0053	0.0072	0.0248
2009	ALL	GRTS	0.0083	0.0022	0.0046	0.0120
2010	0	GRTS	0.0138	0.0029	0.0090	0.0186
2010	1	GRTS	0.0291	0.0068	0.0178	0.0403
2010	ALL	GRTS	0.0200	0.0033	0.0146	0.0254
2008	Low use	Index	0.0062	0.0027	0.0018	0.0106
2008	High use	Index	0.0000	0.0000	0.0000	0.0000
2010	Low use	Index	0.0062	0.0027	0.0018	0.0106
2010	High use	Index	0.0056	0.0031	0.0004	0.0107

Table 13: Percent cover estimates of bare ground or litter by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.7857	0.0320	0.7331	0.8383
2008	1	GRTS	0.6950	0.0674	0.5842	0.8058
2008	ALL	GRTS	0.7542	0.0313	0.7026	0.8058
2009	0	GRTS	0.9871	0.0043	0.9800	0.9943
2009	1	GRTS	0.9760	0.0045	0.9686	0.9834
2009	ALL	GRTS	0.9827	0.0032	0.9775	0.9879
2010	0	GRTS	0.9060	0.0124	0.8856	0.9264
2010	1	GRTS	0.9273	0.0137	0.9047	0.9498
2010	ALL	GRTS	0.9146	0.0092	0.8994	0.9298
2008	Low use	Index	0.7800	0.1061	0.6055	0.9545
2008	High use	Index	0.7422	0.0833	0.6053	0.8792
2010	Low use	Index	0.9350	0.0247	0.8943	0.9757
2010	High use	Index	0.9350	0.0389	0.8710	0.9990

Table 14: Percent cover estimates of bare ground by stratum for 2010 with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2010	0	GRTS	0.2953	0.0242	0.2555	0.3352
2010	1	GRTS	0.3118	0.0592	0.2144	0.4092
2010	ALL	GRTS	0.3020	0.0280	0.2560	0.3481
2010	Low use	Index	0.2050	0.0672	0.0945	0.3155
2010	High use	Index	0.5200	0.0849	0.3804	0.6596

Table 15: Percent cover estimates of litter by stratum for 2010 with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2010	0	GRTS	0.6100	0.0243	0.5701	0.6499
2010	1	GRTS	0.6145	0.0591	0.5173	0.7118
2010	ALL	GRTS	0.6118	0.0280	0.5658	0.6579
2010	Low use	Index	0.7250	0.0884	0.5796	0.8704
2010	High use	Index	0.4150	0.0460	0.3394	0.4906

Table 16: Percent cover estimates of green understory by year and stratum with SE calculated from the neighborhood variance estimator for GRTS samples (Stevens and Olsen, 2003).

Year	Stratum	Site Type	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
2008	0	GRTS	0.4212	0.0438	0.3493	0.4932
2008	1	GRTS	0.1950	0.0218	0.1591	0.2309
2008	ALL	GRTS	0.3493	0.0306	0.2989	0.3997
2009	0	GRTS	0.5686	0.0651	0.4615	0.6756
2009	1	GRTS	0.2780	0.0589	0.1811	0.3749
2009	ALL	GRTS	0.4525	0.0456	0.3774	0.5275
2010	0	GRTS	0.6000	0.0311	0.5488	0.6512
2010	1	GRTS	0.2673	0.0360	0.2080	0.3266
2010	ALL	GRTS	0.4649	0.0236	0.4261	0.5037
2008	Low use	Index	0.4250	0.0389	0.3610	0.4890
2008	High use	Index	0.2748	0.0532	0.1873	0.3623
2010	Low use	Index	0.3700	0.0354	0.3118	0.4282
2010	High use	Index	0.3000	0.0778	0.1721	0.4279

Comparing cover metrics for low- and high-use subjectively-chosen sites

The subjectively-chosen sites are further examined to determine if threshold values can be obtained by comparing low- and high-use sites. Confidence intervals on status estimates from subjectively-chosen sites are compared to identify metrics that may differ between sites with low use and desired condition and high-use sites of concern. Recall that the deliberately-chosen sites are not statistically representative of a larger population of sites, and confidence intervals are based on only two sites. Since the sample size is so small, formal hypothesis testing and p-value reporting is not provided. Because means that are statistically different at the α level will have non-overlapping $100*(1- \alpha)\%$-confidence intervals, the confidence intervals are simply compared without formal testing. Confidence intervals for means of low- and high-use sites are found to be non-overlapping for the following percent cover metrics: LWD, Nonvascular Plants, Shrubs, Evergreens, Deciduous Trees, Bare Ground, and Litter (Table 17).

Table 17: Ranges of 2010 bank-level means of subjectively-chosen sites.

Metric	Use	Est. Mean	SE	90%-CI lower bound	90%-CI upper bound
Substrate Size Class	Low	1.7750	0.2722	1.3272	2.2228
	High	1.7100	0.0778	1.5821	1.8379
Lwd	Low	0.0500	0.0141	0.0267	0.0733
	High	0.0061	0.0027	0.0016	0.0106
Exposed Roots	Low	0.0400	0.0141	0.0167	0.0633
	High	0.0122	0.0055	0.0031	0.0213
Nonvascular Plants	Low	0.0600	0.0212	0.0251	0.0949
	High	0.0100	0.0071	-0.0016	0.0216
Annuals/Biennials	Low	0.0400	0.0000	0.0400	0.0400
	High	0.0700	0.0212	0.0351	0.1049
Fibrous Rooted/ Rhizomatous Perennials	Low	0.2000	0.0495	0.1186	0.2814
	High	0.2400	0.0707	0.1237	0.3563
Tap-Rooted Perennials	Low	0.0622	0.0409	-0.0050	0.1294
	High	0.0106	0.0067	-0.0004	0.0215
Shrub	Low	0.0350	0.0106	0.0176	0.0524
	High	0.0033	0.0008	0.0021	0.0046
Woody Seedlings	Low	0.0350	0.0106	0.0176	0.0524
	High	0.0150	0.0035	0.0092	0.0208
Evergreen	Low	0.3100	0.0778	0.1821	0.4379
	High	0.0700	0.0071	0.0584	0.0816
Deciduous	Low	0.3000	0.0778	0.1721	0.4279
	High	0.1500	0.0071	0.1384	0.1616
Snag	Low	0.0062	0.0027	0.0018	0.0106
	High	0.0056	0.0031	0.0004	0.0107
Bare Ground	Low	0.2050	0.0672	0.0945	0.3155
	High	0.5200	0.0849	0.3804	0.6596
Litter	Low	0.7250	0.0884	0.5796	0.8704
	High	0.4150	0.0460	0.3394	0.4906

The 2010 bank-level means are examined for the seven metrics that differed significantly between low- and high-use categories. Recall that there are two sites within each use category, so there are 4 total means from which to obtain a range. The ranges of the bank-level means (Table 18) do not overlap for LWD and Shrub mean percent cover with a value of 1% cover creating the threshold for both metrics. The remaining metrics do exhibit some overlap between the four bank-level means of the low-use sites and the high-use sites. However, the distribution of those four means within each use category may provide some information on which to base a threshold for condition.

Table 18: Ranges of 2010 bank-level means of subjectively-chosen sites.

Percent Cover Metric	Range of Values in Low Use Sites	Range of Values in High Use Sites
LWD	0.01, 0.08	0.00, 0.01
NonVascularPlant	0.02, 0.20	0.00, 0.10
Shrub	0.01, 0.06	0.00, 0.01
Evergreen	0.12, 0.45	0.00, 0.19
Deciduous	0.19, 0.54	0.09, 0.36
Bare Ground	0.07, 0.39	0.18, 0.76
Litter	0.57, 0.88	0.23, 0.70

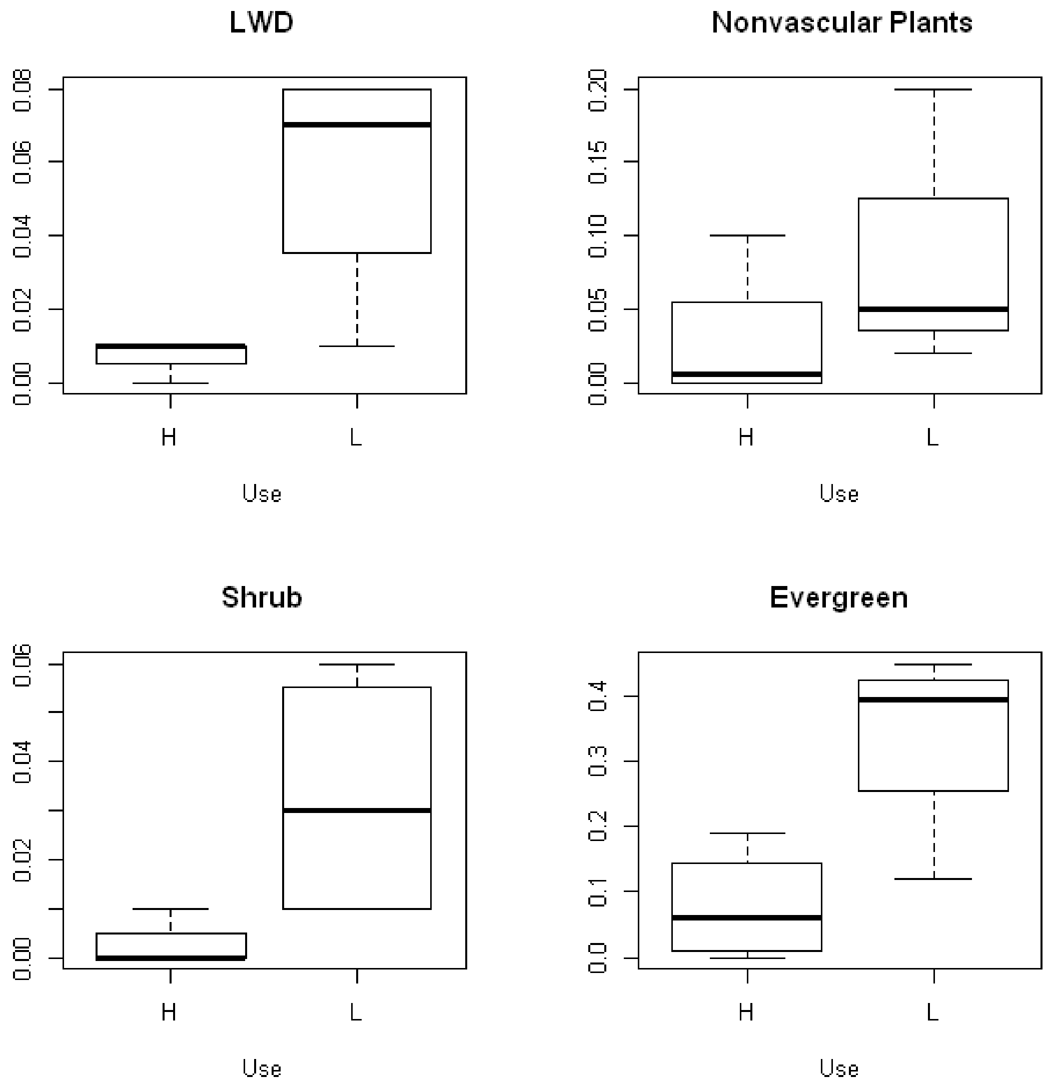


Figure 1: Boxplots of bank-level means.

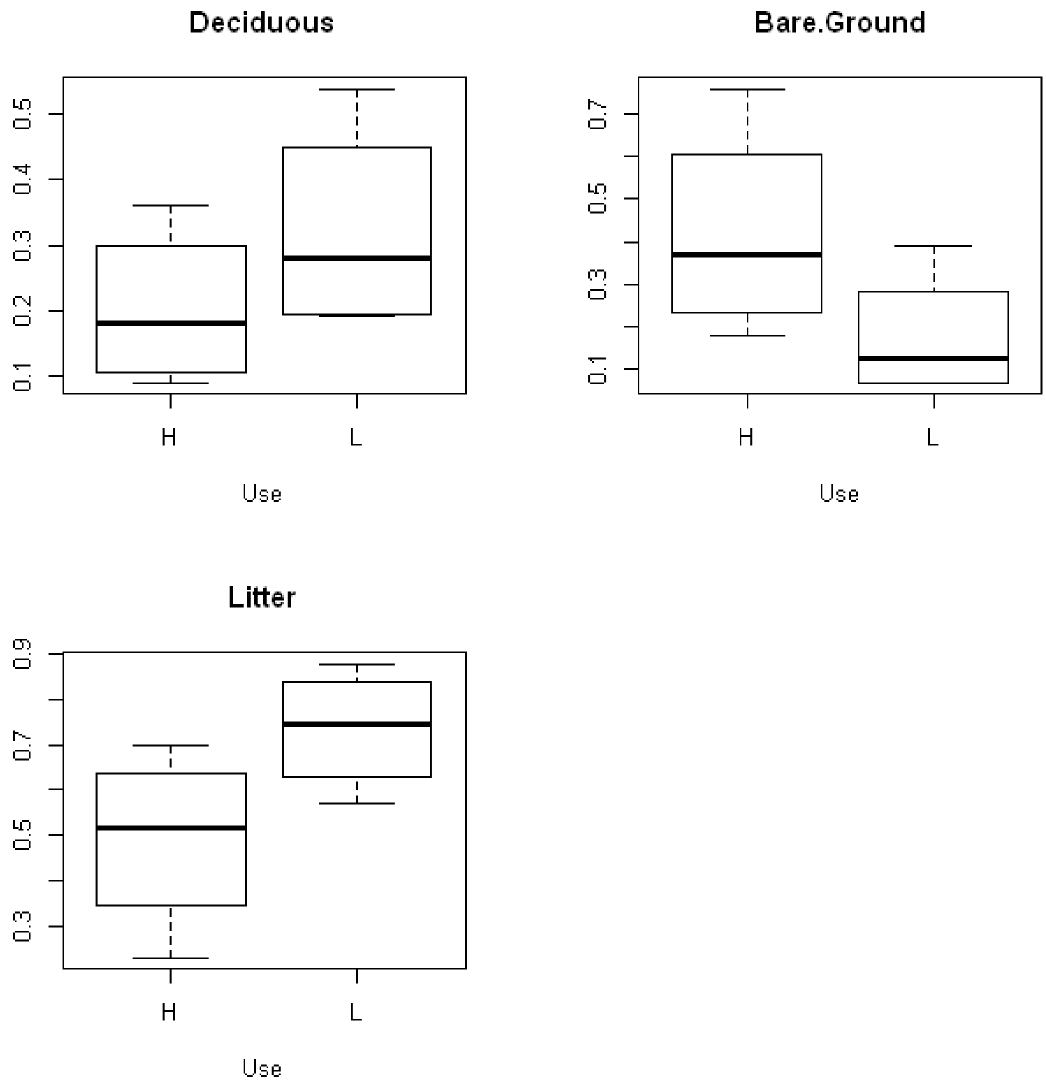


Figure 2: Boxplots of bank-level means.

Trend Estimation and Power Analysis

Modeling of the pilot data was conducted with a mixed model proposed by Piepho and Ogutu (2002). Mixed models allow some effects to be treated as fixed and others as random. The fixed effects contribute to the mean of the outcome of interest and are not considered to be representative of a larger population. Random effects contribute to the variance and are considered a random sample from a larger population of effects. Random effects are used to estimate variation of linear trends among a random sample of subjects (lakes) and over time (years). Piepho and Ogutu (2002) consider the site effect as fixed or random. If this effect is assumed random, it may also be modeled to be correlated with the random slope associated with lakes. The mixed model approach is an extension of simple linear regression that allows a partition of the variance into components that indicate major sources of variability.

The proposed mixed model for trend is:

$$y_{ij} = \mu + w_j\beta + b_j + a_i + w_j t_i + e_{ij},$$

where $i = 1,..,m_\mathrm{a}$; $j = 1,..,m_\mathrm{b}$; and

m_a = the number of sites in the sample;

m_b = the number of consective years in the sample;

y_{ij} = the outcome of interest for site i and year j;

w_j = constant representing the j^{th} year (covariate);

μ and β = fixed intercept and slope of the linear time trend;

b_j = random effect of the j^{th} year;

a_i = random intercept of i^{th} site, independent and identically distributed as $\mathrm{N}\left(0,\sigma_\mathrm{a}^2\right)$;

t_i = random slope of i^{th} site, independent and identically distributed as $\mathrm{N}\left(0,\sigma_\mathrm{t}^2\right)$; and

e_{ij} = unexplained error, independent and identically distributed as $\mathrm{N}\left(0,\sigma_\mathrm{e}^2\right)$.

Trend is estimated from site-level means of each outcome of interest. Trend models for site-by-bank-level means were also examined, but trend modeling at this level inflated residual variance estimates. For five of the 13 outcomes, p-values for trend tests were smaller than p-values for trend tests of site-level means but inference at the $\alpha = 0.10$ level was not affected. The use of transects on both banks is treated as part of the response design rather than a level of randomization that needs to be represented in the trend model. This response design accounts for the variation within a site but data are summarized at the sampling unit (site) level.

Data transformations were considered for each outcome of interest to better meet assumptions of homoscedastic and normally-distributed errors. Modeling percent cover variables ranging from 0% to 100% better satisfied modeling assumptions that did modeling proportional data falling between 0 and 1. For all vegetative cover variables except evergreen tree percent cover and bare ground/litter percent cover, logarithmic transformations were necessary to meet model assumptions. Substrate class size means at the site level were also analyzed with the logarithmic transformation. Note that inference for logged outcomes is on the median rather than the mean.

Trend models contained fixed effects for year, stratum, and year-by-stratum interaction if the data exhibited separate trends for each stratum. Model selection was conducted using Bayes Information Criterion (BIC) as suggested by Gurka (2006). When variance components were estimated at or near zero, the corresponding random effects were omitted from the model. The transformations for each outcome, estimates of fixed effects and random effects variances, and the results of trend tests are provided for each outcome in Table 19. R code for the trend models is provided in Appendix B. The trend tests are two-sided tests for change in either direction. Significant trends were detected for large woody debris, non-vascular plants, annual biennials, tap-rooted perennials, woody seedlings, evergreen trees, and deciduous trees.

Note that trend estimates represent additive changes for untransformed outcomes, and trend estimates for outcomes modeled with the logarithmic transformation must be back-transformed and interpreted as multiplicative changes. For example, the trend test for percent cover of evergreen trees is significant at the 0.10 level. The estimate of the trend is -9.1342, indicating an annual decline of the percent cover of 9.1342 percentage points. An increasing trend is estimated for the percent cover of woody seedlings which increases by a multiplicative factor of $\exp\left(\hat{\beta}_1\right) = \exp\left(0.3246\right) = 1.3835$. Therefore, the median percent cover of woody seedlings increases by an estimated 38.35% annually. Confidence intervals on the multiplicative trend are obtained by computing the confidence intervals for the trend of the transformed response and back-transforming the endpoints. For example, the confidence interval for the slope of the trend line for logged woody seedlings is:

$$\hat{\beta}_1 \pm t_{df,\alpha} * SE\left(\hat{\beta}_1\right) = 0.3246 \pm 1.7042 * \left(0.0639\right) = \left(0.2157,\ 0.4335\right).$$

Note that the t-statistic used to compute the confidence interval is based on Satterthwaite degrees of freedom which are recommended for unbalanced data (Spilke et al, 2005). Then the 90%-confidence interval for the multiplicative trend of the median percent cover of woody seedlings is calculated as:

$$\left(\exp\left(0.2157\right),\ \exp\left(0.4335\right)\right) = \left(1.2407,\ 1.5426\right).$$

Table 19: Transformations, fixed effects estimates, trend test results, and variance components estimates by outcome.

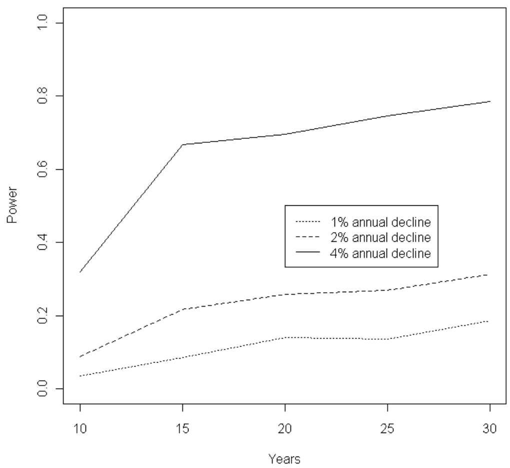
Outcome	Transfor-mation	$\hat{\beta}_o$ (stratum 1)	$\hat{\beta}_o$ (stratum 0 additional intercept)	$\hat{\beta}_1$ Est. trend (SE)	Trend test p-value (two-sided)	$\hat{\sigma}_b^2$	$\hat{\sigma}_a^2$	$\hat{\sigma}_t^2$	$\hat{\sigma}_{at}$	$\hat{\sigma}_e^2$
Substrate Size Class	log(y+1)	1.0705	-0.2646	-0.01405 (0.05773)	0.8481	0.0062	0.0160	0.0020	-0.0022	0.0022
Large Woody Debris	log(100*y+1)	0.8195	0	0.1098 (0.0640)	**0.0990**		0.1283			0.1195
Exposed Roots	log(100*y+1)	1.3244	-0.6454	0.2044 (0.1229)	0.3448	0.0223	0.0433			0.1117
Non-vascular Plants	log(100*y+1)	1.4060	-1.1107	0.2135 (0.1006)	**0.0439**		0.1557			0.3010
Annuals/Biennial	log(100*y+1)	0.1945	0.6919	0.4992 (0.1247)	**0.0005**		0.0800			0.4758
Fibrous Rooted or Rhizomatous Perennials	log(100*y+1)	2.3448	1.0223	0.1272 (0.1669)	0.5854	0.0500	0.1900	0.0018	0.0279	0.0741
Tap-rooted Perennials	log(100*y+1)	0.2784	0.9182	0.3139 (0.1144)	**0.0114**		0.5708			0.3786
Shrubs	log(100*y+1)	1.8312	-0.8807	-0.1575 (0.1602)	0.4637	0.0198	0.4209	0.2499	-0.2470	0.0632
Woody Seedlings	log(100*y+1)	0.3528	0	0.3246 (0.0639)	**<.0001**		0.0204			0.1251
Evergreen trees	100*y	36.2529	-9.1342	-5.4965 (1.1148)	**<.0001**		263.57	15.757 7	-64.5682	14.272 8
Deciduous trees	log(100*y+1)	3.5117	-0.7277	-0.0856 (0.0344)	**0.0209**		0.5311	0.0271	-0.0886	0.0002
Snags	log(100*y+1)	0.8681	-0.3872	0.1190 (0.1249)	0.5152	0.0190	0.1903			0.1638
Bare Ground or Litter	100*y	79.0742	2.0890	7.7135 (8.8149)	0.5424	150.53	1.1295			73.240 4

The estimates of fixed effects and random effects variances are used in a Monte Carlo power simulation to determine the power to detect trends of various sizes under several revisit designs and for several possible sample sizes. Annual declines of 1%, 2%, and 4% over a 30-year monitoring period were examined. For outcomes not incorporating the logarithmic outcome, the corresponding net trend was simulated but annual changes were simulated as additive rather than multiplicative. Three revisit designs were examined and included samples of the same sites once every 3 years, every five years, or every 10 years. Using the notation of McDonald (2003), these revisit designs may be referred to as the [1-2], [1-4], and [1-9] revisit designs, respectively. Three levels of sampling were also examined: a third of the sites for a total of 8 sites with 5 in stratum 0 and 3 in stratum 1, two-thirds of the sites for a total of 16 sites with 10 sites in stratum 0 and 6 in stratum 1, and the total sample of 24 sites. For each outcome of interest, trend effect size, sample size, and revisit design, 500 iterations of the power simulation were run with a new population generated from the estimates of fixed effects and random effects variances. The population was generated to exhibit the known trend, and the revisit design and sample size were imposed when random sampling occurred. Note that a GRTS sample was not chosen in this case because the trend approach is purely model-based and does not reflect the sampling design. The trend model was then used to conduct a two-sided test of trend in either direction using Satterthwaite (1946) degrees of freedom for the t-test or corresponding F-test. Simulation power is calculated as the proportion of times the null hypothesis is rejected in favor of the alternative hypothesis where the hypothesis test is given by:

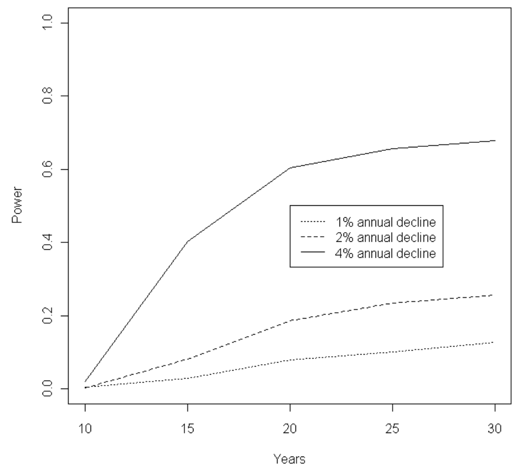
$$H_o : \beta_1 = 0 \text{ vs. } H_1 : \beta_1 \neq 0 .$$

The results of the power simulation are provided in Figures 3 through 41 and a subset of results are provided in tabular format in Appendix C. Note that trend cannot be estimated before 20 years of monitoring for the [1-9] revisit design. Overall, the power to detect trends is high when the trend is extreme, the length of the monitoring period, and/or the revisit design has a shorter interval. Note that power increases monotonically with time. The benefit of increasing the sample size from 8 to 16 sites impacts the power to detect trends more than increasing the sample from 16 to 24 sites. The exceptions include percent cover of shrubs, evergreen trees, and deciduous trees which exhibiting low power across all scenarios. The combined percent cover of bare ground and litter provided the high power for trend detection.

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

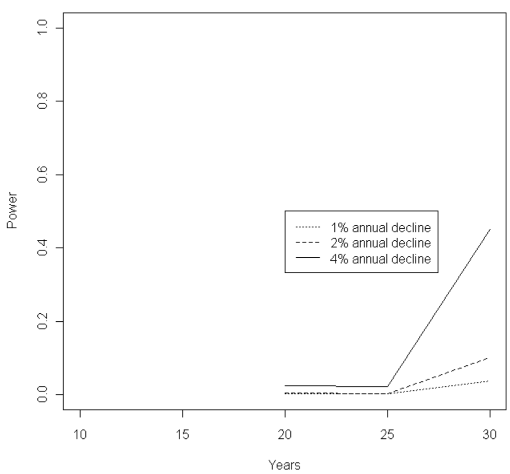
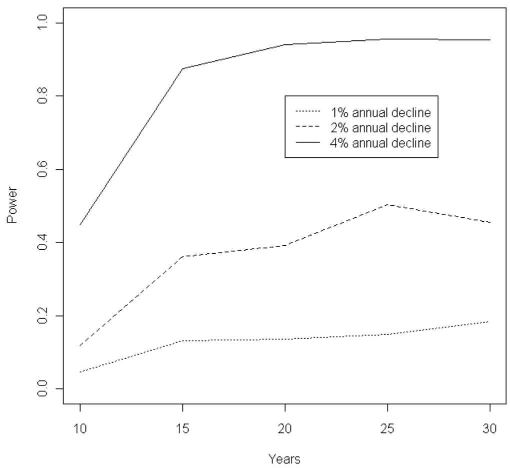
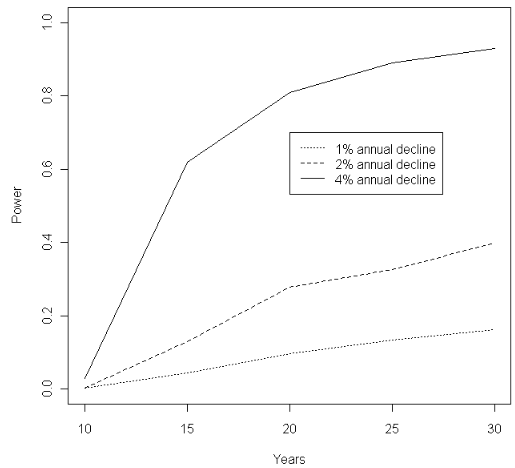


Figure 3: Power to detect trends in either direction in mean substrate class for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

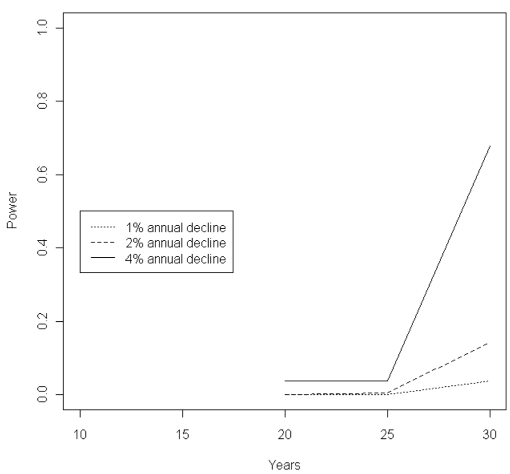
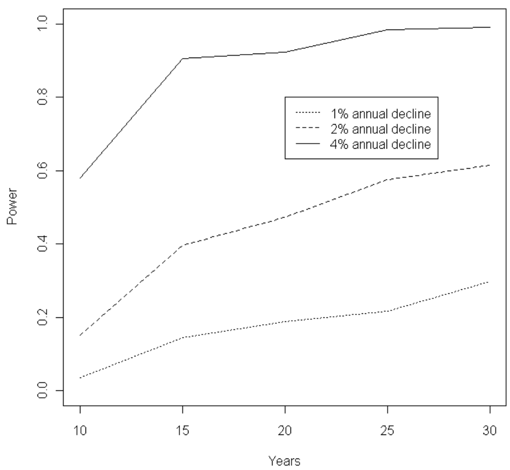
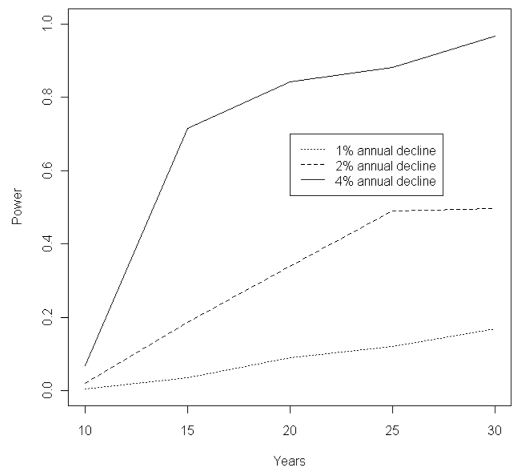


Figure 4: Power to detect trends in either direction in mean substrate class for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

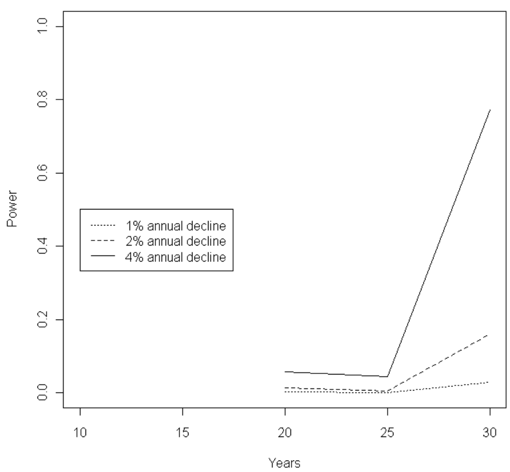


Figure 5: Power to detect trends in either direction in mean substrate class for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

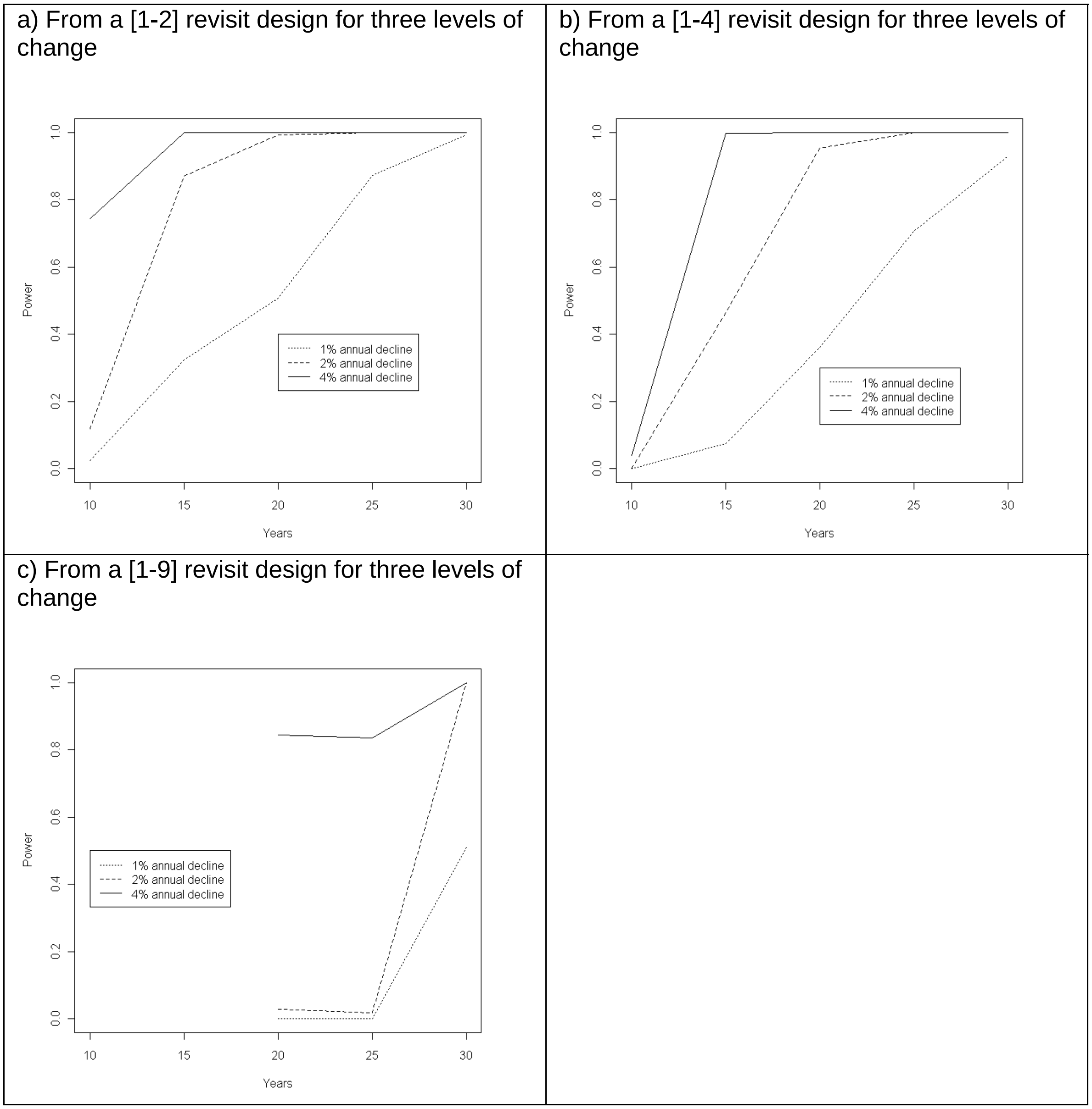
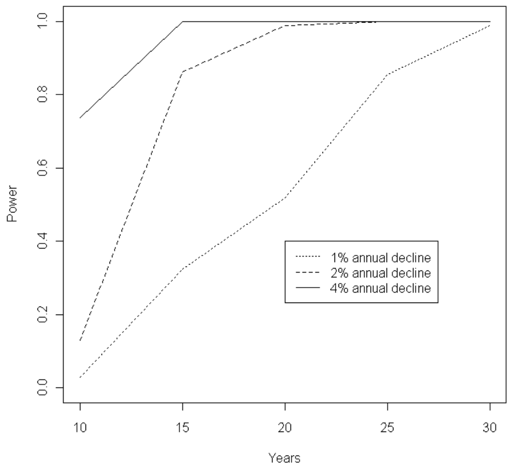
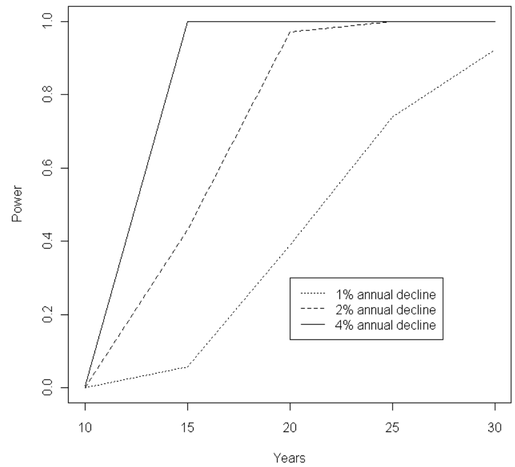


Figure 6: Power to detect trends in either direction in the percent cover of large woody debris for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

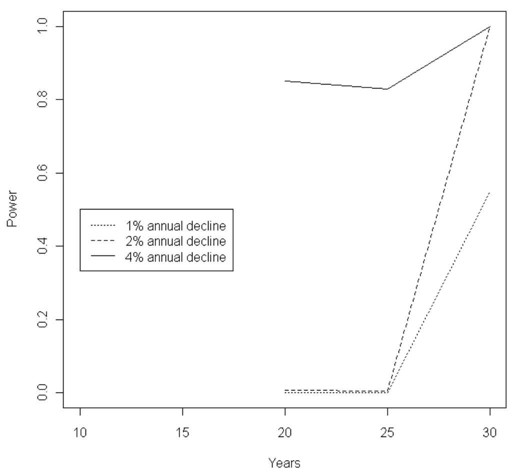
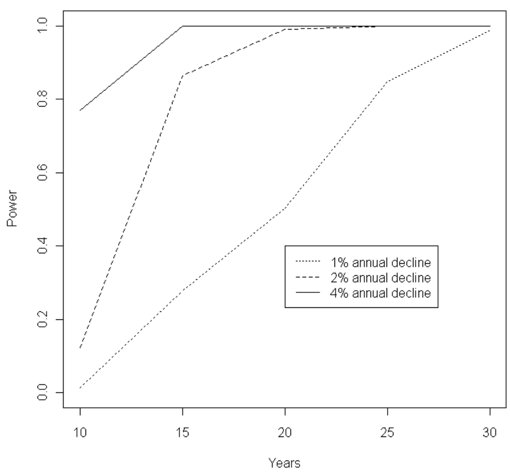
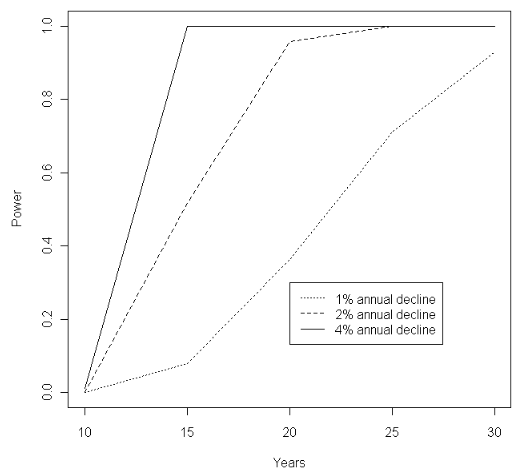


Figure 7: Power to detect trends in either direction in the percent cover of large woody debris for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

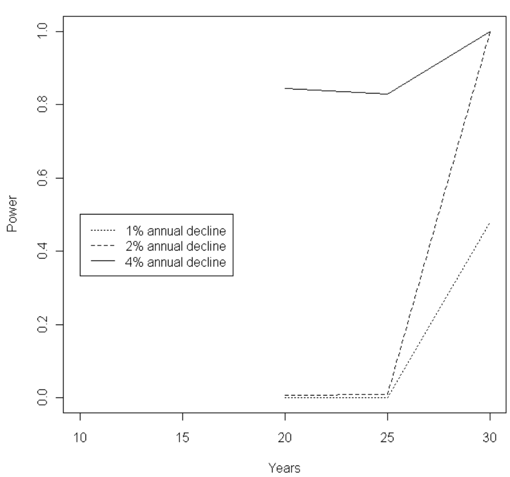
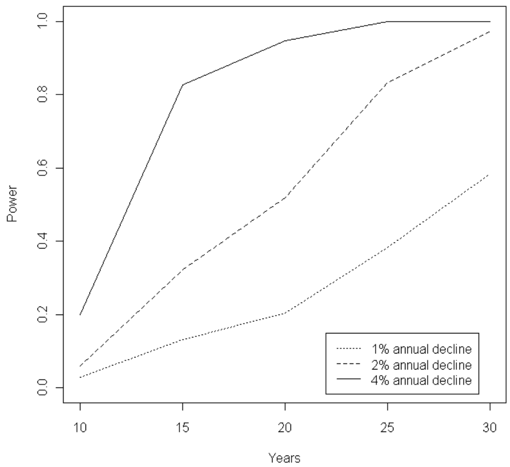
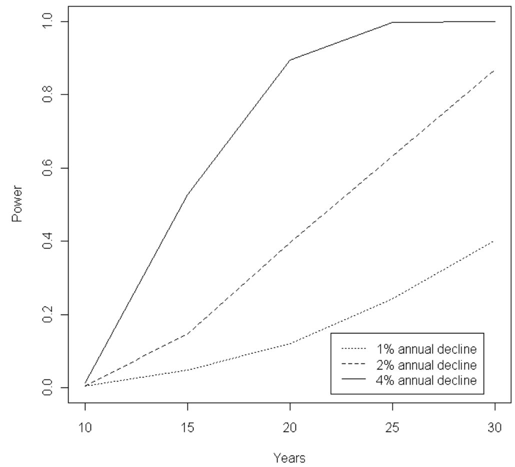


Figure 8: Power to detect trends in either direction in the percent cover of large woody debris for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

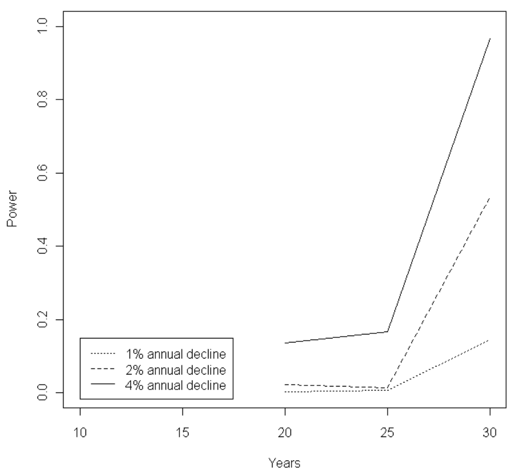
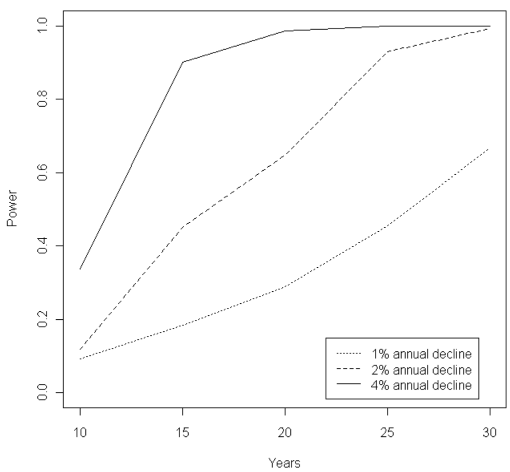
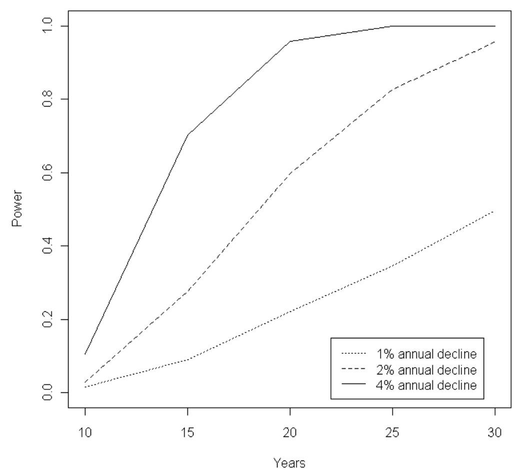


Figure 9: Power to detect trends in either direction in the percent cover of exposed roots for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

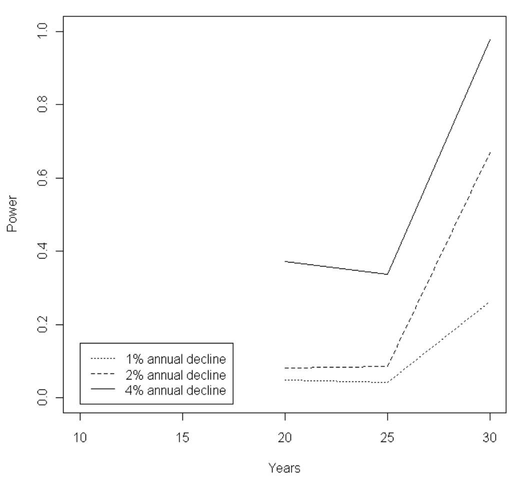
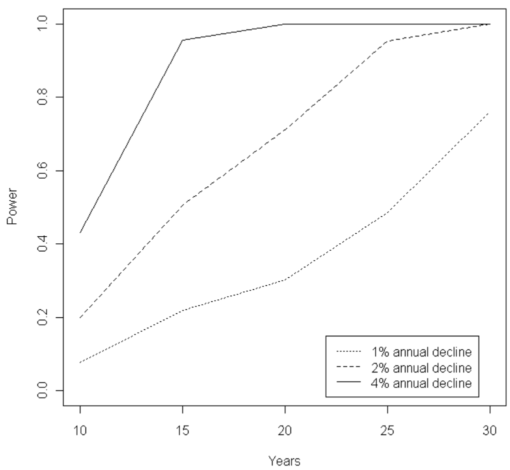
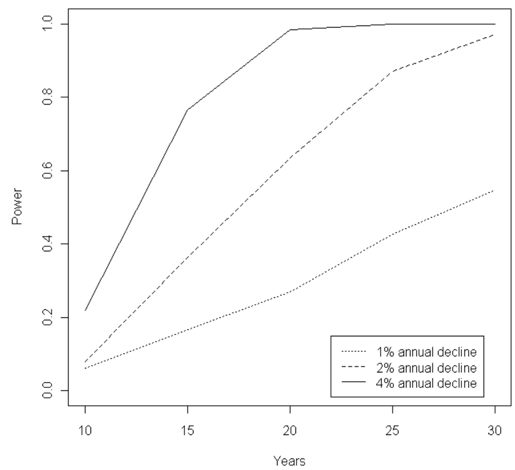


Figure 10: Power to detect trends in either direction in the percent cover of exposed roots for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

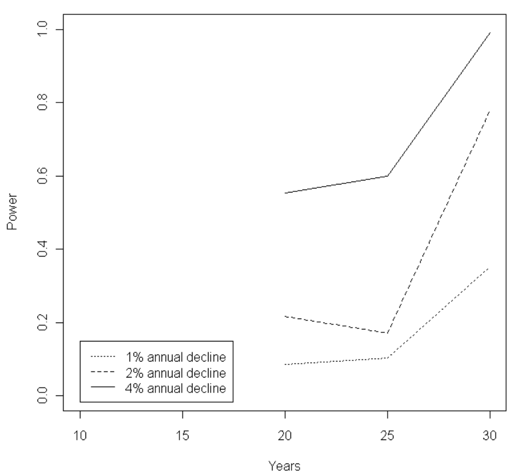
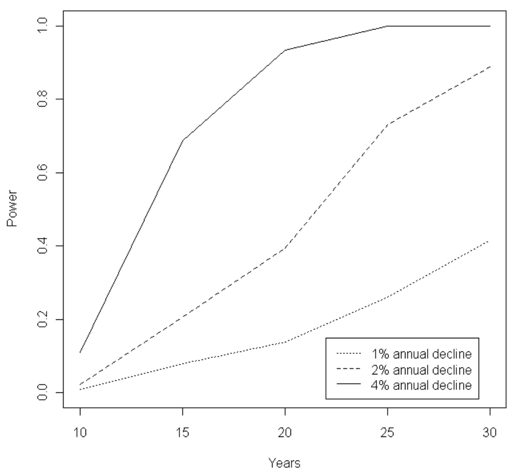
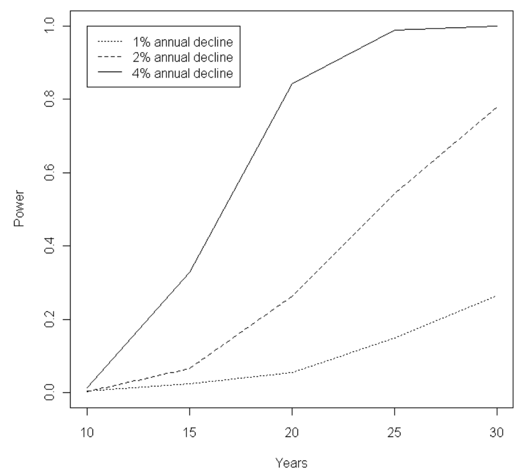


Figure 11: Power to detect trends in either direction in the percent cover of exposed roots for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

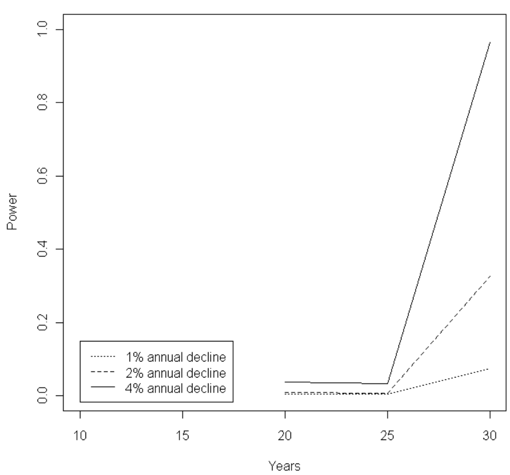
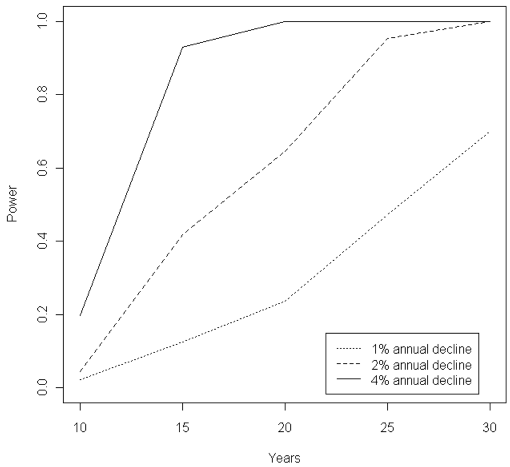
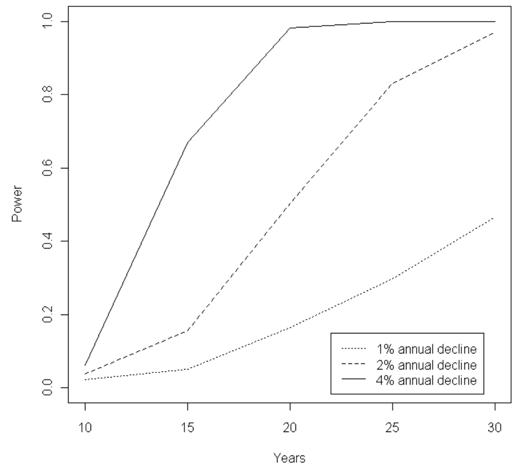


Figure 12: Power to detect trends in either direction in the percent cover of nonvascular plants for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

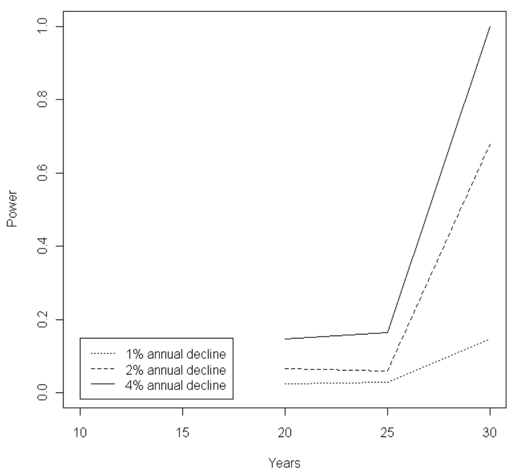


Figure 13: Power to detect trends in either direction in the percent cover of nonvascular plants for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

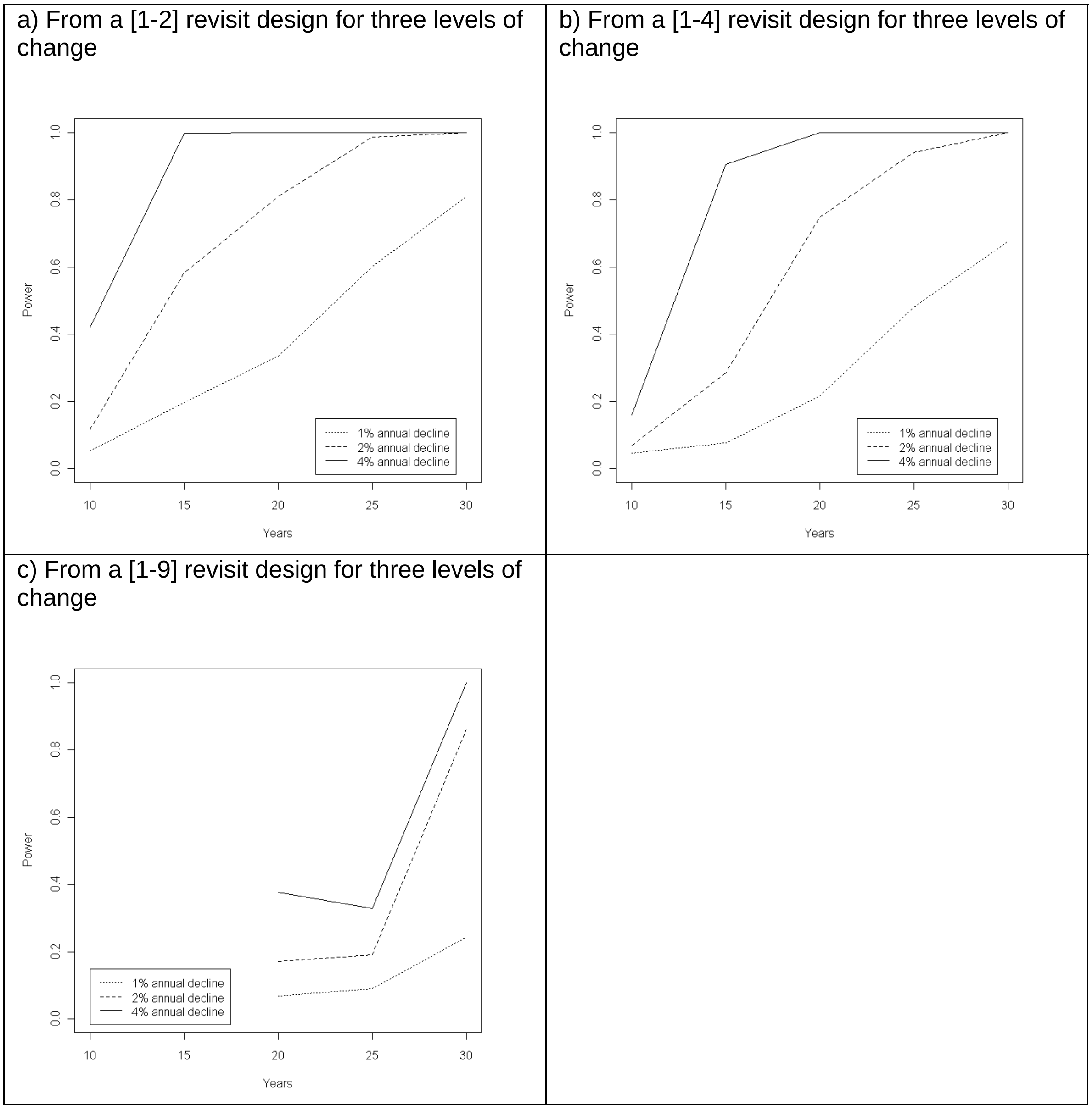
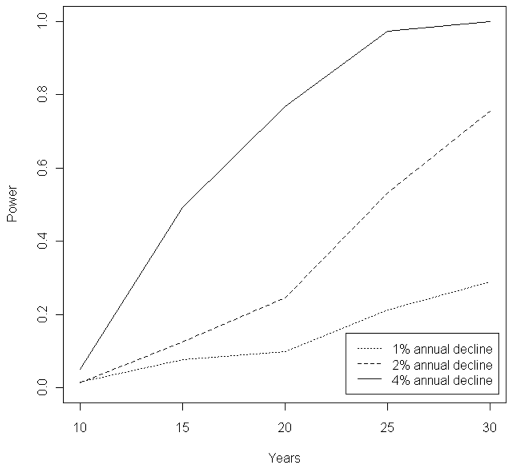
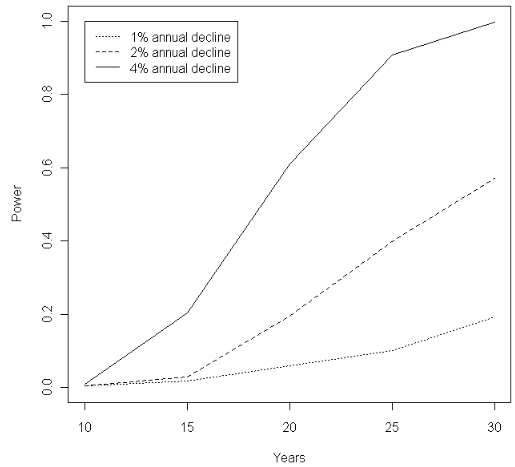


Figure 14: Power to detect trends in either direction in the percent cover of nonvascular plants for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

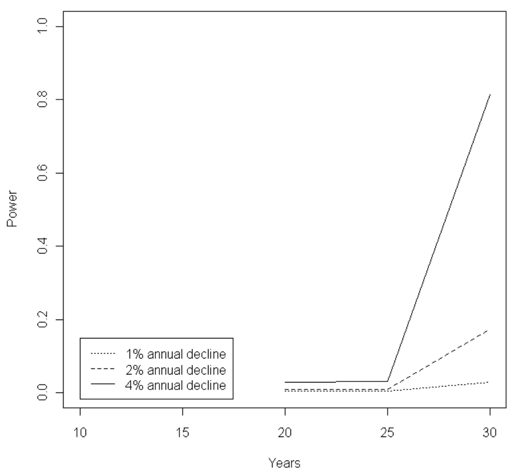
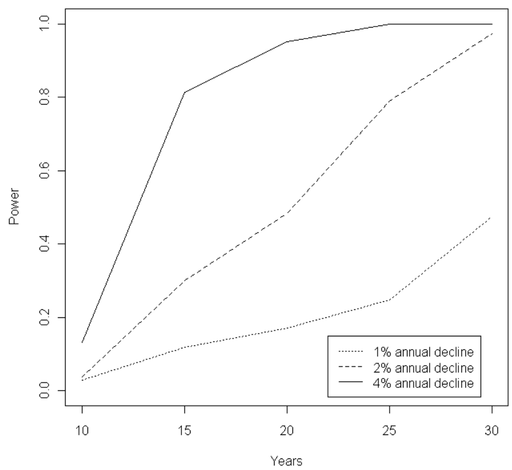
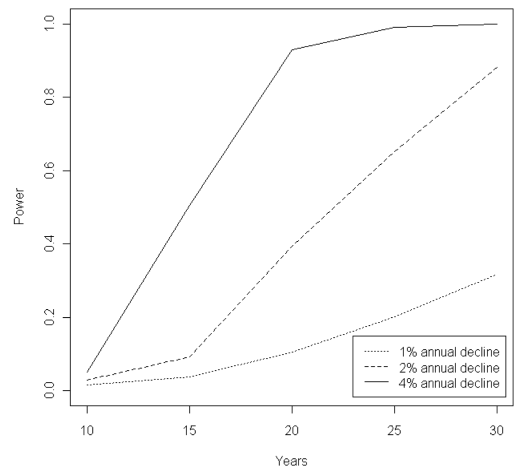


Figure 15: Power to detect trends in either direction in the percent cover of annuals and biennials for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

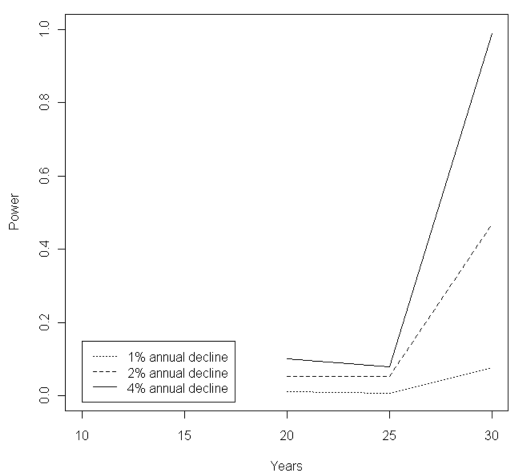
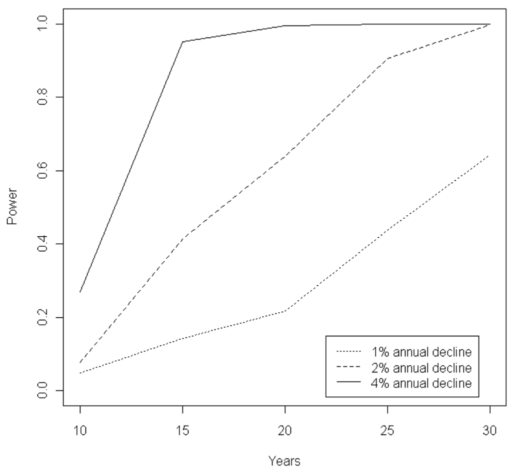
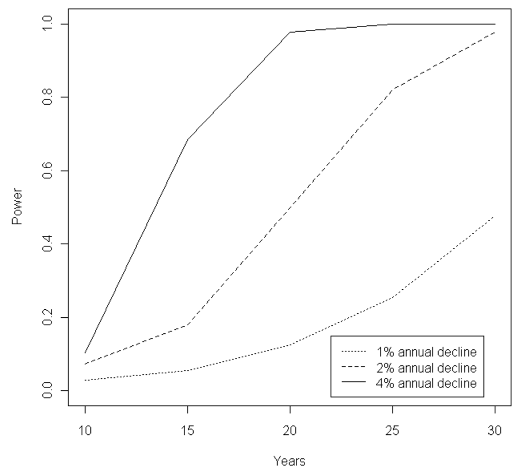


Figure 16: Power to detect trends in either direction in the percent cover of annuals and biennials for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

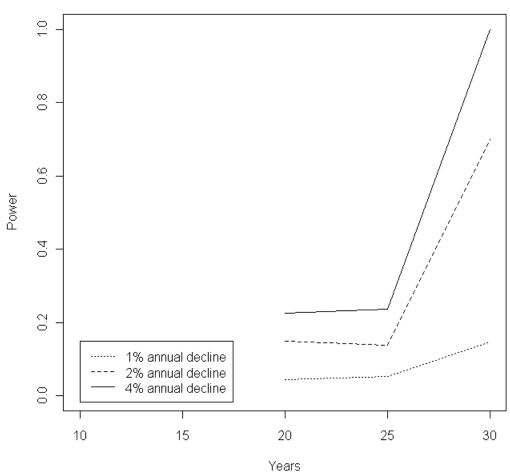
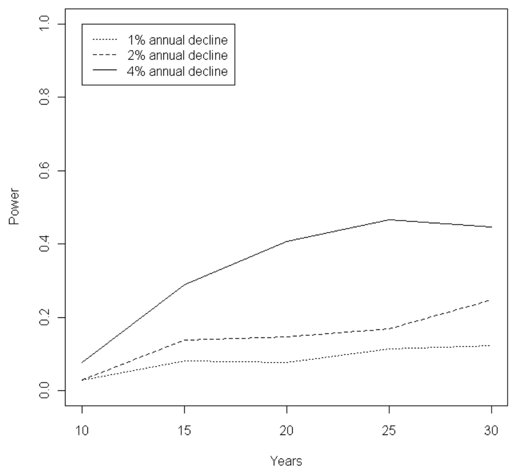
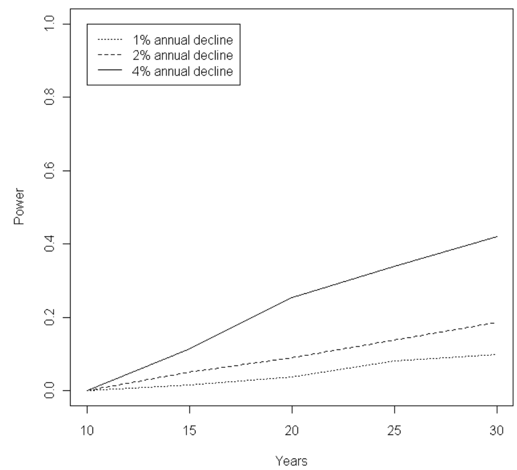


Figure 17: Power to detect trends in either direction in the percent cover of annuals and biennials for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

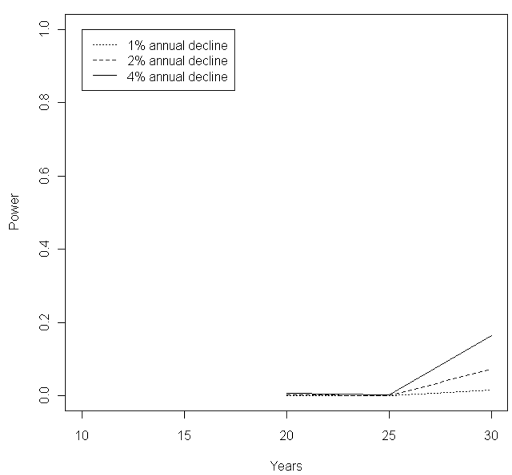
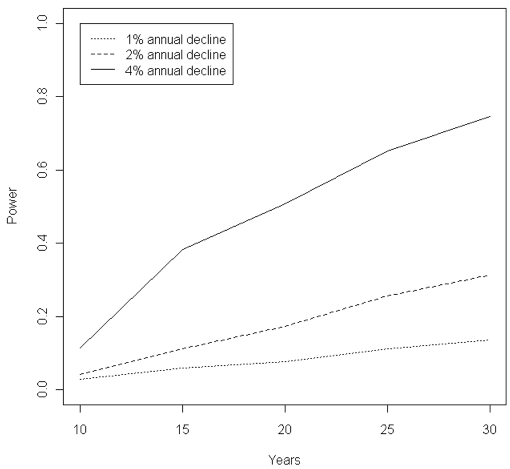
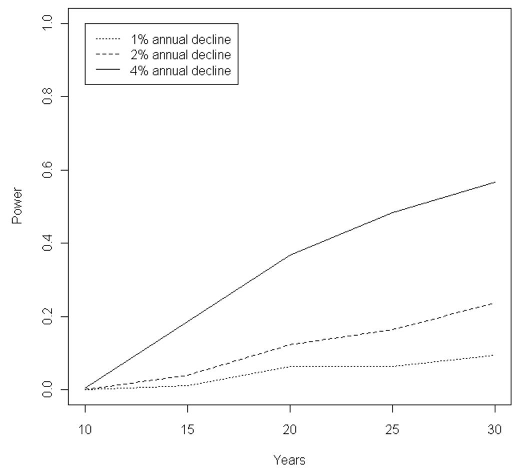


Figure 18: Power to detect trends in either direction in the percent cover of fibrous rooted/rhizomatous perennials for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

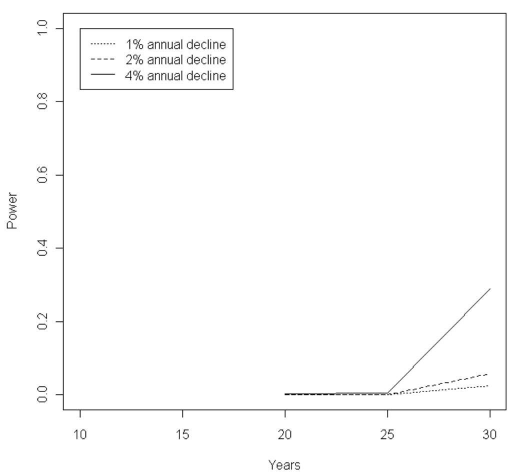
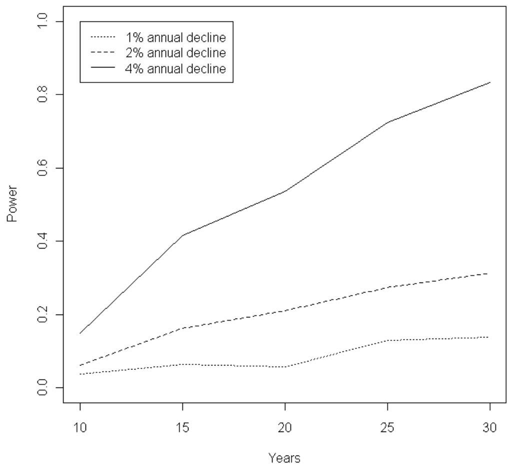
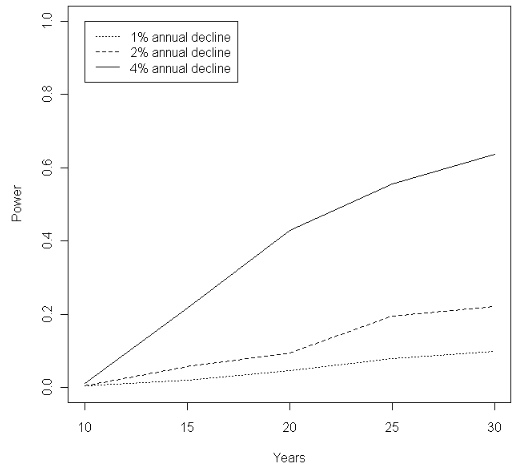


Figure 19: Power to detect trends in either direction in the percent cover of fibrous rooted/rhizomatous perennials for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

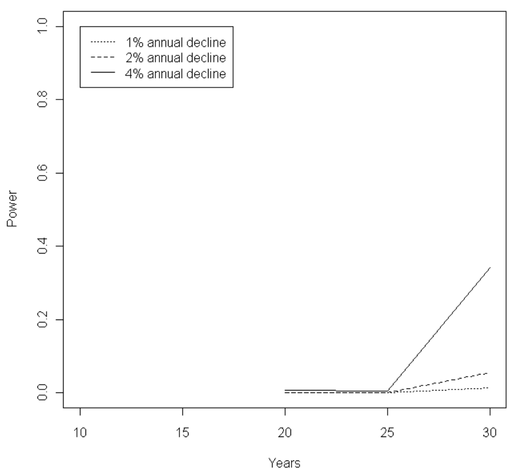
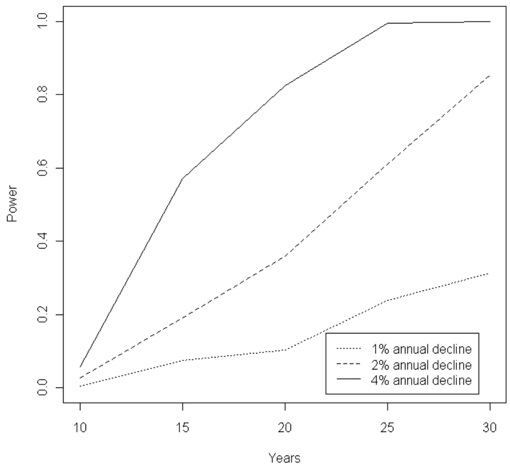
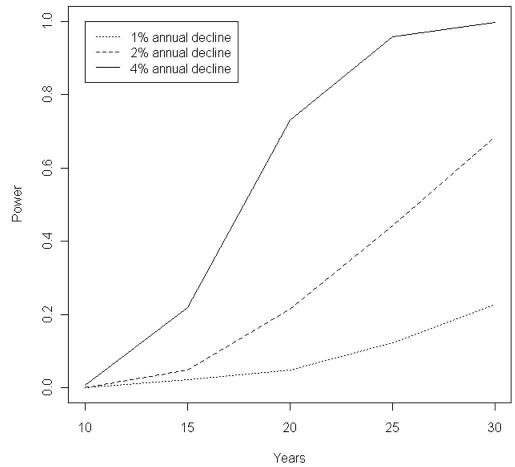


Figure 20: Power to detect trends in either direction in the percent cover of fibrous rooted/rhizomatous perennials for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

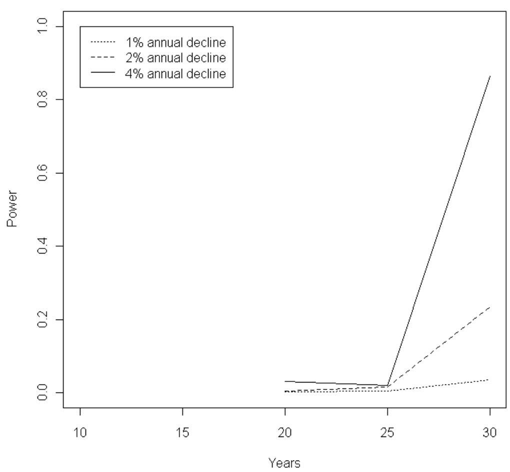
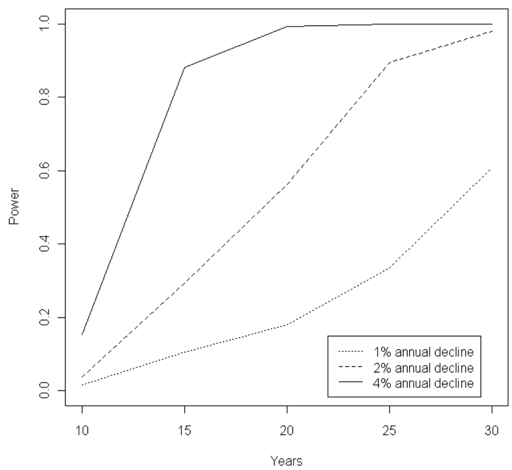
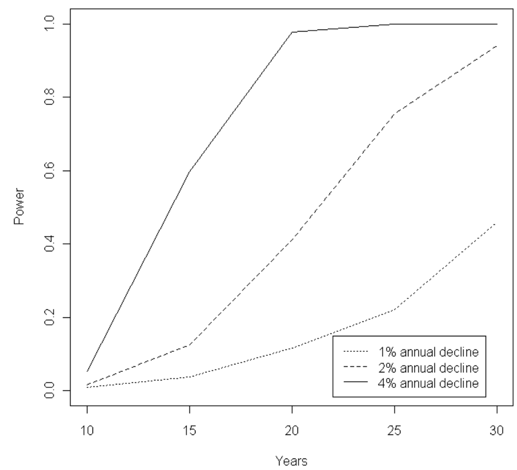


Figure 21: Power to detect trends in either direction in the percent cover of tap-rooted perennials for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

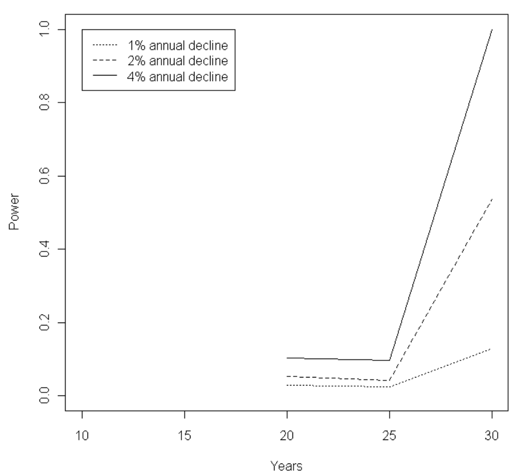
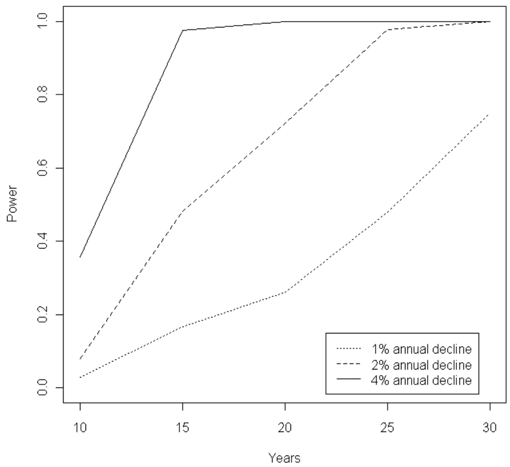
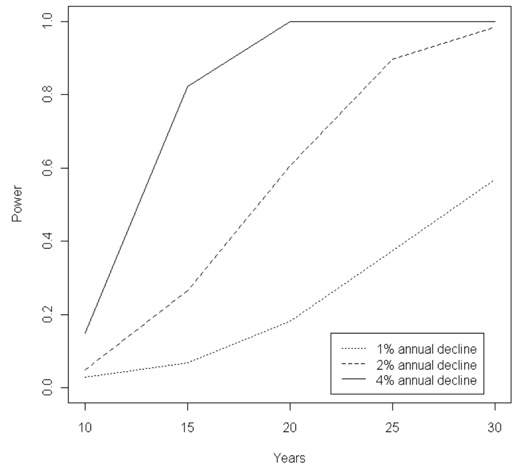


Figure 22: Power to detect trends in either direction in the percent cover of tap-rooted perennials for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

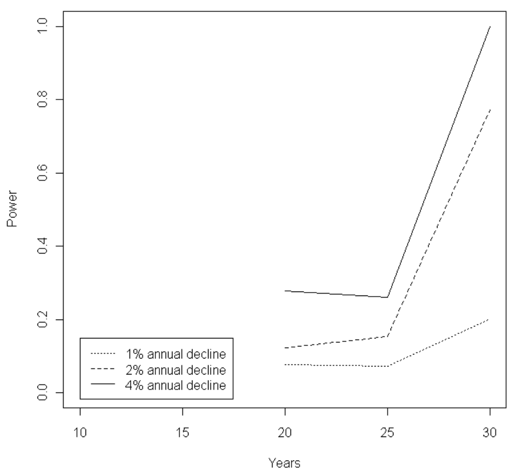


Figure 23: Power to detect trends in either direction in the percent cover of tap-rooted perennials for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

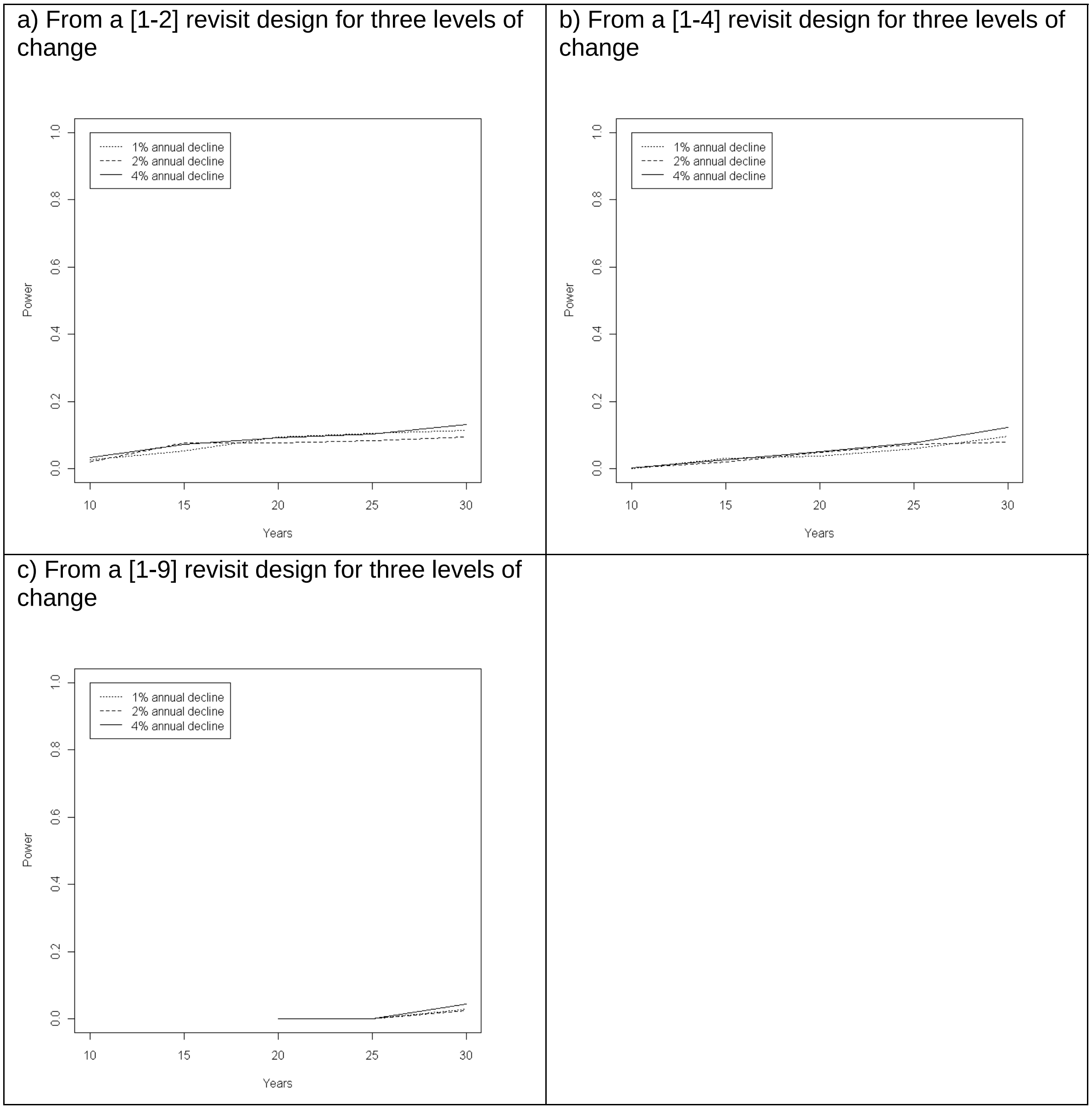
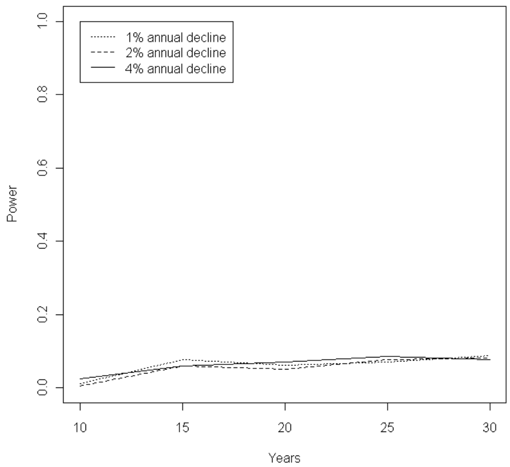
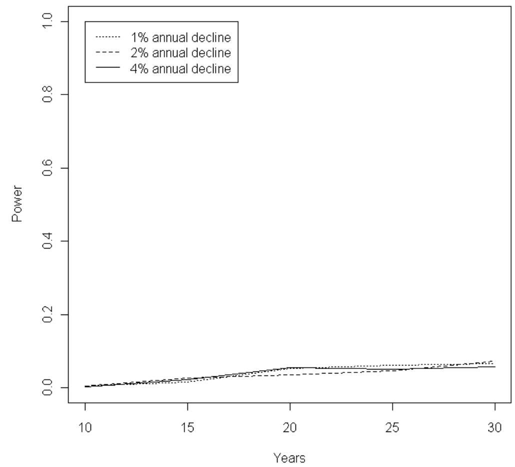


Figure 24: Power to detect trends in either direction in the percent cover of shrubs for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

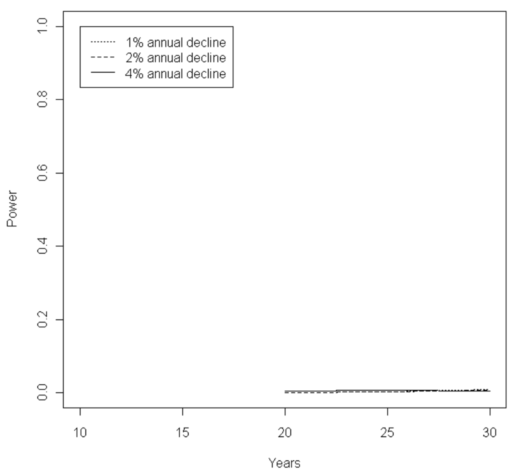
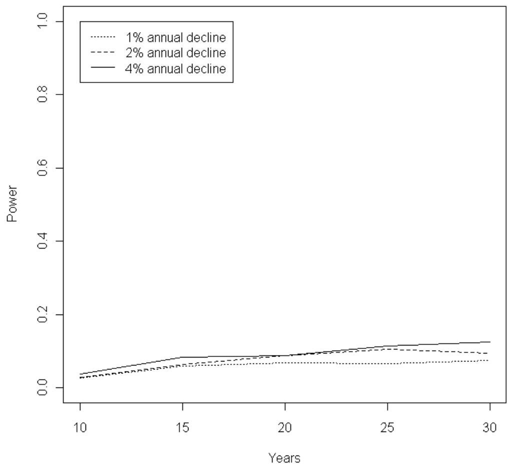
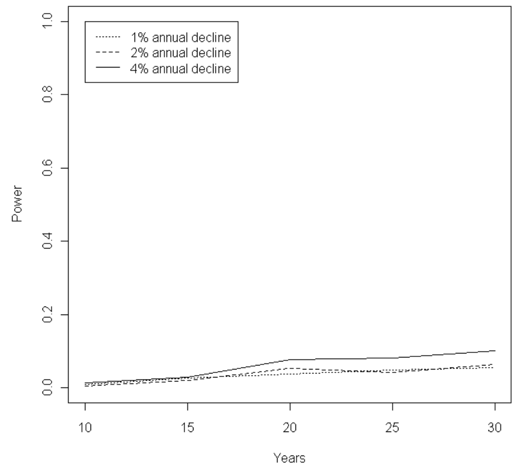


Figure 25: Power to detect trends in either direction in the percent cover of shrubs for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

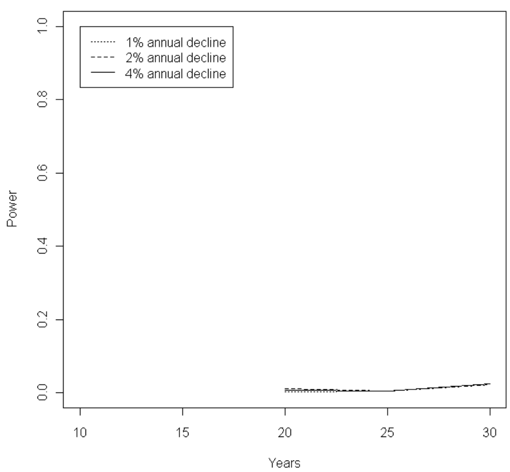
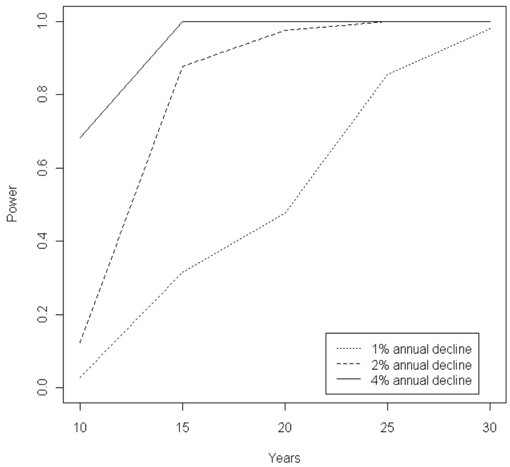
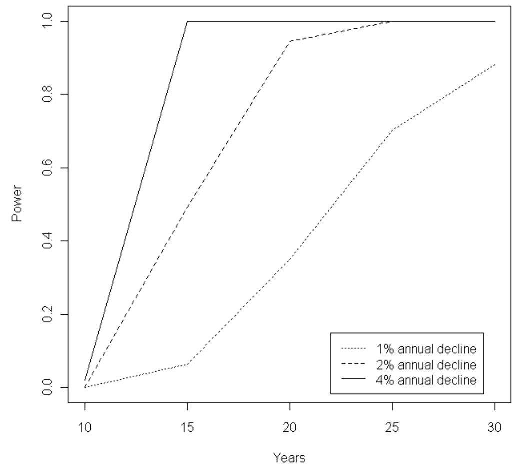


Figure 26: Power to detect trends in either direction in the percent cover of shrubs for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

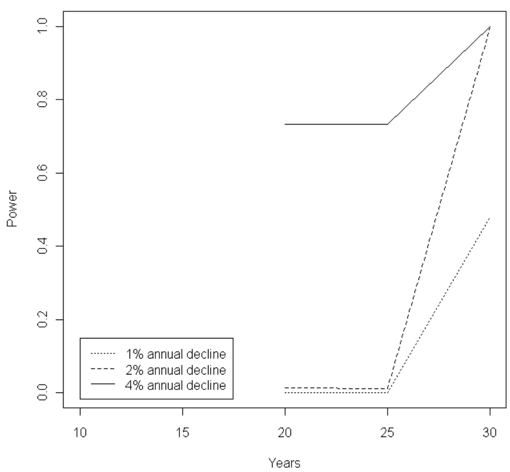
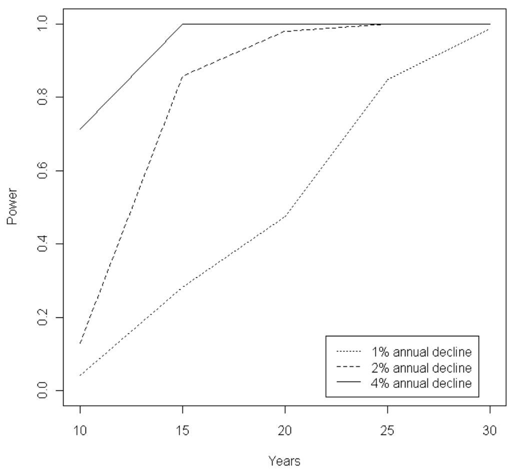
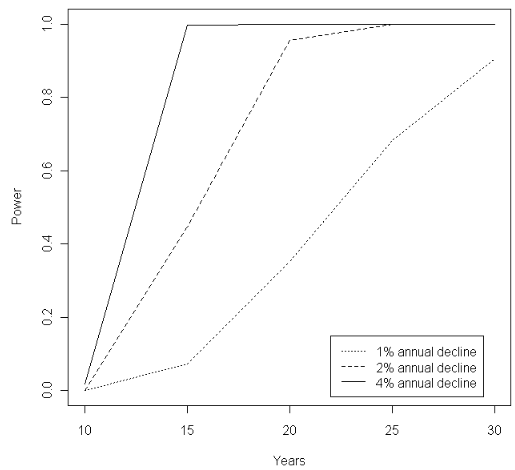


Figure 27: Power to detect trends in either direction in the percent cover of woody seedlings for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

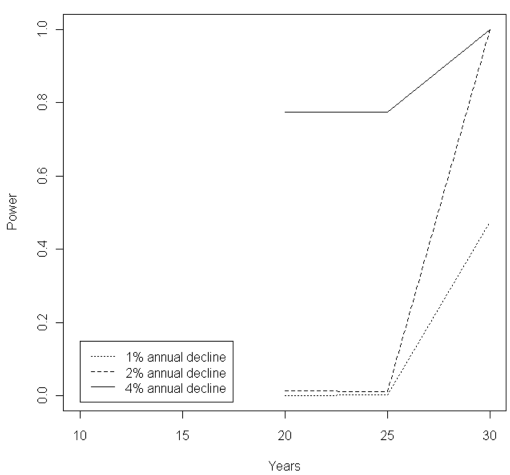
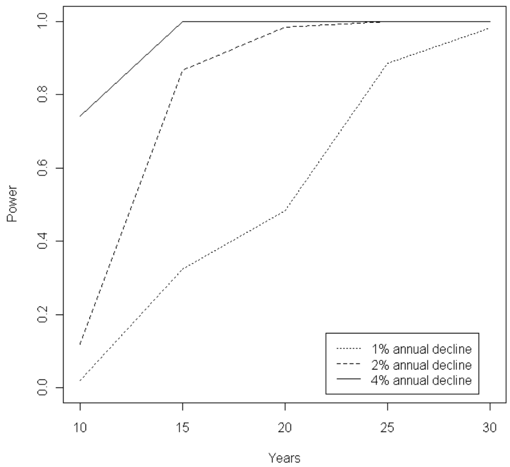
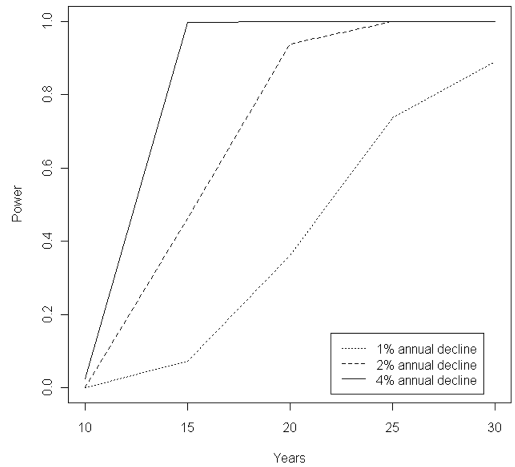


Figure 28: Power to detect trends in either direction in the percent cover of woody seedlings for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

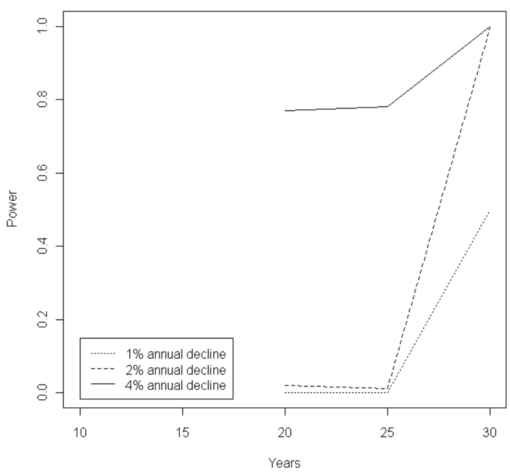
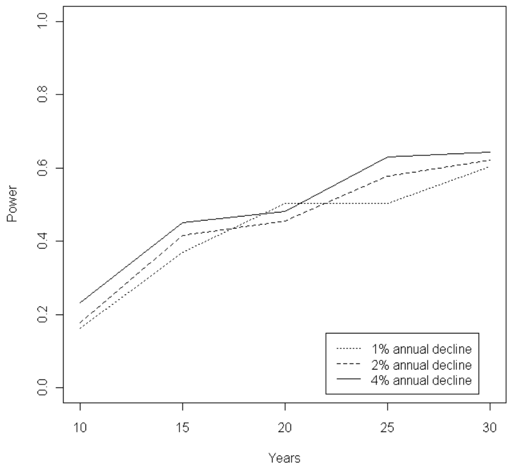
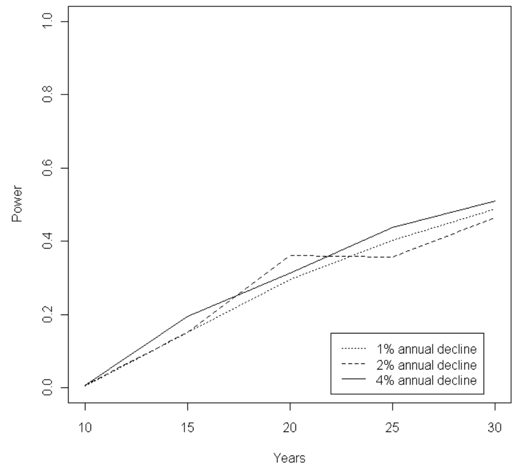


Figure 29: Power to detect trends in either direction in the percent cover of woody seedlings for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

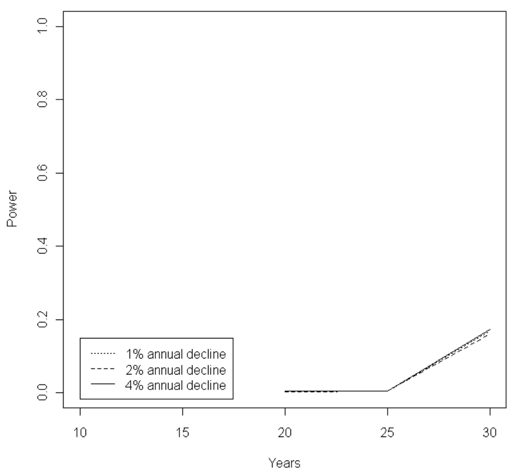
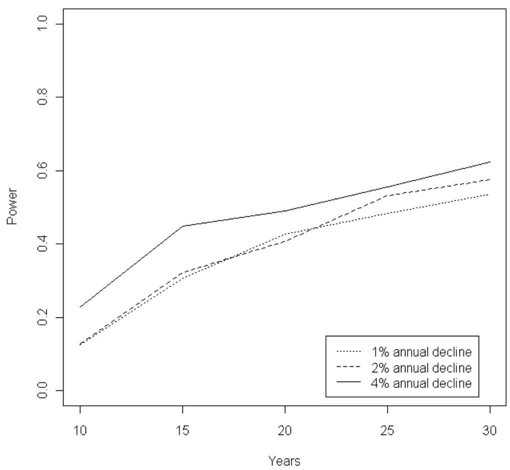
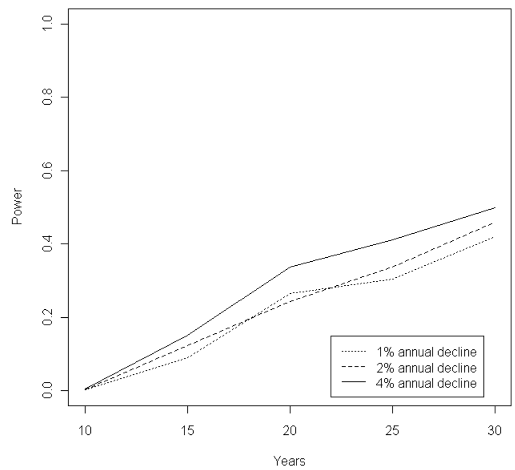


Figure 30: Power to detect trends in either direction in the percent cover of evergreen trees for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

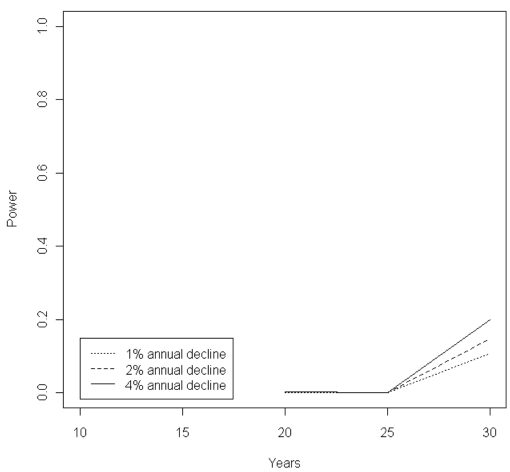
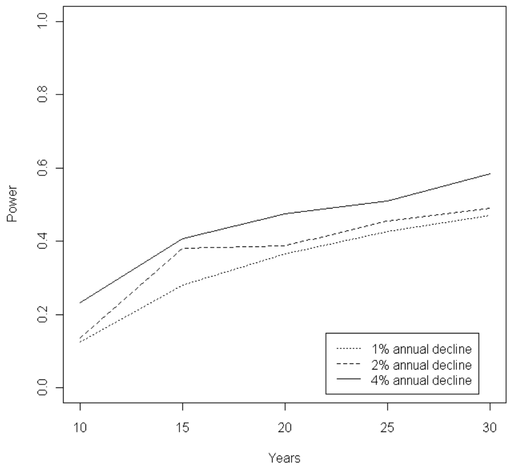
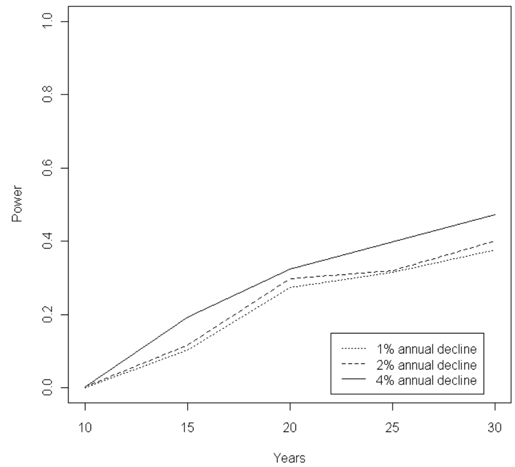


Figure 31: Power to detect trends in either direction in the percent cover of evergreen trees for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

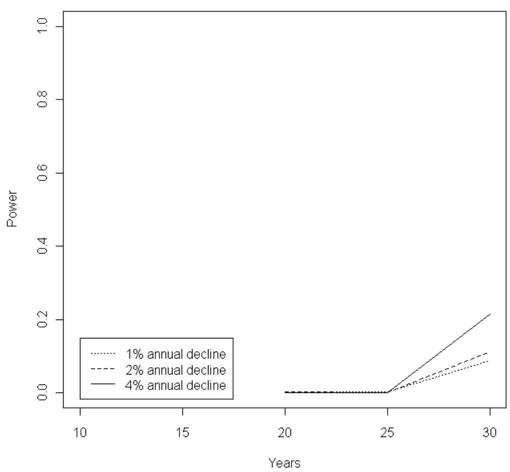
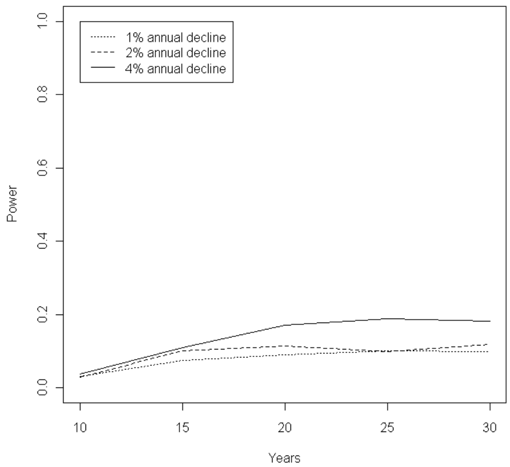
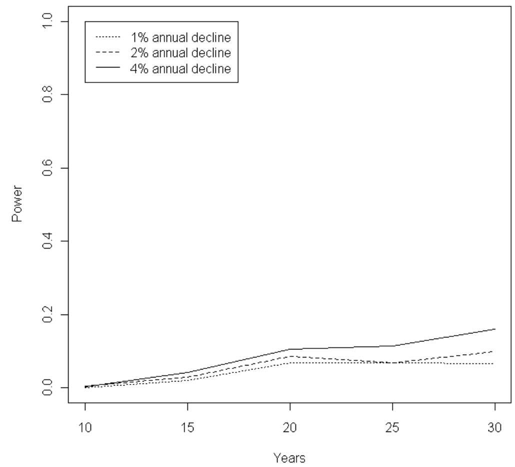


Figure 32: Power to detect trends in either direction in the percent cover of evergreen trees for a sample of 8 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

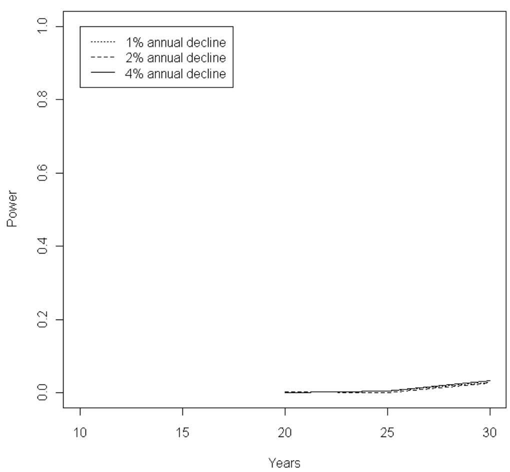
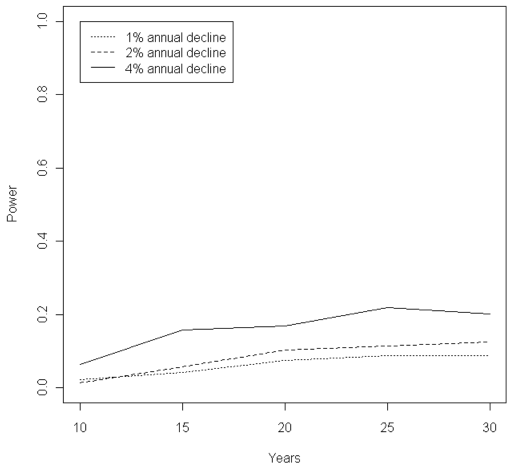
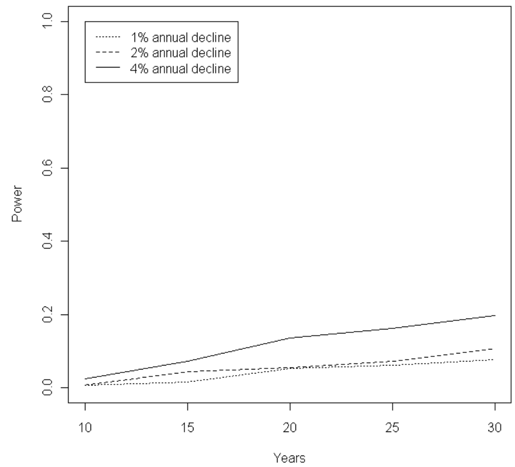


Figure 33: Power to detect trends in either direction in the percent cover of deciduous trees for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

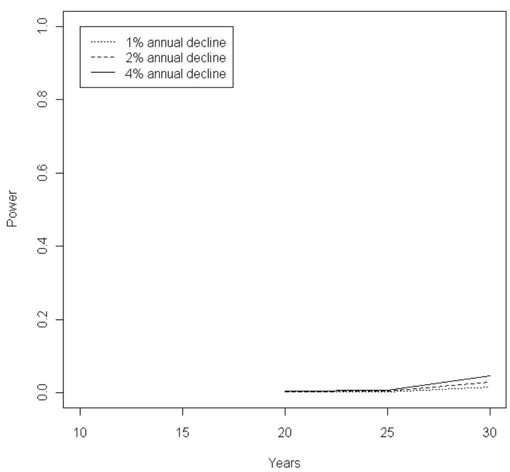
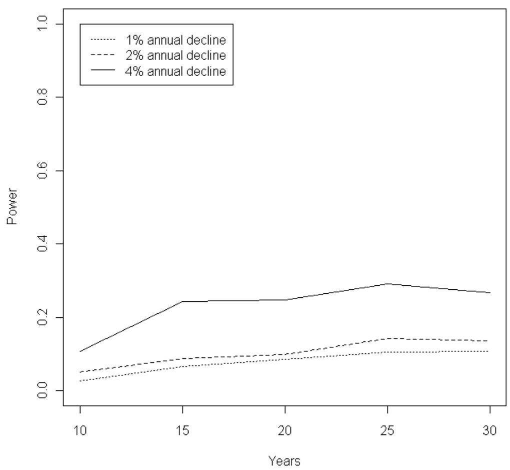
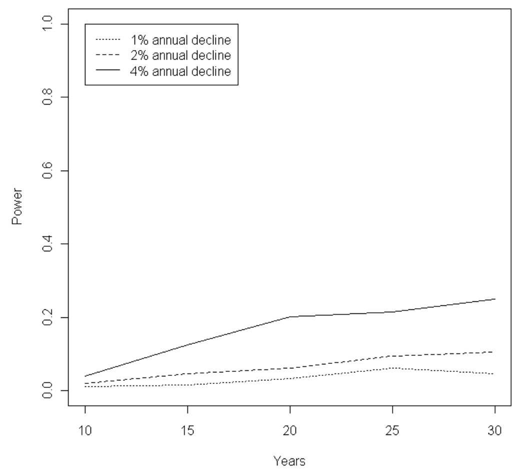


Figure 34: Power to detect trends in either direction in the percent cover of deciduous trees for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

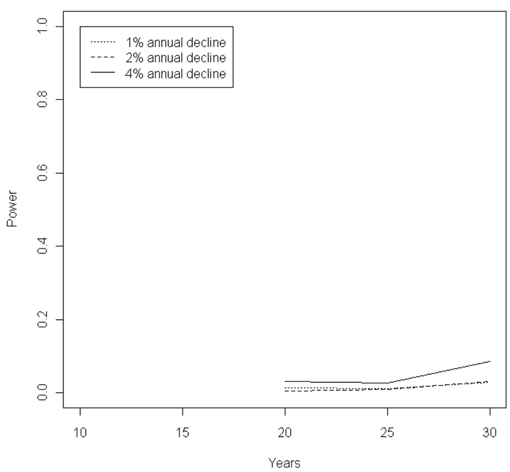
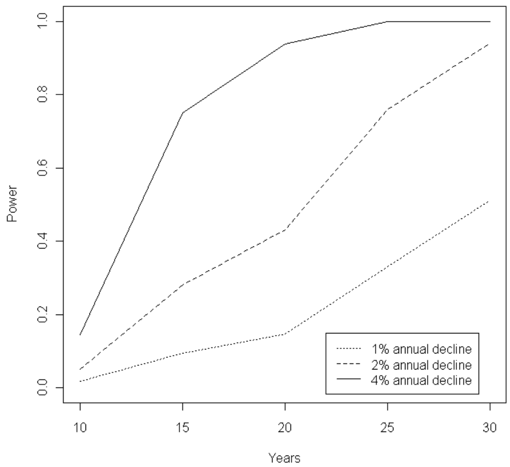
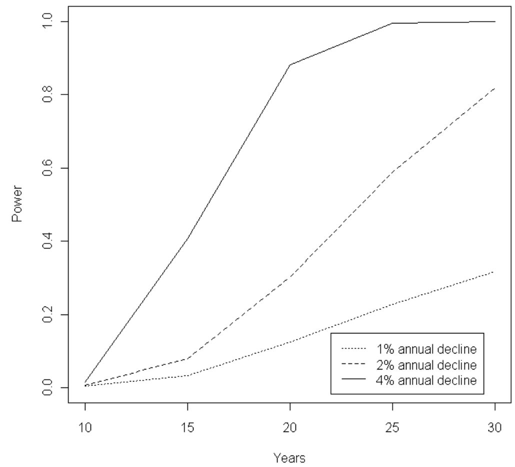


Figure 35: Power to detect trends in either direction in the percent cover of deciduous trees for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

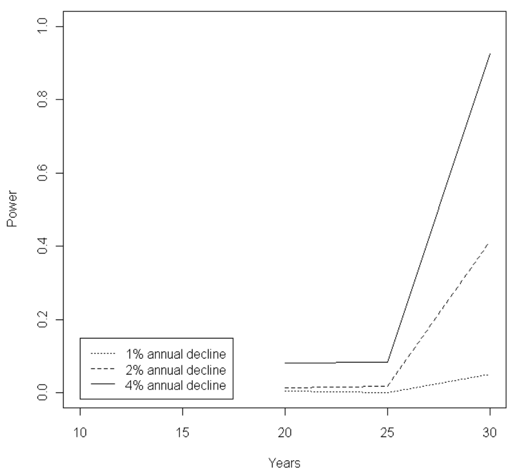
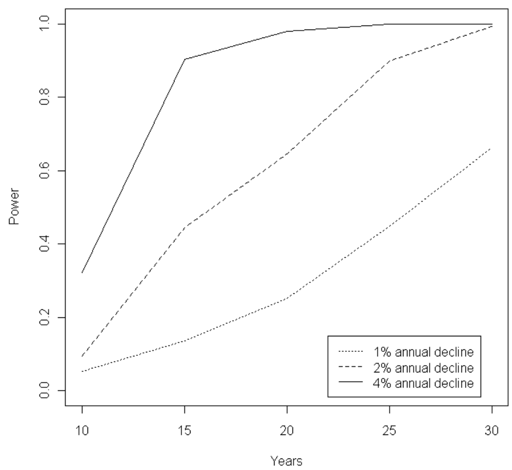
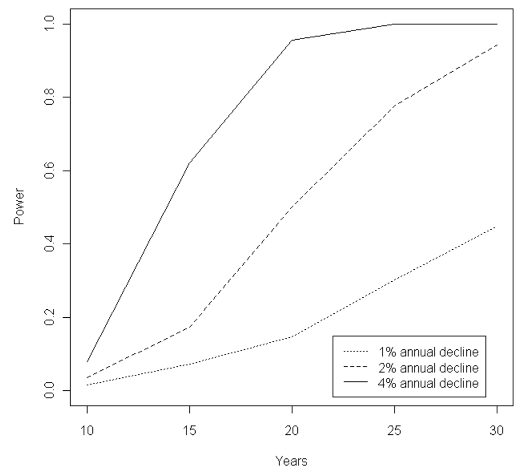


Figure 36: Power to detect trends in either direction in the percent cover of snags for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

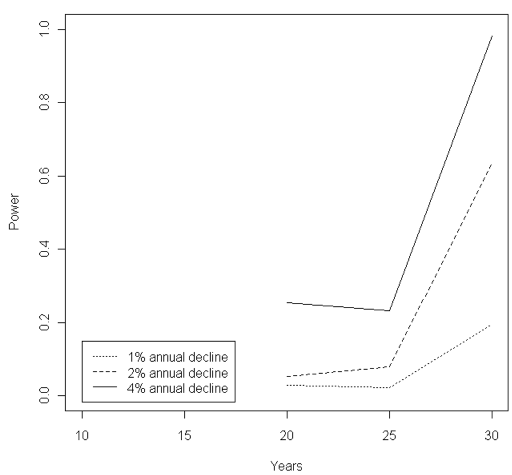
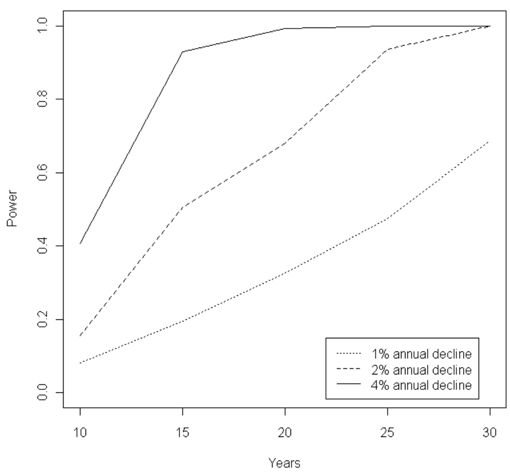
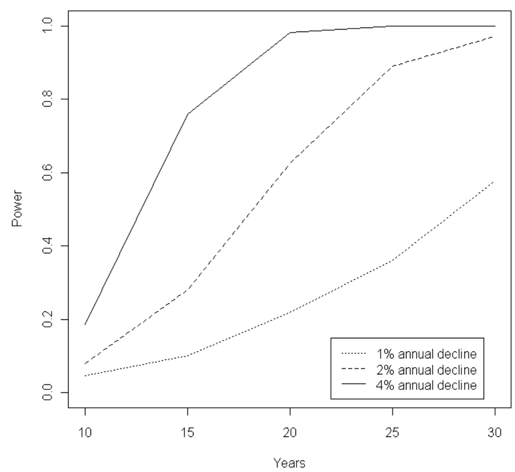


Figure 37: Power to detect trends in either direction in the percent cover of snags for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

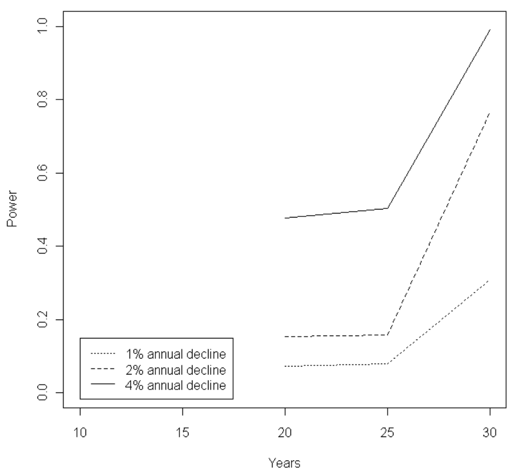
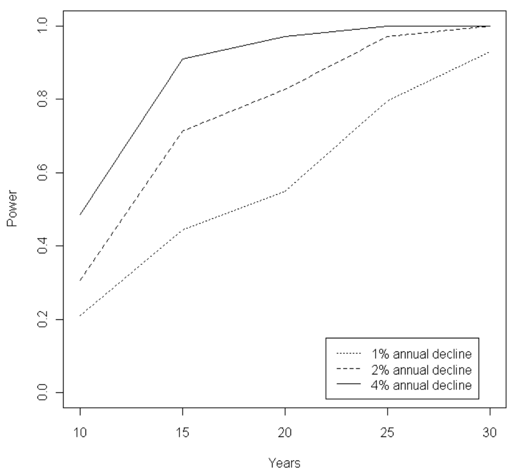
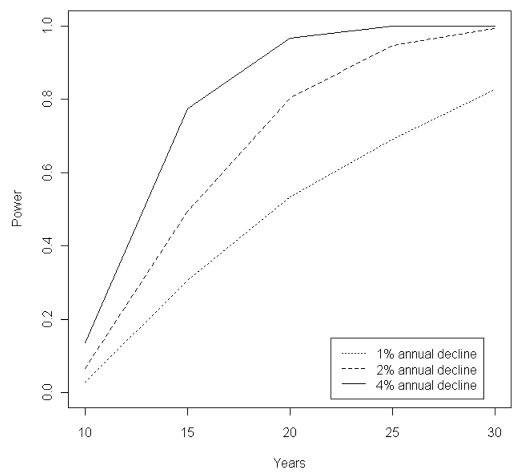


Figure 38: Power to detect trends in either direction in the percent cover of snags for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

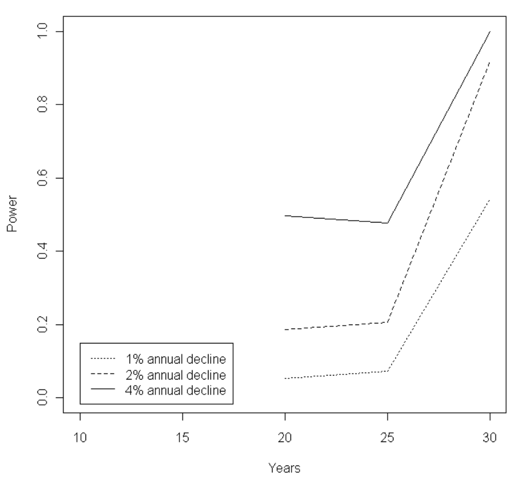
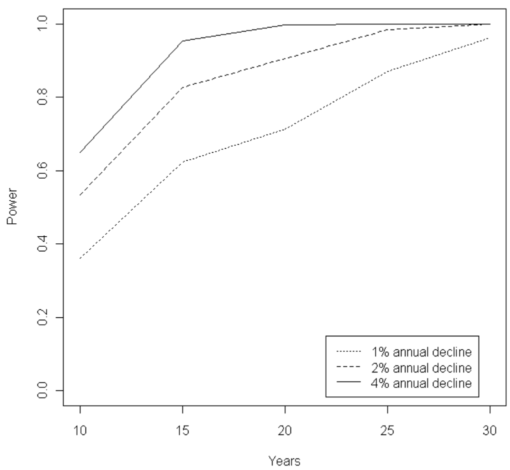
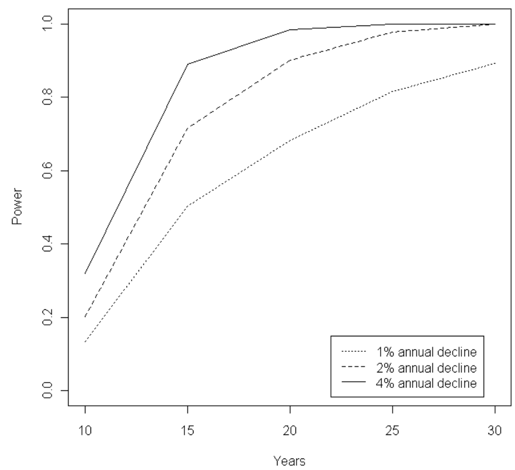


Figure 39: Power to detect trends in either direction in the percent cover of bare ground or litter for a sample of 8 sites (5 from stratum 0 and 3 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

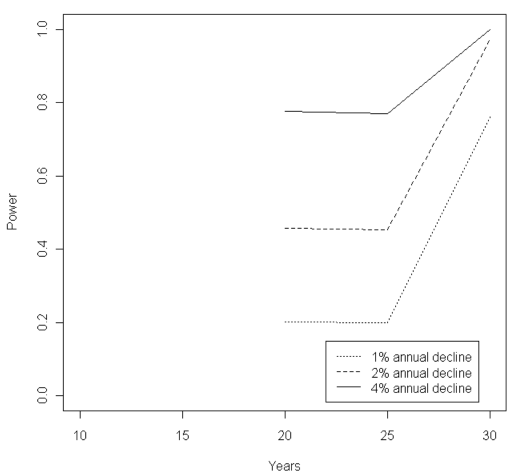
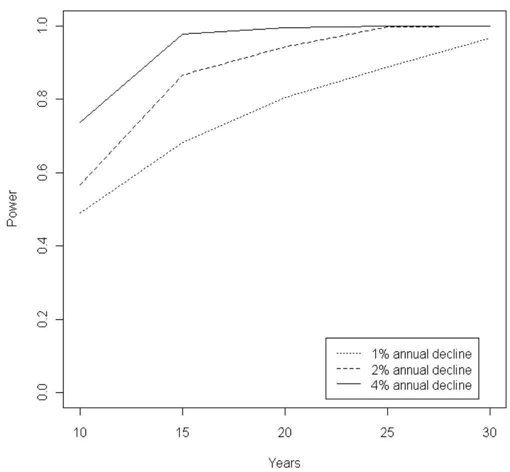
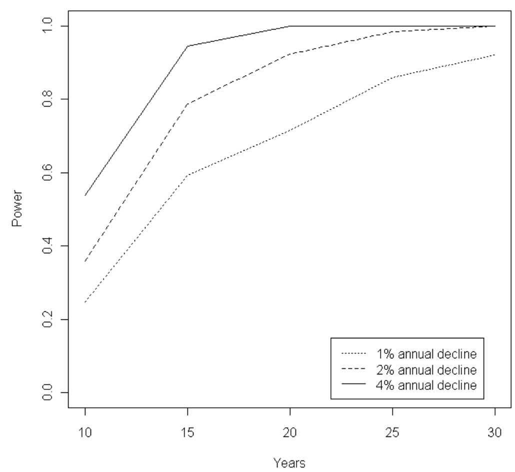


Figure 40: Power to detect trends in either direction in the percent cover of bare ground or litter for a sample of 16 sites (10 from stratum 0 and 6 from stratum 1).

a) From a [1-2] revisit design for three levels of change



b) From a [1-4] revisit design for three levels of change



c) From a [1-9] revisit design for three levels of change

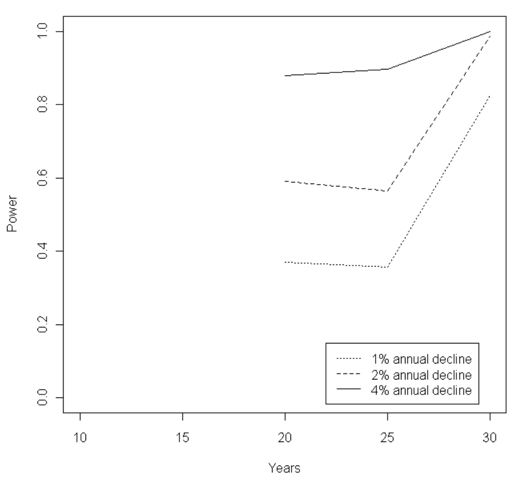


Figure 41: Power to detect trends in either direction in the percent cover of bare ground or litter for a sample of 24 sites (15 from stratum 0 and 9 from stratum 1).

Visitor use data

In 2009, visitor use surveys were conducted at the four deliberately-chosen sites which include two sites in high-use areas and two sites in low-use areas. In 2010, four GRTS sample sites were selectively chosen from the GRTS sample of 24 sites for the visitor use survey. During the survey, observers counted the number of visitors to a site in 5- or 15-minute increments between 10 AM and 5 PM. Surveys lasted between 4 and 7 days per site. The maximum number of visitors per acre was computed within each bank for each site. The mean site area by bank was calculated from vegetation survey data collected in 2008 and 2010 because site area by bank varies within a year and among years. The maximum number of visitors per acre is calculated as the maximum number of visitors to a site within a bank divided by the mean site-by-bank area in acres. Therefore, this index of visitor use varies by site and bank but not over time because visitor use data is only available for one year for each site and bank.

This metric was used as a covariate to model each of the outcomes of interest to examine relationships between the index of visitor use and the outcomes of interest. Means calculated at the site-by-bank level were modeled as a function of the year, bank, and maximum visitors per acre. The results of the analysis are provided in Table 20. The only two outcomes that exhibit a relationship with the visitor use index are the percent cover of exposed roots and the percent cover of tap-rooted perennials. The estimated effect of visitor use is positive, indicating that increased visitor use is associated with an increased percentage of exposed roots. The negative effect of visitor use on the percent cover of tap-rooted perennials indicates that increased visitor use is associated with a decline in percent cover of tap-rooted perennials.

Table 20: Analysis of Effect of Maximum Visitors per Acre on Vegetation Metrics

Outcome	Transformation	Est. Effect of Maximum Visitors per Acre	SE	p-value
Substrate Size Class	log(y+1)	-0.0040	0.0155	0.7993
Large Woody Debris	log(100*y+1)	-0.0377	0.0995	0.7187
Exposed Roots	log(100*y+1)	0.5271	0.0654	<0.0001
Non-vascular Plants	log(100*y+1)	0.0669	0.0226	0.2070
Annuals/Biennials	log(100*y+1)	0.1022	0.1798	0.5814
Fibrous Rooted or Rhizomatous Perennials	log(100*y+1)	0.0549	0.0787	0.5034
Tap-rooted Perennials	log(100*y+1)	-0.3772	0.0985	0.0105
Shrubs	log(100*y+1)	0.0585	0.0957	0.5516
Woody Seedlings	log(100*y+1)	0.1107	0.0674	0.1266
Evergreen trees	100*y	-0.1410	2.1009	0.9477
Deciduous trees	log(100*y+1)	0.1608	0.1053	0.2044
Snags	log(100*y+1)	-0.0746	0.0998	0.4709
Bare Ground or Litter	100*y	-3.2150	1.9394	0.1266

If future visitor use studies are conducted, survey timing may be optimized to reduce costs. Figures 40 and 41 display the maximum number of visitors to a site by day for 2009 and 2010, respectively. The plots suggest that the last week of July and the first week of August provide the best information for maximum visitor numbers. Figures 42 and 43 provide plots of the number of visitors within a date by time of day. These plots suggest, with several exceptions, that the highest visitor counts are obtained between noon and 4 PM each day.

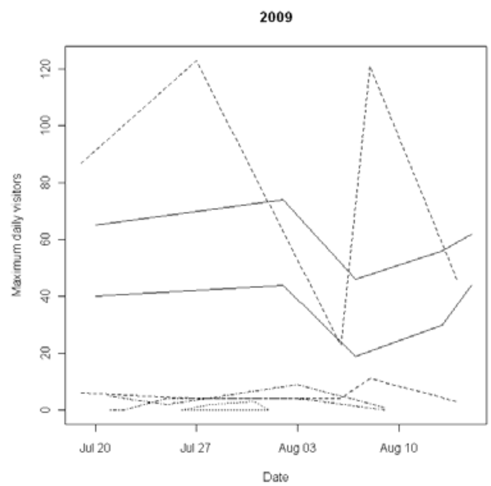


Figure 42: Maximum daily visitors by site in 2009

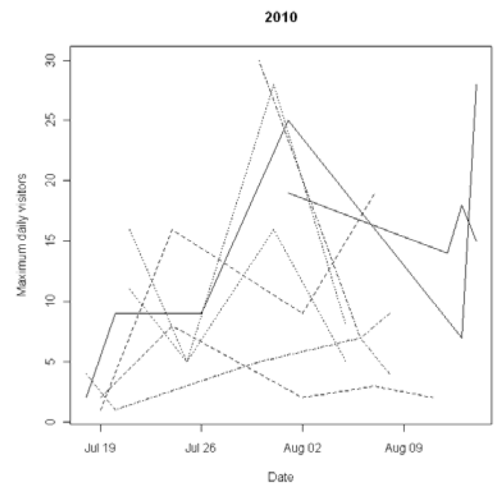


Figure 43: Maximum daily visitors by site in 2010

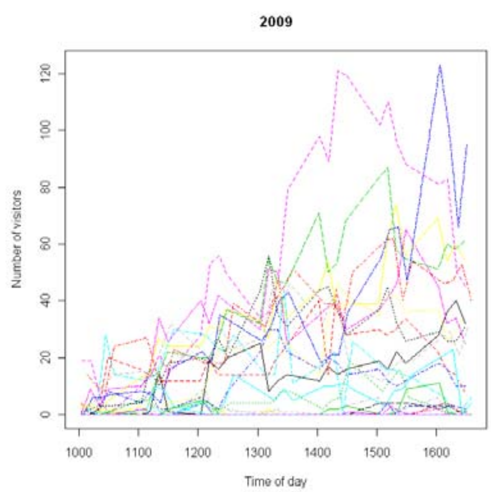


Figure 44: Number of 2009 visitors by time of day

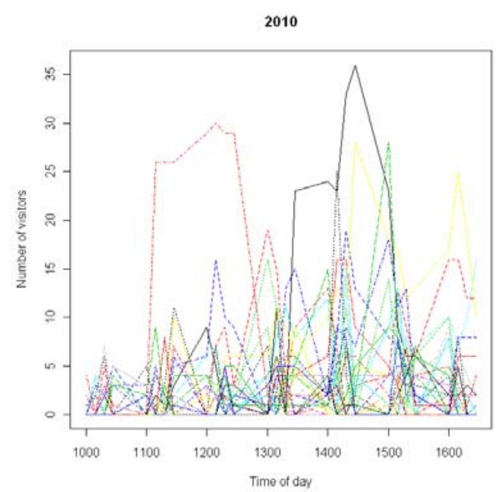


Figure 45: Number of 2010 visitors by time of day

Conclusions

Data analyses indicate that significant trends may be observed in the outcomes of interest studied in the Merced River bank monitoring program. Power analysis also suggests that adequate power to detect trends is feasible if sample sizes are sufficient, the revisit design cycle is short, and the monitoring period is long for small trend effects. Power results vary by outcome of interest and, in general, the revisit design impacts the power to detect trend more than the sample size.

Trend detection for an annual decline of 4% in mean substrate class attains power of at least 80% for a two-sided test within 30 years when a combined sample of at least 16 sites is visited. Power to detect trend in the percent cover of large woody debris exceeds 80% when the population exhibits an overall annual decline of 4% over at least 15 years regardless of sample size or revisit design. For annual declines of 1%, two-sided trend tests of the percent cover of large woody debris exhibit 80% power or better for the [1-2] and [1-4] revisits designs after 25 or 30 years, respectively. Power to detect trends in the percent cover of exposed roots is uniformly low for an annual change of -1%. For annual declines of 2%, 80% power is attained within 25 to 30 years for the [1-2] and [1-4] designs. Trend tests for percent cover of exposed roots declining an average of 4% annually achieve 80% power within about 15 years with the exception of samples collected with the [1-9] design, for which a 30-year monitoring period is necessary to attain 80% power.

Trend testing of the percent cover of non-vascular plants exhibits 80% power for 1% annual declines only when the [1-2] revisit design is used with a sample of 24 sites. Annual trends of -2% in the percent cover of non-vascular plants are detected in 20 to 25 years with at least 80% power when the [1-2] and [1-4] revisit designs are used, and annual trends of -4% attain similar power within 15 to 30 years for all revisit designs explored in this power analysis. Power to detect trends in the percent cover of annuals and biennials is uniformly low for an annual change of -1%. Trend tests for populations exhibiting annual trends of -2% attain 80% power within 25 to 30 years for the [1-2] and [1-4] revisit designs when samples consist of at least 16 sites, and annual trends of -4% may be detected within 15 to 30 years depending on the revisit design.

Power to detect trends in the percent cover of fibrous rooted or rhizomatous perennials only reaches 80% for a sample of 24 sites collected in a [1-2] revisit design when the population declines an average of 4% annually. Power to detect trends in tap-rooted perennial percent cover is consistently low for an annual decline of 1%. For an annual decline of 2%, 80% power to detect a trend can be obtained within 25 to 30 years when the [1-2] revisit design is used and for samples of at least 16 sites when the [1-4] design is used. Trend tests for tap-rooted perennial percent cover declining at a rate of 4% annually achieve 80% power within 15 to 20 years for the [1-2] and [1-4] revisit designs but require a 30-year monitoring interval to obtain 80% power for the [1-9] design. Power to detect trends in the percent cover of shrubs is uniformly low, not exceeding 20% for any combination of sample size, revisit design, or annual change.

Trend testing of the percent cover of woody seedlings exhibits 80% power for annual declines of 1% after 25 to 30 years for the [1-2] and [1-4] revisit designs. Annual declines of 2% and 4% may be detected with 80% power within 15 to 30 years depending on the revisit design. Power to detect trends in the percent cover of evergreen trees does not exceed 70% and the power to detect trends in the percent cover of deciduous trees does not exceed 30% for any scenario examined in this power analysis. Power to detect trends in the percent cover of snags is uniformly low for annual trends of -1%. Annual trends of -2% may be detected with a two-sided trend test with at least 80% power for the [1-2] and [1-4] revisit designs within 25 to 30 years. The power to detect with a two-sided trend test an annual decline of 4% in the percent cover of snags exceeds 80% within 15 to 20 years for the [1-2] and [1-4] revisit designs, but a 30-year monitoring period is required for the [1-9] revisit design. The highest power for trend detection was observed for the percent cover of bare ground or litter, for which 80% power may be attained with 30 years for annual declines of 1%, 2%, or 4% with the [1-2] revisit design and for the [1-4] revisit design when at least 16 sites are visited during each survey occasion.

While an increase in the sample size corresponds to an increase in the power to detect trend, the revisit design has a greater impact on power. Data collected from the [1-2] design yields tests with higher power than the other two designs as a function of time because replication of sites is obtained at a higher frequency. Revisit designs with longer revisit intervals essentially "stretch" the power curve over a longer time period, resulting in lower power over the same monitoring interval for the revisit designs with longer revisit cycles. The [1-9] revisit design is impractical for trend monitoring since true replication will require a minimum of 11 years and three visits to each site is attained after 21 years.

Visitor use of riverbanks is found to be an important predictor of the percent cover of exposed roots and tap-rooted perennials. As visitor use increases, the percent cover of exposed roots increases and the percent cover of tap-rooted perennials decreases. These effects are likely associated with increased trampling from higher visitor numbers. Note that the analysis of the effect of visitor use on percent cover variables is based on a total of four sites in each of two years. Larger sample sizes may improve the ability to detect relationships between visitor use and percent cover variables.

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APPENDIX A: R code for status estimation

For a table of site-level means called *SiteMeans*, the following R code may be used to obtain estimates of means, their standard errors, and 100*(1-α)%-confidence intervals on the mean. The table *SiteMeans* contains columns for UTM coordinates (*XCOORD* and *YCOORD*), the GRTS sample design weight (*WGT*), the strata (*Str*), and the outcome of interest (in this example code, *SubstrateSizeClass*). The assumed Type I error rate is 0.10 so 90%-confidence intervals are calculated (*conf=90*). For each year, estimates are computed by stratum and across stratum, but it is necessary to account for the strata in the across-stratum analysis (*stratum = Str*).

```
Est.SubstrateSizeClass.2008.0<-with(SiteMeans
[(SiteMeans$Year==2008)&(SiteMeans$Str==0),],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90))
Est.SubstrateSizeClass.2008.1<-with(SiteMeans
[(SiteMeans$Year==2008)&(SiteMeans$Str==1),],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90))
Est.SubstrateSizeClass.2008<-with(SiteMeans [SiteMeans$Year==2008,],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90,
stratum=Str))

Est.SubstrateSizeClass.2009.0<-with(SiteMeans
[(SiteMeans$Year==2009)&(SiteMeans$Str==0),],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90))
Est.SubstrateSizeClass.2009.1<-with(SiteMeans
[(SiteMeans$Year==2009)&(SiteMeans$Str==1),],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90))
Est.SubstrateSizeClass.2009<-with(SiteMeans [SiteMeans$Year==2009,],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90,
stratum=Str))

Est.SubstrateSizeClass.2010.0<-with(SiteMeans
[(SiteMeans$Year==2010)&(SiteMeans$Str==0),],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90))
Est.SubstrateSizeClass.2010.1<-with(SiteMeans
[(SiteMeans$Year==2010)&(SiteMeans$Str==1),],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90))
Est.SubstrateSizeClass.2010<-with(SiteMeans [SiteMeans$Year==2010,],
total.est(SubstrateSizeClass,WGT,x= XCOORD, y= YCOORD, conf=90,
stratum=Str))
```

APPENDIX B: R code for trend modeling

This trend analysis requires the lme4 package in R. For a data set *samp* with fields for the outcome *Y*, the year factor *Year*, the integer valued *WYear*, and the site identifier *Site*, the following code will provide information to conduct a trend test. The *WYear* variable is a location-shifted variable centered at 0 for the year of least variation among the site-level slopes. For example, if the site-level slopes vary the least during the first year of the survey, then *WYear* = 0, 1, 2, …, $m_b - 1$ for the m_b years in the monitoring period. See VanLeeuwen et al. (1996) and Piepho and Ogutu (2006) for more information.

Note that the *lmer* function does not provide degrees of freedom or a p-value. We approximate the degrees of freedom using the Sattherthwaite approximation proposed by Sims et al. (2006):

load the lme4 library
```
library(lme4)
```

load the lme4 library
```
samp$Year<-as.factor(samp$Year)
```

Obtain the trend model
```
fit<-lmer(Y ~ WYear + (1+WYear|Site) + (1|Year), data= samp)
```

Calculate the degrees of freedom
```
sig2a.hat.2<-VarCorr(fit.2)$Site[1,1]     # var(ai)
sig2t.hat.2<-VarCorr(fit.2)$Site[2,2]     # var(ti)
sig2b.hat.2<- VarCorr(fit.2)$Year[1]
sig2e.hat.2<-attr(VarCorr(fit.2),"sc")^2
VarBeta<- vcov(fit)[2,2]
Z1<- (sig2b.hat + (sig2e.hat/n))/sum(((1:mb)-(mb+1)/2)^2)
Z2<- sig2t.hat/ma
denomDF <- VarBeta^2/(((Z1^2)/(mb-2))+ ((Z2^2)/(ma-1)))
```

Calculate the p-value for the trend test
```
pval<-1-pf((beta/SEbeta)^2, 1, denomDF)
```

APPENDIX C: Power analysis results in tabular form

Table C1: Power results for the [1-2] revisit design

Outcome	Annual change	5 sites in stratum 0, 3 sites in stratum 1			10 sites in stratum 0, 6 sites in stratum 1			15 sites in stratum 0, 9 sites in stratum 1		
		10	20	30	10	20	30	10	20	30
Substrate Size Class	1%	0.036	0.140	0.186	0.046	0.136	0.184	0.036	0.188	0.298
	2%	0.088	0.258	0.314	0.118	0.392	0.454	0.152	0.472	0.614
	4%	0.320	0.696	0.784	0.448	0.940	0.954	0.580	0.922	0.990
Large Woody Debris	1%	0.024	0.508	0.992	0.030	0.518	0.988	0.014	0.504	0.988
	2%	0.118	0.992	1.000	0.130	0.988	1.000	0.122	0.990	1.000
	4%	0.744	1.000	1.000	0.736	1.000	1.000	0.770	1.000	1.000
Exposed Roots	1%	0.030	0.204	0.584	0.092	0.288	0.666	0.078	0.302	0.760
	2%	0.060	0.518	0.972	0.118	0.648	0.992	0.200	0.710	0.998
	4%	0.200	0.946	1.000	0.338	0.986	1.000	0.430	1.000	1.000
Non-vascular Plants	1%	0.010	0.138	0.416	0.022	0.236	0.700	0.052	0.334	0.810
	2%	0.022	0.394	0.888	0.044	0.646	0.998	0.116	0.810	1.000
	4%	0.110	0.934	1.000	0.198	1.000	1.000	0.420	1.000	1.000
Annuals/ Biennials	1%	0.016	0.098	0.290	0.030	0.170	0.474	0.048	0.216	0.642
	2%	0.014	0.246	0.754	0.038	0.484	0.972	0.076	0.638	0.996
	4%	0.050	0.768	1.000	0.132	0.950	1.000	0.270	0.994	1.000
Fibrous Rooted or Rhizomatous Perennials	1%	0.030	0.078	0.122	0.028	0.076	0.136	0.038	0.058	0.138
	2%	0.028	0.148	0.248	0.042	0.174	0.312	0.062	0.210	0.314
	4%	0.076	0.408	0.446	0.114	0.508	0.746	0.150	0.536	0.834
Tap-rooted Perennials	1%	0.006	0.104	0.314	0.016	0.180	0.608	0.030	0.260	0.750
	2%	0.026	0.358	0.852	0.038	0.562	0.980	0.080	0.722	0.998
	4%	0.058	0.824	1.000	0.154	0.992	1.000	0.356	0.998	1.000
Shrubs	1%	0.026	0.094	0.114	0.012	0.062	0.088	0.026	0.068	0.074
	2%	0.020	0.078	0.094	0.006	0.050	0.082	0.028	0.088	0.094
	4%	0.034	0.092	0.132	0.024	0.070	0.076	0.038	0.088	0.126
Woody Seedlings	1%	0.030	0.476	0.980	0.042	0.474	0.986	0.020	0.484	0.982
	2%	0.122	0.974	1.000	0.130	0.980	1.000	0.118	0.984	1.000
	4%	0.682	1.000	1.000	0.712	1.000	1.000	0.742	1.000	1.000
Evergreen trees	1%	0.162	0.504	0.604	0.126	0.426	0.536	0.126	0.366	0.470
	2%	0.178	0.456	0.622	0.128	0.408	0.576	0.136	0.388	0.490
	4%	0.232	0.482	0.642	0.228	0.490	0.624	0.232	0.474	0.584
Deciduous trees	1%	0.032	0.090	0.098	0.022	0.074	0.088	0.026	0.086	0.108
	2%	0.028	0.114	0.118	0.014	0.104	0.126	0.050	0.098	0.136
	4%	0.038	0.172	0.182	0.064	0.168	0.202	0.108	0.248	0.268
Snags	1%	0.018	0.148	0.512	0.054	0.252	0.662	0.082	0.326	0.686
	2%	0.050	0.430	0.940	0.094	0.644	0.992	0.156	0.680	0.998
	4%	0.144	0.938	1.000	0.322	0.980	1.000	0.408	0.992	1.000
Bare Ground or Litter	1%	0.210	0.548	0.930	0.360	0.712	0.962	0.490	0.804	0.966
	2%	0.306	0.826	0.998	0.534	0.904	1.000	0.566	0.942	1.000
	4%	0.486	0.970	1.000	0.650	0.996	1.000	0.736	0.994	1.000

Table C2: Power results for the [1-4] revisit design

Outcome	Annual change	5 sites in stratum 0, 3 sites in stratum 1			10 sites in stratum 0, 6 sites in stratum 1			15 sites in stratum 0, 9 sites in stratum 1		
		10	20	30	10	20	30	10	20	30
Substrate Size Class	1%	0.004	0.080	0.128	0.002	0.096	0.162	0.004	0.090	0.168
	2%	0.002	0.186	0.256	0.002	0.278	0.398	0.020	0.340	0.496
	4%	0.020	0.604	0.678	0.028	0.810	0.930	0.068	0.842	0.966
Large Woody Debris	1%	0.000	0.362	0.928	0.000	0.390	0.922	0.000	0.364	0.930
	2%	0.000	0.954	1.000	0.000	0.970	1.000	0.000	0.958	1.000
	4%	0.040	1.000	1.000	0.006	1.000	1.000	0.012	1.000	1.000
Exposed Roots	1%	0.004	0.120	0.402	0.016	0.222	0.496	0.062	0.270	0.546
	2%	0.004	0.396	0.868	0.028	0.596	0.956	0.080	0.634	0.970
	4%	0.014	0.894	1.000	0.106	0.958	1.000	0.218	0.984	1.000
Non-vascular Plants	1%	0.004	0.056	0.264	0.022	0.164	0.466	0.046	0.216	0.676
	2%	0.002	0.262	0.778	0.038	0.502	0.970	0.068	0.748	1.000
	4%	0.014	0.842	1.000	0.062	0.982	1.000	0.160	1.000	1.000
Annuals/ Biennials	1%	0.004	0.060	0.192	0.016	0.106	0.318	0.028	0.126	0.476
	2%	0.004	0.194	0.570	0.030	0.394	0.880	0.072	0.498	0.978
	4%	0.010	0.610	0.996	0.050	0.930	1.000	0.104	0.978	1.000
Fibrous Rooted or Rhizomatous Perennials	1%	0.000	0.038	0.098	0.000	0.064	0.094	0.004	0.046	0.098
	2%	0.000	0.090	0.186	0.000	0.124	0.236	0.004	0.094	0.222
	4%	0.000	0.254	0.420	0.004	0.368	0.566	0.012	0.428	0.636
Tap-rooted Perennials	1%	0.000	0.048	0.228	0.010	0.116	0.460	0.030	0.182	0.568
	2%	0.000	0.214	0.684	0.016	0.412	0.940	0.048	0.606	0.984
	4%	0.008	0.730	0.996	0.054	0.978	1.000	0.150	1.000	1.000
Shrubs	1%	0.000	0.038	0.096	0.004	0.052	0.066	0.010	0.038	0.056
	2%	0.002	0.048	0.080	0.006	0.036	0.072	0.004	0.054	0.064
	4%	0.002	0.050	0.124	0.002	0.056	0.058	0.014	0.078	0.100
Woody Seedlings	1%	0.000	0.350	0.882	0.000	0.352	0.906	0.000	0.362	0.890
	2%	0.000	0.944	1.000	0.000	0.956	1.000	0.000	0.938	1.000
	4%	0.020	1.000	1.000	0.018	1.000	1.000	0.024	1.000	1.000
Evergreen trees	1%	0.004	0.296	0.488	0.002	0.264	0.420	0.000	0.274	0.376
	2%	0.008	0.362	0.464	0.002	0.242	0.460	0.002	0.298	0.400
	4%	0.008	0.314	0.510	0.006	0.336	0.498	0.002	0.324	0.472
Deciduous trees	1%	0.000	0.068	0.066	0.008	0.052	0.078	0.012	0.034	0.046
	2%	0.004	0.086	0.098	0.008	0.056	0.108	0.020	0.062	0.106
	4%	0.002	0.106	0.160	0.024	0.136	0.198	0.040	0.202	0.250
Snags	1%	0.006	0.126	0.318	0.016	0.146	0.448	0.046	0.218	0.578
	2%	0.008	0.302	0.818	0.036	0.500	0.942	0.080	0.626	0.970
	4%	0.016	0.882	1.000	0.080	0.956	1.000	0.186	0.982	1.000
Bare Ground or Litter	1%	0.030	0.534	0.826	0.134	0.682	0.892	0.248	0.716	0.920
	2%	0.066	0.802	0.992	0.202	0.900	0.998	0.358	0.922	1.000
	4%	0.136	0.966	1.000	0.320	0.984	1.000	0.538	0.998	1.000

Table C3: Power results for the [1-9] revisit design

Outcome	Annual change	5 sites in stratum 0, 3 sites in stratum 1			10 sites in stratum 0, 6 sites in stratum 1			15 sites in stratum 0, 9 sites in stratum 1		
		10	20	30	10	20	30	10	20	30
Substrate Size Class	1%	-	0.002	0.038	-	0.000	0.038	-	0.002	0.030
	2%	-	0.004	0.102	-	0.000	0.142	-	0.014	0.160
	4%	-	0.024	0.450	-	0.038	0.678	-	0.058	0.772
Large Woody Debris	1%	-	0.000	0.510	-	0.000	0.548	-	0.000	0.478
	2%	-	0.028	1.000	-	0.008	0.998	-	0.008	0.996
	4%	-	0.844	1.000	-	0.850	1.000	-	0.844	1.000
Exposed Roots	1%	-	0.002	0.144	-	0.048	0.262	-	0.086	0.352
	2%	-	0.022	0.534	-	0.082	0.670	-	0.216	0.778
	4%	-	0.136	0.966	-	0.372	0.978	-	0.554	0.990
Non-vascular Plants	1%	-	0.004	0.074	-	0.024	0.146	-	0.068	0.244
	2%	-	0.010	0.326	-	0.066	0.678	-	0.170	0.860
	4%	-	0.038	0.964	-	0.148	1.000	-	0.376	1.000
Annuals/ Biennials	1%	-	0.006	0.030	-	0.012	0.078	-	0.044	0.146
	2%	-	0.010	0.174	-	0.052	0.468	-	0.150	0.700
	4%	-	0.030	0.814	-	0.102	0.988	-	0.226	1.000
Fibrous Rooted or Rhizomatous Perennials	1%	-	0.000	0.016	-	0.000	0.024	-	0.000	0.014
	2%	-	0.002	0.072	-	0.000	0.058	-	0.000	0.056
	4%	-	0.008	0.164	-	0.002	0.290	-	0.008	0.342
Tap-rooted Perennials	1%	-	0.002	0.036	-	0.030	0.130	-	0.078	0.202
	2%	-	0.006	0.234	-	0.052	0.536	-	0.124	0.772
	4%	-	0.032	0.864	-	0.104	1.000	-	0.278	1.000
Shrubs	1%	-	0.000	0.030	-	0.004	0.010	-	0.002	0.024
	2%	-	0.000	0.024	-	0.000	0.008	-	0.012	0.022
	4%	-	0.000	0.044	-	0.004	0.006	-	0.008	0.024
Woody Seedlings	1%	-	0.000	0.480	-	0.000	0.474	-	0.000	0.498
	2%	-	0.014	0.994	-	0.014	0.998	-	0.020	0.994
	4%	-	0.732	1.000	-	0.774	1.000	-	0.770	1.000
Evergreen trees	1%	-	0.004	0.168	-	0.000	0.108	-	0.000	0.088
	2%	-	0.002	0.160	-	0.002	0.148	-	0.002	0.112
	4%	-	0.006	0.174	-	0.002	0.200	-	0.000	0.214
Deciduous trees	1%	-	0.000	0.030	-	0.002	0.016	-	0.014	0.028
	2%	-	0.002	0.026	-	0.002	0.028	-	0.006	0.032
	4%	-	0.000	0.034	-	0.006	0.046	-	0.032	0.086
Snags	1%	-	0.006	0.050	-	0.028	0.194	-	0.072	0.308
	2%	-	0.014	0.414	-	0.052	0.632	-	0.154	0.766
	4%	-	0.082	0.924	-	0.254	0.982	-	0.476	0.990
Bare Ground or Litter	1%	-	0.054	0.542	-	0.202	0.760	-	0.370	0.824
	2%	-	0.186	0.918	-	0.458	0.970	-	0.590	0.986
	4%	-	0.496	1.000	-	0.776	1.000	-	0.878	1.000