In cooperation with the National Park Service

Field Evaluations of Sampling Methods for Long-Term Monitoring of Upland Ecosystems on the Colorado Plateau

By Mark E. Miller, Dana L. Witwicki, Rebecca K. Mann, and Nicole J. Tancreto

2007

Open-File Report 2007-1243

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia 2007

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth,
its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

Suggested citation:
Miller, Mark E., Witwicki, Dana L., Mann, Rebecca K., and Tancreto, Nicole J., 2007, Field evaluations of sampling methods for long-term monitoring of upland ecosystems on the Colorado Plateau: U.S. Geological Survey Open-File Report 2007-1243, 188 p. [http://pubs.usgs.gov/of/2007/1243/].

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted material contained within this report.

Contents

Abstract 1
Acknowledgments 2
Introduction and Background 2
Methods 3
  Study Areas 3
  Field Sampling 4
    Sampling Phases 4
    Macroplot Characterization and Evaluation 4
    Macroplot Layout 5
    Line-Point Intercept Sampling 7
    Gap-Intercept Sampling 10
    Quadrat Sampling 10
    Documentation of Unknown Species 13
    Assessment of Sampling Impacts 13
  Date Entry and Management 14
    Database Design 14
    Field Procedures 14
    Office Procedures 18
  Data Analyses 18
    Sampling Efficiency 18
    Among-Method Trends in Cover Estimates 19
    Repeatability 19
    Sampling Impacts 20
Results 20
  Macroplot Characterization and Evaluation 20
  Sampling Efficiency 21
    Sampling Times 21
    Within-Macroplot Variability 24
    Among-Macroplot Variability 31
    Species-Area Relationships and Community Composition 34
  Among-Method Trends in Cover Estimates 39
  Repeatability 41
  Sampling Impacts 53
Discussion 54
  Evaluation of Sampling Methods 54
    Efficiency 54
    Repeatability 56
    Sampling Impacts 57
  Issues Associated with Electronic Data Entry and Management 58
References Cited 59
Appendix A—Species List and Species Occurrence by Ecological Site 61
Appendix B—Within-Macroplot Variability of Cover Estimates by Sampling Technique and Ecological Site 66
Appendix C—Summaries of Frequency and Cover Estimates by Macroplot and Sampling Technique 78

Appendix D—Among-Macroplot Variation in Selected Cover Measures by Ecological Site 127
Appendix E—Mean Species-Area and Compositional Curves by Ecological Site 139
Appendix F—Between-Observer Differences in Estimates of Cover and Density 151
Appendix G—Nested Frequency Data by Ecological Site.....161

Figures

Figure 1. Standard macroplot and transect layout used during the 2005 field season.....6
Figure 2. Transect layouts used for comparing repeatability and efficiency of square and rectangular quadrats during Phase 1 sampling. 6
Figure 3. Transect lengths and types of sampling conducted during Phases 2 (a) and 3 (b). 7
Figure 4. Dimensions of square and rectangular nested quadrats that were evaluated during Phase 1, and of square quadrats that were used during Phases 2 and 3. 11
Figure 5. Photographic key to soil-surface categories used for describing degrees of biological soil crust development on the basis of relative soil darkness (J. Belnap, unpublished). 13
Figure 6. Main effects of (a) ecological site, (b) cover category (total live understory canopy, individual species, and soil-surface features), and (c) sampling method on log-transformed CV values describing within-plot variability in cover measures. Bars indicate 95 percent confidence intervals. Within each panel, values with the same letter are not significantly different by Tukey's HSD test. See table 1 for ecological site codes. 25
Figure 7. Interactive effects of ecological site and cover category (total live understory canopy, individual plant species, and soil-surface features) on log-transformed CV values describing within-plot variability in cover measures. Bars indicate 95 percent confidence intervals for means. See table 1 for ecological site codes. 26
Figure 8. Median numbers (± 25 percentiles) of subsamples required for 20 percent precision in macroplot-level estimates of (a) total live understory canopy cover, (b) live cover of individual plant species, and (c) cover of surface features across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. In (a), there is no difference among median values obtained via different sampling methods (Kruskal-Wallis H = 5.89, df = 2, n = 33, p = 0.0525). In (b), median values from 10-m^2 quadrats and line-point intercepts are significantly different from one another (Kruskal-Wallis H = 15.41, df = 2, n = 94, p = 0.0004). In (c), there is no significant difference among medians from different methods (Kruskal-Wallis H = 3.08, df = 2, n = 98, p = 0.2139). 29
Figure 9. Time required to estimate total live understory cover using (a) the line-point intercept technique, (b) 1-m^2 quadrats, and (c) 10-m^2 quadrats in relation to cover estimates derived from the same sampling techniques. Points are labeled by ecological site codes (see table 1 for key to codes) and symbolized to indicate the general physiognomic structure of the sampled plant community. Ecological sites underlined in (a) are those where line-point intercepts were used to estimate cover of overstory vegetation above 2-m in height, in addition to understory vegetation and soil-surface features. 30
Figure 10. Median numbers of hours (± 25 percentiles) required for subsampling to achieve 20 percent precision in macroplot-level estimates of (a) total live understory canopy cover, (b) live cover of individual plant species, and (c) cover of surface features across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. For each cover category, there is no significant difference among median sampling times for different sampling methods (a. Kruskal-

Wallis H = 0.95, df = 2, n = 33, p = 0.6216; b. Kruskal-Wallis H = 4.51, df = 2, n = 94, p = 0.1045; c. Kruskal-Wallis H = 1.68, df = 2, n = 98, p = 0.4327). 31
Figure 11. Main effects of cover category (total live understory canopy, individual species, and surface features) on log-transformed CV values describing among-macroplot variability in cover estimates across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. Values with different letters are significantly different from one another (Tukey's HSD test, between MS = 0.6231, df = 216, p < 0.01 for all pair-wise comparisons). 32
Figure 12. Median numbers (± 25 percentiles) of macroplots required for 20 percent precision in ecological-site-level estimates of (a) total live understory canopy cover, (b) cover of individual plant species, and (c) cover of surface features across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. For each cover category, there is no significant difference among median macroplot numbers for different sampling methods (a. Kruskal-Wallis H = 0.95, df = 2, n = 33, p = 0.6218; b. Kruskal-Wallis H = 1.38, df = 2, n = 96, p = 0.5005; c. Kruskal-Wallis H = 3.05, df = 2, n = 96, p = 0.2174). 34
Figure 13. Median ratios of within-to-among macroplot variability (based on log-transformed CV values) for estimates of (a) total live understory canopy cover, (b) live cover of individual plant species, and (c) cover of surface features across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. For each cover category, there is no significant difference among median ratios for different sampling methods (a. Kruskal-Wallis H = 2.39, df = 2, n = 33, p = 0.3033; b. Kruskal-Wallis H = 4.33, df = 2, n = 96, p = 0.1147; c. Kruskal-Wallis H = 3.05, df = 2, n = 96, p = 0.3941). 35
Figure 14. Log-transformed species richness data (mean numbers of unique species detected in 15 quadrats) in relation to ecological site and quadrat size (a) for all species detected, and (b) excluding infrequent species that occurred in only one 10-m^2 quadrat from the 10-m^2 data. (See table 1 for key to ecological site codes.) 38
Figure 15. Estimated total live understory canopy cover (standardized means) by method averaged across 11 ecological sites on the Colorado Plateau. Bars indicate 95 percent confidence intervals. Values with different letters are significantly different by Tukey's HSD test. 40
Figure 16. Estimated total live understory canopy cover (standardized means) by method and 11 Colorado Plateau ecological sites. Bars indicate 95 percent confidence intervals for means. See table 1 for ecological site codes. 40
Figure 17. Effect of sampling method on cover estimates (standardized means) for selected surface features (litter, biological soil crust, and bare soil) across 11 ecological sites on the Colorado Plateau. Means with different letters are significantly different by Tukey's HSD test. 41
Figure 18. Effects of sampling method on cover estimates (standardized means) for (a) surface litter, (b) unstable bare soil, and (c) biological soil crusts (moss, lichen, and cyanobacteria combined) at eight Colorado Plateau ecological sites. 42
Figure 19. Scatterplot of average wind speed (m s^{-1}) vs. absolute difference between two observers' estimates of grass cover based on use of the line-point intercept sampling technique at eight Colorado Plateau ecological sites (r = 0.07, p = 0.55, n = 70). 46
Figure 20. Photograph (left) of destabilized soil and trampled biological soil crusts on unsampled side of transect in Arches National Park (Semidesert Shallow Sandy Loam ecological site), and (right) trampled plants on unsampled side of transect in Wupatki National Monument (Limy Upland ecological site). 53

Tables

1. Ecological sites, associated NRCS soil surveys and soil map units, and macroplots sampled during Phases 2 and 3 of the 2005 field season....3
2. Phases of sampling conducted during the 2005 field season....5
3. Measures recorded during line-point intercept sampling....8
4. Definitions of plant material and plant status....9
5. Categories of soil-surface disturbances described during line-point sampling and quadrat sampling....9
6. Soil crust categories used during line-point sampling and quadrat sampling....9
7. Definitions used for gap-intercept sampling....10
8. Cover-class scale used to estimate cover in 10-m^2 quadrats....11
9. Size classes used for recording shrub and tree density....12
10. Soil-surface categories used for estimating cover and development of biological soil crusts in 25 cm x 25 cm quadrats on the basis of relative soil darkness....12
11. Evaluation matrix for rating sampling impacts, considering the entire macroplot visit and all sampling procedures combined....15
12. Explanations of sampling procedures for purposes of impact assessment....17
13. Impact-assessment ratings for individual sampling procedures....17
14. Summary of macroplots that were relocated following site characterization and prior to sampling....21
15. Mean times for setting up and reading frequency (freq), cover (cov), and density (dens) in 1-m^2 and 10-m^2 quadrats....22
16. Mean times for sampling line-point intercept transects, basal- and canopy-gaps transects, and biological soil crust (BSC) frames....23
17. Analysis of variance for effects of ecological site, cover category (total live understory canopy, individual species, and soil-surface features), and sampling method on log-transformed CV values describing within-macroplot variability in cover measures....24
18. Results of multiple-regression models evaluating significance of subsample size, frequency, and mean cover as predictors of log-transformed CV values describing within-macroplot variability in cover measures....27
19. Summary of mean estimates for total live understory canopy cover for each of 11 Colorado Plateau ecological sites, within-macroplot variation in cover estimates summarized across n macroplots within each ecological site, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision....28
20. Analysis of variance for effects of cover category (total live understory canopy, individual species, and surface features) and sampling method on log-transformed CV values describing among-macroplot variability in cover estimates....32
21. Among-macroplot variation in estimates of total live understory canopy cover for 11 ecological sites (n macroplots per ecological site), macroplot sample sizes required to achieve 10 and 20 percent precision in estimates of site-level means, and ratios of within-to-among CV values....33
22. Species richness data for several ecological sites on the Colorado Plateau, based on 10-m^2 and 1-m^2 quadrats....36

23. Analysis of variance for effects of ecological site and quadrat size on log-transformed values for the number of unique species detected in 15 10-m^2 and 1-m^2 quadrats during Phase 3 sampling. 38
24. Analysis of variance for effects of ecological site and quadrat size on log-transformed values for the number of unique species detected in 15 10-m^2 and 1-m^2 quadrats during Phase 3 sampling, excluding infrequent species that occurred in only one 10-m^2 quadrat from the 10-m^2 data. 38
25. Analysis of variance for effects of ecological site and sampling method on total live understory cover (standardized means) at 11 Colorado Plateau ecological sites. 39
26. Analysis of variance for effect of sampling method on standardized mean cover of surface features at 11 Colorado Plateau ecological sites. 41
27. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species POFE, QUGA, SYOR2, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Brushy Loam ecological site at Mesa Verde National Park. 42
28. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species CHLE4, HENE5, PLJA, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Limy Upland, 25-33" ecological site at Grand Canyon National Park. 43
29. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species POFE, POTR5, UNGRCA1, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Loamy Hills, 25-33"pz ecological site at Grand Canyon National Park. 43
30. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species JUOS, PIED, POFE, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Loamy Mesa Top PJ ecological site at Mesa Verde National Park. 43
31. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species ATCO, GIIN2, ORHY, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site at Capitol Reef National Park. 44
32. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species ARTR2, BRTE, STCO4, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Semidesert Loam (Wyoming Big Sagebrush) ecological site in Dinosaur National Monument....44
33. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species CORA, FEOC3, STLO4, and total live understory canopy cover) on arcsin-transformed means of plant canopy cover for the Semidesert Shallow Sandy Loam PJ ecological site at Arches and Canyonlands National Parks. 44
34. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species CEMO2, COWR2, JUOS, and total live understory canopy cover) on arcsin-transformed means of plant canopy cover for the Upland Shallow Loam (Pinyon-Utah Juniper) ecological site at Capitol Reef National Park. 45
35. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), ecological site (BL, LU, LH, LMT, SASL, SL, SShSL, and UShL), and observer on arcsin-transformed means of litter cover data.. 45

36. Results of Wilcoxon tests evaluating effects of observer on estimates of cover for four types of soil crust (undifferentiated, dark cyanobacteria, lichen, and moss) sampled with 10-m^2 quadrats, 1-m^2 quadrats, and line-point intercept techniques at Colorado Plateau ecological sites where biological soil crusts were common. 47
37. Results of Wilcoxon tests evaluating effects of observer on estimates of biological soil crust cover based on the characterization of soil darkness (see table 10 and fig. 5) in 25 cm x 25 cm BSC frames at Colorado Plateau ecological sites where biological soil crusts were common. 50
38. Results of Wilcoxon tests evaluating effects of observer on estimates of shrub density by species and height class at Colorado Plateau ecological sites.. 51
39. Results of Wilcoxon tests evaluating effects of observer on estimates of tree density by species and size class at Colorado Plateau ecological sites. 52
40. Median impact-assessment ratings for procedures at 11 Colorado Plateau ecological sites 55
41. Median impact-assessment ratings for types of impacts (broken branches, trampled plants, destabilized soils, trampled biological soil crusts, and quadrat-frame imprint) in quadrats, on the sampled side of the transect tape, and on the unsampled side of the transect tape at 11 Colorado Plateau ecological sites 55
42. Summary of comparisons among cover-sampling techniques in relation to repeatability between observers, efficiency, and sampling impacts on soils and vegetation 56

Field Evaluations of Sampling Methods for Long-Term Monitoring of Upland Ecosystems on the Colorado Plateau

By Mark E. Miller, Dana L. Witwicki, Rebecca K. Mann, and Nicole J. Tancreto[1]

Abstract

To inform planning for long-term ecological monitoring, we sampled vegetation and soil-surface attributes across a range of terrestrial ecosystems (physiognomic types) in seven National Park Service units on the Colorado Plateau. Primary objectives were (1) to evaluate a suite of sampling methods according to measures of repeatability, efficiency, and impacts on plot conditions; and (2) to characterize within- and among-plot variability in monitoring measures. This work was designed to support NPS staff in selecting the combination of methods that best meets their monitoring objectives and resource constraints. We found no differences among cover-estimation techniques in terms of repeatability between observers (measurement precision). Estimates for total live understory canopy cover, cover of individual species, and cover of soil-surface features were highly repeatable between observers for 10-m^2 quadrats, 1-m^2 quadrats, and line-point intercept sampling methods. Estimates of shrub and tree density in 10-m^2 quadrats also were repeatable between observers, although sample sizes for were small for many species. At 10 of 11 ecological sites, we found that sampling with 10-m^2 quadrats was the most efficient cover-estimation technique with respect to within-plot variability in cover estimates and numbers of subsamples required to estimate plot-level cover with 20 percent precision. According to these same measures, sampling with 1-m^2 quadrats was the least efficient cover-estimation technique at eight of 11 ecological sites. The line-point technique was most efficient at eight of 11 ecological sites in terms of the amount of time required to estimate total plot-level cover with 20 percent precision – largely because 10-m^2 quadrats were more time consuming and 1-m^2 quadrats had greater within-plot variability relative to line-point sampling. However, there was no statistical difference among methods with respect to median subsampling times for 20 percent precision. There also were no differences among methods with respect to mean and median measures of among-plot variability in total live understory canopy cover. But among-plot variability was least for the line-point technique at seven of 11 ecological sites. Sampling activities had greatest impacts on plot conditions at macroplots where there was a high degree of cover by biological and physical soil crusts. Of all sampling procedures, 10-m^2 quadrat sampling, line-point sampling, and gap-intercept sampling had the most impacts on soil conditions due to trampling of soil crusts by the field team.

[1] Authors are Research Ecologist, Plant Ecologist, and Biologist, U.S. Geological Survey, Southwest Biological Science Center; and Data Manager, National Park Service, Southern Colorado Plateau Inventory and Monitoring Network.

Acknowledgments

Funding for this work was provided by the National Park Service (Northern Colorado Plateau and Southern Colorado Plateau Inventory and Monitoring Networks) and the U.S. Geological Survey (Southwest Biological Science Center and the Status and Trends Program). Recommendations from Steve Garman, Lisa Thomas, Chris Lauver, and Thom O'Dell improved the study design. Tonya Troxler assisted with the preparation of tables and figures. Charles Drost and Kathryn Thomas provided review comments that improved the quality of this report.

Introduction and Background

This project involved field evaluations of a limited suite of measures and measurement techniques for long-term monitoring of terrestrial ecosystems characteristic of the Colorado Plateau region. The project was designed to support the Northern and Southern Colorado Plateau Networks (NCPN and SCPN, respectively) of the National Park Service's Inventory and Monitoring Program (NPS I&M Program). In conjunction with the I&M Program, ecoregional networks of NPS units have been charged with the task of identifying "vital signs" to be monitored for the purpose of tracking long-term trends in the "health" or condition of park ecosystems. Collectively, the NCPN and SCPN have identified an integrated suite of vital signs for tracking resource conditions in 35 NPS units located in the Colorado Plateau region of Utah, Arizona, Colorado, and New Mexico. To inform the selection of monitoring methods most suited to NPS monitoring objectives for these parks, the NCPN and SCPN required field evaluations of measures and measurement techniques across the range of ecosystems likely to be monitored.

Following were general objectives of this project.

1. Collect and analyze field data to evaluate a limited suite of measures and measurement techniques for their relative suitability in effectively and efficiently meeting NPS monitoring needs across the range of ecosystems likely to be monitored.
2. Characterize within- and among-macroplot variability in monitoring measures to inform NPS planning for operational monitoring.
3. On the basis of site soil, landscape, and vegetation characteristics, evaluate the accuracy of stratification data used to select field sites for sampling.

This report summarizes data collected during the 2005 field season, emphasizing comparisons among sampling methods in terms of (1) sampling efficiency (defined with respect to time and within- and among-macroplot variability in cover measures), (2) relative trends or differences in cover estimates derived from different sampling methods, (3) between-observer repeatability in measures of cover and density, and (4) sampling impacts on soil and vegetation attributes. In addition, we briefly address issues associated with the accuracy of spatial data used for selecting macroplot locations and challenges associated with data-collection and data-management systems used during the 2005 field season.

Methods

Study Areas

Study areas were selected to sample particular ecological sites[2] delineated by soil map units in soil surveys produced by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). Target ecological sites were identified jointly by USGS and NPS to represent the range of physiognomic types likely to be included in NCPN and SCPN monitoring plans (table 1). NPS staff subsequently determined coordinates for centroids of macroplots to be sampled during the 2005 season.

Table 1. Ecological sites, associated NRCS soil surveys and soil map units, and macroplots sampled during Phases 2 and 3 of the 2005 field season. (See table 2 for descriptions of sampling phases.)

NRCS ecological site			NRCS soil survey area (citation)	NRCS soil map unit	Macroplot	Sampling phase	Location of macroplot center (NAD83)	
Name	Code for this project	Physiog-nomic structure					UTM mE	UTM mN
Brushy Loam	BL	Shrubland	CO671 (NRCS 2001a)	131	MEVE1	2	730064	4131866
					MEVE6	3	725179	4127097
					MEVE7	3	723803	4127722
				13	MEVE2	2	729978	4129690
				79	MEVE5	3	724964	4127964
Desert Sand (Sand Sagebrush)	DS	Grassland	UT633 (SCS 1991)	80	CANY1	2	611824	4225106
					CANY2b	2	610505	4223529
Limy Upland, 6-10" pz	LU	Grassland	AZ631 (SCS 1983)	56	WUPA1	2	452750	3936806
					WUPA2	2	458382	3937598
					WUPA5	3	457109	3935314
					WUPA6	3	451957	3934304
					WUPA7	3	452545	3935929
Loamy Hills, 25-33" pz	LH	Forest	AZ701 (NRCS 2003)	53	GRCA3	2	400825	4019411
				51	GRCA4	2	405721	4009147
					GRCA6	3	404566	4009215
				52	GRCA5	3	403933	4010688
					GRCA7	3	404913	4007824
Loamy Hills, Cold, 25-33" pz	LHC	Forest	AZ701 (NRCS 2003)	49	GRCA1	2	400496	4021102
				53	GRCA2	2	404425	4011908
Loamy Mesa Top PJ	LMT	Woodland	CO671 (NRCS 2001a)	111	MEVE3	2	719717	4116890
				77	MEVE4	2	719690	4117457
					MEVE8	3	724589	4117373
				76	MEVE10	3	723590	4115712
					MEVE9	3	722950	4116950
Semidesert Alkali Sandy Loam (Alkali Sacaton)	SASL	Grassland	UT685 (NRCS 2004)	200	CARE1	2	475775	4257151
					CARE2b	2	475612	4257531
					CARE5	3	483223	4253447
					CARE6	3	482135	4253991
					CARE7	3	481694	4254064
Semidesert Loam (Wyoming Big Sagebrush)	SL	Shrubland	CO692 (NRCS 2001b)	1	DINO1	2	654965	4487760
					DINO2b	2	647936	4476988
					DINO3	3	644018	4483816
					DINO4b	3	653726	4476991
					DINO5	3	675330	4482005

[2] An *ecological site* is defined as a kind of land with specific physical characteristics which differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its response to management (SRM Task Group 1995, Creque et al. 1999). Soil surveys produced by NRCS correlate ecological sites with particular soil series.

Table 1.—Continued

NRCS ecological site			NRCS soil survey area (citation)	NRCS soil map unit	Macroplot	Sampling phase	Location of macroplot center (NAD83)	
Name	Code for this project	Physiog-nomic structure					UTM mE	UTM mN
Semidesert Shallow Sandy Loam PJ	SShSL	Shrubland	UT624 (SCS 1989)	51	ARCH1b	2	620922	4292242
					ARCH2	2	622000	4291604
					ARCH3	3	618798	4289007
					ARCH4b	3	623265	4285247
					ARCH5	3	624686	4283478
			UT633 (SCS 1991)	71	CANY3	2	604432	4259261
					CANY4	2	602370	4255471
Shallow Loamy, 10-14" pz	ShL	Grassland	AZ631 (SCS 1983)	61	WUPA3	2	455525	3937298
				60	WUPA4	2	463894	3934278
Upland Shallow Loam (Pinyon-Utah Juniper)	UShL	Woodland	UT685 (NRCS 2004)	310	CARE3	2	483656	4224951
					CARE4b	2	483364	4223871
					CARE10	3	483584	4223149
					CARE8	3	484724	4220446
					CARE9	3	484314	4220771

Field Sampling

Sampling Phases

Sampling during the 2005 field season was conducted in three phases (table 2). Following the conclusion of Phase 1, NPS made the decision to use square quadrats during Phase 2 and Phase 3 sampling. Data from Phase 1 are not presented in this report.

Macroplot Characterization and Evaluation

Soil and geomorphic characteristics of all preselected and sampled macroplots were described during Phases 2 and 3 using standard protocols developed by NRCS (Schoeneberger et al. 2002). The purpose of this process was to guide the observers in determining whether soil and landscape characteristics at a given location matched those associated with the target soil and ecological site. Thorough site characterization requires description of soil characteristics through the uppermost 1 m of the soil profile. However, for purposes of this project, site characterization was based only on surface properties. No soil pits were dug or samples collected, though a small amount of topsoil was separated using a #10 sieve in the field to characterize the surface soil texture, effervescence, and size and abundance of rock fragments greater than 2 mm in diameter.

In general, the site characterization process involved describing the soil and site properties of the area associated with the macroplot centroid and spanned by the three 50-m or 70-m transects. The macroplot centroid was located by navigating with a GPS unit to a set of pre-determined, randomly-selected UTM coordinates within the target soil map unit. The aspect and azimuth were also given for the NCPN locations or determined by the field crew for the SCPN locations. If a significant soil or geomorphic boundary crossed the macroplot area, the description was focused on the area in which the centroid itself was located. Characterization was conducted approximately 1-2 m down-slope from the centroid to avoid trampling the area sampled by the middle transect.

There were three possible outcomes of the characterization process. If characterization indicated that the location matched the target ecological site and that all transects occurred on the same soil and geomorphic surface, the area was sampled. If the location did not match the target ecological site or if significant portions of the transects did not all fall on the targeted ecological site, the sampling location was relocated to a nearby area (within 250 m) in the target soil map

unit. After relocation, the same characterization procedure was repeated at the new centroid. If the characterized location did not match the target ecological site and no acceptable location could be found nearby, the sampling crew navigated to a new set of pre-selected coordinates within the ecological site.

Table 2. Phases of sampling conducted during the 2005 field season.

Phase	Objectives	Locations / ecosystems	Timing
Phase 1 – Training and preliminary testing	1. Train team members: safety and first aid, plant and biological-soil-crust identification, soil and site characterization, plot layout, sampling and data-entry procedures. 2. Determine whether square or rectangular quadrats are most repeatable with respect to frequency and density measures and least variable with respect to cover, frequency and density measures. Only one quadrat shape will be carried forth into subsequent phases. 3. Practice line-intercept and line-point sampling. 4. Determine optimal / efficient sequencing of sampling procedures to be used during Phases 2 and 3.	- Bureau of Land Management and Forest Service land vicinity of Moab - Grassland, shrubland, woodland, and forest ecosystems	June
Phase 2 – Over sampling	1. Conduct high-intensity sampling to evaluate variability of measures in relation to sample size: - Line-point sampling for cover and understory canopy height - Quadrat sampling for cover (1-m^2 and 10-m^2 quadrats) - Nested-quadrat sampling for frequency - Quadrat sampling for density 2. Sample to evaluate within- and among-site variability in canopy- and basal-gap measures. 3. Evaluate accuracy of spatial data used for selecting study sites. 4. Time all procedures. 5. Qualitatively evaluate plot impacts associated with different sampling techniques.	- NPS units in NCPN and SCPN - 2 replicate sets of full range of ecosystems	July – mid-September
Phase 3 – Repeated sampling	1. Conduct repeat sampling to evaluate repeatability of cover measures obtained through line-point sampling and two methods of quadrat sampling. 2. Sample to evaluate within- and among-site variability in canopy- and basal-gap measures, frequency measures, and shrub density measures. 3. Evaluate accuracy of spatial data used for selecting study sites. 4. Time all procedures. 5. Qualitatively evaluate plot impacts associated with different sampling techniques.	- NPS units in NCPN and SCPN - 3 replicate sets of full range of ecosystems	Late-September – mid-November

Macroplot Layout

Prior to the field season, NPS determined that the standard plot layout would consist of a 1-ha macroplot and three 50-m transects separated by 25 m (fig. 1). Transects used during Phases 1 and 2 were 70-m long to accommodate a larger number of subsamples per macroplot (figs. 2 and 3). During Phase 3, 50-m transects were used (fig. 3). Transects were marked temporarily with a 50-m tape and pin flags, but were not permanently marked. Transects were used for gap intercept and line-point intercept sampling, and for guiding the placement of quadrats used for sampling cover, frequency, and density. Transects were oriented parallel to the

hillslope contour to minimize potential effects of linear soil disturbances on hillslope hydrologic processes. Field observers traversed the down-slope side of the transect when sampling.

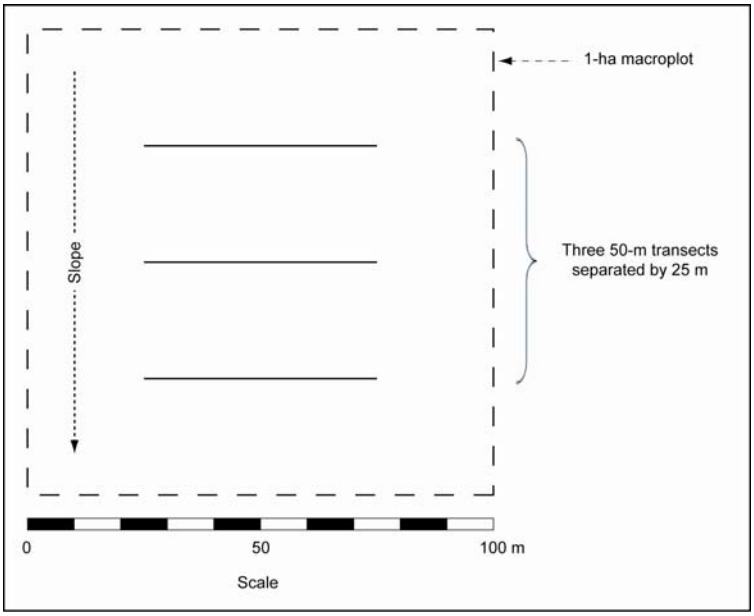

Figure 1. Standard macroplot and transect layout used during the 2005 field season.

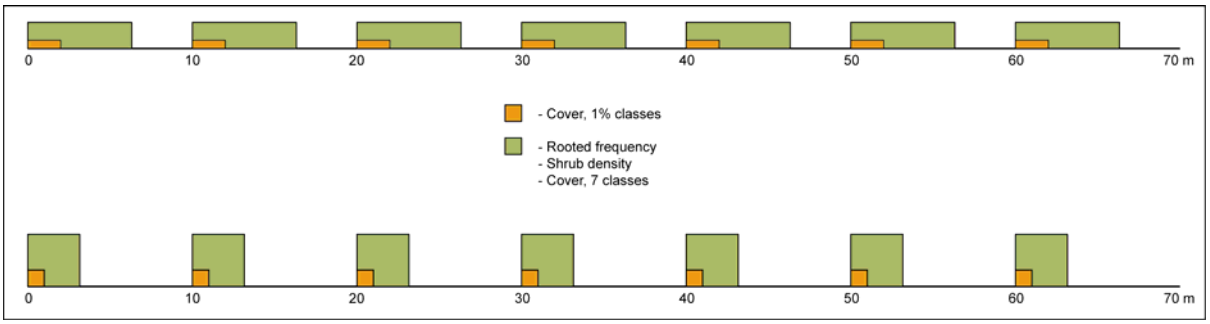

Figure 2. Transect layouts used for comparing repeatability and efficiency of square and rectangular quadrats during Phase 1 sampling.

The method of laying out the transect lines was standardized for all three Phases. The tape was generally stretched taut and anchored at both ends with a steel pin. The tape was also anchored in the middle if necessitated by windy conditions or uneven terrain. Where significant topography (e.g., hills, ditches) crossed the transect line, the tape was pinned down to maintain a relatively even tape height as the terrain rose and fell beneath it and to ensure that it could be replaced in nearly the same position. During Phases 1 and 3, pin flags also were placed precisely at the start, middle, and end points of the transect line to ensure repeatability when the tape was pulled and replaced (under the assumption that transects will be permanently marked during operational monitoring). After tape placement and photographic documentation, the general sequence of sampling events was line-point intercept sampling, gap-intercept sampling, then quadrat-based sampling. Gap sampling was not conducted during Phase 3.

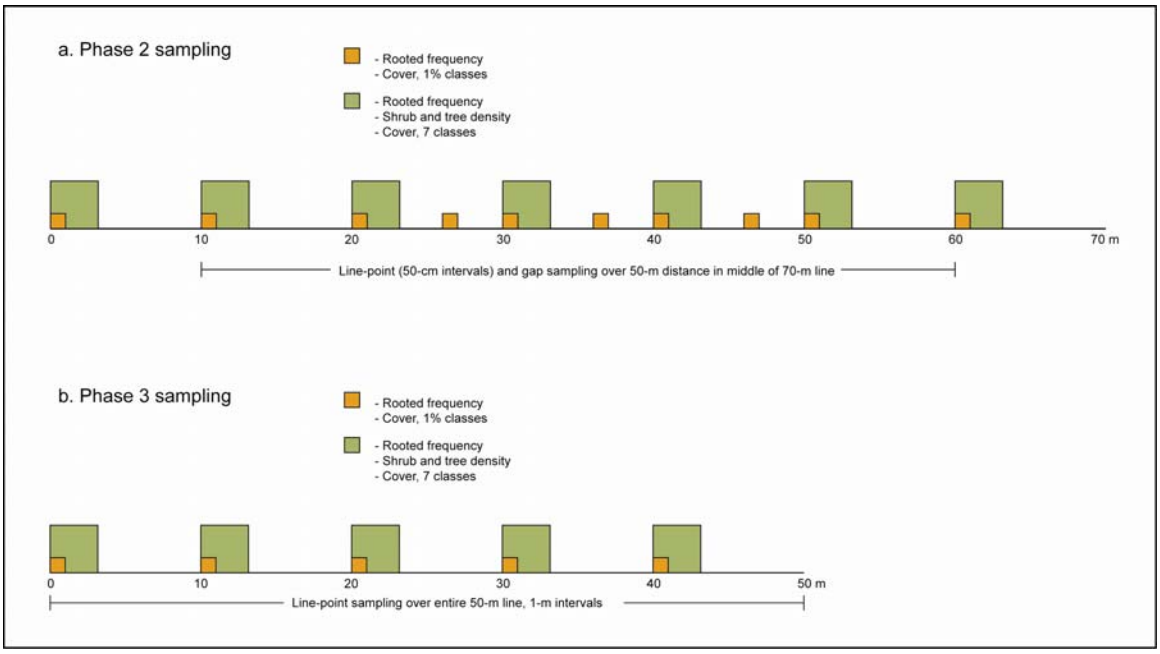

Figure 3. Transect lengths and types of sampling conducted during Phases 2 (a) and 3 (b).

During Phase 3, the transect tape was removed and then replaced between repeat sampling events by different observers. An exception to this practice was made at the Mesa Verde Brushy Loam and Loamy Mesa Top PJ ecological sites (macroplots MEVE5 – MEVE10). The transect tape was not removed and replaced between repeat sampling events at these sites because dense shrubs made the process exceptionally time-consuming.

For visual documentation of site characteristics and vegetation, a set of digital photographs was taken of each transect sampled during the course of the 2005 field season. After a transect line was placed and prior to sampling, a photoboard was placed at the 0-m mark, facing away from the transect line. One or two photographs were taken looking along the transect (towards the endpoint), from eye-level (1.5 - 2 m from the ground) at a vantage point located 5 m from the photoboard. If vegetation or topography prevented a 5-m distance, the photograph was taken as close as possible to 5-m mark and the actual distance was recorded. All photographs were taken with a Nikon Coolpix 4500 camera (4.0 megapixels). The first photograph was taken with no zoom. If a second was taken, the view was zoomed in to include just enough vertical scope to see the start and endpoints of the transect with no extra landscape. Photographs from the following transects were lost or not taken: BLM3-3, ARCH1-3, MEVE1-2, MEVE2-1, CANY3-2, CARE4-1, WUPA4-2, GRCA2-2, GRCA2-3, GRCA3-3. Additional photographs were taken at selected macroplots to document sampling impacts.

Line-Point Intercept Sampling

Line-point intercept sampling was used to estimate the cover of understory vegetation and soil-surface features. Methods generally followed those described by Herrick et al. (2005; hereafter referred to as the "Jornada manual"). Points were sampled over a 50-m span of each transect at 50-cm intervals during Phase 2 and 1-m intervals during Phase 3. At each sampling point, a 1-mm diameter, 90-cm long metal pin was placed by dropping it from breast height. Measures identified in table 3 were recorded on the basis of pin contacts at each placement. Data

were read from the top of the pin down and each species or other measure was only recorded once no matter how many times it intercepted the pin. Each plant hit was recorded by species as live photosynthetic, live non-photosynthetic, or standing dead (see definitions in table 4). Where cover occurred above the height of the pin (but less than 2 m) the point was projected upward to describe those hits. Likewise, if the pin struck a woody stem above ground level, the pin was held in position, the woody stem hit was recorded, and the point was then projected downward to describe the other hits below, including the soil-surface hit. The height of the uppermost canopy hit was measured from ground level using a vertical measuring tape placed next to the pin.

Table 3. Measures recorded during line-point intercept sampling.

Line-point intercept measures
Canopy cover %, live photosynthetic vascular plant tissue by species (understory shrubs and herbaceous)
Canopy cover %, live *non*-photosynthetic vascular plant tissue by species (understory shrubs and herbaceous)
Basal cover % by vascular plant species (all taxa)
Cover %, standing dead vascular plants by species (all taxa)
Overstory canopy cover %
Cover %, biological soil crust by functional / morphological group (dark cyanobacteria, moss and lichen)
Litter % (< 2.5 cm
Woody debris % (> 2.5 cm)
Animal scat %
Rock % by size class (< 20 mm in diameter, or > 20 mm in diameter)
Bare soil %, undifferentiated crust
Bare soil %, loose sediment
Soil-surface disturbance %, coded by type (e.g., ant mound, wildlife excavation, ungulate hoof print, human footprint)
Canopy height cm, uppermost understory intercept

Occurrences of soil-surface disturbances and soil crusts also were recorded during line-point intercept sampling. Soil-surface disturbances were described on the basis of nine categories (table 5). Soil crusts were described on the basis of four categories (table 6).

Table 4. Definitions of plant material and plant status.

Term	Definition
Duff	Partially decomposed plant litter. It consists of decomposing leaves and other organic material (from Herrick et al. 2005).
Litter	The top layer of the forest, shrubland, or grassland floor, directly above the duff layer, including freshly fallen leaves, needles, bark flakes, cone scales, fruits (including acorns and cones), dead matted grass and other vegetative parts that are little altered in structure by decomposition. Does not include larger twigs and stems > 2.5 cm in diameter.
Woody debris	Any woody material larger than 2.5 cm in diameter.
Live, photosynthetic plants	Plant material still attached to a rooted plant that is live and actively photosynthetic. This includes all green plant parts.
Live, non-photosynthetic plants	Plant material still attached to a rooted plant that is not live and actively photosynthetic. This includes non-photosynthetic tissues such as woody stems and flowers, as well as plant parts that were live and photosynthetic in current growing season, but senesced after spring growth and now appear brown.
Standing dead plants	Dead plant material still attached to a rooted plant. All standing dead vegetation produced in previous (not the current) growing season(s) not in contact with the soil surface.

Table 5. Categories of soil-surface disturbances described during line-point sampling and quadrat sampling.

Soil disturbance	Description
Undifferentiated disturbance	A disturbance with indeterminate origin
Ant mound	Holes and mounds caused by ants
Wildlife excavation	Holes and mounds caused by animals
Wildlife track	Any noticeable tracks, marks, or trails left by animals passing through the area
Livestock track/trail	Any noticeable tracks, marks, or trails left by livestock passing through the area
Human track/trail	Any noticeable tracks, marks, or trails left by humans passing through the area
Bicycle	Disturbances caused by bicycles
Motor vehicle	Disturbances caused by any motor vehicle
Other anthropogenic	Human-caused surface disturbance not defined by other categories

Table 6. Soil crust categories used during line-point sampling and quadrat sampling.

Category	Definition
Undifferentiated crust	Physical crust and/or weak cyanobacterial crust; may be characterized by slight microtopographic development
Cyanobacteria	Soil obviously darkened by cyanobacteria; usually with significant microtopographic development
Lichen	Any species, morphological type, or color
Moss	Any species, morphological type, or color

Where cover occurred greater than 2 m above the ground (e.g., Brushy Loam and Loamy Mesa Top PJ ecological sites in Mesa Verde, Loamy Hills and Loamy Hills, Cold, ecological sites in Grand Canyon, and the Upland Shallow Loam ecological site in Capitol Reef), a canopy densitometer (Geographic Resource Solutions, http://www.grsgis.com/densitometer/) was used to estimate overstory canopy cover. The densitometer was placed directly over the dropped pin and held level with the use of leveling bubbles embedded in the sampling device. The device uses mirrors and aligning rings to direct the user's line of sight directly upward from where it was held. Species observed through the densitometer were recorded as overstory hits. All overstory layers detected through the viewer were reported. The plant status of all overstory layers was recorded as seen through the densitometer, rather than attempting to estimate plant status as it would be at the topmost portion of the hit. Height of the top-most species was not measured when an overstory layer was present at the point.

During Phase 3, wind speed was measured with a hand-held anemometer at the beginning and end of each line-point sampling event by different observers. These data were collected to evaluate whether between-observer repeatability of cover estimates from line-point sampling was affected by wind speed.

Gap-Intercept Sampling

During Phase 2, a line-intercept sampling method was used to collect data describing the size-class distribution of gaps between plant bases (basal gap sampling) and between plant canopies (canopy gap sampling). Methods and definitions followed those outlined in the Jornada manual (table 7), with one modification. For canopy gaps, the Jornada method was modified to record three distinct classes along the line: shrub (woody canopies < 2 m tall), other vegetation, and canopy gap. Other vegetation included all suffrutescent and herbaceous species except for annual forbs. All attached plant material was counted as canopy regardless of live or dead status.

Table 7. Definitions used for gap-intercept sampling (from Herrick et al. 2005).

Term	Definition
Plant canopy	Canopy is recorded any time 50% or more of any 3-cm segment of tape intercepts live or dead plant canopy (above-ground plant parts) based on a vertical projection from canopy to ground.
Plant base	Any plant stem emerging from the soil surface along the graduated edge of the tape that would force an ant walking along the line on the soil to step off the line to get around it (minimum diameter of base = 1 mm).
Canopy gap	Gap occurs any time there is at least 20 cm without plant canopy.
Basal gap	Gap occurs any time there is at least 20 cm without a plant base.

Quadrat Sampling

Quadrat sampling was conducted during all three phases of the project to estimate frequency and cover of understory vegetation and soil-surface features, and to estimate density of selected woody species. Quadrats consisted of nested frames measuring 0.01 m^2, 0.1 m^2, 1 m^2, and 10 m^2 in area (fig. 4). The 1-m^2 quadrat frame was constructed of half-inch PVC pipe and marked on all sides with tape to demarcate 10-cm increments. Colored-tape bands on the 1-m^2 frame marked the corners of the 0.01-m^2 and 0.1-m^2 quadrats. Rope and steel pins were used to lay out the 10-m^2 frame. During all sampling phases, rooted frequency of vascular plants and

occurrence frequency of biological soil crusts (table 6), soil-disturbance features (table 5), and scat (wildlife vs. livestock) were recorded at every level of nested quadrats. Frequency sampling was followed by cover sampling in the 1-m^2 quadrat (to nearest 1 percent) and then by cover sampling in the 10-m^2 quadrat (by seven cover classes; table 8). For quadrat sampling, estimates of vegetation cover were restricted to live foliar cover of understory vegetation less than 2 m tall.

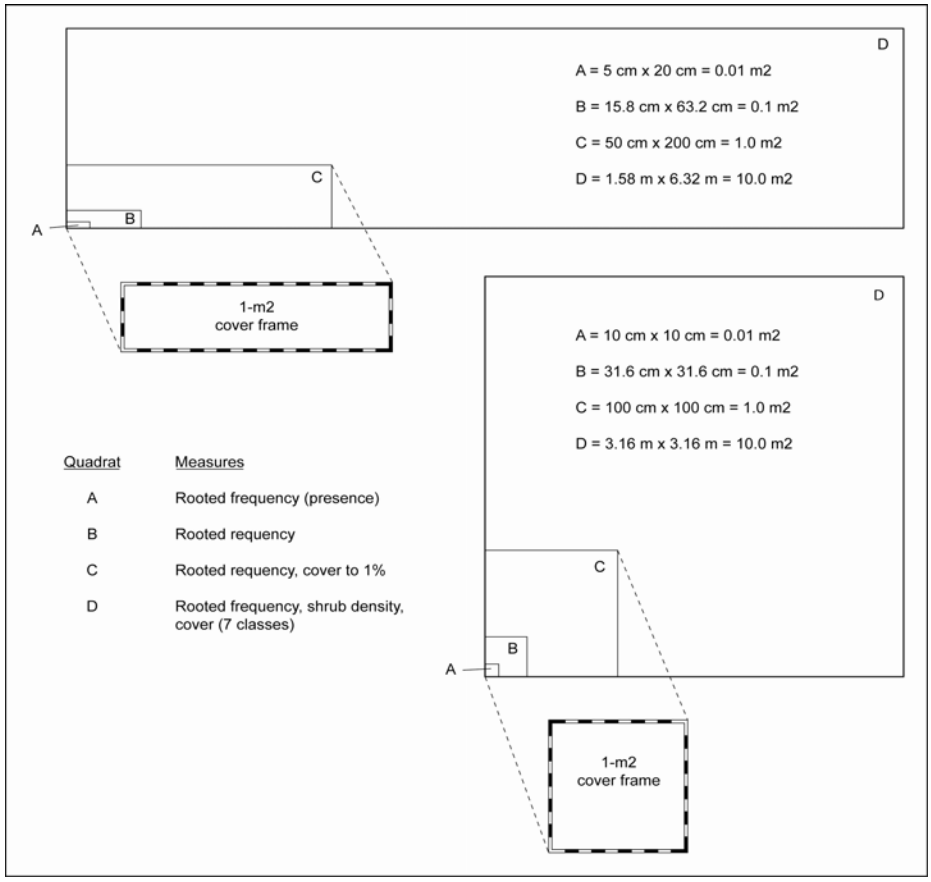

Figure 4. Dimensions of square and rectangular nested quadrats that were evaluated during Phase 1, and of square quadrats that were used during Phases 2 and 3.

Table 8. Cover-class scale used to estimate cover in 10-m^2 quadrats.

Cover class	Range of cover (%)	Class midpoints (%)
1	<1	0.5
2	1-5	3.0
3	5-10	7.5
4	10-25	17.5
5	25-50	37.5
6	50-75	62.5
7	75-100	87.5

After cover sampling, densities of selected woody species were estimated in the 10-m^2 quadrats. During site characterization and prior to sampling the macroplot, the dominant shrubs and trees to be counted for density were determined. *Quercus gambelii* and *Juniperus osteosperma* existed in both shrub and tree growth forms across ecological sites but were consistently counted as trees. During sampling, individual plants were counted only if stems

were at least halfway rooted in the quadrat (as for rooted frequency). For plants with multiple stems, individuals were counted only if at least one stem and half of the canopy were located within the quadrat. Individuals were categorized by size class (table 9). Some species, especially the shrubs *Artemisia tridentata* and *Coleogyne ramosissima*, showed evidence of multiple stems (sometimes due to burial of plant bases by eolian sand), making it difficult to discern true individuals. In such cases, we applied the rule that if two stems were less than 25 cm apart, they would be identified as a single counting unit, unless it was readily apparent that the stems originated from separate individuals, such as small seedlings sprouting near a larger shrub.

Table 9. Size classes used for recording shrub and tree density (dbh = diameter at breast height; drc = diameter at root crown). Tree size classes follow those used by the National Park Service fire program (NPS 2003).

Shrub height classes	Tree	
	Class	Criteria
< 10 cm	Seedling	< 1.37 m tall OR < 2.5 cm dbh / drc
10 - 25 cm		
25 - 50 cm	Pole	>= 1.37 m tall AND 2.5 - 15 cm dbh / drc
50 cm – 1 m		
1 - 2 m	Overstory	dbh / drc > 15 cm
> 2 m		

After a transect was completed for 1-m^2 and 10-m^2 quadrat sampling, an additional technique was used to estimate the cover and development of biological soil crusts (BSCs) on the basis of relative soil darkness. A 25 cm x 25 cm frame (hereafter referred to as a BSC frame) was placed adjacent to the transect tape at 2-m intervals and the predominant soil-surface cover (excluding litter and plant bases) was assigned one of seven soil-surface categories (table 10) and an ordinal cover class (table 8). A photographic key (fig. 5) was used as an aid in characterizing the relative darkness of crusted soils. This technique was used at all ecological sites where biological soil crusts were common (all macroplots excluding those associated with Brushy Loam, Limy Upland, Shallow Loamy, Loamy Hills, and Loamy Hills, Cold, ecological sites).

Table 10. Soil-surface categories used for estimating cover and development of biological soil crusts in 25 cm x 25 cm quadrats on the basis of relative soil darkness. Darkness categories for crusted soils are illustrated in figure 5.

Uncrusted or crusted soil	Soil-surface category
Uncrusted	Bare soil (loose sediment)
Crusted	Darkness 1
	Darkness 2
	Darkness 3
	Darkness 4
	Darkness 5
	Darkness 6

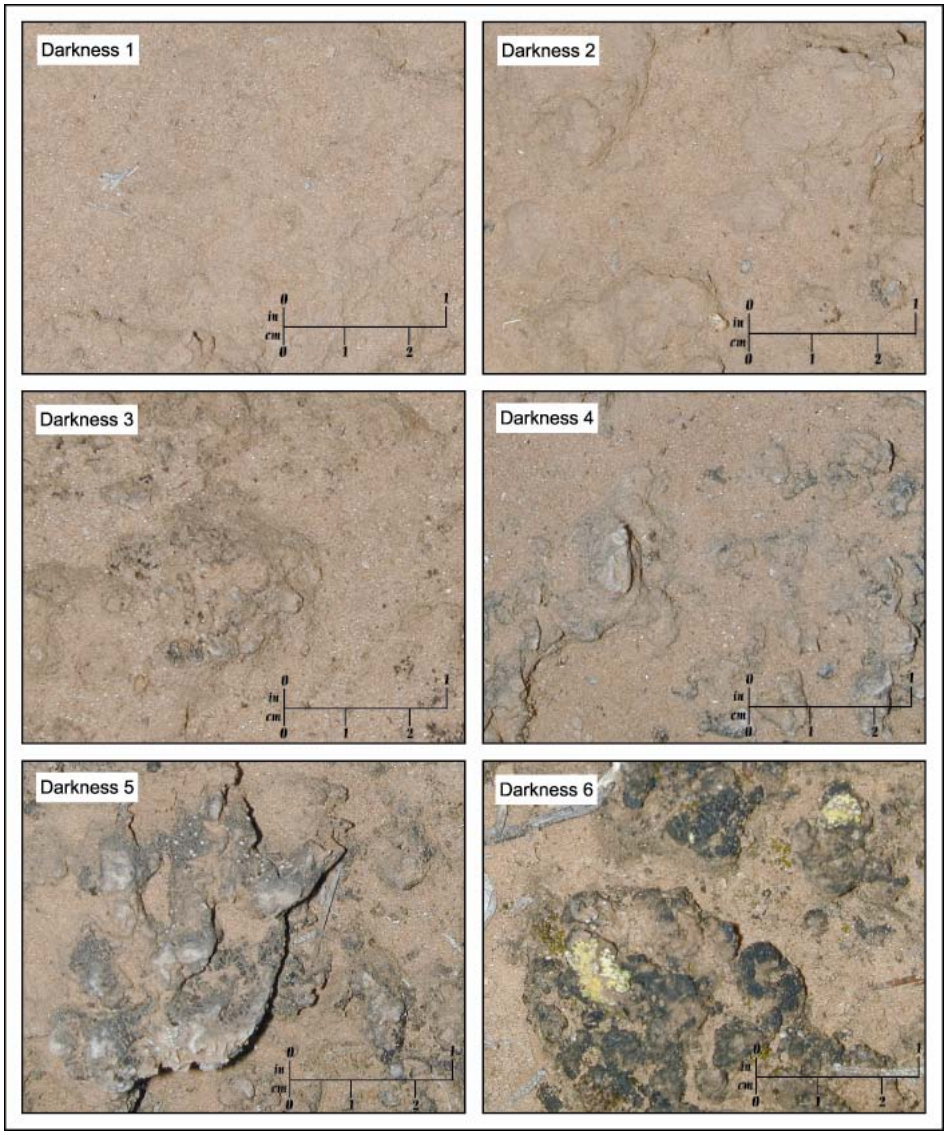

Figure 5. Photographic key to soil-surface categories used for describing degrees of biological soil crust development on the basis of relative soil darkness (J. Belnap, unpublished).

Documentation of Unknown Species

Field observers were challenged by the need to become familiar with the flora of a broad range of ecological sites. For purposes of consistency in describing the identity of unknown taxa over the course of the season, small specimens of unknown taxa were collected at each park and labeled with standardized codes (see Appendix A). These specimens were used throughout Phases 2 and 3 to ensure that the same taxa were not described by different identification codes.

Assessment of Sampling Impacts

After all sampling procedures were completed at a macroplot location, the field team used a standard protocol to assess types and degrees of sampling impacts on soil and vegetation.

The intent of the assessment was to provide information to allow an evaluation of the relative significance of adverse sampling impacts among ecological sites and sampling procedures.

To document impacts caused directly by the overall sampling process, a set of specific observer-caused impacts was assessed. The impacts were assigned a rating according to the degree to which they occurred on the unsampled side of the transect tape, on the sampled side of the transect (but outside of the quadrats), and within the quadrats specifically. Possible ratings ranged from none (no impact caused from specified factor) to high (specified factor having an extreme impact on the site). An evaluation matrix was constructed to aid in this process (table 11). Observer-caused impacts included trampled biological soil crusts (referring only to crusts exhibiting dark cyanobacteria, soil lichens, and mosses), trampled plants, broken branches, destabilized soils (referring to undifferentiated soil crust and bare, loose soil), and quadrat imprints.

Each particular sampling procedure (table 12) also was evaluated to determine the direct causes of the sampling impacts. In this evaluation, a relative degree of responsibility for the adverse impacts that occurred on a site (all impacts combined) was assigned for each sampling procedure. The degree of responsibility again ranged from none to high (table 13). For example, if trampling impacts were rated as extreme, the relative significance of the different sampling procedures as contributors to the extreme degree of trampling on the site was determined.

The final step of the impact-assessment process was to document species affected by the sampling process. If individuals of certain plant species appeared to have been particularly impacted by trampling or breaking of branches, they were identified in the data-entry table.

Date Entry and Management

Database Design

To house and manage data collected throughout the course of the project, the NPS SCPN data-management team developed a database using Microsoft Access software and partnered with USGS to develop data-management protocols and provide ongoing technical support. To facilitate timely incorporation of field data into the database, data were recorded electronically in the field with a Panasonic Toughbook 01 Pocket PC and collected into a Microsoft PocketAccess database, operated in conjunction with Sprint DB Pro interface software.

Field Procedures

Field data collection involved entering data into each of several component database tables, including electronic forms for location definition, site characterization, point-intercept data, frequency data, quadrat-based cover data, and density data. Reference tables were generated for each park in the form of pick lists, based on NPS Inventory and Monitoring species lists. Species encountered during field work were drawn from these pick lists; those species not appearing on the lists and unidentifiable species were given a code name based on the park in which they occurred, a series number, and brief descriptors. Each primary event table contained a start and stop time function allowing for the timing of all data-collection processes. The tables also displayed the collected data immediately, making it available for editing if necessary. The database was backed up several times throughout a day onto an external storage card using SunnySoft Backup Manager software. On the occasion that the database was unavailable or when programming errors prevented the use of the database, the field crew recorded data onto equivalent paper forms and later transferred the data to a corrected database.

Table 11. Evaluation matrix for rating sampling impacts, considering the entire macroplot visit and all sampling procedures combined (BSCs = biological soil crusts).

Sampling impact	Comments	Degree of impact					
		None	Slight	Slight to moderate	Moderate	Moderate to extreme	Extreme
Trampled BSCs	Refers to trampling impacts on dark cyanobacteria, soil lichens, and/or soil mosses. Impacts to undifferentiated crusts are evaluated under "destabilized soils." If BSCs are trampled, soils also are destabilized. The opposite is not necessarily true.	No BSCs were trampled (or no BSCs on site)	Some trampling impacts occurred, but impacts were very slight because BSCs were relatively uncommon on site or it was otherwise possible to avoid trampling them. OR there appeared to be no long-lasting damage.	Intermediate	Trampling of well-developed BSCs was unavoidable in some portions of the site, resulting in significant and persistent damage – but extent of this damage was limited to about half of initial footprints. Subsequent steps in same location may have had less impact because the damage already was done.	Intermediate	Well-developed BSCs were abundant on the site and it was impossible to avoid trampling them. Trampling resulted in significant, persistent damage to BSCs along all three transects. (Envision persistent damage with nearly every initial step taken on the site. Subsequent steps in same location may have had less impact because the damage already was done.)
Trampled plants	Refers to plant impacts attributable to feet, whether they are stepped upon (truly trampled) or kicked. Plant impacts attributable to frame placement are also included, if these are somehow analogous to trampling. Emphasis is on lasting impacts to plant performance (e.g., stem die-back, lost photosynthetic area, damaged reproductive structures.)	No plants were trampled	Plants were trampled, but probably had no lasting impacts on plant performance OR, a very small number of plants were trampled to the degree that there might have been lasting impacts on plant performance.	Intermediate	Many plants were trampled (impossible to avoid), and about half of trampling events probably resulted in lasting impacts on plant performance. OR trampling of plants was somewhat common (not ubiquitous) and probably resulted in lasting impacts on plant performance in most cases.	Intermediate	Many plants were trampled throughout the site (nearly impossible to avoid continuous trampling), AND trampling likely had lasting impacts on plant performance in most cases.

Table 11.—Continued

Sampling impact	Comments	Degree of impact					
		None	Slight	Slight to moderate	Moderate	Moderate to extreme	Extreme
Broken branches	Plant impacts attributable to body movement beneath or between branches of woody plants – e.g., fighting your way through dense shrubs, sapling trees, or low-hanging branches. Emphasis is on lasting impacts to plant performance (e.g., stem die-back, lost photosynthetic area, damaged reproductive structures.)	No branches were broken	Branches were broken, but probably had no lasting impacts on plant performance. OR, a very small number of branches were broken to the degree that there might have been lasting impacts on plant performance.	Intermediate	Many branches were broken (impossible to avoid), and about half of events probably resulted in lasting impacts on plant performance. OR broken branches were somewhat common (not ubiquitous) and probably resulted in lasting impacts on plant performance in most cases.	Intermediate	Many branches were broken throughout the site (nearly impossible to avoid continuous breaking), AND likely had lasting impacts on plant performance in most cases.

Table 12. Explanations of sampling procedures for purposes of impact assessment.

Sampling procedure	Comments
Travel to macroplot	Refers to the overland trek to the macroplot
Site characterization	Refers to all activities associated with site characterization, including texturing soil etc.
Plot establishment	Refers to activities associated with laying out transects – e.g., locating endpoints and centers of transects, laying out the transect tape.
1-m^2 quadrat sampling	Refers to placement and sampling of 1-m^2 quadrats for frequency and cover, as well as to moving the quadrat frame from one location to the next down the transect.
10-m^2 quadrat sampling	Refers to placement and sampling of 10-m^2 quadrats for frequency, cover and density, as well as to moving the quadrat frame from one location to the next down the transect.
Line-point intercept sampling	Refers to point sampling along the transect – e.g., placing the pin, measuring intercept heights, and walking the transect.
Gap-intercept sampling	Refers to sampling canopy and basal gaps along line-intercept transect.
Pin placement	Refers to staking of tape and 10-m^2 quadrat frames with chaining pins
Cumulative travel on line	Refers to impacts associated with repeated, cumulative travel up and down the transect line for all sampling procedures combined.

Table 13. Impact-assessment ratings for individual sampling procedures.

Degree of responsibility foroverall impacts on a site					
None	**Slight**	**Slight to moderate**	**Moderate**	**Moderate to high**	**High**
No observable impact attributable to this procedure	Some impacts were attributable to this procedure, but it had a slight impact overall.	Intermediate	This procedure was responsible for a significant degree of impact on this site. It was not the primary contributor to extreme impacts, but it may have been the primary contributor to moderate impacts.	Intermediate	This procedure was the primary contributor to extreme impacts.

Office Procedures

Upon return to the office following each data-collection trip, the PocketAccess database was synchronized or transferred from the Pocket PC to a desktop computer and converted to an Access database using Microsoft ActiveSync software. A cradle or a direct line connected the Pocket PC to the computer. During Phase 3, a separate database was created for each park visit to minimize file sizes and data-transfer times. These visit-specific databases were then integrated into the single master Access database after every trip. After each data collection Phase, the data were reviewed using standardized quality control and quality assurance methods. A thorough quality check was conducted at the end of the field season and queries were developed to generate data tables for use in statistical analyses and summarization.

Data Analyses

Data were summarized and analyzed to evaluate how sampling efficiency (sampling times, within- and among-plot variability in cover estimates, and measures of community composition), selected cover estimates, and repeatability (measurement precision) differed among sampling techniques and ecological sites. Unless specified otherwise, all statistical analyses were performed with Statistica v.6.1 (Statsoft, Inc. 2004) for Windows, and p-values $\leq$ 0.05 were considered statistically significant.

Sampling Efficiency

As a standardized measure of variability, the coefficient of variation (CV) was used as a primary metric for describing and comparing within- and among-plot variability in cover estimates provided by different sampling techniques:

$$CV = 100 * (\text{sample standard deviation} / \text{sample mean})$$

Analysis of variance (ANOVA; Zar 1999) was used to evaluate effects of ecological site, cover category (total live understory canopy, individual species, and soil-surface features), and sampling method on log-transformed CV values (using the natural log, ln) describing within-macroplot variability and among-plot variability. Tukey's honestly significant difference (HSD) post-hoc test was used to evaluate differences among treatments with significant main effects (Zar 1999). In addition, multiple regression techniques (Zar 1999) were used to evaluate the significance of subsample size, frequency, and mean within-plot cover values as predictors of log-transformed CV values provided by different sampling techniques.

The relative efficiency of different sampling techniques also was evaluated by comparing numbers of subsamples and samples required for estimating within- and among-plot mean cover values with 10 and 20 percent precision. For these analyses, we define *estimation precision* as one-half the width of the 95 percent confidence interval for the mean, expressed as a percentage of the mean. Sample-size estimates were calculated using the software package PASS (Power and Sample Size; NCSS, Kaysville, Utah, http://www.ncss.com/). Data for mean sampling times (minutes per quadrat for 1-m^2 and 10-m^2 quadrats; minutes per 10-pt group for line-point intercept sampling) by ecological site were used to estimate amounts of time required for different sampling techniques to achieve 10 and 20 percent precision in within-plot cover estimates. Non-parametric Kruskal-Wallis analyses (Zar 1999) were used to test null hypotheses of no differences among median numbers of subsamples and among median numbers of hours

required for different sampling methods to estimate mean within-plot cover values and among-plot cover values with 20 percent precision. Kruskal-Wallis analyses also were used to test null hypotheses of no difference among median ratios of within-to-among macroplot variability (based on log-transformed CV values) for cover estimates provided by different sampling techniques.

Finally, 10-m^2 and 1-m^2 quadrat sampling techniques were compared on the basis of species-area curves, compositional curves, and numbers of vascular plant species (richness) detected per macroplot. Mean species-area and compositional curves were developed on an ecological-site basis using the software package PCORD v.4.34 (McCune and Mefford 1999). Species-area curves describe how mean numbers of unique species detected increase with increasing numbers of subsample quadrats. Compositional curves describe how increasing numbers of subsamples cause mean estimates of community composition to change in relation to community composition quantified on the basis of the full set of subsamples. For this particular analysis, community dissimilarity was described on the basis of Sørensen's distance index (McCune and Grace 2002). ANOVA was used to evaluate effects of ecological site and quadrat size on log-transformed species-richness values (natural log transformation) for macroplots sampled during Phase 3. This analysis was repeated after excluding from the 10-m^2 data those species that occurred in only one 10-m^2 quadrat at a given macroplot. The intent of this approach was to determine whether effects of quadrat size on species-richness estimates could be accounted for solely by low-frequency species detected in 10-m^2 quadrats.

Among-Method Trends in Cover Estimates

Data collected during this study could not be used to evaluate the accuracy of cover estimates provided by different sampling methods because true cover values were not determined. Nevertheless, we analyzed cover data to evaluate whether there were any relative trends in cover estimates provided by the different methods. ANOVA techniques were used to evaluate effects of ecological site and sampling method on estimates of total live understory canopy cover and cover of selected soil-surface features. For these analyses, means were standardized by calculating the ratio of the observed mean value for a particular sampling method and cover measure to the among-method mean value for the same measure.

Repeatability

The main focus of the repeatability analysis was to evaluate between-observer repeatability (measurement precision) of different sampling methods, and to assess whether repeatability of methods varied among ecological sites or types of measures (e.g., total plant cover, individual species cover, surface-feature cover, and density). Data were separated into four types: canopy cover, soil crust cover, other surface cover, and shrub and tree density. Cover and density were summarized for each transect sampled during Phase 3 (n = 9 transects for each ecological site). All data were analyzed separately for each ecological site unless otherwise noted.

For each ecological site, a factorial ANOVA was used to evaluate effects of observer and sampling method on litter cover, total live understory canopy cover, and cover of three dominant plant species. Data were arcsine-square-root (arcsin) transformed to improve normality and variance, assumptions of parametric statistics. The lack of normality in the distribution of soil crust data could not be corrected with the arcsin transformation. Therefore, non-parametric Wilcoxon paired-sample tests (Zar 1999) were performed for each soil crust type (undifferentiated crust, cyanobacteria, lichen, and moss) to evaluate effects of observer on cover

estimates derived from 1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept transects. Wilcoxon tests also were used to evaluate effects of observer on estimates of biological soil crust cover using the BSC frame (table 10 and fig. 5). For shrub and tree density, Wilcoxon tests evaluated effects of observer on mean counts per quadrat for each size class of each species across all ecological sites combined.

To evaluate effects of wind on repeatability of line-point intercept canopy cover, absolute differences between observers' cover estimates were regressed on average wind speeds for both observers combined. Separate regression analyses were performed for woody plants and for herbaceous plants.

Sampling Impacts

Sampling impacts on plot conditions were evaluated on the basis of numeric scores assigned to qualitative impact ratings (0 = none, 1 = slight, 2 = slight to moderate, 3 = moderate, 4 = moderate to extreme, 5 = extreme). Kruskal-Wallis tests were used to determine differences in impact ratings (1) among sampling procedures, (2) among ecological sites, and (3) among unsampled and sampled sides of the transect and within quadrats.

Results

Macroplot Characterization and Evaluation

Based on the macroplot characterization process, 15 of the total 48 sampled macroplots were relocated away from the predetermined centroids provided by NPS (table 14). Ten macroplots were relocated due to being located on or near the wrong soil and ecological site. Of the ten, only one macroplot (DINO2b) had to be moved to an entirely new set of coordinates because the target soil and ecological site were nowhere in the area. All other macroplots were close enough to the target soil and ecological site that they were shifted to a nearby location. Seven macroplots were shifted due to a physical barrier (two predetermined centroids were both on the wrong soil and too close to a physical barrier). Physical barriers primarily included roads and steep cliff bands. In one case, the centroid was located within a paved campground.

The field team found that it was relatively straightforward to evaluate soil and ecological site characteristics on the basis of observable field attributes in most cases. The most difficult locations to assess were at Wupatki National Monument, where soil depth was a key attribute for distinguishing ecological sites. This attribute could not be evaluated on the basis of surface features alone. Although the field team was able to successfully evaluate site characteristics in most cases, they would have benefited from additional training and experience in soil-geomorphic concepts underlying the notion of ecological sites. In some cases, decisions to relocate macroplots may have been based on excessive reliance on vegetation characteristics rather than on soil-geomorphic characteristics.

Table 14. Summary of macroplots that were relocated following site characterization and prior to sampling.

Ecological site	Macroplot	Reason for relocation	Details
Desert Sand (Sand Sagebrush)	CANY2b	Close to wrong soil type, which was influenced by alluvial groundwater	Plot moved farther away from Salt Creek to avoid influence of ground water on vegetation composition.
Limy Upland, 6-10" pz	WUPA1	Wrong soil type	Plot shifted about 100 m further down the valley because the original point crossed a cliff band.
	WUPA2	Wrong soil type	Plot moved to a location about 100 m into the valley to avoid including shallow soils in the macroplot.
Loamy Hills, 25-33" pz	GRCA7	Physical barrier: on the road	The predetermined centroid was located at a campsite so the plot was shifted about 100 m away to be just outside the campground.
Semidesert Alkali Sandy Loam (Alkali Sacaton)	CARE1	Close to wrong soil type	Plot moved to avoid proximity to rocky hillslope.
	CARE2b	Close to wrong soil type (drainage)	Plot moved about 100 m south to avoid crossing a large wash.
Semidesert Loam (Wyoming Big Sagebrush)	DINO1	Physical barrier: on the road	This plot was shifted about 50 m to avoid sampling on top of the road.
	DINO2b	Wrong soil type and on the road	Original plot location appeared to be in the wrong soil type. A new location was selected to avoid sampling on a road.
	DINO4b	Wrong soil type	Plot location moved downslope away from edge of soil map unit. Outside of the map unit, the soil appeared to be too gravelly and the vegetation exhibited no remnant sagebrush (the target vegetation).
	DINO5	Wrong soil type	Centroid was located in a gully, right at the edge of a different soil map unit, so the macroplot was relocated on a sagebrush- dominated bench, about 50 m to the east.
Semidesert Shallow Sandy Loam PJ	ARCH1b	Wrong soil type	Soil at predetermined location was much too deep.
	ARCH4b	Wrong soil type and on the road	Original location was on road and in wrong soil type. Centroid shifted nearby to correct soil type off of road.
	CANY4	Physical barrier: too close to cliff	Plot was moved further from the cliff edge.
Upland Shallow Loam (Pinyon-Utah Juniper)	CARE4b	Physical barrier: too close to cliff	Plot location was moved up and out of the canyon to avoid 2 cliffbands.
	CARE9	Physical barrier: too close to cliff	Shifted the plot location about 15 m upslope to avoid sampling on the cliff.

Prior to the field season, NCPN staff provided predetermined transect orientations based on analyses of digital elevation models (DEMs). As intended, these generally aligned with hillslope contours observed in the field. However, some differences occurred between the predetermined orientations and those based on field observations of aspect and contour – probably because the scale of topographic variation in the field was finer than that depicted in DEMs. An extreme example of this difference could be seen at macroplot CARE7, where the predetermined aspect was oriented down a large valley slope whereas the ground-level aspect appeared to follow the slope along the side of the valley wall.

Sampling Efficiency

Sampling Times

Across all ecological sites, the mean amount of time required for setting up and reading frequency and cover in 10-m^2 quadrats (8.2 min per quadrat) was approximately twice that

Table 15. Mean times for setting up and reading frequency (freq), cover (cov), and density (dens) in 1-m^2 and 10-m^2 quadrats. Set-up times for 1-m^2 quadrats were not measured but are estimated here for comparative purposes. Data do not include time required for transect layout.

Ecological site	No. of macro-plots	Mean times by ecological site (min per quadrat)									
		1-m^2 quadrats				10-m^2 quadrats					
		Set-up (s)	Freq (f)*	Cov (c)	Total (s+f+c)	Set-up (s)	Freq (f)*	Cov (c)	Total (s+f+c)	Dens (d)	Total (s+f+c+d)
Brushy Loam	5	1.0	2.2	2.3	5.5	3.9	5.6	2.8	12.3	2.7	15.0
Desert Sand (Sand Sagebrush)	2	0.5	1.9	2.2	4.6	2.3	3.9	2.6	8.8	0.3	9.1
Limy Upland, 6-10" pz	5	0.5	1.2	2.0	3.7	2.0	3.0	2.3	7.3	0.3	7.6
Loamy Hills, 25-33" pz	5	0.5	0.8	1.5	4.1	2.4	2.5	2.0	8.9	0.7	10.8
Loamy Hills, Cold, 25-33" pz	2	0.5	1.4	2.2	2.8	2.8	3.9	2.6	7.3	1.9	8.0
Loamy Mesa Top PJ	5	0.5	1.1	1.9	3.5	3.3	3.1	2.2	8.6	0.9	9.5
Semidesert Alkali Sandy Loam (Alkali Sacaton)	5	0.5	1.9	2.0	4.4	1.8	4.6	2.4	8.8	0.9	9.7
Semidesert Loam (Wyoming Big Sagebrush)	5	0.5	1.9	2.4	4.8	2.1	3.9	2.5	8.4	2.4	10.9
Semidesert Shallow Sandy Loam (PJ)	7	0.5	1.4	1.9	3.8	2.5	3.3	2.0	7.9	1.2	9.1
Shallow Loamy, 10-14" pz	2	0.5	1.1	1.7	3.4	2.2	2.4	2.0	6.5	0.2	6.7
Upland Shallow Loam (Pinyon-Utah Juniper)	5	0.5	0.5	1.7	2.8	2.3	1.5	1.5	5.3	0.3	5.6
Mean		0.55	1.40	1.98	3.93	2.51	3.43	2.26	8.20	1.08	9.28
sd		0.15	0.53	0.26	0.84	0.62	1.14	0.36	1.77	0.89	2.49
CV		27.64	38.09	13.06	21.31	24.87	33.17	16.10	21.62	82.11	26.88

* includes time to read frequency in nested smaller quadrats

Table 16. Mean times for sampling line-point intercept transects, basal- and canopy-gaps transects, and biological soil crust (BSC) frames. Data do not include time required for transect layout. Sites identified in bold italics are those where line-point intercepts were used to estimate cover of overstory vegetation above 2-m in height, in addition to understory vegetation and soil-surface features.

	Line-point intercept		Basal and canopy gaps		BSC frames	
Ecological site	**No. of transects**	**Min per 10-pt group**	**No. of transects**	**Min per 50-m transect**	**No. of transects**	**Sec per frame**
Brushy Loam	13	5.0	3	31.8	-	-
Desert Sand (Sand Sagebrush)	6	3.6	6	23.6	-	-
Limy Upland, 6-10" pz	12	3.3	5	34.6	-	-
Loamy Hills, 25-33" pz	14	4.0	-	-	-	-
Loamy Hills, Cold, 25-33" pz	6	5.7	-	-	-	-
Loamy Mesa Top PJ	14	4.2	6	27.4	14	20.8
Semidesert Alkali Sandy Loam (Alkali Sacaton)	14	2.4	4	24.4	15	20.5
Semidesert Loam (Wyoming Big Sagebrush)	13	3.9	6	41.2	11	24.9
Semidesert Shallow Sandy Loam (PJ)	20	2.5	12	19.9	17	29.2
Shallow Loamy, 10-14" pz	5	3.0	5	31.5	-	-
Upland Shallow Loam (Pinyon-Utah Juniper)	14	2.3	6	5.2	-	-
Mean		3.62		26.63		23.38
sd		1.09		10.27		3.44
CV		30.13		38.57		14.71

required for 1-m^2 quadrats (3.9 min per quadrat; table 15). For both quadrat sizes, mean sampling times were greatest at the Brushy Loam ecological site in Mesa Verde National Park due to dense shrubland vegetation. Mean amounts of time required to sample densities of shrubs and trees in 10-m^2 quadrats varied in relation to the abundance of woody plants and ranged from 2.7 min per quadrat in Brushy Loam shrublands of Mesa Verde to 0.2 min per quadrat in Shallow Loamy desert grasslands of Wupatki National Monument. Across all sites, mean sampling times for line-point intercept transects (3.6 min per 10-pt group) were similar to those for 1-m^2 quadrats (table 16). Combined sampling of basal and canopy gaps along 50-m transects required an average of 26.6 min per transect across all ecological sites. Sampling biological soil crust cover with the BSC frame (table 10, fig. 5) required approximately 23.4 sec per frame, on average.

Within-Macroplot Variability

Ecological site, cover category (total live understory canopy, individual species, and soil-surface features), and sampling method all had significant effects on log-transformed CV values describing within-macroplot variability in cover measures (table 17). In addition, there was a statistically significant interaction between ecological site and cover category (table 17). The Upland Shallow Loam ecological site at Capitol Reef National Park was characterized by the greatest degree of within-macroplot variability in cover measures (fig. 6a), but otherwise there were no clear among-site trends in within-plot variability. Total live understory canopy cover was least variable within macroplots and individual species' cover was most variable, when averaged across all ecological sites (fig. 6b). This general pattern was strongly reflected at some ecological sites (e.g., Brushy Loam at Mesa Verde and Limy Upland at Wupatki), but was weakly represented or not apparent at other ecological sites (e.g., Semidesert Shallow Sandy Loam at Arches and Canyonlands, and the Upland Shallow Loam at Capitol Reef) (fig. 7). Of the sampling methods, 10-m^2 quadrats exhibited the least within-macroplot variability in cover measures, and there was no statistical difference between 1-m^2 quadrats and line-point intercepts with respect to this measure (fig. 6c).

Table 17. Analysis of variance for effects of ecological site, cover category (total live understory canopy, individual species, and soil-surface features), and sampling method on log-transformed CV values describing within-macroplot variability in cover measures.

Effect	SS	df	MS	F	p
Ecological site	36.722	10	3.672	7.919	<0.0001
Cover category	75.154	2	37.577	81.034	<0.0001
Method	15.795	2	7.898	17.031	<0.0001
Ecological site*Category	30.102	20	1.505	3.246	<0.0001
Ecological site*Method	10.828	20	0.541	1.168	0.275
Category*Method	1.919	4	0.480	1.035	0.388
Ecological site*Category*Method	4.103	40	0.103	0.221	1.000
Error	385.814	832	0.464		

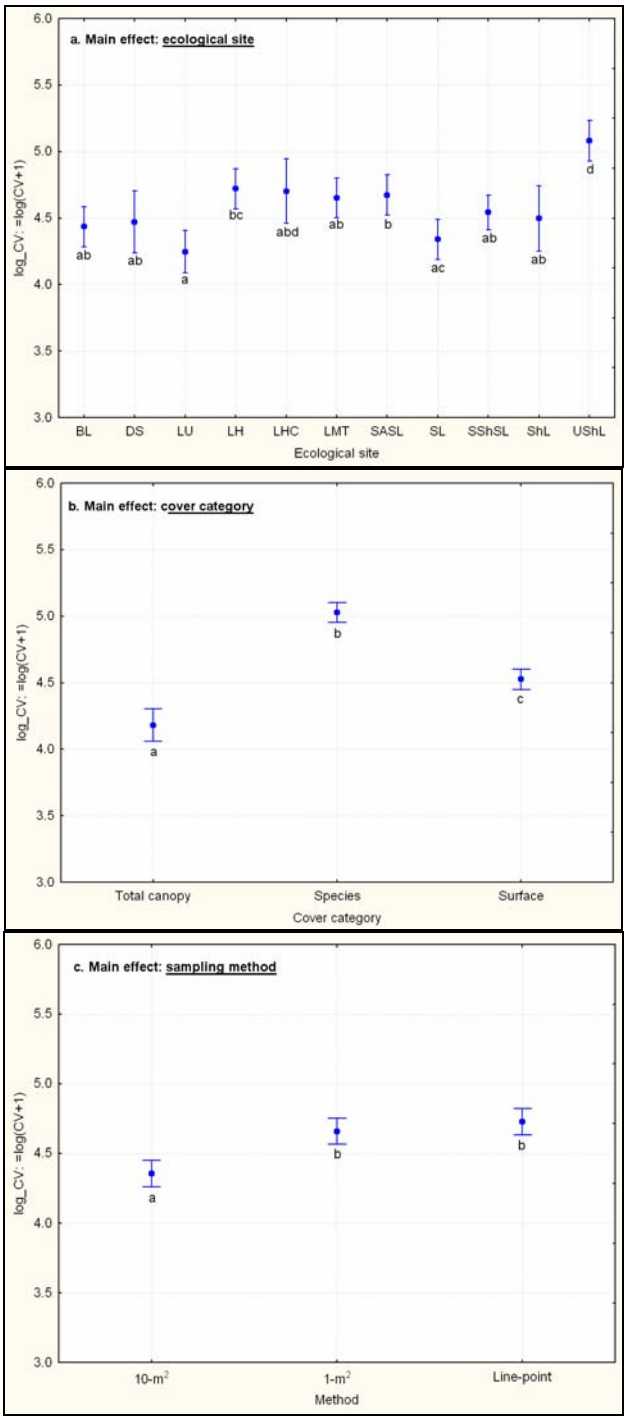

Figure 6. Main effects of (a) ecological site, (b) cover category (total live understory canopy, individual species, and soil-surface features), and (c) sampling method on log-transformed CV values describing within-plot variability in cover measures. Bars indicate 95 percent confidence intervals. Within each panel, values with the same letter are not significantly different by Tukey's HSD test. See table 1 for ecological site codes.

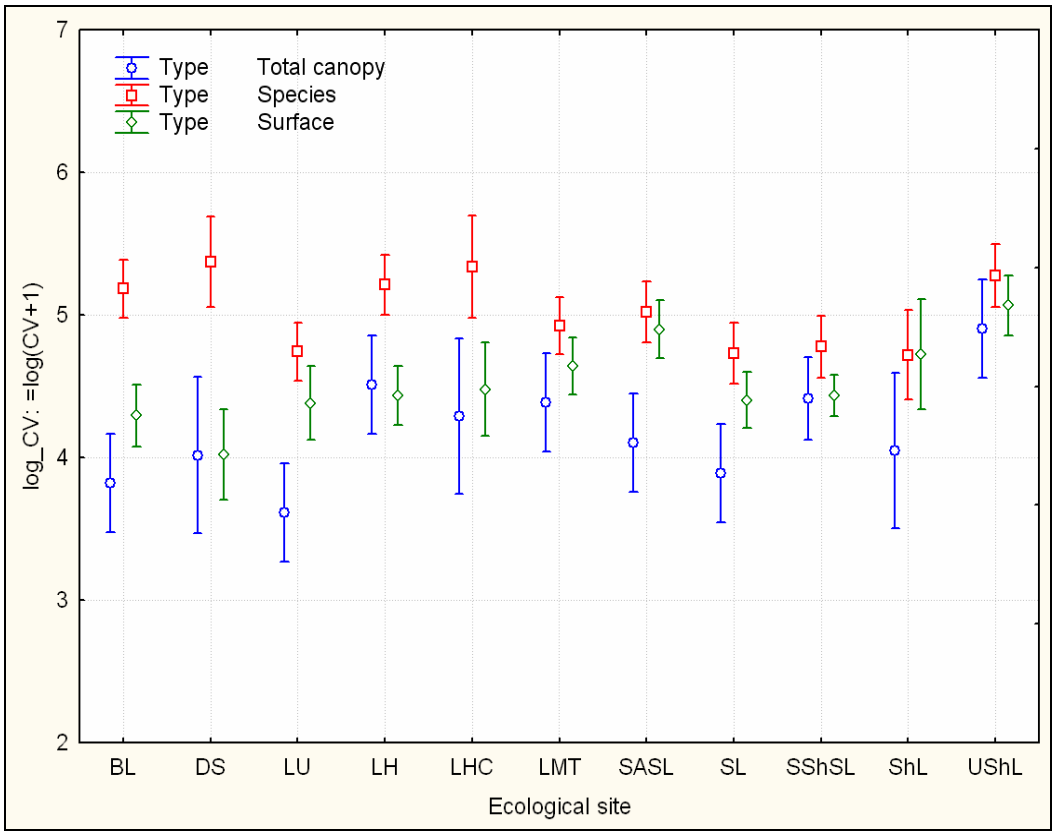

Figure 7. Interactive effects of ecological site and cover category (total live understory canopy, individual plant species, and soil-surface features) on log-transformed CV values describing within-plot variability in cover measures. Bars indicate 95 percent confidence intervals for means. See table 1 for ecological site codes.

In multiple regression models for all sampling methods combined and for each method separately, frequency, mean cover, and subsample size all were significant predictors of log-transformed CV values for within-macroplot cover measures (table 18). Of these, frequency tended to have the greatest effect (with the exception of 10-m^2 quadrats), whereas subsample size consistently had the least (albeit significant) effect as indicated by standardized regression coefficients (Beta values). In models for individual sampling methods, the importance of frequency as a predictor of within-plot CV values increased with decreasing quadrat area. The fit of the overall regression model also increased with decreasing quadrat area, as reflected by adjusted R^2 values.

Table 19 summarizes means and measures of within-macroplot variability for total live understory canopy cover estimated by three different sampling methods at each of 11 ecological sites. (Appendix B presents 11 ecological-site-level tables with measures of average within-macroplot variability and associated sample size estimates for a broader range of cover measures.) Except for the Loamy Mesa Top PJ ecological site at Mesa Verde, mean within-plot CV values for total live understory canopy cover were lowest for 10-m^2 quadrats at all ecological sites. Mean CV values were highest for 1-m^2 quadrats at eight of the 11 ecological sites and highest for line-point intercepts at three of the 11 ecological sites. Among-method patterns in numbers of subsamples required to estimate mean cover values with 10 and 20 percent precision were similar to those for mean CV values. Subsample numbers were lowest for 10-m^2 quadrats

at all ecological sites except the Upland Shallow Loam site at Capitol Reef. Subsample numbers for 1-m^2 quadrats were highest for eight of the 11 ecological sites. Across all ecological sites combined, there was no difference among methods in median numbers of subsamples required to estimate mean plot-level cover of total understory vegetation (fig. 8a) or surface features (fig. 8c) with 20 percent precision. The median number of subsamples required to estimate individual species' cover with 20 percent precision was lower for 10-m^2 quadrats than for line-point intercept transects (fig. 8b).

Table 18. Results of multiple-regression models evaluating significance of subsample size, frequency, and mean cover as predictors of log-transformed CV values describing within-macroplot variability in cover measures.

Model 1:
All methods combined
n=931

Model results	Value
Multiple R	0.85
Multiple R^2	0.73
Adjusted R^2	0.73
F(3,927)	827.74
p	<0.0001

Standardized regression coefficients

Indep. var.	Beta	SE	t(927)	p-level
Subsample n	0.081	0.017	4.63	<0.0001
Freq	-0.536	0.020	-26.98	<0.0001
Mean	-0.447	0.020	-22.58	<0.0001

Model 2:
10-m^2 quadrats
n=321

Model results	Value
Multiple R	0.77
Multiple R^2	0.60
Adjusted R^2	0.59
F(3,317)	156.77
p	<0.0001

Standardized regression coefficients

Indep. var.	Beta	SE	t(317)	p-level
Subsample n	0.098	0.036	2.73	0.0068
Freq	-0.447	0.038	-11.64	<0.0001
Mean	-0.488	0.038	-12.67	<0.0001

Model 3:
1-m^2 quadrats
n=318

Model results	Value
Multiple R	0.83
Multiple R^2	0.69
Adjusted R^2	0.68
F(3,314)	230.00
p	<0.0001

Standardized regression coefficients

Indep. var.	Beta	SE	t(314)	p-level
Subsample n	0.094	0.032	2.96	0.0033
Freq	-0.538	0.036	-15.12	<0.0001
Mean	-0.430	0.036	-12.03	<0.0001

Model 4:
Line-point intercept
n=292

Model results	Value
Multiple R	0.97
Multiple R^2	0.93
Adjusted R^2	0.93
F(3,288)	1342.26
p	<0.0001

Standardized regression coefficients

Indep. var.	Beta	SE	t(288)	p-level
Subsample n	0.032	0.016	2.07	0.0396
Freq	-0.685	0.026	-26.74	<0.0001
Mean	-0.326	0.026	-12.74	<0.0001

Table 19. Summary of mean estimates for total live understory canopy cover for each of 11 Colorado Plateau ecological sites, within-macroplot variation in cover estimates summarized across n macroplots within each ecological site, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. Subsample sizes for line-point sampling refer to numbers of 10-point groups. Sites identified in ***bold italics*** are those where line-point intercepts were used to estimate cover of overstory vegetation above 2 m tall, in addition to understory vegetation and soil-surface features.

Ecological site	Physiog-namic structure	n	Method	Mean cover	Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)		Unit time (min)	Subsample time (hrs by precision)	
					Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%		10%	20%
Brushy Loam	Shrubland	5	10-m^2	49.7	18.1	7.4	24.0	100.0	36.5	54	16	12.3	11.1	3.3
			1-m^2	43.4	26.2	10.8	37.3	100.0	60.1	143	38	5.5	13.1	3.5
			Line-point	52.8	23.7	16.4	33.2	98.7	45.5	80	22	5.0	6.7	1.8
Desert Sand (Sand Sagebrush)	Grassland	2	10-m^2	13.4	3.7	3.4	4.0	100.0	27.7	32	10	8.8	4.7	1.5
			1-m^2	12.3	7.7	6.5	8.8	100.0	61.9	151	40	4.6	11.6	3.1
			Line-point	11.7	11.1	10.2	12.1	68.3	95.4	350	90	3.6	21.0	5.4
Limy Upland, 6-10" pz	Grassland	5	10-m^2	23.6	6.0	3.9	8.0	100.0	26.5	28	9	7.3	3.4	1.1
			1-m^2	16.0	5.3	3.1	8.8	100.0	33.1	45	15	3.7	2.8	0.9
			Line-point	26.7	15.8	13.0	18.7	93.3	59.9	138	37	3.3	7.6	2.0
Loamy Hills, 25-33" pz	Forest	5	10-m^2	19.7	15.8	3.0	32.2	100.0	74.8	248	65	8.9	36.8	9.6
			1-m^2	23.8	27.1	5.2	52.8	94.7	120.4	502	128	4.1	34.3	8.7
			Line-point	16.9	13.8	9.6	23.3	72.0	90.6	257	67	4	17.1	4.5
Loamy Hills, Cold, 25-33" pz	Forest	2	10-m^2	48.8	31.6	29.3	33.9	100.0	64.9	164	43	7.3	20.0	5.2
			1-m^2	57.3	42.5	33.7	51.2	100.0	78.3	211	56	2.8	9.8	2.6
			Line-point	25.7	18.9	17.9	19.9	85.0	74.5	209	55	5.7	19.9	5.2
Loamy Mesa Top PJ	Woodland	5	10-m^2	32.7	20.2	11.7	31.3	91.2	157.9	149	39	8.6	21.4	5.6
			1-m^2	29.6	31.1	15.2	49.8	58.7	198.8	425	109	3.5	24.8	6.4
			Line-point	20.7	15.5	11.6	18.3	46.7	133.4	215	57	4.2	15.1	4.0
Semidesert Alkali Sandy Loam (Alkali Sacaton)	Grassland	5	10-m^2	20.3	8.8	4.5	16.9	100.0	45.5	75	21	8.8	11.0	3.1
			1-m^2	18.1	12.7	6.1	20.1	98.7	72.8	193	50	4.4	14.2	3.7
			Line-point	25.4	16.4	11.9	19.4	85.3	71.7	163	43	2.4	6.5	1.7
Semidesert Loam (Wyoming Big Sagebrush)	Shrubland	5	10-m^2	32.2	11.1	7.9	16.9	100.0	36.6	49	14	8.4	6.9	2.0
			1-m^2	20.2	13.0	9.1	19.4	100.0	67.9	163	43	4.8	13.0	3.4
			Line-point	53.8	22.8	20.3	25.5	98.7	48.4	72	20	3.9	4.7	1.3
Semidesert Shallow Sandy Loam PJ	Shrubland	7	10-m^2	18.8	11.7	6.0	18.4	98.6	65.1	152	40	7.9	20.0	5.3
			1-m^2	16.4	14.7	10.2	25.1	96.7	96.0	311	81	3.8	19.7	5.1
			Line-point	13.3	13.2	7.0	23.6	66.7	102.3	380	98	2.5	15.8	4.1
Shallow Loamy, 10-14" pz	Grassland	2	10-m^2	18.3	7.4	5.8	9.0	100.0	43.0	66	19	6.5	7.2	2.1
			1-m^2	17.2	13.8	10.7	17.0	100.0	87.4	250	65	3.4	14.2	3.7
			Line-point	27.3	12.8	9.6	16.0	90.0	54.9	88	24	3	4.4	1.2
Upland Shallow Loam (Pinyon-Utah Juniper)	Woodland	5	10-m^2	16.5	19.7	11.3	29.3	96.0	117.4	546	139	5.3	48.2	12.3
			1-m^2	15.4	24.5	18.9	30.8	88.7	176.4	976	244	2.8	45.5	11.4
			Line-point	11.7	13.3	9.2	15.4	56.0	126.3	491	126	2.3	18.8	4.8

* frequency for line-point sampling was calculated on the basis of 10-point groups

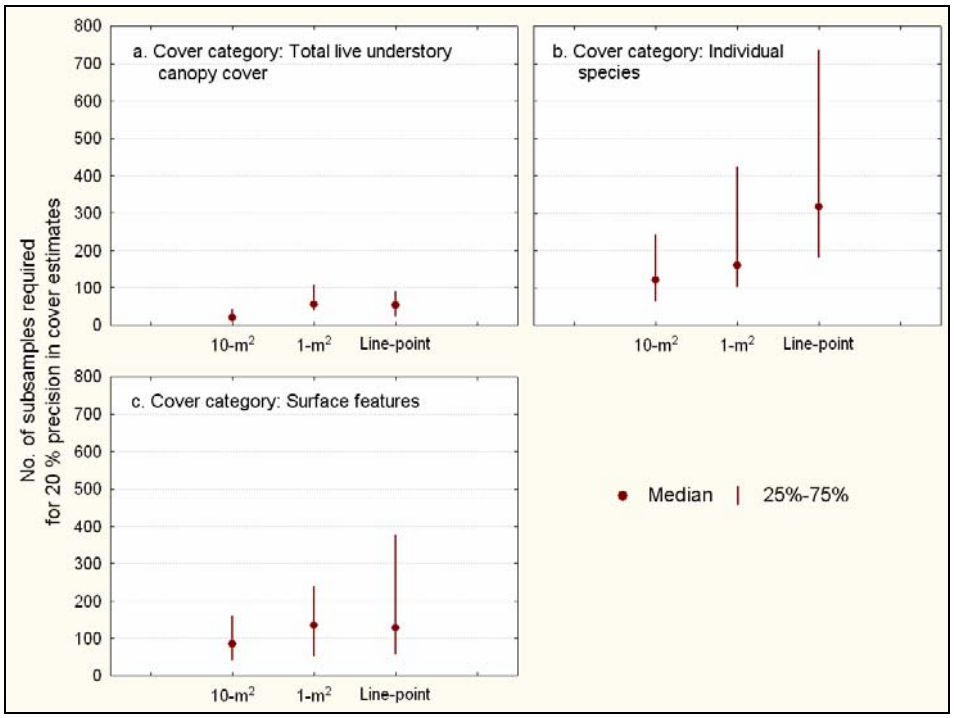

Figure 8. Median numbers (± 25 percentiles) of subsamples required for 20 percent precision in macroplot-level estimates of (a) total live understory canopy cover, (b) live cover of individual plant species, and (c) cover of surface features across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. In (a), there is no difference among median values obtained via different sampling methods (Kruskal-Wallis H = 5.89, df = 2, n = 33, p = 0.0525). In (b), median values from 10-m^2 quadrats and line-point intercepts are significantly different from one another (Kruskal-Wallis H = 15.41, df = 2, n = 94, p = 0.0004). In (c), there is no significant difference among medians from different methods (Kruskal-Wallis H = 3.08, df = 2, n = 98, p = 0.2139).

Per-unit sampling times from tables 15 and 16 and subsample sizes from table 19 were used to estimate total amounts of subsampling time required for the three methods to estimate mean total live understory canopy cover with 10 and 20 percent precision (table 19, fig. 9). (Amounts of time required for transect layout and density sampling were not included in this analysis.) Total subsample times were lowest for line-point intercept transects at eight of the 11 ecological sites – including all sites with shrubland and woodland physiognomic structure, two of four sites with grassland structure, and one of two sites with forest structure. Subsample times also were lowest for line-point intercepts at four of five sites where points were used to estimate cover of overstory vegetation taller than 2 m in addition to cover of understory vegetation and surface features. Total subsample times were highest for 10-m^2 quadrats at four ecological sites, for 1-m^2 quadrats at five ecological sites, and for line-point intercept transects at three ecological sites. Across all ecological sites, the mean subsample time for 20 percent precision was lowest and individual times were least variable for line-point intercept transects (mean = 3.3 hrs, CV = 50.9) relative to 10-m^2 quadrats (mean = 4.6 hrs, CV = 76.1) and 1-m^2 quadrats (mean = 4.8 hrs, CV = 63.0). This result was strongly influenced by high subsample times for 10-m^2 and 1-m^2 quadrats at the Loamy Hills and Upland Shallow Loam ecological sites at Grand Canyon and

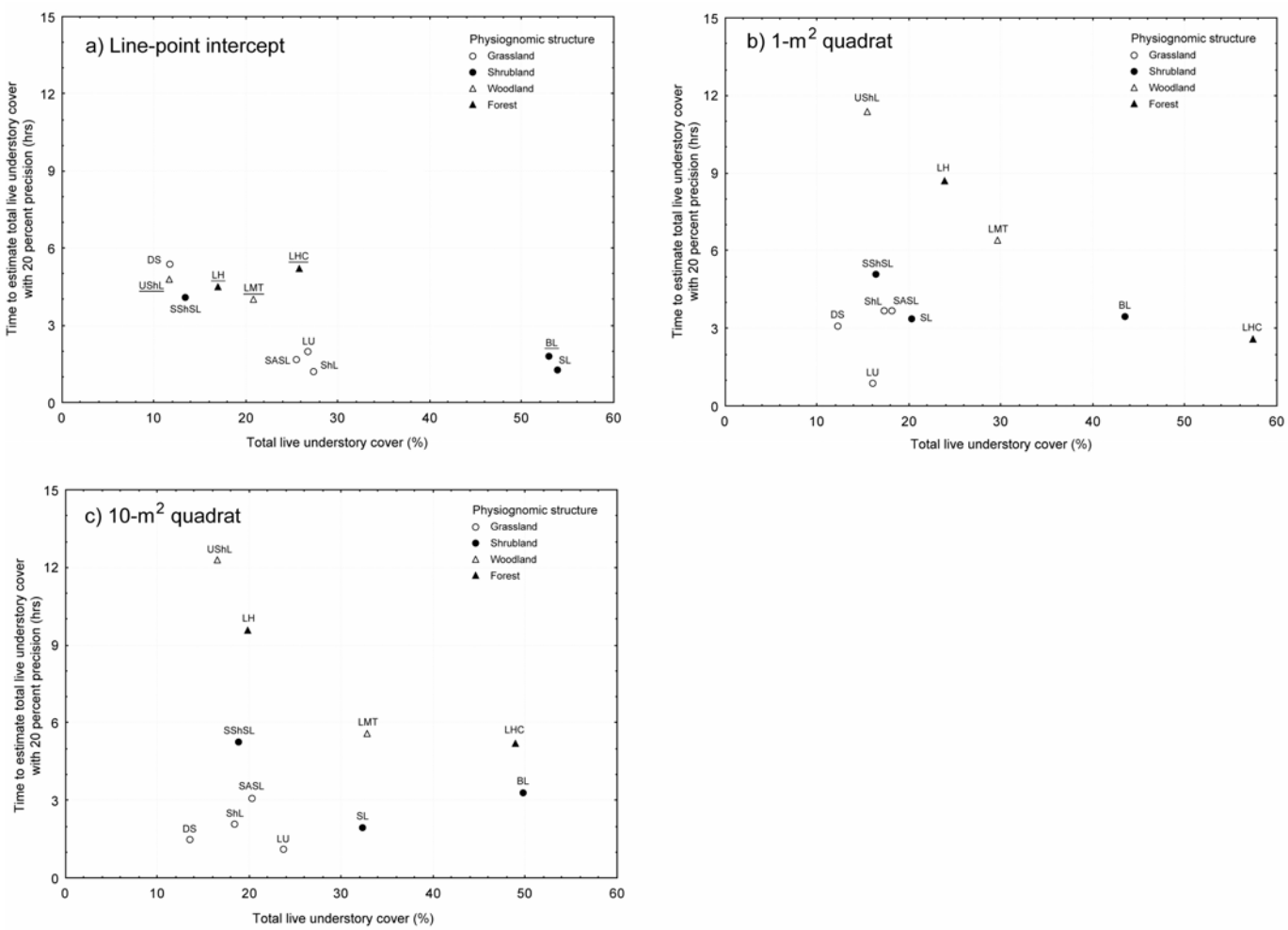

Figure 9. Time required to estimate total live understory cover using (a) the line-point intercept technique, (b) 1-m^2 quadrats, and (c) 10-m^2 quadrats in relation to cover estimates derived from the same sampling techniques. Points are labeled by ecological site codes (see table 1 for key to codes) and symbolized to indicate the general physiognomic structure of the sampled plant community. Ecological sites underlined in (a) are those where line-point intercepts were used to estimate cover of overstory vegetation above 2-m in height, in addition to understory vegetation and soil-surface features.

Capitol Reef, respectively. Statistical analyses on the basis of median values indicate no significant differences among methods for median amounts of time required to estimate total live understory canopy cover (fig. 10a), cover of individual species (fig. 10b), or cover of surface features (fig. 10c) with 20 percent precision. For total live understory canopy cover, median sampling times for 20 percent precision were 3.3, 3.7, and 4.0 hours for 10-m^2 quadrats, 1-m^2 quadrats, and line-intercept transects, respectively. (Appendix C presents 48 tables summarizing actual within-macroplot variability by macroplot, but without sample size estimates.)

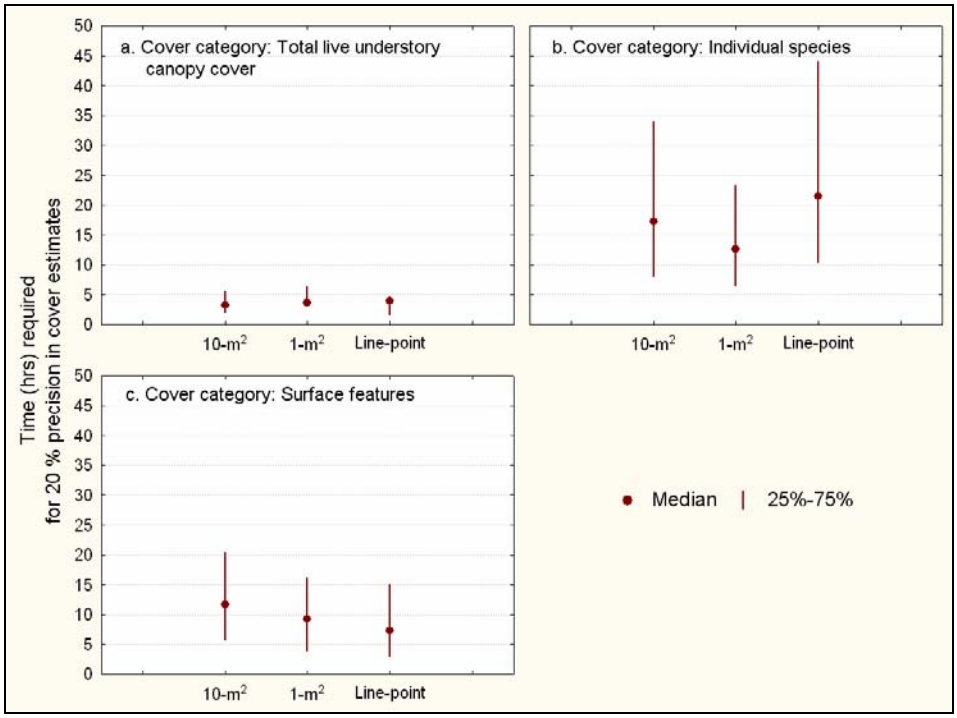

Figure 10. Median numbers of hours (± 25 percentiles) required for subsampling to achieve 20 percent precision in macroplot-level estimates of (a) total live understory canopy cover, (b) live cover of individual plant species, and (c) cover of surface features across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. For each cover category, there is no significant difference among median sampling times for different sampling methods (a. Kruskal-Wallis H = 0.95, df = 2, n = 33, p = 0.6216; b. Kruskal-Wallis H = 4.51, df = 2, n = 94, p = 0.1045; c. Kruskal-Wallis H = 1.68, df = 2, n = 98, p = 0.4327).

Among-Macroplot Variability

Numbers of macroplots sampled per ecological site during the 2005 field season were small, ranging from two to five. Despite these small sample sizes, here we present preliminary summaries and analyses of among-macroplot variability in cover measures. Across all ecological sites, mean among-plot variation (measured on basis of log-transformed CV values) was least for total live understory canopy cover and greatest for cover of individual species (table 20, fig. 11). Although sampling method did not have a statistically significant effect on among-plot variability in cover measures (table 20), among-plot CV values for total live understory canopy cover were lowest for line-point intercept transects at seven of 11 ecological sites and highest for 10-m^2 quadrats at six of 11 sites (table 21). This same pattern was evident for

numbers of macroplot samples required for different sampling methods to estimate site-level total live understory canopy cover with 10 and 20 percent precision (table 21). Across all ecological sites, the mean number of macroplots for 20 percent precision was lowest for line-point intercept transects (mean = 15.6, CV = 91.4) relative to 10-m^2 quadrats (mean = 17.5, CV = 63.5) and 1-m^2 quadrats (mean = 20.9, CV = 95.1). This result was highly influenced by high numbers of macroplots for 10-m^2 and 1-m^2 quadrats at the Loamy Hills ecological site at Grand Canyon. Statistical analyses on the basis of median values indicate no significant differences among methods for the median number of macroplot samples required to estimate total live understory canopy cover with 20 percent precision (fig. 12). Median numbers of macroplots for 20 percent precision in ecological-site-level estimates of total live understory canopy cover were 13, 16, and 17 for 10-m^2 quadrats, 1-m^2 quadrats, and line-intercept transects, respectively. (See Appendix D for tables summarizing among-plot variability for a broader range of cover measures on an ecological site basis, but without sample-size estimates.)

Table 20. Analysis of variance for effects of cover category (total live understory canopy, individual species, and surface features) and sampling method on log-transformed CV values describing among-macroplot variability in cover estimates.

Effect	SS	df	MS	F	p
Cover category	27.618	2	13.809	22.163	<0.0001
Method	0.009	2	0.005	0.007	0.993
Category*Method	2.743	4	0.686	1.101	0.357
Error	134.581	216	0.623		

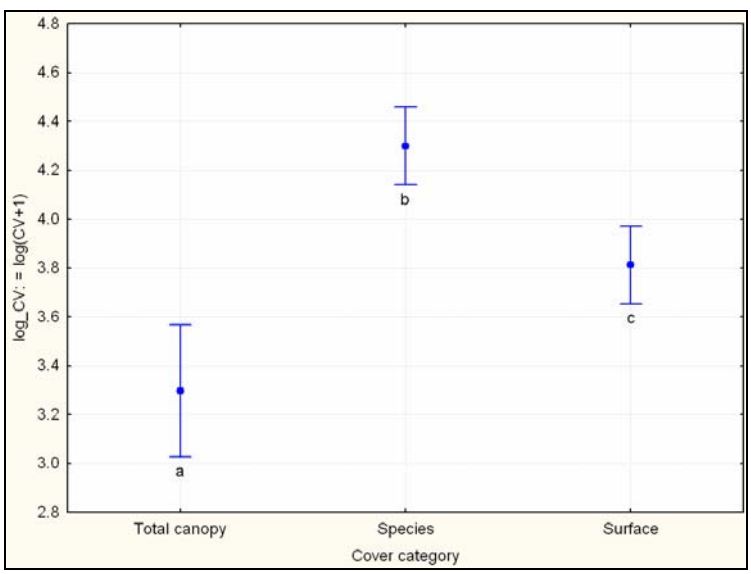

Figure 11. Main effects of cover category (total live understory canopy, individual species, and surface features) on log-transformed CV values describing among-macroplot variability in cover estimates across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. Values with different letters are significantly different from one another (Tukey's HSD test, between MS = 0.6231, df = 216, $p < 0.01$ for all pair-wise comparisons).

Table 21. Among-macroplot variation in estimates of total live understory canopy cover for 11 ecological sites (n macroplots per ecological site), macroplot sample sizes required to achieve 10 and 20 percent precision in estimates of site-level means, and ratios of within-to-among CV values.

Ecological site	Physiog-namic structure	n	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
					sd	Min	Max	Range	CV	10%	20%	
Brushy Loam	Shrubland	5	10-m^2	49.7	16.0	28.4	71.2	42.8	32.2	42	13	1.1
			1-m^2	43.4	13.7	25.8	62.6	36.8	31.6	42	13	1.9
			Line-point	52.8	3.3	48.7	56.0	7.3	6.2	4	3	7.3
Desert Sand (Sand Sagebrush)	Grassland	2	10-m^2	13.4	0.4	13.1	13.7	0.6	3.3	3	3	8.5
			1-m^2	12.3	0.3	12.1	12.5	0.4	2.3	3	3	27.0
			Line-point	11.7	0.0	11.7	11.7	0.0	0.0	2	2	-
Limy Upland, 6-10" pz	Grassland	5	10-m^2	23.6	6.7	18.0	34.4	16.4	28.3	34	11	0.9
			1-m^2	16.0	3.5	11.7	20.1	8.4	21.6	21	7	1.5
			Line-point	26.7	4.4	21.3	31.3	10.0	16.5	13	6	3.6
Loamy Hills, 25-33" pz	Forest	5	10-m^2	19.7	11.6	5.6	35.2	29.5	58.9	136	36	1.3
			1-m^2	23.8	20.9	5.1	57.5	52.4	87.8	297	77	1.4
			Line-point	16.9	7.1	8.0	24.3	16.3	42.2	71	20	2.1
Loamy Hills, Cold, 25-33" pz	Forest	2	10-m^2	48.8	7.4	43.6	54.0	10.5	15.2	12	5	4.3
			1-m^2	57.3	28.2	37.4	77.3	39.9	49.2	96	26	1.6
			Line-point	25.7	2.8	23.7	27.7	4.0	11.0	8	4	6.8
Loamy Mesa Top PJ	Woodland	5	10-m^2	32.7	15.2	20.9	55.7	34.8	46.5	86	24	3.4
			1-m^2	29.6	12.7	13.2	43.7	30.5	42.7	73	21	4.7
			Line-point	20.7	3.5	17.3	26.7	9.3	17.0	14	6	7.8
Semidesert Alkali Sandy Loam (Alkali Sacaton)	Grassland	5	10-m^2	20.3	10.3	7.3	35.5	28.2	50.9	102	28	0.9
			1-m^2	18.1	6.6	7.1	24.6	17.5	36.5	54	16	2.0
			Line-point	25.4	10.1	11.3	37.3	26.0	40.0	64	18	1.8
Semidesert Loam (Wyoming Big Sagebrush)	Shrubland	5	10-m^2	32.2	15.5	20.7	59.4	38.7	48.0	92	25	0.8
			1-m^2	20.2	9.4	14.0	36.6	22.6	46.6	86	24	1.5
			Line-point	53.8	24.9	34.0	96.3	62.3	46.3	85	24	1.0
Semidesert Shallow Sandy Loam PJ	Shrubland	7	10-m^2	18.8	4.8	13.7	28.2	14.5	25.5	28	9	2.6
			1-m^2	16.4	5.4	10.5	24.0	13.5	33.1	45	14	2.9
			Line-point	13.3	5.7	6.7	21.7	15.0	42.7	73	21	2.4
Shallow Loamy, 10-14" pz	Grassland	2	10-m^2	18.3	9.5	11.5	25.0	13.5	52.1	107	29	0.8
			1-m^2	17.2	4.7	13.9	20.5	6.6	27.3	32	10	3.2
			Line-point	27.3	19.3	13.7	41.0	27.3	70.7	195	51	0.8
Upland Shallow Loam (Pinyon-Utah Juniper)	Woodland	5	10-m^2	16.5	4.4	10.2	21.2	11.0	26.4	30	10	4.4
			1-m^2	15.4	6.3	7.2	21.1	13.9	40.9	67	19	4.3
			Line-point	11.7	4.5	4.7	16.0	11.3	38.7	60	17	3.3

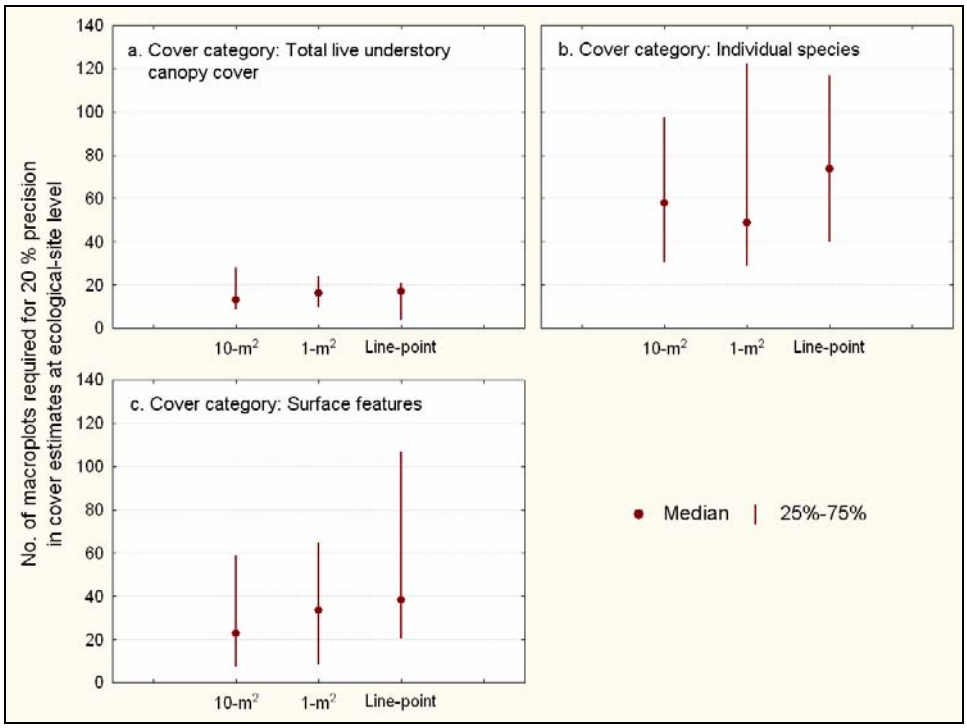

Figure 12. Median numbers (± 25 percentiles) of macroplots required for 20 percent precision in ecological-site-level estimates of (a) total live understory canopy cover, (b) cover of individual plant species, and (c) cover of surface features across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. For each cover category, there is no significant difference among median macroplot numbers for different sampling methods (a. Kruskal-Wallis H = 0.95, df = 2, n = 33, p = 0.6218; b. Kruskal-Wallis H = 1.38, df = 2, n = 96, p = 0.5005; c. Kruskal-Wallis H = 3.05, df = 2, n = 96, p = 0.2174).

Table 21 also summarizes ratios of within-plot CV values to among-plot CV values for total live understory canopy cover by sampling method and ecological site. Across all sites and methods, the average within:among ratio was 3.7:1, indicating greater within-plot variability than among plot variability. The within:among ratio was lowest for 10-m^2 quadrats at seven of 11 ecological sites and highest for line-point intercept transects at six of 11 ecological sites. Mean within:among CV ratios were 2.6, 4.7, and 3.7 for 10-m^2 quadrats, 1-m^2 quadrats, and line-intercept transects, respectively. There were no significant differences among methods in median within:among CV ratios for total live understory canopy cover (fig. 13a),cover of individual species (fig. 13b), and cover of surface features (fig. 13c). Median within:among CV ratios for total live understory cover were 1.2, 2.0, and 3.3 for 10-m^2 quadrats, 1-m^2 quadrats, and line-point intercept transects, respectively.

Species-Area Relationships and Community Composition

This section summarizes differences between 10-m^2 and 1-m^2 quadrats in terms of species-area relationships and community composition. Point-based data are not included in these comparisons because of the superiority of quadrat-based sampling for objectives related to detection of infrequent species. As expected on the basis of sampling area, more unique species were detected in 10-m^2 quadrats than in 1-m^2 quadrats at all macroplots (table 22). Ecological

site and quadrat size both had significant effects on log-transformed species richness in macroplots where subsample sizes were 15 for both sizes of quadrat (table 23, fig. 14a). At these macroplots, ratios of numbers of species detected in 10-m^2 quadrats to numbers detected in 1-m^2 quadrats ranged from a low of 1.3 at Brushy Loam, Semidesert Alkali Sandy Loam, and Semidesert Loam ecological sites, to a high of 1.8 at Loamy Hills and Semidesert Shallow Sandy Loam ecological sites (table 22). When infrequent species occurring in only one 10-m^2 quadrat were excluded from the 10-m^2 quadrat data, quadrat size no longer had a statistically significant effect on log-transformed species richness (table 24, fig. 14b). This indicates that the advantage of 10-m^2 quadrats relative to 1-m^2 quadrats was largely attributable to the ability of the larger quadrats to detect species with a 10-m^2 frequency of 6.7 percent. However, excluding infrequent species occurring in only one 10-m^2 quadrat, ratios of species detected in 10-m^2 quadrats to those detected in 1-m^2 quadrats were still greater than one at most ecological sites. See Appendix E for a set of figures showing mean species-area and compositional curves (mean Sørensen distances) by ecological site, including separate figures for curves including all species and for curves excluding infrequent species with only one quadrat occurrence.

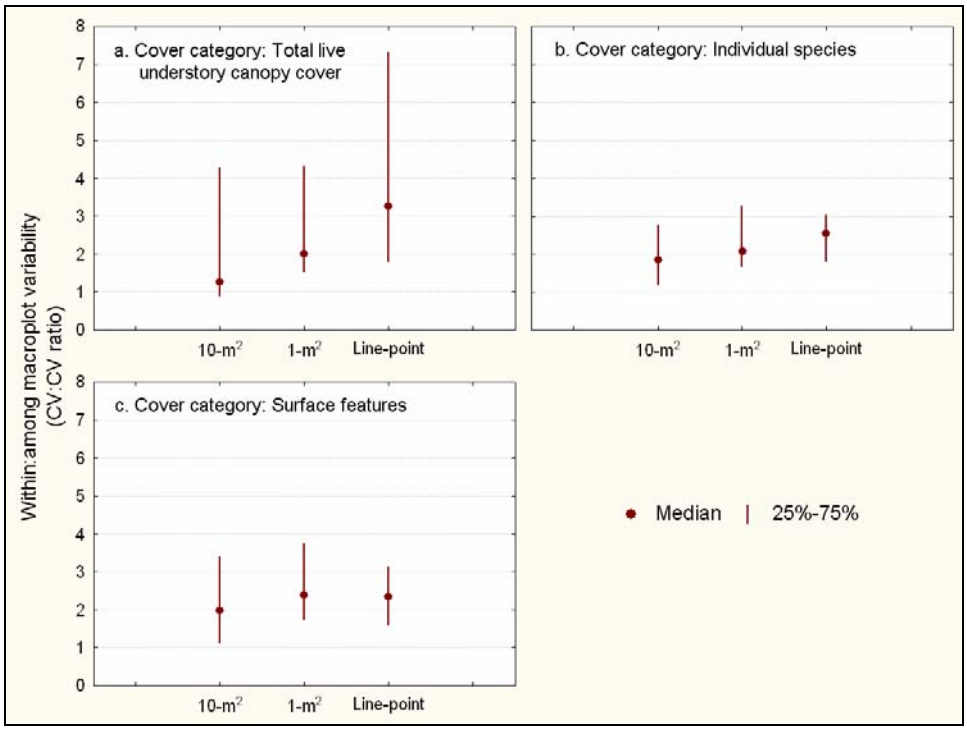

Figure 13. Median ratios of within-to-among macroplot variability (based on log-transformed CV values) for estimates of (a) total live understory canopy cover, (b) live cover of individual plant species, and (c) cover of surface features across 11 ecological sites sampled on the Colorado Plateau in Utah and Arizona. For each cover category, there is no significant difference among median ratios for different sampling methods (a. Kruskal-Wallis H = 2.39, df = 2, n = 33, p = 0.3033; b. Kruskal-Wallis H = 4.33, df = 2, n = 96, p = 0.1147; c. Kruskal-Wallis H = 3.05, df = 2, n = 96, p = 0.3941).

Table 22. Species richness data for several ecological sites on the Colorado Plateau, based on 10-m^2 and 1-m^2 quadrats. For each size quadrat, columns show observed numbers of unique vascular plant species, jacknife estimates of total species per macroplot, numbers of infrequent species found in only one quadrat, and remaining numbers of species after excluding those infrequent species with only 1 quadrat occurrence. Last three columns show ratios of 10-m^2 values to 1-m^2 values, using all observed species (Obs.), and excluding infrequent species (Excl.). Means, coefficients of variation (CV), and ratios are based on macroplots with 15 10-m^2 and 1-m^2 quadrats.

		10-m^2 quadrats					1-m^2 quadrats					10-m^2 : 1-m^2 ratio		
Ecological site	**Macroplot**	**No. quads**	**Obs. no. spp. (a)**	**Jacknife estimate of total spp.**	**Infreq. spp. in only 1 quad**	**No. spp. excluding infrequent (b)**	**No. quads**	**Obs. no. spp. (c)**	**Jacknife estimate of total spp.**	**Infreq. spp. in only 1 quad**	**No. spp. excluding infrequent (d)**	**Obs.:Obs. (a:c)**	**Excl.:Obs. (b:c)**	**Excl.:Excl. (b:d)**
Brushy Loam	MEVE 1	21	28	33.7	6	22	30	21	28.7	8	13	-	-	-
	MEVE2	21	41	49.6	9	32	30	29	32.9	4	25	-	-	-
	MEVE5	15	42	51.3	10	32	15	29	37.4	9	20	1.4	1.1	1.6
	MEVE6	15	38	42.7	5	33	15	32	41.3	10	22	1.2	1.0	1.5
	MEVE7b	15	31	35.7	5	26	15	24	28.7	5	19	1.3	1.1	1.4
	Mean	15	37.0	43.2	6.7	30.3	15	28.3	35.8	8.0	20.3	1.3	1.1	1.5
	CV	-	15.0	18.1	43.3	12.5	-	14.3	18.0	33.1	7.5	10.0	3.5	7.8
Desert Sand	CANY1	21	23	24.9	2	21	30	22	26.8	5	17	-	-	-
	CANY2b	21	25	30.7	4	21	30	22	23.9	2	20	-	-	-
Limy Upland	WUPA1	21	22	25.8	4	18	30	19	22.9	4	15	-	-	-
	WUPA2	21	23	30.6	8	15	30	15	18.9	4	11	-	-	-
	WUPA5	15	16	19.7	4	12	15	9	10.9	2	7	1.8	1.3	1.7
	WUPA6	15	21	26.6	6	15	15	17	20.7	4	13	1.2	0.9	1.2
	WUPA7	15	18	24.5	7	11	15	11	15.7	5	6	1.6	1.0	1.8
	Mean	15	18.3	23.6	5.7	12.7	15	12.3	15.8	3.7	8.7	1.5	1.1	1.6
	CV	-	13.7	15.0	27.0	16.4	-	33.8	31.1	41.7	43.7	18.2	21.8	23.2
Loamy Hills	GRCA3	21	14	15.9	2	12	30	12	14.9	3	9	-	-	-
	GRCA4	21	37	49.4	13	24	30	27	36.7	10	17	-	-	-
	GRCA5	15	26	37.2	12	14	15	14	18.7	5	9	1.9	1.0	1.6
	GRCA6	15	28	35.5	8	20	15	15	19.7	5	10	1.9	1.3	2.0
	GRCA7	15	16	17.9	2	14	15	10	13.7	4	6	1.6	1.4	2.3
	Mean	15	23.3	30.2	7.3	16.0	15	13.0	17.4	4.7	8.3	1.8	1.2	2.0
	CV	-	27.6	35.4	68.6	21.7	-	20.4	18.5	12.4	25.0	8.5	17.2	19.9
Loamy Hills Cold	GRCA1	21	21	24.8	4	17	30	18	19.9	2	16	-	-	-
	GRCA2	21	30	36.7	7	23	30	22	28.8	7	15	-	-	-
Loamy Mesa Top PJ	MEVE3	21	21	27.7	7	14	30	18	26.7	9	9	-	-	-
	MEVE4	21	29	34.7	6	23	30	21	28.7	8	13	-	-	-
	MEVE8	15	16	17.9	2	14	15	11	16.6	6	5	1.5	1.3	2.8
	MEVE9	15	26	33.5	8	18	15	14	18.7	5	9	1.9	1.3	2.0
	MEVE10	15	33	41.4	9	24	15	25	34.3	10	15	1.3	1.0	1.6
	Mean	15	25.0	30.9	6.3	18.7	15	16.7	23.2	7.0	9.7	1.5	1.2	2.1
	CV	-	34.2	38.7	59.8	27.0	-	44.2	41.7	37.8	52.1	18.1	15.7	28.6

Table 22.—Continued

Ecological site	Macroplot	10-m² quadrats					1-m² quadrats					10-m² : 1-m² ratio		
		No. quads	Obs. no. spp. (a)	Jacknife estimate of total spp.	Infreq. spp. in only 1 quad	No. spp. excluding infrequent (b)	No. quads	Obs. no. spp. (c)	Jacknife estimate of total spp.	Infreq. spp. in only 1 quad	No. spp. excluding infrequent (d)	Obs.:Obs. (a:c)	Excl.:Obs. (b:c)	Excl.:Excl. (b:d)
Semidesert Alkali Sandy Loam	CARE1	21	42	46.8	5	37	30	36	37.9	2	34	-	-	-
	CARE2	21	38	43.7	6	32	30	27	29.9	3	24	-	-	-
	CARE5	15	43	49.5	7	36	15	33	41.4	9	24	1.3	1.1	1.5
	CARE6	15	28	35.5	8	20	15	23	35.1	13	10	1.2	0.9	2.0
	CARE7	15	38	45.5	8	30	15	28	34.5	7	21	1.4	1.1	1.4
	Mean	15	36.3	43.5	7.7	28.7	15	28.0	37.0	9.7	18.3	1.3	1.0	1.6
	CV	-	21.0	16.6	7.5	28.2	-	17.9	10.3	31.6	40.2	5.5	12.1	19.0
Semidesert Loam	DINO1	21	29	37.6	9	20	30	25	32.7	8	17	-	-	-
	DINO2b	21	14	15	1	13	30	15	19.8	5	10	-	-	-
	DINO3	15	28	33.6	6	22	15	22	29.5	8	14	1.3	1.0	1.6
	DINO4b	15	21	23.8	3	18	15	18	24.5	7	11	1.2	1.0	1.6
	DINO5	15	20	23.7	4	16	15	14	14.9	1	13	1.4	1.1	1.2
	Mean	15	23.0	27.0	4.3	18.7	15	18.0	23.0	5.3	12.7	1.3	1.0	1.5
	CV	-	19.0	21.0	35.3	16.4	-	22.2	32.3	71.0	12.1	10.2	7.9	14.7
Semidesert Shallow Sandy Loam	ARCH1b	21	24	28.8	5	19	30	19	25.8	7	12	-	-	-
	ARCH2	21	17	24.6	8	9	30	12	15.9	4	8	-	-	-
	CANY3	21	36	46.5	11	25	30	28	35.7	8	20	-	-	-
	CANY4	21	29	31.9	3	26	30	27	35.7	9	18	-	-	-
	ARCH3	15	22	31.3	10	12	15	8	9.9	2	6	2.8	1.5	2.0
	ARCH4b	15	21	25.7	5	16	15	14	19.6	6	8	1.5	1.1	2.0
	ARCH5	15	15	16.9	2	13	15	13	14.9	2	11	1.2	1.0	1.2
	Mean	15	19.3	24.6	5.7	13.7	15	11.7	14.8	3.3	8.3	1.8	1.2	1.7
	CV	-	19.6	29.5	71.3	15.2	-	27.6	32.8	69.3	30.2	46.6	21.2	27.3
Shallow Loamy	WUPA3	21	24	31.6	8	16	30	15	16.9	2	13	-	-	-
	WUPA4	21	21	25.8	5	16	30	16	21.8	6	10	-	-	-
Upland Shallow Loam	CARE3	21	34	49.2	16	18	30	23	32.7	10	13	-	-	-
	CARE4b	21	15	17.9	3	12	30	14	21.7	8	6	-	-	-
	CARE8	15	20	23.7	4	16	15	17	23.5	7	10	1.2	0.9	1.6
	CARE9	15	18	23.6	6	12	15	8	10.8	3	5	2.3	1.5	2.4
	CARE10	15	13	15.8	3	10	15	11	15.7	5	6	1.2	0.9	1.7
	Mean	15	17.0	21.0	4.3	12.7	15	12.0	16.7	5.0	7.0	1.5	1.1	1.9
	CV	-	21.2	21.5	35.3	24.1	-	38.2	38.4	40.0	37.8	40.2	29.8	23.5

Table 23. Analysis of variance for effects of ecological site and quadrat size on log-transformed values for the number of unique species detected in 15 10-m^2 and 1-m^2 quadrats during Phase 3 sampling.

Effect	SS	df	MS	F	p
Ecological site	4.203	7	0.600	9.690	<0.0001
Quad size	1.597	1	1.597	25.770	<0.0002
Ecological site*Quad size	0.133	7	0.019	0.306	0.9459
Error	1.983	32	0.062		

Table 24. Analysis of variance for effects of ecological site and quadrat size on log-transformed values for the number of unique species detected in 15 10-m^2 and 1-m^2 quadrats during Phase 3 sampling, excluding infrequent species that occurred in only one 10-m^2 quadrat from the 10-m^2 data.

Effect	SS	df	MS	F	p
Ecological site	4.837	7	0.691	12.300	<0.0001
Quad size	0.102	1	0.102	1.809	0.1881
Ecological site*Quad size	0.046	7	0.007	0.117	0.9966
Error	1.798	32	0.056		

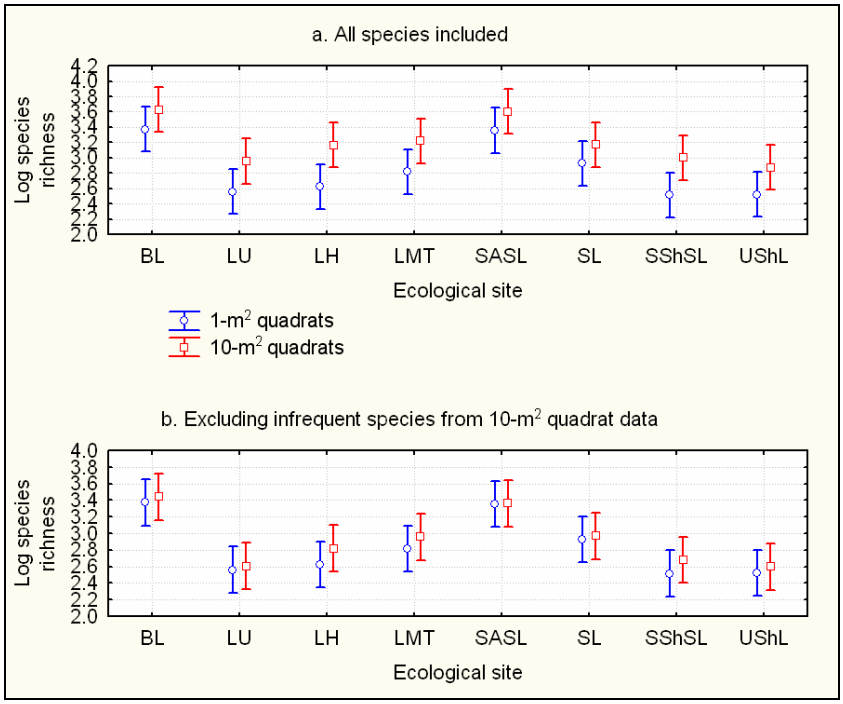

Figure 14. Log-transformed species richness data (mean numbers of unique species detected in 15 quadrats) in relation to ecological site and quadrat size (a) for all species detected, and (b) excluding infrequent species that occurred in only one 10-m^2 quadrat from the 10-m^2 data. (See table 1 for key to ecological site codes.)

Among-Method Trends in Cover Estimates

This section summarizes relative trends in cover estimates provided by different sampling methods. To facilitate comparisons of trends across ecological sites with different amounts of vegetative cover, means were standardized by calculating the ratio of the observed mean value for a particular method and measure to the among-method mean cover value for the same measure (see tables in Appendix C for these data). Across all ecological sites, sampling method had a significant effect on standardized mean values for total live understory canopy cover (table 25). Post-hoc analyses indicated that mean cover values from 1-m^2 quadrats were lower than those provided by 10-m^2 quadrats and line-intercept transects, and that there was no difference between mean cover values provided by the latter two methods (fig. 15). Although ecological site did not have a significant effect on standardized mean cover values (an expected artifact of the standardization process), ecological site and sampling method did have a significant interaction effect (table 25, fig. 15). Line-point intercept transects tended to yield higher cover estimates than quadrats at ecological sites with significant amounts of grass cover (Limy Upland, Semidesert Alkali Sandy Loam, Semidesert Loam, and Shallow Loamy). Particularly noteworthy are high point-based cover estimates for cheatgrass (*Bromus tectorum*, or BRTE) at the Semidesert Loam ecological site in Dinosaur National Monument (SL in Figure 15; also see table B8 in Appendix B). At this site, cover estimates for cheatgrass were 30.1 percent for points, 11.9 percent for 10-m^2 quadrats, and 7.3 percent for 1-m^2 quadrats (table B8). After excluding Semidesert Loam data from the ANOVA, 10-m^2 quadrats were found to provide higher mean values for total live understory canopy cover than 1-m^2 quadrats and points across remaining ecological sites, and there was no statistical difference between mean cover values for the latter two methods.

Table 25. Analysis of variance for effects of ecological site and sampling method on total live understory cover (standardized means) at 11 Colorado Plateau ecological sites.

Effect	SS	df	MS	F	p
Ecological site	0.000	10	0.000	0.000	1.000
Method	0.248	2	0.124	3.475	0.034
Ecological site*Method	4.906	20	0.245	6.865	<0.0001
Error	3.966	111	0.036		

Across all ecological sites, sampling method also had a significant effect on standardized mean cover of surface features (table 26) – with line-point intercepts yielding higher mean values than quadrats (fig. 17). This finding was driven by higher point-based values for bare soil (fig. 18b) that resulted from different methodological approaches between point- and quadrat-based sampling. If a pin were to hit an unembedded piece of litter sitting on the surface of bare (uncrusted) soil, bare soil would show up in the data as the surface feature and litter would appear as a canopy layer above the bare soil. In contrast, quadrat-based sampling would simply report a value for litter cover. Thus the main point to draw from figures 17 and 18 is that 10-m^2 and 1-m^2 quadrats do not differ significantly with respect to cover estimates for surface features.

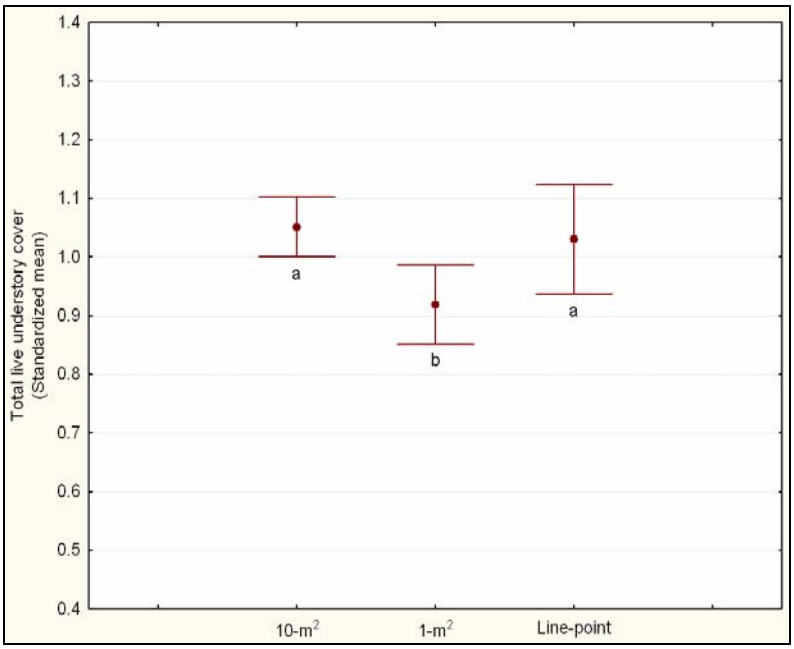

Figure 15. Estimated total live understory canopy cover (standardized means) by method averaged across 11 ecological sites on the Colorado Plateau. Bars indicate 95 percent confidence intervals. Values with different letters are significantly different by Tukey's HSD test.

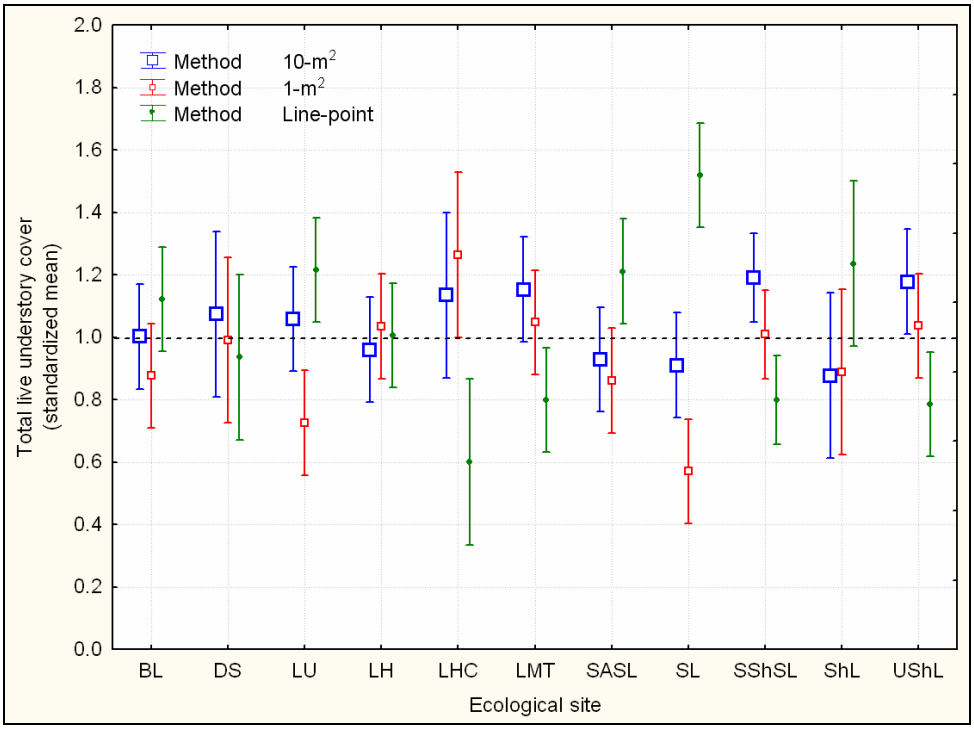

Figure 16. Estimated total live understory canopy cover (standardized means) by method and 11 Colorado Plateau ecological sites. Bars indicate 95 percent confidence intervals for means. See table 1 for ecological site codes.

Table 26. Analysis of variance for effect of sampling method on standardized mean cover of surface features at 11 Colorado Plateau ecological sites.

Effect	SS	df	MS	F	p
Method	14.230	2	7.115	23.004	<0.0001
Error	132.682	429	0.309		

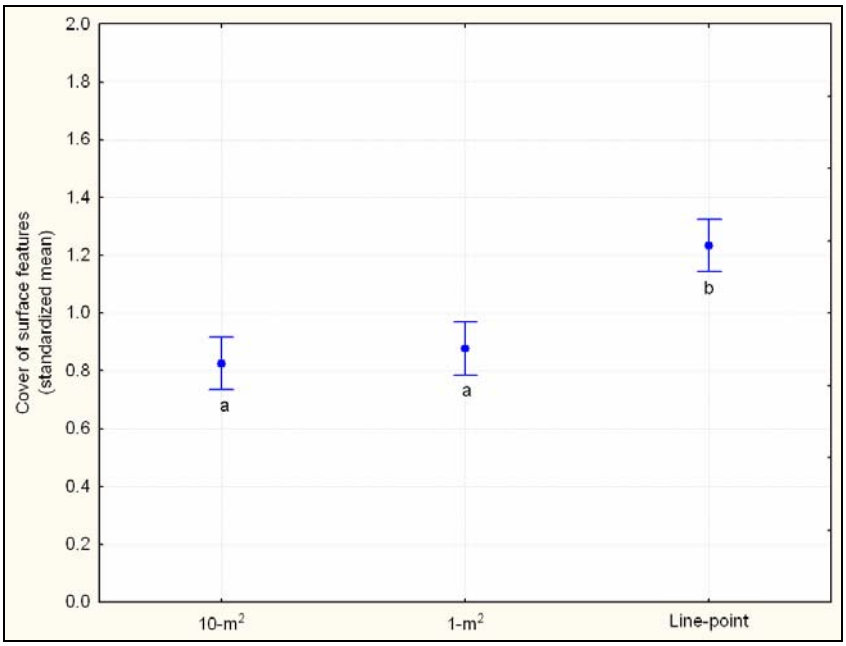

Figure 17. Effect of sampling method on cover estimates (standardized means) for selected surface features (litter, biological soil crust, and bare soil) across 11 ecological sites on the Colorado Plateau. Means with different letters are significantly different by Tukey's HSD test.

Repeatability

This section describes effects of sampling methods and ecological site on differences between two observers' estimates of cover and density. Tables 27-34 summarize analyses of variance (ANOVA) evaluating effects of sampling method, observer, and cover category (individual species and total live understory canopy) on arcsin-transformed means of plant canopy cover for eight ecological sites sampled during Phase 3. In these analyses, the observer-by-method interaction indicates whether there was a significant difference among methods in terms of repeatability between observers. (Tables summarizing actual differences between observers' cover estimates can be found in Appendix F.) Effects of observer and observer-by-method interactions were statistically significant for the Semidesert Shallow Sandy Loam ecological site at Arches National Park (tables 33 and F1) where line-point estimates for blackbrush (*Coleogyne ramosissima*, CORA) cover differed between observers. Inspection of the data suggests that this difference was attributable to a difference between observers in their interpretation of "standing dead" blackbrush versus "live non-photosynthetic" blackbrush, rather than an actual difference in cover estimates. Effects of observer and observer-by-method interaction on mean arcsin-transformed litter cover were not statistically significant (table 35).

We found no statistical relationships between wind-speed measures and differences between two observers' cover estimates for woody plants, herbaceous plants, or grasses using the line-point intercept technique (fig. 19).

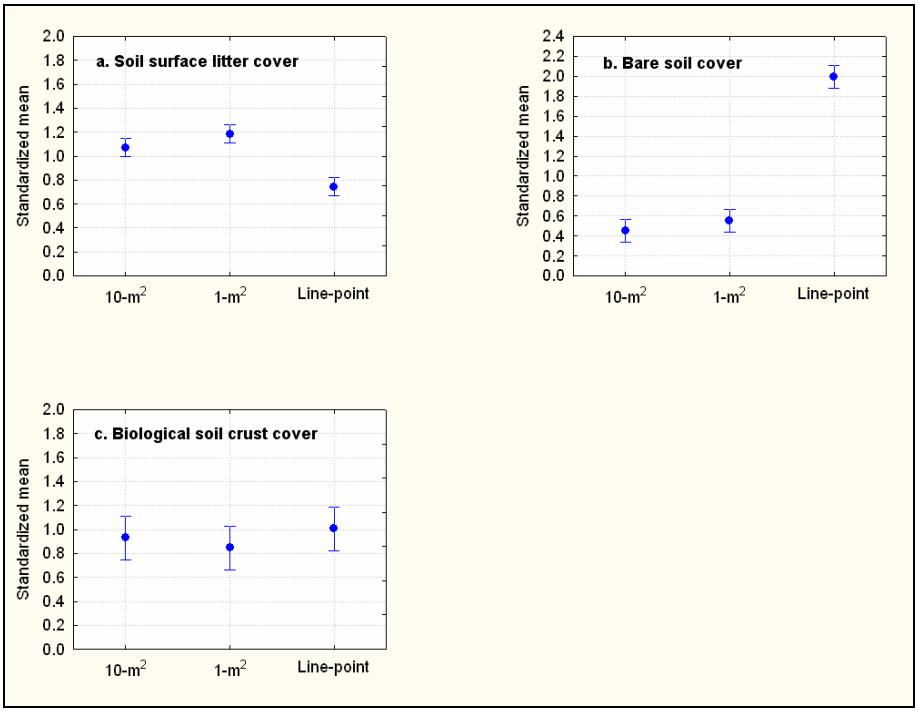

Figure 18. Effects of sampling method on cover estimates (standardized means) for (a) surface litter, (b) unstable bare soil, and (c) biological soil crusts (moss, lichen, and cyanobacteria combined) at eight Colorado Plateau ecological sites.

Table 27. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species POFE, QUGA, SYOR2, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Brushy Loam ecological site at Mesa Verde National Park. See Appendix A for key to species codes.

Effect	SS	df	MS	F	p
Sampling Method	1.034	2	0.517	16.008	<0.0001
Observer	<0.0001	1	<0.0001	0.001	0.982
Cover category	14.395	3	4.798	148.537	<0.0001
Sampling Method*Observer	0.033	2	0.016	0.504	0.605
Sampling Method*Cover category	0.773	6	0.129	3.989	0.001
Observer*Cover category	0.020	3	0.007	0.210	0.889
Sampling Method*Observer*Cover cat.	0.067	6	0.011	0.347	0.911
Error	6.202	192	0.032		

Table 28. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species CHLE4, HENE5, PLJA, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Limy Upland, 25-33" ecological site at Grand Canyon National Park. See Appendix A for key to species codes.

Effect	SS	df	MS	F	p
Sampling Method	0.333	2	0.167	14.845	<0.0001
Observer	0.001	1	0.001	0.061	0.805
Cover category	3.071	3	1.024	91.204	<0.0001
Sampling Method*Observer	0.022	2	0.011	0.982	0.376
Sampling Method*Cover category	0.230	6	0.038	3.416	0.003
Observer*Cover category	0.010	3	0.003	0.308	0.820
Sampling Method*Observer*Cover cat.	0.009	6	0.002	0.140	0.991
Error	2.155	192	0.011		

Table 29. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species POFE, POTR5, UNGRCA1, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Loamy Hills, 25-33"pz ecological site at Grand Canyon National Park. See Appendix A for key to species codes.

Effect	SS	df	MS	F	p
Sampling Method	0.355	2	0.177	20.300	<0.0001
Observer	0.001	1	0.001	0.125	0.724
Cover category	2.808	3	0.936	107.130	<0.0001
Sampling Method*Observer	0.001	2	0.0004	0.041	0.960
Sampling Method*Cover category	0.242	6	0.040	4.608	<0.0001
Observer*Cover category	0.010	3	0.003	0.376	0.770
Sampling Method*Observer*Cover cat.	0.024	6	0.004	0.464	0.834
Error	1.677	192	0.009		

Table 30. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species JUOS, PIED, POFE, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Loamy Mesa Top PJ ecological site at Mesa Verde National Park. See Appendix A for key to species codes.

Effect	SS	df	MS	F	p
Sampling Method	0.195	2	0.097	6.149	0.003
Observer	0.015	1	0.015	0.925	0.337
Cover category	3.280	3	1.093	69.098	<0.0001
Sampling Method*Observer	0.012	2	0.006	0.394	0.675
Sampling Method*Cover category	0.140	6	0.023	1.472	0.190
Observer*Cover category	0.000	3	<0.0001	0.001	1.000
Sampling Method*Observer*Cover cat.	0.018	6	0.003	0.188	0.980
Error	3.038	192	0.016		

Table 31. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species ATCO, GIIN2, ORHY, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site at Capitol Reef National Park. See Appendix A for key to species codes.

Effect	SS	df	MS	F	p
Sampling Method	0.002	2	0.001	0.157	0.855
Observer	0.0005	1	0.0005	0.082	0.775
Cover category	4.838	3	1.613	279.354	<0.0001
Sampling Method*Observer	0.004	2	0.002	0.369	0.692
Sampling Method*Cover category	0.133	6	0.022	3.839	0.001
Observer*Cover category	0.001	3	0.0004	0.065	0.978
Sampling Method*Observer*Cover cat.	0.007	6	0.001	0.188	0.980
Error	1.108	192	0.006		

Table 32. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species ARTR2, BRTE, STCO4, and total live understory canopy cover) on mean arcsin-transformed plant canopy cover values for the Semidesert Loam (Wyoming Big Sagebrush) ecological site in Dinosaur National Monument. See Appendix A for key to species codes.

Effect	SS	df	MS	F	p
Sampling Method	1.254	2	0.627	50.279	<0.0001
Observer	<0.0001	1	<0.0001	0.004	0.951
Cover category	5.887	3	1.962	157.322	<0.0001
Sampling Method*Observer	0.024	2	0.012	0.967	0.382
Sampling Method*Cover category	1.107	6	0.185	14.793	<0.0001
Observer*Cover category	0.004	3	0.001	0.113	0.952
Sampling Method*Observer*Cover cat.	0.013	6	0.002	0.178	0.982
Error	2.395	192	0.012		

Table 33. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species CORA, FEOC3, STLO4, and total live understory canopy cover) on arcsin-transformed means of plant canopy cover for the Semidesert Shallow Sandy Loam PJ ecological site at Arches and Canyonlands National Parks. See Appendix A for key to species codes.

Effect	SS	df	MS	F	p
Sampling Method	0.102	2	0.051	12.163	<0.0001
Observer	0.017	1	0.017	4.094	0.044
Cover category	4.829	3	1.610	382.362	<0.0001
Sampling Method*Observer	0.027	2	0.013	3.151	0.045
Sampling Method*Cover category	0.063	6	0.010	2.483	0.025
Observer*Cover category	0.011	3	0.004	0.893	0.446
Sampling Method*Observer*Cover cat.	0.017	6	0.003	0.687	0.661
Error	0.808	192	0.004		

Table 34. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), observer, and cover category (species CEMO2, COWR2, JUOS, and total live understory canopy cover) on arcsin-transformed means of plant canopy cover for the Upland Shallow Loam (Pinyon-Utah Juniper) ecological site at Capitol Reef National Park. See Appendix A for key to species codes.

Effect	SS	df	MS	F	p
Sampling Method	0.285	2	0.142	9.516	<0.0001
Observer	0.034	1	0.034	2.245	0.136
Cover category	2.819	3	0.940	62.848	<0.0001
Sampling Method*Observer	0.007	2	0.004	0.240	0.787
Sampling Method*Cover category	0.166	6	0.028	1.846	0.092
Observer*Cover category	0.018	3	0.006	0.394	0.757
Sampling Method*Observer*Cover cat.	0.006	6	0.001	0.067	0.999
Error	2.871	192	0.015		

Table 35. Analysis of variance for effects of sampling method (1-m^2 quadrats, 10-m^2 quadrats, and line-point intercept), ecological site (BL, LU, LH, LMT, SASL, SL, SShSL, and UShL), and observer on arcsin-transformed means of litter cover data. See table 1 for key to ecological site codes.

Effect	SS	df	MS	F	p
Sampling Method	2.251	2	1.126	66.758	<0.0001
Ecological Site	47.334	7	6.762	401.071	<0.0001
Observer	0.001	1	0.001	0.086	0.770
Sampling Method* Ecological Site	1.482	14	0.106	6.277	<0.0001
Sampling Method* Observer	0.056	2	0.028	1.661	0.191
Ecological Site *Observer	0.031	7	0.004	0.260	0.969
Sampling Method* Ecological Site *Observer	0.049	14	0.003	0.207	0.999
Error	6.474	384	0.017		

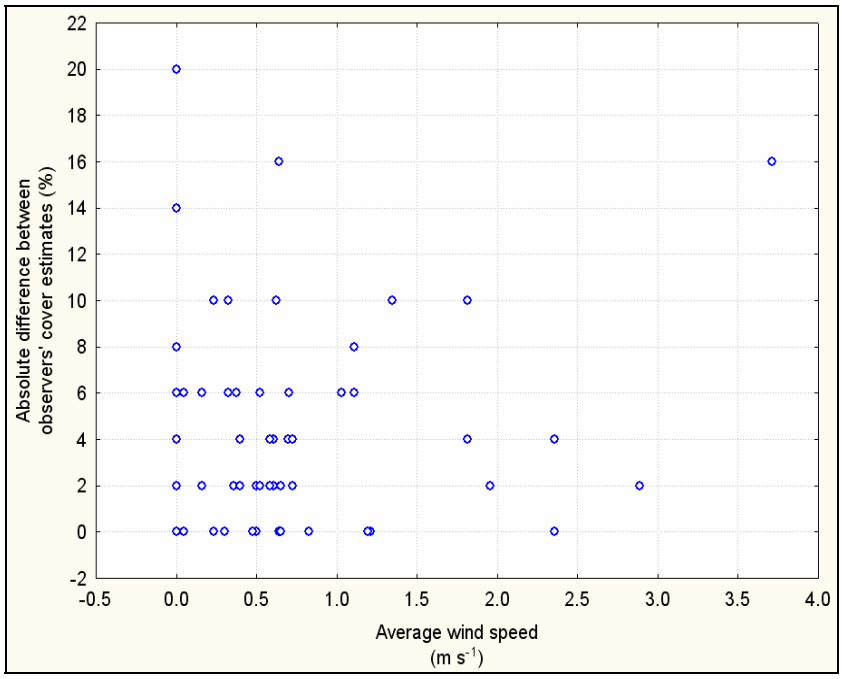

Figure 19. Scatterplot of average wind speed (m s^{-1}) vs. absolute difference between two observers' estimates of grass cover based on use of the line-point intercept sampling technique at eight Colorado Plateau ecological sites (r = 0.07, p = 0.55, n = 70).

Table 36 summarizes results of Wilcoxon tests evaluating effects of observer on cover estimates for four types of soil crust (undifferentiated crust, dark cyanobacteria, lichen, and moss) for 10-m^2, 1-m^2, and line-point intercept sampling methods at ecological sites where biological soil crusts were common. At the Upland Shallow Loam (Pinyon-Utah Juniper) ecological site at Capitol Reef National Park (tables 36 and F2), estimates of undifferentiated crust cover based on 1-m^2 quadrats and line-point intercepts both differed between observers. Observer 1 estimated lower undifferentiated crust cover than observer 2 for both 1-m^2 quadrats and line-point intercepts. At this same site, estimates of moss cover in 10-m^2 quadrats also were significantly different between observers (tables 36 and F2). The soil at this ecological site was extremely rocky with very low levels of biological soil crust cover.

Table 37 summarizes results of Wilcoxon tests evaluating effects of observer on estimates of biological soil crust cover based on use of the 25 cm x 25 cm BSC frame at ecological sites where biological soil crusts were common. No significant differences were found between observers' cover estimates for five soil-surface categories related to soil darkness and biological soil crust development. Appendix table F3 summarizes additional data collected with the BSC frame.

Tables 38 and 39 summarize results of Wilcoxon tests evaluating effects of observer on estimates of shrub and tree density by species and size class. No significant differences were found between observers' estimates of shrub and tree density. Appendix table F7 reports shrub and tree density for transects sampled during Phase 3.

Table 36. Results of Wilcoxon tests evaluating effects of observer on estimates of cover for four types of soil crust (undifferentiated, dark cyanobacteria, lichen, and moss) sampled with 10-m^2 quadrats, 1-m^2 quadrats, and line-point intercept techniques at Colorado Plateau ecological sites where biological soil crusts were common. **Bold values** indicate statistically significant differences between observers' cover estimates.

Type of soil crust		Rank sum						
Ecological site	Sampling method	Observer 1	Observer 2	U	Z	p-level	n	2*1sided exact p
Undifferentiated crust								
Loamy Mesa Top PJ	10-m^2	89	82	37	0.31	0.76	9	0.80
	1-m^2	83	88	38	-0.22	0.83	9	0.86
	Line-point	97	75	30	0.97	0.33	9	0.34
Semidesert Alkali Sandy Loam (Alkali Sacaton)	10-m^2	83	88	38	-0.22	0.83	9	0.86
	1-m^2	75	96	30	-0.93	0.35	9	0.39
	Line-point	105	66	21	1.72	0.09	9	0.09
Semidesert Loam (Wyoming Big Sagebrush)	10-m^2	79	92	34	-0.57	0.57	9	0.60
	1-m^2	82	89	37	-0.31	0.76	9	0.80
	Line-point	93	78	33	0.66	0.51	9	0.55
Semidesert Shallow Sandy Loam (PJ)	10-m^2	96	76	31	0.88	0.38	9	0.39
	1-m^2	98	74	29	1.06	0.29	9	0.30
	Line-point	97	75	30	0.97	0.33	9	0.34
Upland Shallow Loam (Pinyon-Utah Juniper)	10-m^2	93	79	34	0.62	0.54	9	0.55
	1-m^2	60	112	15	**-2.30**	**0.02**	9	**0.02**
	Line-point	61	110	16	**-2.16**	**0.03**	9	**0.03**
Dark cyanobacteria								
Loamy Mesa Top PJ	10-m^2	77	94	32	-0.75	0.45	9	0.49
	1-m^2	71	101	26	-1.32	0.19	9	0.19
	Line-point	78	93	33	-0.66	0.51	9	0.55

Table 36.—Continued

Type of soil crust			Rank sum						
Ecological site		Sampling method	Observer 1	Observer 2	U	Z	p-level	n	2*1sided exact p
		10-m^2	84	87	39	-0.13	0.89	9	0.93
	Semidesert Alkali Sandy Loam (Alkali Sacaton)	1-m^2	80	92	35	-0.53	0.60	9	0.60
		Line-point	40	39	18	0.08	0.94	6	0.94
		10-m^2	73	98	28	-1.10	0.27	9	0.30
	Semidesert Loam (Wyoming Big Sagebrush)	1-m^2	74	97	29	-1.02	0.31	9	0.34
		Line-point	34	44	13	-0.80	0.42	6	0.48
		10-m^2	65	107	20	-1.85	0.06	9	0.06
	Semidesert Shallow Sandy Loam (PJ)	1-m^2	74	97	29	-1.02	0.31	9	0.34
		Line-point	58	79	22	-1.10	0.27	8	0.28
Lichen									
		10-m^2	85	87	39.5	-0.09	0.93	9	0.93
	Loamy Mesa Top PJ	1-m^2	79	92	34	-0.57	0.57	9	0.60
		Line-point	17	20	7	-0.43	0.67	4	0.69
		10-m^2	82	89	37	-0.31	0.76	9	0.80
	Semidesert Alkali Sandy Loam (Alkali Sacaton)	1-m^2	76	96	31	-0.88	0.38	9	0.39
		Line-point	3	7	0	-1.55	0.12	2	0.33
		10-m^2	3	7	0	-1.55	0.12	2	0.33
	Semidesert Loam (Wyoming Big Sagebrush)	1-m^2	82	89	37	-0.31	0.76	9	0.80
		Line-point	33	46	12	-1.04	0.30	6	0.31
		10-m^2	90	81	36	0.40	0.69	9	0.73
	Semidesert Shallow Sandy Loam (PJ)	1-m^2	82	89	37	-0.31	0.76	9	0.80
		Line-point	3	7	0	-1.55	0.12	2	0.33

Table 36.—Continued

Type of soil crust		Rank sum						
Ecological site	Sampling method	Observer 1	Observer 2	U	Z	p-level	n	2*1sided exact p
Moss								
Loamy Mesa Top PJ	10-m^2	81	91	36	-0.44	0.66	9	0.67
	1-m^2	87	85	40	0.09	0.93	9	0.93
	Line-point	69	68	32	0.05	0.96	8	0.96
Semidesert Alkali Sandy Loam (Alkali Sacaton)	10-m^2	71	100	26	-1.28	0.20	9	0.22
	1-m^2	7	14	1	-1.53	0.13	3	0.20
	Line-point	---	---	---	---	---	1	---
Semidesert Loam (Wyoming Big Sagebrush)	10-m^2	83	89	38	-0.26	0.79	9	0.80
	1-m^2	75	96	30	-0.93	0.35	9	0.39
	Line-point	82	89	37	-0.31	0.76	9	0.80
Semidesert Shallow Sandy Loam (PJ)	10-m^2	74	98	29	-1.06	0.29	9	0.30
	1-m^2	67	104	22	-1.63	0.10	9	0.11
	Line-point	83	89	38	-0.26	0.79	9	0.80
Upland Shallow Loam (Pinyon-Utah Juniper)	10-m^2	60	112	15	**-2.30**	**0.02**	**9**	**0.02**
	1-m^2	66	106	21	-1.77	0.08	9	0.08
	Line-point	3	7	0	-1.55	0.12	2	0.33

Table 37. Results of Wilcoxon tests evaluating effects of observer on estimates of biological soil crust cover based on the characterization of soil darkness (see table 10 and fig. 5) in 25 cm x 25 cm BSC frames at Colorado Plateau ecological sites where biological soil crusts were common.

Soil-surface category	Ecological site	Rank sum		U	Z	p-level	n	2*1sided exact p
		Observer 1	Observer 2					
Darkness 1	Loamy Mesa Top PJ	5	5	2	0	1.00	2	1.00
	Semidesert Alkali Sandy Loam (Alkali Sacaton)	75	61	25	0.74	0.46	8	0.51
	Semidesert Shallow Sandy Loam (PJ)	73	64	28	0.47	0.64	8	0.65
	Upland Shallow Loam (Pinyon-Utah Juniper)	89	83	38	0.26	0.79	9	0.80
Darkness 2	Loamy Mesa Top PJ	85	87	40	-0.09	0.93	9	0.93
	Semidesert Alkali Sandy Loam (Alkali Sacaton)	80	91	35	-0.49	0.63	9	0.67
	Semidesert Loam (Wyoming Big Sagebrush)	102	70	25	1.41	0.16	9	0.16
	Semidesert Shallow Sandy Loam (PJ)	85	86	40	-0.04	0.96	9	1.00
	Upland Shallow Loam (Pinyon-Utah Juniper)	3	7	0	-1.55	0.12	2	0.33
Darkness 3	Loamy Mesa Top PJ	83	88	38	-0.22	0.83	9	0.86
	Semidesert Alkali Sandy Loam (Alkali Sacaton)	58	78	22	-1.05	0.29	8	0.33
	Semidesert Loam (Wyoming Big Sagebrush)	72	99	27	-1.19	0.23	9	0.26
	Semidesert Shallow Sandy Loam (PJ)	61	76	25	-0.79	0.43	8	0.44
Darkness 4	Loamy Mesa Top PJ	50	56	22	-0.38	0.70	7	0.71
Darkness 5	Loamy Mesa Top PJ	5	5	2	0	1.00	2	1.00

Table 38. Results of Wilcoxon tests evaluating effects of observer on estimates of shrub density by species and height class at Colorado Plateau ecological sites. See Appendix A for key to species codes.

Species	Height class (cm)	Rank Sum		U	Z	p-level	n	2*1sided exact p
		Observer 1	Observer 2					
AMUT	0-10	21	15	5	0.87	0.39	4	0.49
	10-25	48	30	9	1.44	0.15	6	0.18
	25-50	116	94	39	0.83	0.41	10	0.44
	50-100	150	151	72	-0.03	0.98	12	0.98
	100-200	156	144	66	0.35	0.73	12	0.76
	>200	5	5	2	0.00	1.00	2	1.00
	All combined	2281	1998	917	1.10	0.27	46	0.27
ARBI3	0-10	5	5	2	0.00	1.00	2	1.00
	10-25	---	---	---	---	---	1	---
	25-50	7	4	1	1.16	0.25	2	0.33
	50-100	---	---	---	---	---	1	---
	All combined	45	34	13	0.88	0.38	6	0.39
ARTR2	0-10	57	48	20	0.57	0.57	7	0.62
	10-25	109	101	46	0.30	0.76	10	0.80
	25-50	158	143	65	0.43	0.67	12	0.67
	50-100	157	143	65	0.40	0.69	12	0.71
	All combined	2499	2352	1127	0.52	0.60	49	0.61
ATCA2	25-50	5	5	2	0.00	1.00	2	1.00
	50-100	10	11	4	-0.22	0.83	3	1.00
	All combined	27	29	12	-0.21	0.83	5	0.84
ATCO	0-10	142	111	45	1.02	0.31	11	0.33
	10-25	68	68	32	0.00	1.00	8	1.00
	25-50	96	76	31	0.88	0.38	9	0.39
	50-100	---	---	---	---	---	1	---
	All combined	921	790	355	1.02	0.31	29	0.31
BEFR	10-25	---	---	---	---	---	1	---
	50-100	12	9	3	0.65	0.51	3	0.70
	All combined	18	18	8	0.00	1.00	4	1.00
CHNA2	10-25	11	11	5	0.00	1.00	3	1.00
	25-50	73	64	28	0.47	0.64	8	0.65
	50-100	17	19	7	-0.29	0.77	4	0.89
	100-200	---	---	---	---	---	1	---
	All combined	262	267	126	-0.09	0.92	16	0.93
CORA	0-10	20	17	7	0.43	0.67	4	0.69
	10-25	60	45	17	0.96	0.34	7	0.38
	25-50	91	81	36	0.44	0.66	9	0.67
	50-100	90	81	36	0.40	0.69	9	0.73
	All combined	893	818	383	0.58	0.56	29	0.57
PUME	25-50						1	
	50-100	12	9	3	0.65	0.51	3	0.70
	100-200	5	5	2	0.00	1.00	2	1.00
	All combined	42	37	16	0.40	0.69	6	0.70

Table 38.—Continued

Species	Height class (cm)	Rank Sum Observer 1	Rank Sum Observer 2	U	Z	p-level	n	2*1sided exact p
PUTR2	0-10	18	18	8	0.00	1.00	4	1.00
	25-50	25	12	2	1.88	0.06	4	0.06
	50-100	13	23	3	-1.44	0.15	4	0.20
	All combined	156	144	66	0.35	0.73	12	0.76
SAVE4	0-10	18	18	8	0.00	1.00	4	1.00
	10-25	17	20	7	-0.43	0.67	4	0.69
	25-50	74	63	27	0.58	0.56	8	0.57
	50-100	107	104	49	0.11	0.91	10	0.91
	100-200	16	20	6	-0.58	0.56	4	0.69
	>200	---	---	---	---	---	1	---
	All combined	983	970	474	0.09	0.93	31	0.93
SHRO	25-50	---	---	---	---	---	1	---
	50-100	---	---	---	---	---	1	---
	100-200	5	5	2	0.00	1.00	2	1.00
	All combined	18	18	8	0.00	1.00	4	1.00
SYOR2	0-10	---	---	---	---	---	---	---
	10-25	11	11	5	0.00	1.00	3	1.00
	25-50	8	13	2	-1.09	0.28	3	0.40
	50-100	11	10	4	0.22	0.83	3	1.00
	100-200	10	12	4	-0.44	0.66	3	0.70
	All combined	145	155	67	-0.29	0.77	12	0.80

Table 39. Results of Wilcoxon tests evaluating effects of observer on estimates of tree density by species and size class at Colorado Plateau ecological sites. See Appendix A for key to species codes.

Species	Size class	Rank Sum Observer 1	Rank Sum Observer 2	U	Z	p-level	n	2*1sided exact p
ABCO	Seedling	5	5	2	0.00	1.00	2	---
JUOS	Seedling	275	253	117	0.41	0.68	16	0.70
	Pole	152	149	71	0.09	0.93	12	0.93
	Overstory	120	90	35	1.13	0.26	10	0.28
	All combined	1555	1372	631	0.95	0.34	38	0.34
PIED	Seedling	170	182	79	-0.31	0.76	13	0.76
	Pole	89	82	37	0.31	0.76	9	0.80
	Overstory	5	5	2	0.00	1.00	2	---
	Total	582	595	282	-0.13	0.89	24	0.89
PIEN	Seedling	---	---	---	---	---	1	---
	Pole	5	5	2	0.00	1.00	2	1.00
	All combined	11	11	5	0.00	1.00	3	1.00
PIPO	Pole	---	---	---	---	---	1	---
	Overstory	25	30	10	-0.52	0.60	5	0.69
	All combined	36	42	15	-0.48	0.63	6	0.70

Table 39.—Continued

Species	Size class	Rank Sum Observer 1	Rank Sum Observer 2	U	Z	p-level	n	2*1sided exact p
POTR5	Seedling	52	53	24	-0.06	0.95	7	1.00
	Pole	19	18	8	0.14	0.89	4	0.89
	Overstory	---	---	---	---	---	1	---
	All combined	150	150	72	0.00	1.00	12	1.00
QUGA	Seedling	20	16	6	0.58	0.56	4	0.69
	Pole	---	---	---	---	---	1	---
	All combined	29	26	11	0.31	0.75	5	0.84

Sampling Impacts

Sampling impacts on soil and vegetation conditions depended on the structure of plant communities at ecological sites and the types and amounts of soil crusts that were present. Ecological sites most impacted by our sampling procedures (Desert Sand at Canyonlands, Loamy Mesa Top PJ at Mesa Verde, Semidesert Alkali Sandy Loam at Capitol Reef, Semidesert Loam at Dinosaur, and Semidesert Shallow Sandy Loam at Arches and Canyonlands) were those with biological soil crusts and undifferentiated soil crusts (table 40). At these ecological sites, destabilized soils and trampled biological soil crusts were the most common types of impact. Figure 20 illustrates trampling impacts on soils at Arches National Park and on vegetation at Wupatki National Monument.

Sampling resulted in few broken branches, except at sites where dense shrubs or trees had to be penetrated in order to sample. A slight degree of plant trampling occurred at most ecological sites. Some sites had little sampling impact (Limy Upland at Wupatki, Loamy Hills at Grand Canyon, Shallow Loamy at Wupatki, and Upland Shallow Loam at Capitol Reef) due to low cover of plants and biological soil crusts, and/or due to armoring of soils by cinders or rock.

Figure 20. Photograph (left) of destabilized soil and trampled biological soil crusts on unsampled side of transect in Arches National Park (Semidesert Shallow Sandy Loam ecological site), and (right) trampled plants on unsampled side of transect in Wupatki National Monument (Limy Upland ecological site).

Sampling methods and procedures varied in terms of their impacts on site conditions (table 40). Line-point intercept sampling, 10-m^2 quadrat sampling, and gap-intercept sampling nearly always created the most impact, although travel to macroplots caused a large degree of impact where undifferentiated soil crusts and biological soil crusts were trampled while enroute to macroplots located relatively far from roads. Impacts also varied by location (table 41), with greatest impacts along the unsampled side of the transect and least impacts within quadrats. This was most noticeable at sites with extensive undifferentiated soil crusts and biological soil crusts, where trampled foot paths formed along the unsampled side of the transect and around the perimeter of 10-m^2 quadrats (fig. 20).

Discussion

Evaluation of Sampling Methods

A primary objective of this project was to evaluate a suite of sampling methods according to measures of repeatability, efficiency, and impacts on plot conditions across a range of upland ecosystems likely to be monitored in Colorado Plateau NPS units. In this section and in table 42 we summarize results of these evaluations.

Efficiency

We evaluated the efficiency of cover-estimation techniques on the basis of several measures including per-unit subsampling times, within-plot CV values for total live understory canopy cover, numbers of subsamples and amounts of time required to estimate plot-level cover with 20 percent precision, among-plot CV values for total live understory cover, numbers of macroplot samples required to estimate site-level cover with 20 percent precision, and numbers of species detected per macroplot and ecological site.

Across all ecological sites combined, we found few unambiguous trends in the efficiency of cover-estimation techniques. The amount of time required to sample cover in one 10-m^2 quadrat was about twice that required for one 1-m^2 quadrat and one 10-pt group of line-point intercepts. On the basis of within-plot CV values and numbers of subsamples required to estimate total plot-level cover with 20 percent precision, 10-m^2 quadrats were most efficient and 1-m^2 quadrats least efficient at 10 and eight of 11 ecological sites, respectively. The line-point technique was most efficient at eight of 11 ecological sites in terms of the amount of time required to estimate total plot-level cover with 20 percent precision – largely because 10-m^2 quadrats were more time consuming and 1-m^2 quadrats had greater within-plot variability relative to line-point sampling. Mean quadrat subsampling times were highly influenced by results at two ecological sites, and across all sites there was no statistical difference among methods with respect to median subsampling times for 20 percent precision. We also found no difference among methods with respect to mean and median CV values describing among-plot variability in total live understory cover. Nevertheless, the line-point technique had the lowest among-plot CV values for 7 of 11 ecological sites.

For monitoring objectives requiring the detection of infrequent species, quadrat-based techniques are superior to point-based techniques because of greater areal coverage. For species detection, we found that the relative advantage of 10-m^2 quadrats over 1-m^2 quadrats varied among ecological sites. Across all ecological sites, we also found that this detection advantage

Table 40. Median impact-assessment ratings for procedures at 11 Colorado Plateau ecological sites (0 = none, 1 = slight, 2 = slight to moderate, 3 = moderate, 4 = moderate to extreme, 5 = extreme). See table 1 for key to ecological site codes.

Procedure	Ecological site										
	BL	DS	LU	LH	LHC	LMT	SASL	SL	SShSL	ShL	UShL
Travel to macroplot	0	2.5	1	0	1	2	2	1	1.5	0.5	1
Site characterization	0	1	0	0	1	1	1	0	1	0	0
Plot establishment	0	1.5	0	0	1	2	1	1	2	0	0
1-m^2 quadrat sampling	0	1	0	0	0	0	1	0	1	0.5	0
10-m^2 quadrat sampling	1	2.5	1	0	1	2	3	2	3	0.5	1
Line-point intercept sampling	0	2.5	1	0	1	1	3	1	3	0.5	1
Gap-intercept sampling	0	2	0	0	0	0	3	0	2.5	0.5	0
Pin placement	0	0.5	0	0	0	1	1	0	1	0	0
Cumulative travel on line	1	3	1	1	2	4	3	2	3.5	0.5	1

Table 41. Median impact-assessment ratings for types of impacts (broken branches, trampled plants, destabilized soils, trampled biological soil crusts, and quadrat-frame imprint) in quadrats, on the sampled side of the transect tape, and on the unsampled side of the transect tape at 11 Colorado Plateau ecological sites (0 = none, 1 = slight, 2 = slight to moderate, 3 = moderate, 4 = moderate to extreme, 5 = extreme). See table 1 for key to ecological site codes.

Type of impact	Impact location	Ecological site										
		BL	DS	LU	LH	LHC	LMT	SASL	SL	SShSL	ShL	UShL
Broken branches	In quadrats	0	0	0	0	0	0	0	0	0	0	0
	Sampled side of transect	0	0	0	0	0	0	0	0	0	0	0
	Unsampled side of transect	0	0	0	0	0	1	0	1	0	0	0
Trampled plants	In quadrats	0	0	0	0	1	1	1	0	0	0	0
	Sampled side of transect	1	0	1	1	1.5	1	1	0	0	0	0
	Unsampled side of transect	1	1	1	1	2	1	1	1	0	0.5	0
Destabilized soils	In quadrats	0	1	0	0	0	2	2	1	1	0	0
	Sampled side of transect	1	2	0	0	0	3	2	2	3	0	1
	Unsampled side of transect	1	3	0	0	0.5	3	3	2	4	0	1
Trampled BSCs	In quadrats	0	1	0	0	0	1	0	1	0	0	0
	Sampled side of transect	0	3	0	0	0	2	1	1	2	0	0
	Unsampled side of transect	0	3	0	0	0	3	1	2	2	0	0
Quadrat imprint	In quadrats	0	1	0	0	0	1	1	0	1	0	0

could largely be accounted for by species with 6.7 percent frequency (or less) in 10-m^2 quadrats. That is,after excluding these very infrequent species from 10-m^2 quadrat data, we found no difference between 10- and 1-m^2 quadrats in terms of mean estimates of site-level species richness.

Table 42. Summary of comparisons among cover-sampling techniques in relation to repeatability between observers, efficiency, and sampling impacts on soils and vegetation (0 indicates no clear difference among techniques; -- indicates worst technique[s]; + indicates best technique[s]).

Evaluation criteria		Cover-sampling technique		
		Line-point intercept	1-m^2 quadrats	10-m^2 quadrats
Efficiency				
	Per-unit subsampling time	+	+	--
	Within-plot CV values for total live understory canopy cover		--	+
	Time to estimate within-plot total live understory canopy cover with 20 percent precision	+	0	0
	Among-plot CV values for total live understory canopy cover	+	0	0
	Species detection (all species)	--		+
	Species detection (frequent species)	--	+	+
Repeatability between observers (measurement precision)		0	0	0
Sampling impacts on soil and vegetation		--	+	--

Repeatability

We found no differences among cover-estimation techniques in terms of observer repeatability (measurement precision). Cover estimates were highly repeatable between observers for 10-m^2 quadrats, 1-m^2 quadrats, and line-point intercept sampling methods. Statistically significant differences between observers' cover estimates were found only in three cases: (1) line-point estimates of blackbrush cover at the Semidesert Shallow Sandy Loam PJ ecological site at Arches National Park, (2) line-point and 1-m^2 quadrat estimates of undifferentiated soil crust at the Upland Shallow Loam ecological site at Capitol Reef National Park, and (3) 10-m^2 quadrat estimates of moss cover at the same Upland Shallow Loam ecological site. Differences in blackbrush cover estimates were due to the observers' differing interpretations of line-point intercepts as "standing dead" vs. "live non-photosynthetic." Repeatability in such cases can be improved by ensuring that observers use a standardized decision-making process for determining the status ("standing dead" vs. "live non-photosynthetic") of plant intercepts. For undifferentiated soil crust and moss cover at the Upland Shallow Loam ecological site, absolute differences in mean cover estimates between observers were low for 1-m^2 and 10-m^2 quadrats, respectively (table F2).

Because one member of the two-person field team recorded the other member's cover estimates, repeat sampling events were not fully independent of one another. This was

particularly true for quadrat-based sampling because repeat events sampled the same quadrat space. However, it is unlikely that this sampling approach significantly affected the results. Although it was easy for the second observer to remember unique or infrequent species detected by the first observer, actual cover estimates could not be easily recalled. Independence of repeat observations was not an issue with line-point sampling, since it is highly improbable that the exact same points were resampled during repeat events. This factor explains why differences between observers' cover estimates tended to be slightly greater for line-point sampling than for quadrat-based sampling (Appendix F).

We found that density measures also were repeatable between observers. Our analyses did not detect significant differences in density estimates between observers for any tree or shrub species. The power of our analyses may have been affected by small sample sizes because counts for many species such as Gambel oak (*Quercus gambelii,* QUGA) were low ($n < 10$). Additional data may be necessary for a more robust evaluation of the repeatability of density measures. Some shrubs were extremely difficult to sample for density because of their multistemmed growth habit. Gambel oak in the Brushy Loam ecological site at Mesa Verde was particularly challenging with respect to density sampling. First, it was difficult to classify as either a shrub or a tree. (We consistently called it a tree in this analysis.) Older specimens may have one or a few main stems and can appear "tree like," but younger plants exist as dense, multistemmed shrubs. Second, in the dense shrub form it is extremely difficult to distinguish individual plants or stems as unique counting units. Counting Gambel oak stems in dense stands was tedious and time consuming, sometimes taking longer than 10 minutes per quadrat. It also was time consuming to count high numbers of big sagebrush (*Artemisia tridentata,* ARTR2*)* seedlings (up to 474 seedlings in one 10-m^2 quadrat) encountered at one Semidesert Loam macroplot in Dinosaur National Monument. To facilitate future density sampling in such cases, we recommend the use of 25- or 50-unit counting categories when individual stem counts exceed a threshold value such as 100 per 10-m^2 quadrat.

Sampling Impacts

As expected, sampling activities had greatest impacts on soil and vegetation conditions at macroplots where there was a high degree of cover by biological or undifferentiated soil crusts. Impacts occurred primarily on paths on the unsampled sides of transects and around the perimeters of 10-m^2 quadrats. Of all sampling procedures, 10-m^2 quadrat sampling, line-point sampling, and gap-intercept sampling had the most impacts. Sampling 10-m^2 quadrats resulted in foot paths surrounding all sides of the quadrat, although observers could choose and walk paths of least impact when moving from one quadrat location to the next. In contrast, line-point sampling at 50-cm and 1-m intervals and continuous gap-intercept sampling forced observers to trample crusts and plants in a continuous path very close to the tape, allowing little flexibility to minimize trampling impacts. Repeated travel back and forth along transects had the greatest cumulative impacts, but these impacts could be minimized by carefully stepping in previous footprints where possible. Although 1-m^2 quadrats had the least impacts in this study, impacts would be expected to increase proportionally if sampling objectives required a larger number of subsamples (perhaps placed at smaller intervals along the transect) in order to compensate for the fact that 1-m^2 quadrats typically had the highest within-plot CV values for total live understory canopy cover.

Issues Associated with Electronic Data Entry and Management

As described above, a Pocket PC was used to collect and store data in a database during the field season with the goal of facilitating real-time data analyses and reducing the amount of time required for post-season data entry. When transferred to a desktop computer, the database format provided immediate access and easy manipulation of data for purposes of review during the field season. Ideally, savings realized by eliminating post-season data entry are not offset by time delays attributable to recording data on the hand-held device or by complications associated with computer hardware or software. In reality, there were time costs associated with use of the Pocket PC for data entry, and cumulative technical complications slowed the pace of data collection to such a degree that the number of macroplots sampled over the course of the season was reduced relative to what might have been accomplished in the absence of such complications. Following are several issues encountered over the course of the field season.

1. The database program that we used requires an expert in data management to design the database and to resolve problems which inevitably arise when adopting new techniques. These problems likely will become less significant as sampling and data-management protocols are refined, but technical complications always will occur to some degree – requiring contingencies to resolve issues without compromising the quality or quantity of data collected by field teams.
2. Data can be lost from the computer. This can occur from an error in the back-up method, a power outage and subsequent operating system reset, and accidental deletions when the wrong key is pushed. Data loss also can occur while collecting data on paper, but it may be prevented in both cases with adequate safeguards. On the Pocket PC, it must be ensured that the field crew is properly trained in back-up procedures and is diligent and careful while recording data. During the 2005 field season, a back-up error caused data for an entire macroplot (Capitol Reef, Phase 2) to be lost – requiring that the plot be resampled in its entirety during a subsequent visit to the park. Because of the potential for power loss, system resets, and data loss, we recommend that future field crews be equipped with a laptop computer with a back-up copy of the most recent database, connection cables, and CDs for software that may need to be reloaded on the hand-held. The likelihood of data loss also may be minimized in the future by ensuring that the field crew has multiple batteries and reliable procedures for charging batteries in remote settings.
3. Computer-based methods require training time for field crews. This may require only a couple of days to initially learn the programs and procedures, but there also is a certain amount of comfort and speed only obtained after weeks or months of sampling. During the 2005 season, the field crew was still becoming familiar with operation of the Pocket PC two-thirds of the way through the field season.
4. The actual time required to enter data with the Pocket PC while in the field is dependent upon several factors – the memory capacity and processor speed of the hand-held computer, the size (thus speed) of the program in relation to memory capacity, the size of the dataset, and the design of data-entry forms (e.g., the length of drop-down menus and pick-lists). When data were recorded by hand in field books during the 2005 season, sampling proceeded at a pace 10-20 percent faster than when using the Pocket PC. Excessive file size (i.e., running the PocketAccess database with all data accumulated during the entire field season) and long pick-lists were

major factors slowing data entry with the Pocket PC. When procedures were modified to address these factors, the pace of sampling increased considerably.

5. When data are collected on paper due to technical issues with the Pocket PC, entry of data into the database in the office can be very time consuming. Data entry in the office was very slow because data entry forms were designed specifically for the small, Pocket PC format using Sprint DB Pro interface software. In the future we recommend that alternative data entry forms (e.g., in Microsoft Access) be developed to facilitate direct entry of data into the project database when necessary.
6. Data transfers between the Pocket PC and a desktop computer can be time consuming, particularly if the system is designed so that all accumulated data must be transferred during each synchronization event. We recommend that systems be designed so that a minimum amount of data must be transferred between the Pocket PC and the desktop during synchronization.

Overall, the Pocket PC did provide data accessibility more quickly than had the crew recorded and entered data by hand, in spite of the various technical challenges that were encountered. However, the pace of field work delayed quality-assurance work until after the end of the field season. As a result, "real-time" data analyses were hampered by various issues (e.g., mislabeled data, missing data, consistency in species identification and naming across plots) that could not be fully resolved until data collection was completed. The handheld computer seemed to withstand the rigors of fieldwork, and it promises to be a useful tool for facilitating the collection and management of large data sets.

References Cited

Creque, J. A., S. D. Bassett, and N. E. West. 1999. Viewpoint: Delineating ecological sites. Journal of Range Management 52: 546-549.

Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005. Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start. Las Cruces, NM: USDA-ARS Jornada Experimental Range. 36 p.

McCune, B. and M. J. Mefford. 1999. PC-ORD. Multivariate Analysis of Ecological Data. Version 4.34. Gleneden Beach, OR: MjM Software.

McCune, B. P., and J. B. Grace. 2002. Analysis of ecological communities. Gleneden Beach, OR: MjM Software Design. 300 p.

NPS (U.S.D.I. National Park Service). 2003. Fire monitoring handbook. Boise, ID: Fire Management Program Center, National Interagency Fire Center. 274 p.

NRCS (U.S.D.A. Natural Resources Conservation Service). 2001a. Soil survey of Cortez Area, Colorado, parts of Dolores and Montezuma counties. Denver: U.S. Department of Agriculture, Natural Resources Conservation Service. 627 p.

NRCS (U.S.D.A. Natural Resources Conservation Service). 2001b. Soil survey of Dinosaur National Monument, Colorado and Utah. Denver: U.S. Department of Agriculture, Natural Resources Conservation Service. 381 p.

NRCS (U.S.D.A. Natural Resources Conservation Service). 2003. Soil survey of Grand Canyon area, Arizona, parts of Coconino and Mohave counties. Phoenix: U.S. Department of Agriculture, Natural Resources Conservation Service. 602 p.

NRCS (U.S.D.A. Natural Resources Conservation Service). 2004. Draft soil survey report for Capitol Reef National Park (soil survey area UT685). Salt Lake City: U.S. Department of Agriculture, Natural Resources Conservation Service. 389 p.

Schoeneberger, P. J., D. A. Wysocki, E. C. Benham, and W. D. Broderson, eds. 2002. Field book for describing and sampling soils, version 2.0. U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

SCS (U.S.D.A. Soil Conservation Service). 1983. Soil survey of Coconino County, Azizona, central part. Phoenix: U.S. Department of Agriculture, Natural Resources Conservation Service. 212 p.

SCS (U.S.D.A. Soil Conservation Service). 1989. Soil survey of Grand County, Utah, central part. Salt Lake City: U.S. Department of Agriculture, Natural Resources Conservation Service. 200 p.

SCS (U.S.D.A. Soil Conservation Service). 1991. Soil survey of Canyonlands area, Utah, parts of Grand and San Juan counties. Salt Lake City: U.S. Department of Agriculture, Natural Resources Conservation Service. 293 p.

SRM Task Group (Society for Range Management Task Group on Unity in Concepts and Terminology Committee). 1995. New concepts for assessment of rangeland condition. Journal of Range Management 48: 271-282.

StatSoft, Inc. 2004. STATISTICA (data analysis software system), version 6. www.statsoft.com.

Zar, J. H. 1999. Biostatistical analysis. Fourth edition. Upple Saddle River, NJ: Prentice Hall. 663 p.

Appendix A—Species List and Species Occurrence by Ecological Site

[Species codes are from the U.S. Department of Agriculture, Natural Resources Conservation Service, PLANTS database (http://plants.usda.gov, June 2005), National Plant Data Center, Baton Rouge, LA 70874-4490 USA.]

Species code	Species name	Family name	Brushy Loam	Desert Sand (Sand Sagebrush)	Limy Upland, 6-10" pz	Loamy Hills, 25-33" pz	Loamy Hills, Cold, 25-33" pz	Loamy Mesa Top PJ	Semidesert Alkali Sandy Loam (Alkali Sacaton)	Semidesert Loam (Wyoming Big Sagebrush)	Semidesert Shallow Sandy Loam (PJ)	Shallow Loamy, 10-14" pz	Upland Shallow Loam (Pinyon-Utah Juniper)
ABCO	*Abies concolor*	Pinaceae				X	X						
ABFR2	*Abronia fragrans*	Nyctaginaceae		X									
ABLA	*Abies lasiocarpa*	Pinaceae				X	X						
ACHY	*Achnatherum hymenoides*	Poaceae			X							X	
ACMI2	*Achillea millefolium*	Asteraceae	X			X	X						
AGCR	*Agropyron cristatum*	Poaceae	X										
AGSM	*Agropyron smithii*	Poaceae								X			
ALAC4	*Allium acuminatum*	Liliaceae	X										
AMAC2	*Ambrosia acanthicarpa*	Asteraceae							X				
AMUT	*Amelanchier utahensis*	Rosaceae	X										X
ANPA5	*Antennaria parvifolia*	Asteraceae				X	X						
ARBI3	*Artemisia bigelovii*	Asteraceae	X						X		X		
ARDR4	*Artemisia dracunculus*	Asteraceae	X						X				
ARFI2	*Artemisia filifolia*	Asteraceae							X		X		
ARNO4	*Artemisia nova*	Asteraceae									X		
ARPU9	*Aristida purpurea*	Poaceae		X	X								
ARTR2	*Artemisia tridentata*	Asteraceae						X	X	X			
ASMA10	*Asclepias macrosperma*	Asclepiadaceae									X		
ASMO7	*Astragalus mollissimus*	Fabaceae								X	X		
ATCA2	*Atriplex canescens*	Chenopodiaceae		X					X	X	X	X	
ATCO	*Atriplex confertifolia*	Chenopodiaceae							X	X			
BASA3	*Balsamorhiza sagittata*	Asteraceae	X										
BEFR	*Berberis fremontii*	Berberidaceae											X
BOCU	*Bouteloua curtipendula*	Poaceae			X								
BOER4	*Bouteloua eriopoda*	Poaceae			X				X			X	
BOGR2	*Bouteloua gracilis*	Poaceae			X				X				
BRIN2	*Bromus inermis*	Poaceae				X	X		X				

Species code	Species name	Family name	Brushy Loam	Desert Sand (Sand Sagebrush)	Limy Upland, 6-10" pz	Loamy Hills, 25-33" pz	Loamy Hills, Cold, 25-33" pz	Loamy Mesa Top PJ	Semidesert Alkali Sandy Loam (Alkali Sacaton)	Semidesert Loam (Wyoming Big Sagebrush)	Semidesert Shallow Sandy Loam (PJ)	Shallow Loamy, 10-14" pz	Upland Shallow Loam (Pinyon-Utah Juniper)
BRTE	*Bromus tectorum*	Poaceae	X	X	X	X		X	X	X	X		X
CANU3	*Calochortus nuttallii*	Liliaceae	X					X		X	X		
CANU4	*Carduus nutans*	Asteraceae	X					X					
CEMO2	*Cercocarpus montanus*	Rosaceae	X										X
CELA4	*Ceratoides lanata*	Chenopodiaceae		X					X	X			
CHAL7	*Chenopodium album*	Chenopodiaceae	X	X		X		X	X		X		X
CHLE4	*Chenopodium leptophyllum*	Chenopodiaceae	X		X			X	X	X		X	
CHNA2	*Chrysothamnus nauseosus*	Asteraceae			X				X	X		X	
CHST	*Chaenactis stevioides*	Asteraceae		X					X		X		
CHVI8	*Chrysothamnus viscidiflorus*	Asteraceae	X								X		X
COME5	*Cowania mexicana*	Rosaceae											X
CORA	*Coleogyne ramosissima*	Rosaceae		X							X		
COUM	*Comandra umbellata*	Santalaceae	X										
COWR2	*Cordylanthus wrightii*	Scrophulariaceae						X	X		X		X
CRCI3	*Cryptantha cinerea*	Boraginaceae			X							X	
CRFL5	*Cryptantha flava*	Boraginaceae											X
DAFL	*Dalea flavescens*	Fabaceae									X		
DEPI	*Descurainia pinnata*	Brassicaceae	X		X			X	X	X	X	X	X
ELEL5	*Elymus elymoides*	Poaceae	X		X	X	X	X			X	X	
EPAN	*Epilobium angustifolium*	Onagraceae				X							
EPVI	*Ephedra viridis*	Ephedraceae		X							X	X	X
ERCE2	*Eriogonum cernuum*	Polygonaceae		X					X	X	X		X
ERCO14	*Eriogonum corymbosum*	Polygonaceae									X		
ERFO3	*Erigeron formosissimus*	Asteraceae					X						
ERIN4	*Eriogonum inflatum*	Polygonaceae							X		X		
ERMI4	*Eriogonum microthecum*	Polygonaceae									X		X
ERUM	*Eriogonum umbellatum*	Polygonaceae	X					X					
ESVI2	*Escobaria vivipara*	Cactaceae						X					
EUFE2	*Euphorbia fendleri*	Euphorbiaceae									X		
FEOC3	*Festuca octoflora*	Poaceae		X							X		
FERU	*Fendlera rupicola*	Hydrangeaceae	X										
FRAN2	*Fraxinus anomala*	Oleaceae									X		X

Species code	Species name	Family name	Brushy Loam	Desert Sand (Sand Sagebrush)	Limy Upland, 6-10" pz	Loamy Hills, 25-33" pz	Loamy Hills, Cold, 25-33" pz	Loamy Mesa Top PJ	Semidesert Alkali Sandy Loam (Alkali Sacaton)	Semidesert Loam (Wyoming Big Sagebrush)	Semidesert Shallow Sandy Loam (PJ)	Shallow Loamy, 10-14" pz	Upland Shallow Loam (Pinyon-Utah Juniper)
FRVI	*Fragaria virginiana*	Rosaceae				X	X						
GACO5	*Gaura coccinea*	Onagraceae										X	
GAPI	*Gaillardia pinnatifida*	Asteraceae		X									
GECA3	*Geranium caespitosum*	Geraniaceae				X	X						
GIIN2	*Gilia inconspicua*	Polemoniaceae			X				X	X	X	X	X
GOOB2	*Goodyera oblongifolia*	Orchidaceae				X	X						
GUSA2	*Gutierrezia sarothrae*	Asteraceae						X	X	X	X	X	X
HAGL	*Halogeton glomeratus*	Chenopodiaceae							X				
HECO26	*Hesperostipa comata*	Poaceae	X					X					
HENE5	*Hesperostipa neomexicana*	Poaceae			X							X	
HIJA	*Hilaria jamesii*	Poaceae		X					X	X	X		X
HYAC4	*Hymenoxys acaulis*	Asteraceae									X		
IPAG	*Ipomopsis aggregata*	Polemoniaceae	X										
JUCO6	*Juniperus communis*	Cupressaceae				X	X						
JUMO	*Juniperus monosperma*	Cupressaceae			X							X	
JUOS	*Juniperus osteosperma*	Cupressaceae	X					X		X	X		X
KOMA	*Koeleria macrantha*	Poaceae	X					X					
LAOC3	*Lappula occidentalis*	Boraginaceae		X	X			X	X	X	X		
LARE	*Lappula redowskii*	Boraginaceae								X			
LASE	*Lactuca serriola*	Asteraceae								X			
LATA	*Lactuca tatarica*	Asteraceae	X					X					
LEMO2	*Lepidium montanum*	Brassicaceae									X		
LEPE2	*Lepidium perfoliatum*	Brassicaceae						X			X		
LEPU	*Leptodactylon pungens*	Polemoniaceae						X		X			
LIAR3	*Linum aristatum*	Linaceae		X					X				
LUAR3	*Lupinus argenteus*	Fabaceae				X							
LUCA	*Lupinus caudatus*	Fabaceae	X					X					
MACA2	*Machaeranthera canescens*	Asteraceae		X					X				
MAFR3	*Mahonia fremontii*	Berberidaceae									X		
MARE11	*Mahonia repens*	Berberidaceae	X			X	X						
MATA2	*Machaeranthera tanacetifolia*	Asteraceae							X				
MEAL6	*Mentzelia albicaulis*	Loasaceae		X	X				X		X	X	

Species code	Species name	Family name	Brushy Loam	Desert Sand (Sand Sagebrush)	Limy Upland, 6-10" pz	Loamy Hills, 25-33" pz	Loamy Hills, Cold, 25-33" pz	Loamy Mesa Top PJ	Semidesert Alkali Sandy Loam (Alkali Sacaton)	Semidesert Loam (Wyoming Big Sagebrush)	Semidesert Shallow Sandy Loam (PJ)	Shallow Loamy, 10-14" pz	Upland Shallow Loam (Pinyon-Utah Juniper)
MUSQ	*Munroa squarrosa*	Poaceae							X				
OECE2	*Oenothera cespitosa*	Onagraceae							X		X		
OEPA	*Oenothera pallida*	Onagraceae		X					X				
OPER	*Opuntia erinacea*	Cactaceae			X			X	X	X	X	X	
OPPO	*Opuntia polyacantha*	Cactaceae		X							X		
ORHY	*Oryzopsis hymenoides*	Poaceae							X	X			X
PAMY	*Paxistima myrsinites*	Celastraceae	X										
PASM	*Pascopyrum smithii*	Poaceae	X										
PEPU7	*Petradoria pumila*	Asteraceae	X					X			X		X
PHCR	*Phacelia crenulata*	Hydrophyllaceae			X				X		X		
PHHE2	*Phacelia heterophylla*	Hydrophyllaceae	X										
PIED	*Pinus edulis*	Pinaceae	X				X	X			X		X
PIEN	*Picea engelmannii*	Pinaceae				X	X						
PIPO	*Pinus ponderosa*	Pinaceae				X	X						
PLJA	*Pleuraphis jamesii*	Poaceae			X							X	
PLPA2	*Plantago patagonica*	Plantaginaceae		X					X	X	X		
POFE	*Poa fendleriana*	Poaceae	X			X	X	X			X		X
POSA12	*Poa sandbergii*	Poaceae											X
POSE	*Poa secunda*	Poaceae								X			
POTR5	*Populus tremuloides*	Salicaceae				X	X						
PSME	*Pseudotsuga menziesii*	Pinaceae				X	X						
PSSP	*Psilostrophe sparsiflora*	Asteraceae			X								
PTAQ	*Pteridium aquilinum*	Dennstaedtiaceae				X	X						
PUME	*Purshia mexicana*	Rosaceae									X		X
PUTR2	*Purshia tridentata*	Rosaceae	X					X					X
PYCH	*Pyrola chlorantha*	Pyrolaceae				X	X						
QUGA	*Quercus gambelii*	Fagaceae	X										
RATE	*Ranunculus testiculatus*	Ranunculaceae						X		X	X		
SAIB	*Salsola iberica*	Chenopodiaceae							X	X			
SAKA	*Salsola kali*	Chenopodiaceae			X							X	
SAPA8	*Salsola paulsenii*	Chenopodiaceae		X					X				
SAPE10	*Salsola pestifer*	Chenopodiaceae		X							X		

Species code	Species name	Family name	Brushy Loam	Desert Sand (Sand Sagebrush)	Limy Upland, 6-10" pz	Loamy Hills, 25-33" pz	Loamy Hills, Cold, 25-33" pz	Loamy Mesa Top PJ	Semidesert Alkali Sandy Loam (Alkali Sacaton)	Semidesert Loam (Wyoming Big Sagebrush)	Semidesert Shallow Sandy Loam (PJ)	Shallow Loamy, 10-14" pz	Upland Shallow Loam (Pinyon-Utah Juniper)
SAVE4	*Sarcobatus vermiculatus*	Chenopodiaceae							X	X			
SCWH	*Sclerocactus whipplei*	Cactaceae									X		
SEMU3	*Senecio multilobatus*	Asteraceae				X	X	X			X		
SHRO	*Shepherdia rotundifolia*	Elaeagnaceae											X
SIAL2	*Sisymbrium altissimum*	Brassicaceae	X							X			
SIHY	*Sitanion hystrix*	Poaceae							X	X			X
SISC7	*Silene scouleri*	Caryophyllaceae					X						
SPAI	*Sporobolus airoides*	Poaceae			X				X			X	
SPCO	*Sphaeralcea coccinea*	Malvaceae	X	X				X	X	X	X		
SPCO4	*Sporobolus contractus*	Poaceae							X				
SPCR	*Sporobolus cryptandrus*	Poaceae							X				
SPGR2	*Sphaeralcea grossulariifolia*	Malvaceae		X									
SPHA	*Sphaeralcea hastulata*	Malvaceae			X								
SPPA2	*Sphaeralcea parvifolia*	Malvaceae			X				X			X	
STCO4	*Stipa comata*	Poaceae								X			
STEX	*Stephanomeria exigua*	Asteraceae		X							X		
STHY6	*Stipa hymenoides*	Poaceae		X				X			X		
STLO4	*Streptanthella longirostris*	Brassicaceae	X	X				X	X	X	X		
STPI	*Stanleya pinnata*	Brassicaceae										X	X
SYOR2	*Symphoricarpos oreophilus*	Caprifoliaceae	X			X							
TESP2	*Tetradymia spinosa*	Asteraceae							X				
THFE	*Thalictrum fendleri*	Ranunculaceae				X							
THSU	*Thelesperma subnudum*	Asteraceae							X				
TOAN	*Townsendia annua*	Asteraceae		X									
UNGRCA1	unkGRCA1 (*Carex* sp.)	Cyperaceae				X	X						
VUOC	*Vulpia octoflora*	Poaceae							X	X			
WYAR	*Wyethia arizonica*	Asteraceae	X										
YUBA	*Yucca baccata*	Agavaceae	X					X			X		
YUHA	*Yucca harrimaniae*	Agavaceae									X		
ZIGR	*Zinnia grandiflora*	Asteraceae			X								
ZIPA2	*Zigadenus paniculatus*	Liliaceae								X	X		

Appendix B—Within-Macroplot Variability of Cover Estimates by Sampling Technique and Ecological Site

Ecological site	Table	Page
Brushy Loam	B1	67
Desert Sand (Sand Sagebrush)	B2	68
Limy Upland, 6-10" pz	B3	69
Loamy Hills, 25-33" pz	B4	70
Loamy Hills, Cold, 25-33" pz	B5	71
Loamy Mesa Top PJ	B6	72
Semidesert Alkali Sandy Loam (Alkali Sacaton)	B7	73
Semidesert Loam (Wyoming Big Sagebrush)	B8	74
Semidesert Shallow Sandy Loam PJ	B9	75
Shallow Loamy, 10-14" pz	B10	76
Upland Shallow Loam (Pinyon-Utah Juniper)	B11	77

Table B1. Summary of mean cover estimates for selected cover measures across five Brushy Loam macroplots at Mesa Verde National Park, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Brushy Loam ecological site, n = 5 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	49.7	18.1	7.4	24.0	100.0	36.5	54	16	12.3	11.1	3.3
	1-m^2	43.4	26.2	10.8	37.3	100.0	60.1	143	38	5.5	13.1	3.5
	Line-point	52.8	23.7	16.4	33.2	98.7	45.5	81	22	5.0	6.8	1.8
AMUT	10-m^2	6.5	10.9	4.5	18.7	56.8	205.5	1077	270	12.3	220.8	55.4
	1-m^2	3.2	9.2	0.4	22.3	25.3	259.7	3216	804	5.5	294.8	73.7
	Line-point	5.2	9.2	2.6	15.4	26.7	227.7	1198	300	5.0	99.8	25.0
POFE	10-m^2	9.6	8.8	0.2	22.6	62.7	145.0	324	84	12.3	66.4	17.2
	1-m^2	7.6	10.2	0.2	32.2	52.7	219.3	684	174	5.5	62.7	16.0
	Line-point	8.8	11.3	2.5	18.1	42.7	173.8	635	162	5.0	52.9	13.5
QUGA	10-m^2	14.5	13.3	4.5	24.2	46.9	213.3	320	83	12.3	65.6	17.0
	1-m^2	16.2	20.7	2.6	35.7	39.3	237.6	633	161	5.5	58.0	14.8
	Line-point	14.5	14.4	2.6	27.4	44.7	188.4	384	99	5.0	32.0	8.3
Bare soil	10-m^2	14.3	9.9	5.2	13.9	95.8	88.4	190	50	12.3	39.0	10.3
	1-m^2	16.8	17.1	9.3	28.4	79.3	158.8	398	102	5.5	36.5	9.4
	Line-point	41.3	18.9	15.2	21.8	83.3	79.8	83	23	5.0	6.9	1.9
Litter	10-m^2	70.4	15.8	8.8	22.1	100.0	25.3	22	8	12.3	4.5	1.6
	1-m^2	75.4	19.8	10.5	31.4	100.0	29.6	30	10	5.5	2.8	0.9
	Line-point	52.3	18.7	9.8	23.9	95.3	49.1	52	15	5.0	4.3	1.3
BSC	10-m^2	0.2	0.6	0.2	0.9	21.0	214.7	3998	1005	12.3	819.6	206.0
	1-m^2	0.1	0.4	0.2	0.8	7.3	380.7	6777	1695	5.5	621.2	155.4
	Line-point	0.2	2.2	1.8	2.6	2.0	467.5	46482	11621	5.0	3873.5	968.4

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B2. Summary of mean cover estimates for selected cover measures across two Desert Sand macroplots at Canyonlands National Park, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Desert Sand (Sand Sagebrush) ecological site, n = 2 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	13.4	3.7	3.4	4.0	100.0	27.7	32	10	8.8	4.7	1.5
	1-m^2	12.3	7.7	6.5	8.8	100.0	61.9	151	40	4.6	11.6	3.1
	Line-point	11.7	11.1	10.2	12.1	68.3	95.4	350	90	3.6	21.0	5.4
ATCA2	10-m^2	1.5	2.3	2.3	2.3	50.0	170.8	973	243	8.8	142.7	35.6
	1-m^2	1.7	7.1	5.1	9.1	11.7	426.8	7174	1794	4.6	550.0	137.5
	Line-point	1.3	3.7	2.5	4.8	11.7	311.3	2944	736	3.6	176.6	44.2
HIJA	10-m^2	1.7	2.3	2.2	2.4	57.1	148.5	659	168	8.8	96.7	24.6
	1-m^2	1.1	2.1	1.6	2.5	35.0	194.2	1309	348	4.6	100.4	26.7
	Line-point	1.2	4.4	3.1	5.7	8.3	366.8	5412	1354	3.6	324.7	81.2
STHY6	10-m^2	0.6	0.7	0.2	1.1	69.0	115.1	418	107	8.8	61.3	15.7
	1-m^2	0.5	0.5	0.3	0.7	40.0	192.2	389	100	4.6	29.8	7.7
	Line-point	1.8	3.3	1.8	4.8	18.3	345.8	1253	313	3.6	75.2	18.8
Litter	10-m^2	6.9	4.4	3.4	5.3	100.0	63.0	158	42	8.8	23.2	6.2
	1-m^2	6.6	5.1	4.7	5.5	100.0	78.2	231	61	4.6	17.7	4.7
	Line-point	8.3	8.9	7.2	10.7	56.7	108.3	441	113	3.6	26.5	6.8
Undifferentiated crust	10-m^2	67.6	14.7	12.4	17.0	97.6	22.1	21	8	8.8	3.1	1.2
	1-m^2	79.1	10.6	10.2	11.0	100.0	13.4	10	5	4.6	0.8	0.4
	Line-point	81.5	14.6	14.1	15.1	100.0	18.0	15	6	3.6	0.9	0.4
BSC	10-m^2	4.3	3.9	0.9	7.0	92.9	91.4	325	84	8.8	47.7	12.3
	1-m^2	4.8	4.4	1.6	7.1	70.0	113.8	326	84	4.6	25.0	6.4
	Line-point	6.7	7.6	3.8	11.5	40.0	162.9	504	129	3.6	30.2	7.7

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B3. Summary of mean cover estimates for selected cover measures across five Limy Upland macroplots at Wupatki National Monument, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes.

Limy Upland, 6-10" pz ecological site, n = 5 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	23.6	6.0	3.9	8.0	100.0	26.5	28	9	7.3	3.4	1.1
	1-m^2	16.0	5.3	3.1	8.8	100.0	33.1	45	15	3.7	2.8	0.9
	Line-point	26.7	15.8	13.0	18.7	93.3	59.9	138	37	3.3	7.6	2.0
CHLE4	10-m^2	5.1	3.6	1.8	6.3	92.0	92.0	187	49	7.3	22.8	6.0
	1-m^2	3.5	2.1	1.4	2.9	80.0	95.8	142	38	3.7	8.8	2.3
	Line-point	3.6	6.6	3.1	10.1	27.3	184.5	1280	320	3.3	70.4	17.6
HENE5	10-m^2	3.7	3.0	1.8	6.5	84.8	125.1	248	65	7.3	30.2	7.9
	1-m^2	2.8	2.3	1.0	3.6	65.3	150.9	258	75	3.7	15.9	4.6
	Line-point	6.5	8.9	6.8	12.5	40.0	130.7	720	183	3.3	39.6	10.1
PLJA	10-m^2	4.4	3.4	1.7	6.1	74.5	149.0	233	61	7.3	28.3	7.4
	1-m^2	2.3	1.8	0.8	3.2	70.0	132.0	237	62	3.7	14.6	3.8
	Line-point	6.7	7.4	1.8	11.0	44.7	226.8	462	118	3.3	25.4	6.5
Bare soil	10-m^2	7.3	5.0	0.9	12.8	100.0	67.4	181	48	7.3	22.0	5.8
	1-m^2	7.3	6.2	1.3	14.0	97.3	87.4	282	73	3.7	17.4	4.5
	Line-point	16.3	12.5	5.1	26.4	59.3	112.0	227	59	3.3	12.5	3.2
Litter	10-m^2	6.6	4.4	2.4	6.0	100.0	64.9	167	44	7.3	20.3	5.4
	1-m^2	7.1	4.9	2.6	9.7	100.0	66.3	181	47	3.7	11.2	2.9
	Line-point	3.6	10.2	9.2	11.2	21.3	116.5	3084	771	3.3	169.6	42.4

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B4. Summary of mean cover estimates for selected cover measures across five Loamy Hills macroplots at Grand Canyon National Park, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Loamy Hills, 25-33" pz ecological site, n = 5 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	19.7	15.8	3.0	32.2	100.0	74.8	248	65	8.9	36.8	9.6
	1-m^2	23.8	27.1	5.2	52.8	94.7	120.4	502	128	4.1	34.3	8.7
	Line-point	16.9	13.8	9.6	23.3	72.0	90.6	257	67	4.0	17.1	4.5
POFE	10-m^2	0.5	1.0	0.1	2.1	39.6	230.9	1451	363	8.9	215.2	53.8
	1-m^2	0.4	0.7	0.3	1.2	25.3	220.8	1280	320	4.1	87.5	21.9
	Line-point	1.5	3.7	1.8	4.9	15.3	282.4	2238	560	4.0	149.2	37.3
POTR5	10-m^2	2.6	3.7	0.2	6.7	55.2	176.0	775	197	8.9	115.0	29.2
	1-m^2	4.1	10.5	0.4	19.5	36.7	261.7	2551	638	4.1	174.3	43.6
	Line-point	1.8	4.4	2.6	6.4	16.0	251.1	2285	572	4.0	152.3	38.1
UNGRCA1 (*Carex* sp.)	10-m^2	1.4	1.7	0.2	2.5	74.7	142.7	529	135	8.9	78.5	20.0
	1-m^2	1.2	1.5	0.4	2.1	54.7	177.2	586	150	4.1	40.0	10.3
	Line-point	6.5	10.0	5.2	12.6	40.0	123.4	925	232	4.0	61.7	15.5
Bare soil	10-m^2	1.5	1.9	1.3	2.3	72.2	126.9	571	145	8.9	84.7	21.5
	1-m^2	1.9	3.2	1.4	6.6	53.3	157.5	1059	265	4.1	72.4	18.1
	Line-point	14.9	17.1	9.0	28.0	49.3	138.0	502	128	4.0	33.5	8.5
Litter	10-m^2	74.8	11.8	8.8	20.1	100.0	16.6	12	5	8.9	1.8	0.7
	1-m^2	80.1	15.6	5.2	22.6	99.3	20.2	18	7	4.1	1.2	0.5
	Line-point	69.3	22.1	15.5	36.3	98.7	33.2	42	13	4.0	2.8	0.9
BSC	10-m^2	0.7	1.3	0.1	4.1	36.8	275.1	1242	310	8.9	184.2	46.0
	1-m^2	0.6	1.5	0.3	3.5	23.3	291.1	2498	625	4.1	170.7	42.7
	Line-point	0.3	2.9	1.8	4.0	2.0	475.2	46261	11609	4.0	3084.1	773.9

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B5. Summary of mean cover estimates for selected cover measures across two Loamy Hills, Cold, macroplots at Grand Canyon National Park, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Loamy Hills, Cold, 25-33" pz ecological site, n = 2 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	48.8	31.6	29.3	33.9	100.0	64.9	164	43	7.3	20.0	5.2
	1-m^2	57.3	42.5	33.7	51.2	100.0	78.3	211	56	2.8	9.8	2.6
	Line-point	25.7	18.9	17.9	19.9	85.0	74.5	209	55	5.7	19.9	5.2
ABCO	10-m^2	8.6	25.8	25.8	25.8	31.0	149.5	3432	858	7.3	417.6	104.4
	1-m^2	12.9	29.6	29.6	29.6	33.3	115.1	2036	509	2.8	95.0	23.8
	Line-point	4.5	11.8	11.8	11.8	23.3	131.6	2664	666	5.7	253.1	63.3
PIEN	10-m^2	6.9	15.7	13.6	17.8	28.6	311.7	2004	501	7.3	243.8	61.0
	1-m^2	8.3	26.1	26.1	26.1	21.7	157.9	3831	958	2.8	178.8	44.7
	Line-point	4.2	8.1	3.7	12.5	20.0	355.4	1445	362	5.7	137.3	34.4
POTR5	10-m^2	4.7	9.3	5.2	13.3	59.5	186.3	1478	370	7.3	179.8	45.0
	1-m^2	6.2	13.5	8.3	18.7	38.3	210.8	1805	452	2.8	84.2	21.1
	Line-point	1.0	3.0	2.5	3.5	10.0	319.9	3458	865	5.7	328.5	82.2
Bare soil	10-m^2	2.5	4.0	4.0	4.0	83.3	160.4	984	246	7.3	119.7	29.9
	1-m^2	1.8	3.3	2.3	4.4	51.7	183.9	1323	331	2.8	61.7	15.4
	Line-point	4.0	9.2	5.8	12.5	21.7	226.8	2024	506	5.7	192.3	48.1
Litter	10-m^2	70.2	15.3	14.4	16.1	100.0	21.7	21	8	7.3	2.6	1.0
	1-m^2	80.4	13.4	12.6	14.2	100.0	16.7	14	6	2.8	0.7	0.3
	Line-point	81.3	16.9	16.4	17.3	100.0	20.7	19	7	5.7	1.8	0.7
BSC	10-m^2	1.1	1.3	0.7	1.9	78.6	132.3	593	151	7.3	72.1	18.4
	1-m^2	1.2	3.0	2.9	3.1	41.7	317.6	2454	613	2.8	114.5	28.6
	Line-point	1.0	4.8	4.8	4.8	8.3	242.1	8999	2250	5.7	854.9	213.8

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B6. Summary of mean cover estimates for selected cover measures across five Loamy Mesa Top PJ macroplots at Mesa Verde National Park, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Loamy Mesa Top PJ ecological site, n = 5 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	32.7	20.2	11.7	31.3	91.2	157.9	149	39	8.6	21.4	5.6
	1-m^2	29.6	31.1	15.2	49.8	58.7	198.8	425	109	3.5	24.8	6.4
	Line-point	20.7	15.5	11.6	18.3	46.7	133.4	215	57	4.2	15.1	4.0
JUOS	10-m^2	7.7	11.9	6.0	17.4	67.2	162.4	903	226	8.6	129.4	32.4
	1-m^2	9.8	18.6	6.1	32.4	36.7	214.2	1396	349	3.5	81.4	20.4
	Line-point	3.4	5.8	4.1	7.8	28.0	179.8	1134	284	4.2	79.4	19.9
PIED	10-m^2	12.4	13.8	7.7	23.8	73.7	128.6	473	121	8.6	67.8	17.3
	1-m^2	10.9	21.9	10.5	27.5	36.7	207.4	1566	392	3.5	91.4	22.9
	Line-point	7.3	10.7	4.6	13.6	44.7	151.0	812	203	4.2	56.8	14.2
POFE	10-m^2	7.0	4.7	0.1	8.5	98.7	60.9	176	46	8.6	25.2	6.6
	1-m^2	4.7	5.0	0.5	8.3	85.3	106.7	420	108	3.5	24.5	6.3
	Line-point	7.7	8.6	4.1	14.2	55.3	128.7	485	124	4.2	34.0	8.7
Bare soil	10-m^2	2.1	3.7	0.6	8.6	100.0	63.9	1191	298	8.6	170.7	42.7
	1-m^2	2.3	5.1	0.5	12.1	98.7	107.0	1908	477	3.5	111.3	27.8
	Line-point	7.1	8.0	4.6	11.1	84.0	75.2	478	122	4.2	33.5	8.5
Litter	10-m^2	47.2	29.1	23.2	34.7	100.0	63.0	149	39	8.6	21.4	5.6
	1-m^2	50.5	34.0	29.7	39.0	100.0	71.7	178	47	3.5	10.4	2.7
	Line-point	47.5	22.7	16.6	25.6	94.7	52.6	90	25	4.2	6.3	1.8
BSC	10-m^2	3.9	3.7	2.0	5.2	97.1	97.4	346	89	8.6	49.6	12.8
	1-m^2	5.4	7.8	1.9	14.9	77.3	132.5	796	202	3.5	46.4	11.8
	Line-point	7.4	10.0	7.4	13.6	46.0	152.4	708	180	4.2	49.6	12.6

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B7. Summary of mean cover estimates for selected cover measures across five Semidesert Alkali Sandy Loam macroplots at Capitol Reef National Park, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site, n = 5 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	20.3	8.8	4.5	16.9	100.0	45.5	75	21	8.8	11.0	3.1
	1-m^2	18.1	12.7	6.1	20.1	98.7	72.8	193	50	4.4	14.2	3.7
	Line-point	25.4	16.4	11.9	19.4	85.3	71.7	163	43	2.4	6.5	1.7
ATCO	10-m^2	2.6	3.1	1.0	5.2	71.6	138.2	554	141	8.8	81.3	20.7
	1-m^2	2.5	4.4	1.3	12.4	46.7	186.0	1178	295	4.4	86.4	21.6
	Line-point	3.1	7.6	5.9	9.7	20.7	205.3	2378	595	2.4	95.1	23.8
GIIN2	10-m^2	0.3	0.2	0.2	0.3	56.8	95.0	252	66	8.8	37.0	9.7
	1-m^2	0.4	0.5	0.4	0.5	38.7	140.0	567	145	4.4	41.6	10.6
	Line-point	0.3	2.7	1.8	3.5	3.3	405.8	24697	6156	2.4	987.9	246.2
ORHY	10-m^2	0.5	0.5	0.1	0.8	86.1	85.7	310	80	8.8	45.5	11.7
	1-m^2	0.6	0.6	0.5	0.7	55.3	100.7	355	92	4.4	26.0	6.7
	Line-point	1.2	3.8	2.5	6.6	10.0	307.5	3873	969	2.4	154.9	38.8
Bare soil	10-m^2	0.8	1.6	0.3	4.1	75.4	162.2	1337	335	8.8	196.1	49.1
	1-m^2	1.2	1.5	0.5	2.7	63.3	178.7	654	166	4.4	48.0	12.2
	Line-point	4.3	6.6	2.6	8.6	33.3	201.8	892	223	2.4	35.7	8.9
Litter	10-m^2	9.7	7.0	1.2	9.3	98.7	78.1	203	54	8.8	29.8	7.9
	1-m^2	10.6	15.0	1.9	23.5	98.7	138.2	770	195	4.4	56.5	14.3
	Line-point	5.5	7.5	2.6	11.3	37.3	182.6	723	184	2.4	28.9	7.4
BSC	10-m^2	1.8	1.5	0.4	4.3	78.7	94.4	273	71	8.8	40.0	10.4
	1-m^2	1.5	1.5	0.6	2.9	58.0	126.7	411	106	4.4	30.1	7.8
	Line-point	3.3	6.5	3.5	9.7	22.7	233.9	1502	376	2.4	60.1	15.0

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B8. Summary of mean cover estimates for selected cover measures across five Semidesert Loam macroplots at Dinosaur National Monument, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Semidesert Loam (Wyoming Big Sagebrush) ecological site, n = 5 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	32.2	11.1	7.9	16.9	100.0	36.6	49	14	8.4	6.9	2.0
	1-m^2	20.2	13.0	9.1	19.4	100.0	67.9	163	43	4.8	13.0	3.4
	Line-point	53.8	22.8	20.3	25.5	98.7	48.4	72	20	3.9	4.7	1.3
ARTR2	10-m^2	9.6	7.0	1.2	10.7	83.6	93.9	205	54	8.4	28.7	7.6
	1-m^2	5.3	7.0	0.7	10.2	58.0	223.0	674	171	4.8	53.9	13.7
	Line-point	4.8	7.9	6.3	9.2	36.0	137.4	1044	261	3.9	67.9	17.0
BRTE	10-m^2	11.9	9.1	2.7	24.7	93.7	114.4	227	60	8.4	31.8	8.4
	1-m^2	7.3	7.7	1.6	22.0	77.3	140.0	431	111	4.8	34.5	8.9
	Line-point	30.1	20.1	14.2	29.4	80.0	90.3	174	46	3.9	11.3	3.0
STCO4	10-m^2	2.5	3.0	0.3	9.4	62.7	97.8	544	139	8.4	76.2	19.5
	1-m^2	1.3	1.6	0.5	3.4	48.0	134.5	568	145	4.8	45.4	11.6
	Line-point	4.2	12.7	5.9	19.5	16.0	164.5	3518	880	3.9	228.7	57.2
Bare soil	10-m^2	0.7	0.7	0.2	1.9	72.0	93.5	372	96	8.4	52.1	13.4
	1-m^2	1.1	1.6	0.4	3.7	51.3	159.7	843	211	4.8	67.4	16.9
	Line-point	10.5	10.6	4.9	15.9	57.3	109.2	394	101	3.9	25.6	6.6
Litter	10-m^2	34.2	14.3	9.3	22.0	98.7	46.7	70	20	8.4	9.8	2.8
	1-m^2	35.0	22.9	17.7	27.8	100.0	85.3	167	44	4.8	13.4	3.5
	Line-point	29.8	16.5	13.0	20.3	83.3	69.5	121	32	3.9	7.9	2.1
BSC	10-m^2	5.5	5.5	1.1	12.9	100.0	88.2	384	99	8.4	53.8	13.9
	1-m^2	5.5	4.8	1.1	15.1	98.7	68.6	285	74	4.8	22.8	5.9
	Line-point	12.1	11.6	6.3	20.4	60.0	107.6	356	92	3.9	23.1	6.0

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B9. Summary of mean cover estimates for selected cover measures across seven Semidesert Shallow Sandy Loam macroplots at Arches and Canyonlands National Parks, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site, n = 7 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	18.8	11.7	6.0	18.4	98.6	65.1	152	40	7.9	20.0	5.3
	1-m^2	16.4	14.7	10.2	25.1	96.7	96.0	311	81	3.8	19.7	5.1
	Line-point	13.3	13.2	7.0	23.6	66.7	102.3	380	98	2.5	15.8	4.1
CORA	10-m^2	10.3	7.5	5.5	11.4	68.3	106.5	202	53	7.9	26.6	7.0
	1-m^2	9.2	9.8	4.8	12.9	72.4	130.7	438	112	3.8	27.7	7.1
	Line-point	6.2	7.4	5.1	11.0	46.7	135.4	548	140	2.5	22.8	5.8
FEOC3	10-m^2	0.5	0.8	0.1	4.4	68.8	108.9	961	241	7.9	126.5	31.7
	1-m^2	0.5	0.4	0.3	0.5	49.0	129.4	283	73	3.8	17.9	4.6
	Line-point	0.9	4.1	2.5	8.3	7.1	320.0	7923	1981	2.5	330.1	82.5
Bare soil	10-m^2	1.0	1.2	0.0	4.0	88.8	92.1	572	146	7.9	75.3	19.2
	1-m^2	1.5	2.2	0.5	5.7	58.6	141.2	833	209	3.8	52.8	13.2
	Line-point	4.3	7.3	4.6	10.1	29.5	198.7	1103	276	2.5	46.0	11.5
Litter	10-m^2	5.6	8.7	1.5	18.8	99.3	149.9	920	230	7.9	121.1	30.3
	1-m^2	6.0	12.0	1.4	23.7	99.0	181.5	1575	394	3.8	99.8	25.0
	Line-point	3.6	7.3	2.6	18.1	19.5	303.4	1555	389	2.5	64.8	16.2
Crusundi	10-m^2	69.8	16.7	0.0	28.7	99.3	30.9	25	8	7.9	3.3	1.1
	1-m^2	73.7	19.7	5.6	33.4	96.7	29.9	30	10	3.8	1.9	0.6
	Line-point	70.4	18.7	13.7	28.0	98.6	30.3	30	10	2.5	1.3	0.4
BSC	10-m^2	5.6	5.1	2.8	8.5	89.5	106.2	321	83	7.9	42.3	10.9
	1-m^2	6.3	6.5	2.3	11.6	81.0	113.9	400	103	3.8	25.3	6.5
	Line-point	10.8	11.9	3.8	17.8	51.4	133.4	464	119	2.5	19.3	5.0

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B10. Summary of mean cover estimates for selected cover measures across two Shallow Loamy macroplots at Wupatki National Monument, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes.

Shallow Loamy, 10-14" pz ecological site, n = 2 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	18.3	7.4	5.8	9.0	100.0	43.0	66	19	6.5	7.2	2.1
	1-m^2	17.2	13.8	10.7	17.0	100.0	87.4	250	65	3.4	14.2	3.7
	Line-point	27.3	12.8	9.6	16.0	90.0	54.9	88	24	3.0	4.4	1.2
CHLE4	10-m^2	2.0	1.6	0.6	2.6	95.2	89.3	252	66	6.5	27.3	7.2
	1-m^2	1.7	2.2	1.2	3.1	71.7	124.1	625	159	3.4	35.4	9.0
	Line-point	3.0	4.4	2.5	6.3	26.7	249.2	831	208	3.0	41.6	10.4
HENE5	10-m^2	3.5	3.7	1.8	5.5	92.9	102.2	428	110	6.5	46.4	11.9
	1-m^2	2.3	2.1	1.3	2.9	81.7	92.2	335	87	3.4	19.0	4.9
	Line-point	6.2	7.6	4.3	10.8	43.3	146.3	578	147	3.0	28.9	7.4
PLJA	10-m^2	4.5	3.4	2.3	4.4	100.0	77.6	210	55	6.5	22.8	6.0
	1-m^2	4.3	3.5	2.1	5.0	93.3	85.6	262	68	3.4	14.8	3.9
	Line-point	7.2	8.7	6.8	10.7	48.3	128.2	572	146	3.0	28.6	7.3
Bare soil	10-m^2	1.8	1.7	1.2	2.2	100.0	93.7	349	90	6.5	37.8	9.8
	1-m^2	3.5	5.1	1.7	8.6	98.3	127.0	807	202	3.4	45.7	11.4
	Line-point	9.3	11.4	8.6	14.3	50.0	149.0	579	147	3.0	29.0	7.4
Litter	10-m^2	6.4	5.1	4.7	5.6	92.9	81.5	251	65	6.5	27.2	7.0
	1-m^2	8.5	12.2	11.1	13.3	95.0	143.2	789	200	3.4	44.7	11.3
	Line-point	8.8	9.5	8.9	10.1	56.7	114.7	444	114	3.0	22.2	5.7

* frequency for line-point sampling was calculated on the basis of 10-point groups

Table B11. Summary of mean cover estimates for selected cover measures across five Upland Shallow Loam macroplots at Capitol Reef National Parks, within-macroplot variation in cover estimates summarized across macroplots, subsample sizes required to achieve 10 and 20 percent precision in estimates of macroplot-level means, and estimated amounts of sampling time required to achieve those degrees of precision. See Appendix C for macroplot-level tables summarizing within-plot variability. See Appendix A for key to species codes (BSC = biological soil crust).

Upland Shallow Loam (Pinyon-Utah Juniper) ecological site, n = 5 macroplots												
			Within-macroplot variation in cover estimates (summarized across macroplots)					Subsample size (by precision)			Subsample time (hrs by precision)	
Measure	Method	Mean cover	Mean sd	Min sd	Max sd	Mean freq*	Mean CV	10%	20%	Unit time (min)	10%	20%
Total live understory canopy cover	10-m^2	16.5	19.7	11.3	29.3	96.0	117.4	546	139	5.3	48.2	12.3
	1-m^2	15.4	24.5	18.9	30.8	88.7	176.4	976	244	2.8	45.5	11.4
	Line-point	11.7	13.3	9.2	15.4	56.0	126.3	491	126	2.3	18.8	4.8
CEMO2	10-m^2	1.9	6.1	5.0	7.1	18.7	204.3	4159	1040	5.3	367.4	91.9
	1-m^2	1.3	5.5	1.4	12.3	12.0	252.6	6828	1709	2.8	318.6	79.8
	Line-point	2.4	11.3	8.3	14.2	13.3	192.5	8456	2114	2.3	324.1	81.0
COWR2	10-m^2	1.2	1.3	1.0	1.8	80.4	116.9	484	124	5.3	42.8	11.0
	1-m^2	1.1	1.2	0.8	2.3	63.3	115.1	482	124	2.8	22.5	5.8
	Line-point	2.3	5.9	3.5	9.4	18.7	208.8	2424	606	2.3	92.9	23.2
JUOS	10-m^2	5.6	12.1	9.7	17.0	29.0	228.0	1792	448	5.3	158.3	39.6
	1-m^2	4.8	13.9	2.6	19.4	15.3	307.2	3168	792	2.8	147.8	37.0
	Line-point	2.5	5.8	2.6	8.0	17.3	255.7	2022	506	2.3	77.5	19.4
Bare soil	10-m^2	1.1	1.4	0.1	2.5	95.8	108.1	588	150	5.3	51.9	13.3
	1-m^2	1.6	1.5	1.1	2.0	86.7	98.5	367	95	2.8	17.1	4.4
	Line-point	15.3	13.5	10.1	19.4	72.7	96.8	300	78	2.3	11.5	3.0
Litter	10-m^2	16.8	22.1	9.9	28.1	100.0	142.2	667	170	5.3	58.9	15.0
	1-m^2	22.0	31.4	23.3	39.5	99.3	169.9	783	198	2.8	36.5	9.2
	Line-point	6.8	11.4	5.9	16.4	32.7	209.9	1071	268	2.3	41.1	10.3
BSC	10-m^2	0.1	0.2	0.2	0.2	15.2	221.0	2661	666	5.3	235.1	58.8
	1-m^2	0.1	0.3	0.2	0.5	6.0	399.7	7197	1827	2.8	335.9	85.3
	Line-point	0.2	2.2	1.8	2.5	2.0	464.1	45641	11411	2.3	1749.6	437.4

* frequency for line-point sampling was calculated on the basis of 10-point groups

Appendix C—Summaries of Frequency and Cover Estimates by Macroplot and Sampling Technique

Ecological site	Macroplot	Phase	Table	Page
Brushy Loam	MEVE1	2	C1	79
	MEVE2	2	C2	80
	MEVE5	3	C3	81
	MEVE6	3	C4	82
	MEVE7b	3	C5	83
Desert Sand (Sand Sagebrush)	CANY1	2	C6	84
	CANY2b	2	C7	85
Limy Upland, 6-10" pz	WUPA1	2	C8	86
	WUPA2	2	C9	87
	WUPA5	3	C10	88
	WUPA6	3	C11	89
	WUPA7	3	C12	90
Loamy Hills, 25-33" pz	GRCA3	2	C13	91
	GRCA4	2	C14	92
	GRCA5	3	C15	93
	GRCA6	3	C16	94
	GRCA7	3	C17	95
Loamy Hills, Cold, 25-33" pz	GRCA1	2	C18	96
	GRCA2	2	C19	97
Loamy Mesa Top PJ	MEVE3	2	C20	98
	MEVE4	2	C21	99
	MEVE8	3	C22	100
	MEVE9	3	C23	101
	MEVE10	3	C24	102
Semidesert Alkali Sandy Loam (Alkali Sacaton)	CARE1	2	C25	103
	CARE2	2	C26	104
	CARE5	3	C27	105
	CARE6	3	C28	106
	CARE7	3	C29	107
Semidesert Loam (Wyoming Big Sagebrush)	DINO1	2	C30	108
	DINO2b	2	C31	109
	DINO3	3	C32	110
	DINO4b	3	C33	111
	DINO5	3	C34	112
Semidesert Shallow Sandy Loam PJ	ARCH1b	2	C35	113
	ARCH2	2	C36	114
	ARCH3	3	C37	115
	ARCH4b	3	C38	116
	ARCH5	3	C39	117
	CANY3	2	C40	118
	CANY4	2	C41	119
Shallow Loamy, 10-14" pz	WUPA3	2	C42	120
	WUPA4	2	C43	121
Upland Shallow Loam (Pinyon-Utah Juniper)	CARE3	2	C44	122
	CARE4b	2	C45	123
	CARE8	3	C46	124
	CARE9	3	C47	125
	CARE10	3	C48	126

Table C1. Summary of frequency (freq) and cover estimates in macroplot MEVE1 (Brushy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Brushy Loam ecological site – MEVE1 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	71.21	21.60	30.34	9.24	12.97		1.16
	1-m^2	30	100.0	62.60	30.26	48.34	10.83	17.30	61.3	1.02
	Line-point	30	93.3	50.00	33.22	66.44	11.89	23.77		0.82
AMUT	10-m^2	21	71.4	15.45	18.67	120.84	7.99	51.68		1.27
	1-m^2	30	46.7	10.77	22.31	207.18	7.98	74.14	12.2	0.88
	Line-point	30	36.7	10.33	15.42	149.24	5.52	53.40		0.85
POFE	10-m^2	21	57.1	0.29	0.25	88.74	0.11	37.95		0.67
	1-m^2	30	33.3	0.33	0.48	143.84	0.17	51.47	0.4	0.78
	Line-point	30	6.7	0.67	2.54	380.56	0.91	136.18		1.56
QUGA	10-m^2	21	95.2	37.40	24.23	64.79	10.37	27.71		1.07
	1-m^2	30	80.0	37.13	31.43	84.64	11.25	30.29	34.8	1.07
	Line-point	30	80.0	30.00	27.42	91.39	9.81	32.70		0.86
Bare soil	10-m^2	21	85.7	7.02	11.46	163.12	4.90	69.76		1.09
	1-m^2	30	43.3	4.23	15.47	365.46	5.54	130.78	6.4	0.66
	Line-point	30	30.0	8.00	17.69	221.18	6.33	79.15		1.25
Litter	10-m^2	21	100.0	76.79	14.94	19.46	6.39	8.32		0.92
	1-m^2	30	100.0	86.03	21.93	25.49	7.85	9.12	83.3	1.03
	Line-point	30	100.0	87.00	18.96	21.80	6.79	7.80		1.04
BSC	10-m^2	21	38.1	0.43	0.88	206.36	0.38	88.26		1.62
	1-m^2	30	3.3	0.03	0.18	547.72	0.07	196.00	0.3	0.13
	Line-point	30	3.3	0.33	1.83	547.72	0.65	196.00		1.26

Table C2. Summary of frequency (freq) and cover estimates in macroplot MEVE2 (Brushy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Brushy Loam ecological site – MEVE 2 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	46.21	23.96	51.85	10.25	22.18		0.93
	1-m^2	30	100.0	48.97	37.26	76.09	13.33	27.23	49.7	0.98
	Line-point	30	100.0	54.00	27.24	50.45	9.75	18.05		1.09
AMUT	10-m^2	21	52.4	3.60	8.30	230.95	3.55	98.78		1.15
	1-m^2	30	26.7	2.80	7.80	278.45	2.79	99.64	3.1	0.89
	Line-point	30	16.7	3.00	7.94	264.79	2.84	94.75		0.96
POFE	10-m^2	21	9.5	0.05	0.15	315.83	0.06	135.08		1.76
	1-m^2	30	3.3	0.03	0.18	547.72	0.07	196.00	0.0	1.24
	Line-point	30	0.0	0.00	-	-	-	-		0.00
QUGA	10-m^2	21	85.7	27.43	22.21	80.99	9.50	34.64		0.91
	1-m^2	30	63.3	29.67	35.70	120.33	12.77	43.06	30.0	0.99
	Line-point	30	83.3	33.00	25.62	77.63	9.17	27.78		1.10
Bare soil	10-m^2	21	100.0	32.26	13.92	43.14	5.95	18.45		0.80
	1-m^2	30	93.3	40.93	28.38	69.33	10.16	24.81	40.2	1.02
	Line-point	30	100.0	47.33	21.80	46.06	7.80	16.48		1.18
Litter	10-m^2	21	100.0	44.19	22.05	49.90	9.43	21.34		0.94
	1-m^2	30	100.0	48.97	31.39	64.10	11.23	22.94	46.8	1.05
	Line-point	30	96.7	47.33	23.92	50.53	8.56	18.08		1.01
BSC	10-m^2	21	0.0	0.00	-	-	-	-		-
	1-m^2	30	0.0	0.00	-	-	-	-	0.0	-
	Line-point	30	0.0	0.00	-	-	-	-		-

Table C3. Summary of frequency (freq) and cover estimates in macroplot MEVE5 (Brushy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Brushy Loam ecological site – MEVE 5 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	44.73	19.60	43.81	9.92	22.17		0.98
	1-m^2	15	100.0	37.13	30.28	81.54	15.32	41.27	45.7	0.81
	Line-point	15	100.0	55.33	17.67	31.94	8.94	16.16		1.21
AMUT	10-m^2	15	60.0	8.20	18.17	221.54	9.19	112.12		1.57
	1-m^2	15	13.3	0.13	0.35	263.90	0.18	133.55	5.2	0.03
	Line-point	15	40.0	7.33	11.63	158.58	5.89	80.25		1.40
POFE	10-m^2	15	73.3	15.03	22.56	150.04	11.41	75.93		0.88
	1-m^2	15	73.3	20.87	32.24	154.50	16.32	78.19	17.1	1.22
	Line-point	15	60.0	15.33	18.07	117.87	9.15	59.65		0.90
QUGA	10-m^2	15	13.3	1.37	4.53	331.43	2.29	167.72		0.68
	1-m^2	15	6.7	0.67	2.58	387.30	1.31	196.00	2.0	0.33
	Line-point	15	26.7	4.00	8.28	207.02	4.19	104.76		1.99
Bare soil	10-m^2	15	93.3	6.67	5.18	77.72	2.62	39.33		0.21
	1-m^2	15	100.0	11.87	17.94	151.21	9.08	76.52	32.2	0.37
	Line-point	15	100.0	78.00	21.11	27.07	10.68	13.70		2.42
Litter	10-m^2	15	100.0	80.83	14.84	18.36	7.51	9.29		1.36
	1-m^2	15	100.0	80.53	19.34	24.01	9.79	12.15	59.6	1.35
	Line-point	15	80.0	17.33	20.86	120.36	10.56	60.91		0.29
BSC	10-m^2	15	13.3	0.07	0.18	263.90	0.09	133.55		1.50
	1-m^2	15	6.7	0.07	0.26	387.30	0.13	196.00	0.0	1.50
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C4. Summary of frequency (freq) and cover estimates in macroplot MEVE6 (Brushy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Brushy Loam ecological site – MEVE 6 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	28.37	7.37	25.99	3.73	13.15		0.83
	1-m^2	15	100.0	25.80	10.75	41.67	5.44	21.09	34.3	0.75
	Line-point	15	100.0	48.67	24.16	49.65	12.23	25.13		1.42
AMUT	10-m^2	15	13.3	1.37	4.53	331.43	2.29	167.72		2.02
	1-m^2	15	0.0	0.00	-	-	-	-	0.7	0.00
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		0.98
POFE	10-m^2	15	73.3	2.30	2.51	108.94	1.27	55.13		0.58
	1-m^2	15	53.3	2.20	3.32	150.95	1.68	76.39	3.9	0.56
	Line-point	15	53.3	7.33	8.84	120.51	4.47	60.98		1.86
QUGA	10-m^2	15	6.7	1.17	4.52	387.30	2.29	196.00		0.93
	1-m^2	15	20.0	1.93	6.94	359.14	3.51	181.74	1.3	1.54
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		0.53
Bare soil	10-m^2	15	100.0	17.27	12.04	69.74	6.09	35.29		0.61
	1-m^2	15	86.7	20.27	14.53	71.71	7.35	36.29	28.5	0.71
	Line-point	15	100.0	48.00	15.21	31.69	7.70	16.04		1.68
Litter	10-m^2	15	100.0	65.83	18.58	28.22	9.40	14.28		1.10
	1-m^2	15	100.0	70.47	16.10	22.85	8.15	11.56	59.9	1.18
	Line-point	15	100.0	43.33	9.76	22.52	4.94	11.40		0.72
BSC	10-m^2	15	0.0	0.00	-	-	-	-		-
	1-m^2	15	0.0	0.00	-	-	-	-	0.0	-
	Line-point	15	0.0	0.00	-	-	-	-		-

Table C5. Summary of frequency (freq) and cover estimates in macroplot MEVE7b (Brushy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Brushy Loam ecological site– MEVE 7b macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	58.10	17.82	30.66	9.02	15.52		1.11
	1-m^2	15	100.0	42.40	22.50	53.06	11.38	26.85	52.2	0.81
	Line-point	15	100.0	56.00	16.39	29.26	8.29	14.81		1.07
AMUT	10-m^2	15	86.7	3.93	4.84	122.95	2.45	62.22		1.09
	1-m^2	15	40.0	2.20	6.36	289.12	3.22	146.31	3.6	0.61
	Line-point	15	33.3	4.67	8.34	178.67	4.22	90.42		1.30
POFE	10-m^2	15	100.0	30.37	18.62	61.33	9.42	31.04		1.39
	1-m^2	15	100.0	14.60	14.53	99.55	7.36	50.38	21.9	0.67
	Line-point	15	93.3	20.67	15.80	76.43	7.99	38.68		0.94
QUGA	10-m^2	15	33.3	5.37	10.83	201.87	5.48	102.16		0.75
	1-m^2	15	26.7	11.40	27.00	236.84	13.66	119.85	7.1	1.60
	Line-point	15	26.7	4.67	8.34	178.67	4.22	90.42		0.65
Bare soil	10-m^2	15	100.0	8.10	7.14	88.17	3.61	44.62		0.60
	1-m^2	15	73.3	6.80	9.27	136.29	4.69	68.97	13.4	0.51
	Line-point	15	86.7	25.33	18.46	72.89	9.34	36.89		1.89
Litter	10-m^2	15	100.0	84.17	8.80	10.45	4.45	5.29		1.04
	1-m^2	15	100.0	91.07	10.47	11.50	5.30	5.82	80.6	1.13
	Line-point	15	100.0	66.67	20.24	30.36	10.24	15.36		0.83
BSC	10-m^2	15	53.3	0.43	0.75	173.72	0.38	87.91		0.87
	1-m^2	15	26.7	0.40	0.83	207.02	0.42	104.76	0.5	0.80
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		1.33

Table C6. Summary of frequency (freq) and cover estimates in macroplot CANY1 (Desert Sand ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Desert Sand (Sand Sagebrush) ecological site – CANY 1 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	13.07	3.45	26.37	1.47	11.28		1.06
	1-m^2	30	100.0	12.13	6.49	53.49	2.32	19.14	12.3	0.99
	Line-point	30	63.3	11.67	12.06	103.36	4.31	36.99		0.95
ATCA2	10-m^2	21	66.7	1.83	2.30	125.67	0.99	53.75		1.02
	1-m^2	30	13.3	1.57	5.13	327.48	1.84	117.19	1.8	0.87
	Line-point	30	16.7	2.00	4.84	242.12	1.73	86.64		1.11
HIJA	10-m^2	21	28.6	1.17	2.36	202.08	1.01	86.43		1.00
	1-m^2	30	23.3	1.00	2.53	253.25	0.91	90.62	1.2	0.86
	Line-point	30	6.7	1.33	5.71	428.51	2.04	153.34		1.14
STHY6	10-m^2	21	38.1	0.19	0.25	130.62	0.11	55.87		0.92
	1-m^2	30	10.0	0.10	0.31	305.13	0.11	109.19	0.2	0.48
	Line-point	30	3.3	0.33	1.83	547.72	0.65	196.00		1.60
Litter	10-m^2	21	100.0	7.69	5.30	68.88	2.27	29.46		0.90
	1-m^2	30	100.0	7.53	5.53	73.35	1.98	26.25	8.5	0.88
	Line-point	30	63.3	10.33	10.66	103.18	3.82	36.92		1.21
Undifferentiated crust	10-m^2	21	100.0	72.02	12.44	17.27	5.32	7.39		0.91
	1-m^2	30	100.0	80.90	10.18	12.58	3.64	4.50	79.2	1.02
	Line-point	30	100.0	84.67	14.08	16.63	5.04	5.95		1.07
BSC	10-m^2	21	85.7	1.02	0.93	90.68	0.40	38.78		0.80
	1-m^2	30	50.0	1.13	1.61	142.34	0.58	50.93	1.3	0.89
	Line-point	30	16.7	1.67	3.79	227.43	1.36	81.38		1.31

Table C7. Summary of frequency (freq) and cover estimates in macroplot CANY2b (Desert Sand ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Desert Sand (Sand Sagebrush) ecological site – CANY 2b macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	13.69	3.98	29.09	1.70	12.44		1.08
	1-m^2	30	100.0	12.53	8.82	70.40	3.16	25.19	12.6	0.99
	Line-point	30	73.3	11.67	10.20	87.42	3.65	31.28		0.92
ATCA2	10-m^2	21	33.3	1.07	2.31	216.02	0.99	92.39		0.93
	1-m^2	30	10.0	1.73	9.12	526.13	3.26	188.27	1.2	1.50
	Line-point	30	6.7	0.67	2.54	380.56	0.91	136.18		0.58
HIJA	10-m^2	21	85.7	2.29	2.17	94.99	0.93	40.63		1.54
	1-m^2	30	46.7	1.17	1.58	135.21	0.56	48.38	1.5	0.79
	Line-point	30	10.0	1.00	3.05	305.13	1.09	109.19		0.67
STHY6	10-m^2	21	100.0	1.10	1.09	99.62	0.47	42.61		0.61
	1-m^2	30	70.0	0.93	0.74	79.25	0.26	28.36	1.8	0.52
	Line-point	30	33.3	3.33	4.79	143.84	1.72	51.47		1.87
Litter	10-m^2	21	100.0	6.05	3.45	57.04	1.48	24.39		1.01
	1-m^2	30	100.0	5.63	4.68	83.06	1.67	29.72	6.0	0.94
	Line-point	30	50.0	6.33	7.18	113.43	2.57	40.59		1.05
Undifferentiated crust	10-m^2	21	95.2	63.10	16.99	26.93	7.27	11.52		0.87
	1-m^2	30	100.0	77.37	10.98	14.20	3.93	5.08	72.9	1.06
	Line-point	30	100.0	78.33	15.10	19.28	5.41	6.90		1.07
BSC	10-m^2	21	100.0	7.55	6.95	92.13	2.97	39.40		0.82
	1-m^2	30	90.0	8.37	7.13	85.24	2.55	30.50	9.2	0.91
	Line-point	30	63.3	11.67	11.47	98.33	4.11	35.19		1.27

Table C8. Summary of frequency (freq) and cover estimates in macroplot WUPA1 (Limy Upland ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes.

Limy Upland, 6-10" pz ecological site – WUPA 1 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	34.40	5.98	17.39	2.56	7.44		1.20
	1-m^2	30	100.0	20.07	5.46	27.20	1.95	9.73	28.6	0.70
	Line-point	30	90.0	31.33	16.34	52.16	5.85	18.67		1.10
CHLE4	10-m^2	21	100.0	10.71	6.26	58.45	2.68	25.00		1.43
	1-m^2	30	100.0	5.40	2.82	52.29	1.01	18.71	7.5	0.72
	Line-point	30	46.7	6.33	8.50	134.26	3.04	48.04		0.85
HENE5	10-m^2	21	100.0	1.79	1.79	100.40	0.77	42.94		0.73
	1-m^2	30	53.3	1.27	1.82	143.54	0.65	51.36	2.5	0.51
	Line-point	30	26.7	4.33	8.17	188.58	2.92	67.48		1.76
PLJA	10-m^2	21	19.0	0.55	1.72	314.84	0.74	134.66		1.35
	1-m^2	30	16.7	0.33	0.88	265.23	0.32	94.91	0.4	0.82
	Line-point	30	3.3	0.33	1.83	547.72	0.65	196.00		0.82
Bare soil	10-m^2	21	100.0	16.12	8.89	55.15	3.80	23.59		0.66
	1-m^2	30	100.0	16.67	13.97	83.84	5.00	30.00	24.5	0.68
	Line-point	30	93.3	40.67	26.38	64.88	9.44	23.22		1.66
Litter	10-m^2	21	100.0	7.43	4.70	63.26	2.01	27.06		0.88
	1-m^2	30	100.0	6.83	3.93	57.53	1.41	20.59	8.4	0.81
	Line-point	30	63.3	11.00	11.25	102.27	4.03	36.60		1.31

Table C9. Summary of frequency (freq) and cover estimates in macroplot WUPA2 (Limy Upland ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes.

Limy Upland, 6-10" pz ecological site – WUPA 2 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	25.79	7.04	27.30	3.01	11.68		1.10
	1-m^2	30	100.0	18.17	8.75	48.19	3.13	17.24	23.5	0.77
	Line-point	30	96.7	26.67	14.22	53.34	5.09	19.09		1.13
CHLE4	10-m^2	21	66.7	1.14	1.83	160.24	0.78	68.53		1.19
	1-m^2	30	26.7	0.73	1.76	240.05	0.63	85.90	1.0	0.76
	Line-point	30	10.0	1.00	3.05	305.13	1.09	109.19		1.04
HENE5	10-m^2	21	90.5	2.19	2.18	99.36	0.93	42.50		0.81
	1-m^2	30	73.3	1.63	1.50	91.64	0.54	32.79	2.7	0.60
	Line-point	30	33.3	4.33	6.79	156.67	2.43	56.06		1.59
PLJA	10-m^2	21	100.0	9.64	6.06	62.81	2.59	26.86		0.99
	1-m^2	30	100.0	5.53	3.23	58.46	1.16	20.92	9.7	0.57
	Line-point	30	86.7	14.00	10.03	71.67	3.59	25.65		1.44
Bare soil	10-m^2	21	100.0	14.67	12.79	87.20	5.47	37.30		0.81
	1-m^2	30	100.0	12.67	11.16	88.14	4.00	31.54	18.1	0.70
	Line-point	30	90.0	27.00	15.79	58.48	5.65	20.93		1.49
Litter	10-m^2	21	100.0	7.21	4.80	66.50	2.05	28.44		1.01
	1-m^2	30	100.0	7.30	4.28	58.58	1.53	20.96	7.2	1.02
	Line-point	30	43.3	7.00	9.15	130.77	3.28	46.79		0.98

Table C10. Summary of frequency (freq) and cover estimates in macroplot WUPA5 (Limy Upland ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes.

Limy Upland, 6-10" pz ecological site – WUPA 5 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	18.00	5.24	29.11	2.65	14.73		0.87
	1-m^2	15	100.0	13.33	5.84	43.79	2.95	22.16	20.7	0.65
	Line-point	15	100.0	30.67	18.70	60.96	9.46	30.85		1.48
CHLE4	10-m^2	15	93.3	7.37	3.55	48.16	1.80	24.37		1.01
	1-m^2	15	100.0	6.60	2.87	43.54	1.45	22.03	7.3	0.90
	Line-point	15	53.3	8.00	10.14	126.77	5.13	64.15		1.09
HENE5	10-m^2	15	33.3	0.63	1.91	302.05	0.97	152.86		2.11
	1-m^2	15	6.7	0.27	1.03	387.30	0.52	196.00	0.3	0.89
	Line-point	15	0.0	0.00	-	-	-	-		0.00
PLJA	10-m^2	15	100.0	6.30	2.06	32.70	1.04	16.55		1.03
	1-m^2	15	100.0	2.07	0.80	38.65	0.40	19.56	6.1	0.34
	Line-point	15	73.3	10.00	8.45	84.52	4.28	42.77		1.63
Bare soil	10-m^2	15	100.0	2.00	1.27	63.39	0.64	32.08		0.58
	1-m^2	15	100.0	2.33	1.29	55.33	0.65	28.00	3.4	0.68
	Line-point	15	40.0	6.00	9.10	151.71	4.61	76.77		1.74
Litter	10-m^2	15	100.0	8.37	6.04	72.16	3.06	36.51		1.50
	1-m^2	15	100.0	8.33	9.69	116.23	4.90	58.82	5.6	1.50
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C11. Summary of frequency (freq) and cover estimates in macroplot WUPA6 (Limy Upland ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes.

Limy Upland, 6-10" pz ecological site – WUPA 6 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	19.57	3.92	20.02	1.98	10.13		1.01
	1-m^2	15	100.0	16.93	3.10	18.33	1.57	9.28	19.3	0.88
	Line-point	15	93.3	21.33	13.02	61.03	6.59	30.89		1.11
CHLE4	10-m^2	15	100.0	4.53	4.21	92.89	2.13	47.01		1.34
	1-m^2	15	100.0	2.93	1.44	49.01	0.73	24.80	3.4	0.87
	Line-point	15	26.7	2.67	4.58	171.65	2.32	86.87		0.79
HENE5	10-m^2	15	100.0	4.93	2.56	51.94	1.30	26.29		0.79
	1-m^2	15	100.0	5.20	3.65	70.17	1.85	35.51	6.3	0.83
	Line-point	15	60.0	8.67	8.34	96.21	4.22	48.69		1.38
PLJA	10-m^2	15	53.3	0.90	1.97	219.43	1.00	111.04		0.70
	1-m^2	15	40.0	0.93	2.05	219.83	1.04	111.25	1.3	0.73
	Line-point	15	13.3	2.00	5.61	280.31	2.84	141.85		1.57
Bare soil	10-m^2	15	100.0	2.67	0.88	32.99	0.45	16.69		0.84
	1-m^2	15	100.0	2.87	2.29	80.06	1.16	40.51	3.2	0.90
	Line-point	15	40.0	4.00	5.07	126.77	2.57	64.15		1.26
Litter	10-m^2	15	100.0	3.87	2.42	62.68	1.23	31.72		1.34
	1-m^2	15	100.0	4.80	2.62	54.67	1.33	27.67	2.9	1.66
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C12. Summary of frequency (freq) and cover estimates in macroplot WUPA7 (Limy Upland ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes.

Limy Upland, 6-10" pz ecological site – WUPA 7 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	20.47	7.96	38.91	4.03	19.69		1.11
	1-m^2	15	100.0	11.67	3.24	27.81	1.64	14.07	18.5	0.63
	Line-point	15	86.7	23.33	16.76	71.84	8.48	36.35		1.26
CHLE4	10-m^2	15	100.0	1.97	1.97	100.08	1.00	50.65		1.65
	1-m^2	15	73.3	1.60	1.50	93.90	0.76	47.52	1.2	1.35
	Line-point	15	0.0	0.00	-	-	-	-		0.00
HENE5	10-m^2	15	100.0	9.03	6.47	71.63	3.27	36.25		0.90
	1-m^2	15	93.3	5.67	3.52	62.09	1.78	31.42	10.0	0.57
	Line-point	15	80.0	15.33	12.46	81.26	6.31	41.12		1.53
PLJA	10-m^2	15	100.0	4.60	5.31	115.41	2.69	58.41		0.96
	1-m^2	15	93.3	2.47	1.92	77.93	0.97	39.44	4.8	0.51
	Line-point	15	46.7	7.33	11.00	149.97	5.57	75.89		1.53
Bare soil	10-m^2	15	100.0	1.17	1.14	98.09	0.58	49.64		0.50
	1-m^2	15	86.7	1.87	2.42	129.44	1.22	65.50	2.3	0.80
	Line-point	15	33.3	4.00	6.32	158.11	3.20	80.02		1.71
Litter	10-m^2	15	100.0	6.37	3.80	59.70	1.92	30.21		1.29
	1-m^2	15	100.0	8.47	3.78	44.61	1.91	22.58	4.9	1.71
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C13. Summary of frequency (freq) and cover estimates in macroplot GRCA3 (Loamy Hills ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, 25-33" pz ecological site – GRCA 3 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory vegetation	10-m^2	21	100.0	25.76	17.08	66.30	7.31	28.36		1.23
	1-m^2	30	93.3	28.90	39.58	136.94	14.16	49.00	20.9	1.38
	Line-point	30	46.7	8.00	12.15	151.86	4.35	54.34		0.38
POFE	10-m^2	21	0.0	0.00	-	-	-	-		-
	1-m^2	30	0.0	0.00	-	-	-	-	0.0	-
	Line-point	30	0.0	0.00	-	-	-	-		-
POTR5	10-m^2	21	71.4	4.02	5.25	130.59	2.25	55.85		0.84
	1-m^2	30	63.3	7.97	19.47	244.46	6.97	87.48	4.8	1.67
	Line-point	30	20.0	2.33	5.04	216.00	1.80	77.29		0.49
UNGRCA1	10-m^2	21	14.3	0.07	0.18	251.00	0.08	107.35		1.25
	1-m^2	30	6.7	0.10	0.40	402.58	0.14	144.06	0.1	1.75
	Line-point	30	0.0	0.00	-	-	-	-		0.00
Bare soil	10-m^2	21	71.4	1.50	2.27	151.66	0.97	64.86		0.47
	1-m^2	30	43.3	2.73	6.56	240.18	2.35	85.95	3.2	0.86
	Line-point	30	33.3	5.33	9.73	182.48	3.48	65.30		1.67
Litter	10-m^2	21	100.0	63.69	9.61	15.08	4.11	6.45		0.89
	1-m^2	30	100.0	73.93	17.47	23.62	6.25	8.45	71.9	1.03
	Line-point	30	100.0	78.00	18.27	23.42	6.54	8.38		1.09
BSC	10-m^2	21	85.7	1.50	1.85	123.38	0.79	52.77		1.14
	1-m^2	30	53.3	1.43	2.08	145.06	0.74	51.91	1.3	1.09
	Line-point	30	6.7	1.00	4.03	402.58	1.44	144.06		0.76

Table C14. Summary of frequency (freq) and cover estimates in macroplot GRCA4 (Loamy Hills ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, 25-33" pz ecological site – GRCA 4 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	35.17	32.20	91.57	13.77	39.16		0.90
	1-m^2	30	100.0	57.47	52.82	91.91	18.90	32.89	39.0	1.47
	Line-point	30	66.7	24.33	23.29	95.73	8.34	34.26		0.62
POFE	10-m^2	21	4.8	0.02	0.11	458.26	0.05	196.00		0.17
	1-m^2	30	6.7	0.07	0.25	380.56	0.09	136.18	0.1	0.47
	Line-point	30	3.3	0.33	1.83	547.72	0.65	196.00		2.36
POTR5	10-m^2	21	71.4	2.76	5.37	194.36	2.30	83.13		0.99
	1-m^2	30	26.7	5.60	18.13	323.83	6.49	115.88	2.8	2.01
	Line-point	30	0.0	0.00	-	-	-	-		0.00
UNGRCA1 (*Carex* sp.)	10-m^2	21	85.7	1.57	2.23	142.04	0.95	60.75		0.41
	1-m^2	30	80.0	1.47	1.72	117.05	0.61	41.88	3.8	0.39
	Line-point	30	40.0	8.33	12.62	151.41	4.51	54.18		2.20
Bare soil	10-m^2	21	76.2	1.64	2.27	138.18	0.97	59.10		0.63
	1-m^2	30	50.0	1.50	2.58	172.21	0.92	61.62	2.6	0.58
	Line-point	30	26.7	4.67	9.00	192.76	3.22	68.98		1.79
Litter	10-m^2	21	100.0	61.31	20.12	32.81	8.60	14.03		0.88
	1-m^2	30	96.7	74.90	21.40	28.57	7.66	10.22	69.5	1.08
	Line-point	30	100.0	72.33	16.33	22.58	5.84	8.08		1.04
BSC	10-m^2	21	71.4	1.93	4.12	213.84	1.76	91.46		1.57
	1-m^2	30	50.0	1.43	3.51	244.91	1.26	87.64	1.2	1.16
	Line-point	30	3.3	0.33	1.83	547.72	0.65	196.00		0.27

Table C15. Summary of frequency (freq) and cover estimates in macroplot GRCA5 (Loamy Hills ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, 25-33" pz ecological site – GRCA 5 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	11.67	8.51	72.96	4.31	36.92		0.84
	1-m^2	15	100.0	10.13	12.06	119.06	6.11	60.25	13.9	0.73
	Line-point	15	93.3	20.00	11.34	56.69	5.74	28.69		1.44
POFE	10-m^2	15	33.3	0.97	2.08	215.46	1.05	109.04		0.69
	1-m^2	15	26.7	0.60	1.18	197.20	0.60	99.80	1.4	0.43
	Line-point	15	26.7	2.67	4.58	171.65	2.32	86.87		1.89
POTR5	10-m^2	15	80.0	5.70	6.70	117.49	3.39	59.46		1.07
	1-m^2	15	66.7	5.60	11.62	207.57	5.88	105.04	5.3	1.05
	Line-point	15	40.0	4.67	6.40	137.13	3.24	69.40		0.88
UNGRCA1 (*Carex* sp.)	10-m^2	15	86.7	1.90	2.03	106.76	1.03	54.03		0.45
	1-m^2	15	60.0	1.33	2.13	159.52	1.08	80.73	4.2	0.32
	Line-point	15	53.3	9.33	11.63	124.60	5.89	63.05		2.23
Bare soil	10-m^2	15	100.0	2.00	1.27	63.39	0.64	32.08		0.19
	1-m^2	15	73.3	1.60	1.40	87.75	0.71	44.41	10.8	0.15
	Line-point	15	73.3	28.67	26.15	91.22	13.23	46.16		2.67
Litter	10-m^2	15	100.0	80.83	11.44	14.16	5.79	7.16		1.04
	1-m^2	15	100.0	89.53	5.24	5.85	2.65	2.96	77.5	1.16
	Line-point	15	100.0	62.00	23.96	38.65	12.13	19.56		0.80
BSC	10-m^2	15	6.7	0.03	0.13	387.30	0.07	196.00		3.00
	1-m^2	15	0.0	0.00	-	-	-	-	0.0	0.00
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C16. Summary of frequency (freq) and cover estimates in macroplot GRCA6 (Loamy Hills ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, 25-33" pz ecological site – GRCA 6 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	20.37	18.34	90.06	9.28	45.57		1.04
	1-m^2	15	100.0	17.20	26.09	151.71	13.21	76.77	19.6	0.88
	Line-point	15	86.7	21.33	12.46	58.40	6.31	29.56		1.09
POFE	10-m^2	15	66.7	0.50	0.73	146.39	0.37	74.08		0.71
	1-m^2	15	20.0	0.27	0.59	222.61	0.30	112.65	0.7	0.38
	Line-point	15	13.3	1.33	3.52	263.90	1.78	133.55		1.90
POTR5	10-m^2	15	33.3	0.17	0.24	146.39	0.12	74.08		0.52
	1-m^2	15	13.3	0.13	0.35	263.90	0.18	133.55	0.3	0.41
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		2.07
UNGRCA1 (*Carex* sp.)	10-m^2	15	100.0	1.93	2.48	128.15	1.25	64.85		0.42
	1-m^2	15	66.7	1.87	1.88	100.97	0.95	51.10	4.6	0.41
	Line-point	15	60.0	10.00	10.69	106.90	5.41	54.10		2.17
Bare soil	10-m^2	15	53.3	1.23	2.09	169.85	1.06	85.95		0.26
	1-m^2	15	46.7	1.80	2.68	148.78	1.36	75.29	4.8	0.38
	Line-point	15	53.3	11.33	12.46	109.94	6.31	55.63		2.37
Litter	10-m^2	15	100.0	84.17	8.80	10.45	4.45	5.29		1.08
	1-m^2	15	100.0	75.80	22.61	29.83	11.44	15.10	78.0	0.97
	Line-point	15	100.0	74.00	15.49	20.94	7.84	10.59		0.95
BSC	10-m^2	15	6.7	0.03	0.13	387.30	0.07	196.00		1.00
	1-m^2	15	6.7	0.07	0.26	387.30	0.13	196.00	0.0	2.00
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C17. Summary of frequency (freq) and cover estimates in macroplot GRCA7 (Loamy Hills ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, 25-33" pz ecological site – GRCA 7 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	5.63	2.98	52.88	1.51	26.76		0.79
	1-m^2	15	80.0	5.07	5.19	102.41	2.63	51.83	7.1	0.71
	Line-point	15	66.7	10.67	9.61	90.11	4.86	45.60		1.50
POFE	10-m^2	15	93.3	1.13	1.17	103.42	0.59	52.34		0.61
	1-m^2	15	73.3	1.07	0.88	82.85	0.45	41.93	1.8	0.58
	Line-point	15	33.3	3.33	4.88	146.39	2.47	74.08		1.81
POTR5	10-m^2	15	20.0	0.27	0.78	291.05	0.39	147.29		0.29
	1-m^2	15	13.3	1.13	3.04	268.60	1.54	135.93	0.9	1.24
	Line-point	15	13.3	1.33	3.52	263.90	1.78	133.55		1.46
UNGRCA1 (*Carex* sp.)	10-m^2	15	86.7	1.60	1.37	85.34	0.69	43.19		0.62
	1-m^2	15	60.0	1.47	1.55	105.84	0.79	53.56	2.6	0.57
	Line-point	15	46.7	4.67	5.16	110.66	2.61	56.00		1.81
Bare soil	10-m^2	15	60.0	1.30	1.45	111.47	0.73	56.41		0.14
	1-m^2	15	53.3	2.07	2.87	138.64	1.45	70.16	9.3	0.22
	Line-point	15	60.0	24.67	28.00	113.50	14.17	57.44		2.64
Litter	10-m^2	15	100.0	84.17	8.80	10.45	4.45	5.29		1.09
	1-m^2	15	100.0	86.53	11.51	13.30	5.83	6.73	76.9	1.13
	Line-point	15	93.3	60.00	36.25	60.42	18.35	30.58		0.78
BSC	10-m^2	15	13.3	0.07	0.18	263.90	0.09	133.55		1.50
	1-m^2	15	6.7	0.07	0.26	387.30	0.13	196.00	0.0	1.50
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C18. Summary of frequency (freq) and cover estimates in macroplot GRCA1 (Loamy Hills, Cold, ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, Cold, 25-33" pz ecological site – GRCA 1 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	43.57	29.26	67.14	12.51	28.72		1.25
	1-m^2	30	100.0	37.37	33.72	90.23	12.06	32.29	34.9	1.07
	Line-point	30	86.7	23.67	19.91	84.13	7.12	30.10		0.68
ABCO	10-m^2	21	0.0	0.00	-	-	-	-		-
	1-m^2	30	0.0	0.00	-	-	-	-	0.0	-
	Line-point	30	0.0	0.00	-	-	-	-		-
PIEN	10-m^2	21	52.4	10.81	17.84	165.06	7.63	70.60		0.93
	1-m^2	30	43.3	16.50	26.05	157.89	9.32	56.50	11.7	1.42
	Line-point	30	36.7	7.67	12.51	163.14	4.48	58.38		0.66
POTR5	10-m^2	21	81.0	3.74	5.21	139.43	2.23	59.63		1.19
	1-m^2	30	50.0	4.33	8.29	191.20	2.96	68.42	3.1	1.38
	Line-point	30	13.3	1.33	3.46	259.31	1.24	92.79		0.43
Bare soil	10-m^2	21	95.2	2.67	4.04	151.44	1.73	64.77		1.05
	1-m^2	30	63.3	2.30	4.38	190.43	1.57	68.14	2.5	0.90
	Line-point	30	20.0	2.67	5.83	218.73	2.09	78.27		1.05
Litter	10-m^2	21	100.0	70.83	14.43	20.38	6.17	8.72		0.91
	1-m^2	30	100.0	81.80	12.64	15.45	4.52	5.53	77.9	1.05
	Line-point	30	100.0	81.00	17.29	21.35	6.19	7.64		1.04
BSC	10-m^2	21	90.5	1.64	1.91	116.35	0.82	49.76		0.92
	1-m^2	30	73.3	1.70	2.87	168.62	1.03	60.34	1.8	0.95
	Line-point	30	16.7	2.00	4.84	242.12	1.73	86.64		1.12

Table C19. Summary of frequency (freq) and cover estimates in macroplot GRCA2 (Loamy Hills, Cold, ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, Cold, 25-33" pz ecological site – GRCA 2 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	54.05	33.87	62.67	14.49	26.80		1.02
	1-m^2	30	100.0	77.27	51.21	66.27	18.32	23.71	53.0	1.46
	Line-point	30	83.3	27.67	17.94	64.85	6.42	23.21		0.52
ABCO	10-m^2	21	61.9	17.24	25.76	149.46	11.02	63.92		1.00
	1-m^2	30	66.7	25.73	29.62	115.10	10.60	41.19	17.3	1.49
	Line-point	30	46.7	9.00	11.85	131.63	4.24	47.10		0.52
PIEN	10-m^2	21	4.8	2.98	13.64	458.26	5.83	196.00		2.45
	1-m^2	30	0.0	0.00	-	-	-	-	1.2	0.00
	Line-point	30	3.3	0.67	3.65	547.72	1.31	196.00		0.55
POTR5	10-m^2	21	38.1	5.71	13.33	233.21	5.70	99.74		1.18
	1-m^2	30	26.7	8.13	18.74	230.38	6.70	82.44	4.8	1.68
	Line-point	30	6.7	0.67	2.54	380.56	0.91	136.18		0.14
Bare soil	10-m^2	21	71.4	2.33	3.95	169.45	1.69	72.47		0.78
	1-m^2	30	40.0	1.30	2.31	177.44	0.83	63.49	3.0	0.43
	Line-point	30	23.3	5.33	12.52	234.77	4.48	84.01		1.78
Litter	10-m^2	21	100.0	69.64	16.09	23.11	6.88	9.88		0.91
	1-m^2	30	100.0	78.97	14.23	18.02	5.09	6.45	76.8	1.03
	Line-point	30	100.0	81.67	16.42	20.10	5.87	7.19		1.06
BSC	10-m^2	21	66.7	0.50	0.74	148.32	0.32	63.44		1.29
	1-m^2	30	10.0	0.67	3.11	466.65	1.11	166.98	0.4	1.71
	Line-point	30	0.0	0.00	-	-	-	-		0.00

Table C20. Summary of frequency (freq) and cover estimates in macroplot MEVE3 (Loamy Mesa Top PJ ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Mesa Top PJ ecological site – MEVE 3 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	41.07	24.62	59.95	10.53	25.64		1.22
	1-m^2	30	100.0	40.10	38.61	96.29	13.82	34.46	33.6	1.19
	Line-point	30	86.7	19.67	16.08	81.75	5.75	29.25		0.59
JUOS	10-m^2	21	66.7	11.74	13.29	113.26	5.69	48.44		1.20
	1-m^2	30	33.3	15.17	26.70	176.05	9.55	63.00	9.7	1.56
	Line-point	30	20.0	2.33	5.04	216.00	1.80	77.29		0.24
PIED	10-m^2	21	81.0	16.02	16.30	101.72	6.97	43.51		1.21
	1-m^2	30	40.0	15.37	27.49	178.92	9.84	64.03	13.2	1.16
	Line-point	30	40.0	8.33	13.41	160.95	4.80	57.59		0.63
POFE	10-m^2	21	100.0	8.43	6.18	73.34	2.64	31.37		1.15
	1-m^2	30	96.7	6.50	8.31	127.87	2.97	45.76	7.3	0.89
	Line-point	30	53.3	7.00	8.37	119.52	2.99	42.77		0.96
Bare soil	10-m^2	21	90.5	3.62	8.62	238.13	3.69	101.85		0.68
	1-m^2	30	60.0	2.93	9.92	338.07	3.55	120.97	5.3	0.55
	Line-point	30	53.3	9.33	11.12	119.15	3.98	42.64		1.76
Litter	10-m^2	21	100.0	46.55	23.22	49.88	9.93	21.33		0.90
	1-m^2	30	100.0	51.40	39.04	75.95	13.97	27.18	51.6	1.00
	Line-point	30	93.3	57.00	25.21	44.23	9.02	15.83		1.10
BSC	10-m^2	21	100.0	5.17	5.18	100.31	2.22	42.90		0.77
	1-m^2	30	80.0	9.07	13.97	154.06	5.00	55.13	6.7	1.34
	Line-point	30	36.7	6.00	11.92	198.65	4.27	71.09		0.89

Table C21. Summary of frequency (freq) and cover estimates in macroplot MEVE4 (Loamy Mesa Top PJ ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Mesa Top PJ ecological site – MEVE 4 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	55.71	31.30	56.19	13.39	24.03		1.33
	1-m^2	30	100.0	43.67	49.82	114.10	17.83	40.83	42.0	1.04
	Line-point	30	93.3	26.67	17.09	64.07	6.11	22.93		0.63
JUOS	10-m^2	21	76.2	12.19	17.42	142.94	7.45	61.13		0.97
	1-m^2	30	50.0	20.10	32.36	160.98	11.58	57.60	12.5	1.60
	Line-point	30	40.0	5.33	7.76	145.51	2.78	52.07		0.43
PIED	10-m^2	21	81.0	26.21	23.84	90.95	10.20	38.90		1.72
	1-m^2	30	36.7	13.27	25.39	191.41	9.09	68.49	15.3	0.87
	Line-point	30	43.3	6.33	10.66	168.35	3.82	60.24		0.41
POFE	10-m^2	21	100.0	13.10	8.50	64.88	3.63	27.75		1.16
	1-m^2	30	96.7	8.03	7.69	95.78	2.75	34.27	11.3	0.71
	Line-point	30	76.7	12.67	11.12	87.80	3.98	31.42		1.12
Bare soil	10-m^2	21	85.7	4.21	6.10	144.71	2.61	61.89		0.94
	1-m^2	30	73.3	6.27	12.14	193.67	4.34	69.30	4.5	1.39
	Line-point	30	26.7	3.00	5.35	178.33	1.91	63.81		0.67
Litter	10-m^2	21	100.0	58.45	28.05	47.98	12.00	20.52		0.89
	1-m^2	30	100.0	69.70	29.72	42.64	10.63	15.26	65.8	1.06
	Line-point	30	100.0	69.33	16.60	23.94	5.94	8.57		1.05
BSC	10-m^2	21	85.7	3.71	3.73	100.52	1.60	42.99		0.97
	1-m^2	30	53.3	2.80	4.13	147.52	1.48	52.79	3.8	0.73
	Line-point	30	33.3	5.00	8.20	164.00	2.93	58.69		1.30

Table C22. Summary of frequency (freq) and cover estimates in macroplot MEVE8 (Loamy Mesa Top PJ ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Mesa Top PJ ecological site – MEVE 8 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	23.77	14.59	61.37	7.38	31.06		1.08
	1-m^2	15	100.0	21.60	26.38	122.14	13.35	61.81	22.0	0.98
	Line-point	15	80.0	20.67	18.31	88.59	9.27	44.83		0.94
JUOS	10-m^2	15	73.3	3.27	6.09	186.46	3.08	94.36		0.79
	1-m^2	15	33.3	5.07	9.79	193.16	4.95	97.75	4.1	1.23
	Line-point	15	26.7	4.00	7.37	184.20	3.73	93.21		0.97
PIED	10-m^2	15	60.0	6.63	11.09	167.21	5.61	84.62		1.01
	1-m^2	15	46.7	10.47	23.34	223.01	11.81	112.86	6.6	1.59
	Line-point	15	26.7	2.67	4.58	171.65	2.32	86.87		0.40
POFE	10-m^2	15	100.0	10.13	6.58	64.91	3.33	32.85		1.11
	1-m^2	15	100.0	5.33	4.08	76.55	2.07	38.74	9.2	0.58
	Line-point	15	80.0	12.00	14.24	118.69	7.21	60.06		1.31
Bare soil	10-m^2	15	100.0	0.97	1.81	186.97	0.91	94.62		0.18
	1-m^2	15	66.7	1.00	1.46	146.39	0.74	74.08	5.3	0.19
	Line-point	15	80.0	14.00	10.56	75.40	5.34	38.16		2.63
Litter	10-m^2	15	100.0	46.53	29.48	63.35	14.92	32.06		0.98
	1-m^2	15	100.0	54.00	30.99	57.38	15.68	29.04	47.5	1.14
	Line-point	15	93.3	42.00	23.36	55.62	11.82	28.15		0.88
BSC	10-m^2	15	100.0	1.77	2.00	113.14	1.01	57.26		0.64
	1-m^2	15	66.7	1.87	1.88	100.97	0.95	51.10	2.8	0.67
	Line-point	15	33.3	4.67	7.43	159.26	3.76	80.60		1.69

Table C23. Summary of frequency (freq) and cover estimates in macroplot MEVE9 (Loamy Mesa Top PJ ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Mesa Top PJ ecological site – MEVE 9 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	20.90	18.67	89.32	9.45	45.20		1.17
	1-m^2	15	93.3	13.20	15.21	115.26	7.70	58.33	17.8	0.74
	Line-point	15	80.0	19.33	14.38	74.36	7.28	37.63		1.09
JUOS	10-m^2	15	60.0	7.03	16.47	234.11	8.33	118.47		1.80
	1-m^2	15	33.3	2.67	6.14	230.15	3.11	116.47	3.9	0.68
	Line-point	15	20.0	2.00	4.14	207.02	2.10	104.76		0.51
PIED	10-m^2	15	73.3	5.40	10.06	186.21	5.09	94.24		0.81
	1-m^2	15	26.7	4.60	10.47	227.68	5.30	115.22	6.7	0.69
	Line-point	15	60.0	10.00	13.63	136.28	6.90	68.96		1.50
POFE	10-m^2	15	100.0	2.93	2.16	73.70	1.09	37.30		0.80
	1-m^2	15	86.7	3.40	4.17	122.69	2.11	62.09	3.7	0.93
	Line-point	15	46.7	4.67	5.16	110.66	2.61	56.00		1.27
Bare soil	10-m^2	15	80.0	0.90	1.11	122.80	0.56	62.14		0.33
	1-m^2	15	33.3	0.67	1.54	231.46	0.78	117.13	2.7	0.24
	Line-point	15	46.7	6.67	8.16	122.47	4.13	61.98		2.43
Litter	10-m^2	15	100.0	46.37	34.68	74.80	17.55	37.85		1.14
	1-m^2	15	100.0	40.87	36.65	89.68	18.55	45.38	40.6	1.01
	Line-point	15	93.3	34.67	22.64	65.30	11.46	33.04		0.85
BSC	10-m^2	15	100.0	4.07	3.80	93.51	1.92	47.32		0.67
	1-m^2	15	93.3	8.13	14.89	183.13	7.54	92.67	6.1	1.34
	Line-point	15	40.0	6.00	9.10	151.71	4.61	76.77		0.99

Table C24. Summary of frequency (freq) and cover estimates in macroplot MEVE10 (Loamy Mesa Top PJ ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Mesa Top PJ ecological site – MEVE 10 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	22.23	11.66	52.45	5.90	26.54		0.97
	1-m^2	15	100.0	29.53	25.70	87.03	13.01	44.04	23.0	1.28
	Line-point	15	80.0	17.33	11.63	67.09	5.89	33.95		0.75
JUOS	10-m^2	15	60.0	4.47	6.03	135.02	3.05	68.33		0.99
	1-m^2	15	33.3	5.80	18.03	310.84	9.12	157.30	4.5	1.28
	Line-point	15	33.3	3.33	4.88	146.39	2.47	74.08		0.74
PIED	10-m^2	15	73.3	7.90	7.66	96.91	3.87	49.04		0.85
	1-m^2	15	33.3	10.67	23.05	216.05	11.66	109.34	9.3	1.15
	Line-point	15	53.3	9.33	11.00	117.83	5.57	59.63		1.00
POFE	10-m^2	15	93.3	0.47	0.13	27.66	0.07	14.00		0.48
	1-m^2	15	46.7	0.47	0.52	110.66	0.26	56.00	1.0	0.48
	Line-point	15	20.0	2.00	4.14	207.02	2.10	104.76		2.05
Bare soil	10-m^2	15	100.0	0.67	0.65	96.82	0.33	49.00		0.51
	1-m^2	15	60.0	0.60	0.51	84.52	0.26	42.77	1.3	0.46
	Line-point	15	26.7	2.67	4.58	171.65	2.32	86.87		2.03
Litter	10-m^2	15	100.0	38.20	30.25	79.18	15.31	40.07		1.05
	1-m^2	15	100.0	36.40	33.79	92.83	17.10	46.98	36.4	1.00
	Line-point	15	93.3	34.67	25.60	73.84	12.95	37.37		0.95
BSC	10-m^2	15	100.0	4.83	3.84	79.52	1.95	40.24		0.57
	1-m^2	15	93.3	5.07	3.88	76.61	1.96	38.77	8.4	0.60
	Line-point	15	86.7	15.33	13.56	88.42	6.86	44.75		1.82

Table C25. Summary of frequency (freq) and cover estimates in macroplot CARE1 (Semidesert Alkali Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site – CARE 1 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	23.33	7.02	30.09	3.00	12.87		0.87
	1-m^2	30	100.0	19.50	6.93	35.52	2.48	12.71	26.7	0.73
	Line-point	30	93.3	37.33	18.18	48.70	6.51	17.43		1.40
ATCO	10-m^2	21	81.0	4.19	5.16	123.16	2.21	52.68		1.06
	1-m^2	30	46.7	1.97	3.63	184.78	1.30	66.12	3.9	0.50
	Line-point	30	36.7	5.67	9.71	171.43	3.48	61.34		1.44
GIIN2	10-m^2	21	47.6	0.24	0.26	107.47	0.11	45.97		1.25
	1-m^2	30	33.3	0.33	0.48	143.84	0.17	51.47	0.2	1.75
	Line-point	30	0.0	0.00	-	-	-	-		0.00
ORHY	10-m^2	21	95.2	0.71	0.77	107.47	0.33	45.97		0.45
	1-m^2	30	56.7	0.70	0.75	107.10	0.27	38.33	1.6	0.44
	Line-point	30	23.3	3.33	6.61	198.27	2.36	70.95		2.11
Bare soil	10-m^2	21	100.0	0.74	0.75	101.88	0.32	43.57		0.32
	1-m^2	30	90.0	1.53	1.72	111.96	0.61	40.06	2.3	0.66
	Line-point	30	36.7	4.67	7.30	156.49	2.61	56.00		2.02
Litter	10-m^2	21	100.0	15.64	9.08	58.03	3.88	24.82		1.32
	1-m^2	30	96.7	11.83	14.97	126.54	5.36	45.28	11.8	1.00
	Line-point	30	43.3	8.00	11.26	140.81	4.03	50.39		0.68
BSC	10-m^2	21	85.7	1.10	0.85	77.23	0.36	33.03		1.06
	1-m^2	30	50.0	1.00	1.26	125.94	0.45	45.07	1.0	0.97
	Line-point	30	6.7	1.00	4.03	402.58	1.44	144.06		0.97

Table C26. Summary of frequency (freq) and cover estimates in macroplot CARE2 (Semidesert Alkali Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site – CARE 2 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	35.48	16.87	47.55	7.21	20.34		1.18
	1-m^2	30	100.0	24.60	14.49	58.91	5.19	21.08	30.1	0.82
	Line-point	30	93.3	30.33	19.38	63.90	6.94	22.87		1.01
ATCO	10-m^2	21	90.5	4.60	4.92	107.14	2.11	45.82		0.90
	1-m^2	30	53.3	7.13	12.38	173.49	4.43	62.08	5.1	1.39
	Line-point	30	26.7	3.67	6.69	182.37	2.39	65.26		0.71
GIIN2	10-m^2	21	42.9	0.21	0.25	118.32	0.11	50.61		0.86
	1-m^2	30	20.0	0.20	0.41	203.42	0.15	72.79	0.2	0.80
	Line-point	30	3.3	0.33	1.83	547.72	0.65	196.00		1.34
ORHY	10-m^2	21	95.2	0.60	0.56	94.36	0.24	40.36		0.96
	1-m^2	30	53.3	0.60	0.62	103.58	0.22	37.06	0.6	0.97
	Line-point	30	6.7	0.67	2.54	380.56	0.91	136.18		1.07
Bare soil	10-m^2	21	23.8	1.26	4.06	321.80	1.74	137.63		0.68
	1-m^2	30	13.3	0.60	2.74	456.12	0.98	163.22	1.8	0.33
	Line-point	30	23.3	3.67	8.09	220.56	2.89	78.92		1.99
Litter	10-m^2	21	100.0	9.83	8.96	91.11	3.83	38.97		1.11
	1-m^2	30	96.7	9.50	12.59	132.48	4.50	47.41	8.9	1.07
	Line-point	30	56.7	7.33	7.40	100.87	2.65	36.09		0.83
BSC	10-m^2	21	81.0	1.12	1.14	101.79	0.49	43.54		0.39
	1-m^2	30	66.7	1.57	1.77	113.30	0.64	40.54	2.9	0.54
	Line-point	30	33.3	6.00	9.68	161.41	3.47	57.76		2.07

Table C27. Summary of frequency (freq) and cover estimates in macroplot CARE5 (Semidesert Alkali Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site – CARE 5 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	19.17	9.04	47.17	4.58	23.87		0.84
	1-m^2	15	100.0	20.93	20.14	96.20	10.19	48.68	22.9	0.91
	Line-point	15	100.0	28.67	16.42	57.27	8.31	28.98		1.25
ATCO	10-m^2	15	53.3	0.60	1.00	167.26	0.51	84.64		1.35
	1-m^2	15	46.7	0.73	1.28	174.53	0.65	88.32	0.4	1.65
	Line-point	15	0.0	0.00	-	-	-	-		0.00
GIIN2	10-m^2	15	73.3	0.37	0.23	62.42	0.12	31.59		0.48
	1-m^2	15	60.0	0.60	0.51	84.52	0.26	42.77	0.8	0.78
	Line-point	15	13.3	1.33	3.52	263.90	1.78	133.55		1.74
ORHY	10-m^2	15	86.7	0.60	0.69	114.43	0.35	57.91		0.69
	1-m^2	15	66.7	0.67	0.49	73.19	0.25	37.04	0.9	0.77
	Line-point	15	13.3	1.33	3.52	263.90	1.78	133.55		1.54
Bare soil	10-m^2	15	100.0	0.97	1.81	186.97	0.91	94.62		0.38
	1-m^2	15	86.7	2.07	1.83	88.59	0.93	44.83	2.6	0.81
	Line-point	15	40.0	4.67	6.40	137.13	3.24	69.40		1.82
Litter	10-m^2	15	100.0	10.00	9.29	92.87	4.70	47.00		1.08
	1-m^2	15	100.0	11.67	23.50	201.43	11.89	101.93	9.2	1.27
	Line-point	15	33.3	6.00	9.86	164.27	4.99	83.13		0.65
BSC	10-m^2	15	40.0	0.33	0.45	134.96	0.23	68.30		1.67
	1-m^2	15	20.0	0.27	0.59	222.61	0.30	112.65	0.2	1.33
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C28. Summary of frequency (freq) and cover estimates in macroplot CARE6 (Semidesert Alkali Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site – CARE 6 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	7.27	4.46	61.43	2.26	31.09		0.85
	1-m^2	15	93.3	7.07	6.13	86.82	3.10	43.93	8.6	0.83
	Line-point	15	66.7	11.33	11.87	104.76	6.01	53.01		1.32
ATCO	10-m^2	15	46.7	1.03	2.06	199.06	1.04	100.74		0.67
	1-m^2	15	20.0	0.93	2.63	281.93	1.33	142.67	1.5	0.60
	Line-point	15	20.0	2.67	5.94	222.61	3.00	112.65		1.73
GIIN2	10-m^2	15	33.3	0.17	0.24	146.39	0.12	74.08		1.15
	1-m^2	15	26.7	0.27	0.46	171.65	0.23	86.87	0.1	1.85
	Line-point	15	0.0	0.00	-	-	-	-		0.00
ORHY	10-m^2	15	60.0	0.30	0.25	84.52	0.13	42.77		1.42
	1-m^2	15	33.3	0.33	0.49	146.39	0.25	74.08	0.2	1.58
	Line-point	15	0.0	0.00	-	-	-	-		0.00
Bare soil	10-m^2	15	53.3	0.27	0.26	96.82	0.13	49.00		0.67
	1-m^2	15	26.7	0.27	0.46	171.65	0.23	86.87	0.4	0.67
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		1.67
Litter	10-m^2	15	100.0	1.33	1.22	91.49	0.62	46.30		1.07
	1-m^2	15	100.0	1.73	1.91	110.04	0.97	55.69	1.2	1.39
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		0.54
BSC	10-m^2	15	100.0	5.33	4.25	79.76	2.15	40.36		0.97
	1-m^2	15	80.0	3.20	2.88	90.11	1.46	45.60	5.5	0.58
	Line-point	15	60.0	8.00	8.62	107.74	4.36	54.52		1.45

Table C29. Summary of frequency (freq) and cover estimates in macroplot CARE7 (Semidesert Alkali Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site – CARE 7 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	16.27	6.70	41.20	3.39	20.85		0.91
	1-m^2	15	100.0	18.27	15.82	86.62	8.01	43.83	18.0	1.02
	Line-point	15	73.3	19.33	16.24	84.01	8.22	42.51		1.08
ATCO	10-m^2	15	86.7	2.53	2.39	94.50	1.21	47.82		0.99
	1-m^2	15	66.7	1.80	2.08	115.39	1.05	58.40	2.6	0.70
	Line-point	15	20.0	3.33	8.16	244.95	4.13	123.96		1.30
GIIN2	10-m^2	15	86.7	0.43	0.18	40.60	0.09	20.55		1.34
	1-m^2	15	53.3	0.53	0.52	96.82	0.26	49.00	0.3	1.66
	Line-point	15	0.0	0.00	-	-	-	-		0.00
ORHY	10-m^2	15	93.3	0.47	0.13	27.66	0.07	14.00		0.78
	1-m^2	15	66.7	0.67	0.49	73.19	0.25	37.04	0.6	1.11
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		1.11
Bare soil	10-m^2	15	100.0	1.00	1.04	103.51	0.52	52.38		0.29
	1-m^2	15	100.0	1.40	0.91	65.02	0.46	32.90	3.5	0.40
	Line-point	15	60.0	8.00	8.62	107.74	4.36	54.52		2.31
Litter	10-m^2	15	93.3	11.73	6.70	57.08	3.39	28.89		1.00
	1-m^2	15	100.0	18.20	21.92	120.42	11.09	60.94	11.8	1.55
	Line-point	15	46.7	5.33	6.40	119.99	3.24	60.72		0.45
BSC	10-m^2	15	86.7	1.20	0.94	78.43	0.48	39.69		0.95
	1-m^2	15	73.3	1.27	1.03	81.54	0.52	41.26	1.3	1.00
	Line-point	15	13.3	1.33	3.52	263.90	1.78	133.55		1.05

Table C30. Summary of frequency (freq) and cover estimates in macroplot DINO1 (Semidesert Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Loam (Wyoming Big Sagebrush) ecological site – DINO 1 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	59.36	16.86	28.40	7.21	12.15		0.93
	1-m^2	30	100.0	36.63	19.37	52.88	6.93	18.92	64.1	0.57
	Line-point	30	100.0	96.33	23.56	24.46	8.43	8.75		1.50
ARTR2	10-m^2	21	47.6	0.71	1.16	162.02	0.49	69.30		2.53
	1-m^2	30	3.3	0.13	0.73	547.72	0.26	196.00	0.3	0.47
	Line-point	30	0.0	0.00	-	-	-	-		0.00
BRTE	10-m^2	21	100.0	39.21	24.69	62.97	10.56	26.93		0.98
	1-m^2	30	100.0	23.73	22.00	92.68	7.87	33.16	40.0	0.59
	Line-point	30	100.0	57.00	29.38	51.54	10.51	18.44		1.43
STCO4	10-m^2	21	100.0	9.67	9.44	97.64	4.04	41.76		0.92
	1-m^2	30	73.3	3.43	3.43	99.93	1.23	35.76	10.5	0.33
	Line-point	30	60.0	18.33	19.49	106.31	6.97	38.04		1.75
Bare soil	10-m^2	21	71.4	1.76	1.91	108.66	0.82	46.48		0.28
	1-m^2	30	70.0	2.27	2.75	121.48	0.99	43.47	6.3	0.36
	Line-point	30	66.7	15.00	15.92	106.13	5.70	37.98		2.36
Litter	10-m^2	21	100.0	60.12	15.62	25.99	6.68	11.11		0.97
	1-m^2	30	100.0	72.23	17.68	24.47	6.33	8.76	62.2	1.16
	Line-point	30	96.7	54.33	20.29	37.34	7.26	13.36		0.87
BSC	10-m^2	21	100.0	1.76	1.07	60.61	0.46	25.92		0.62
	1-m^2	30	93.3	2.37	1.13	47.71	0.40	17.07	2.8	0.84
	Line-point	30	36.7	4.33	6.26	144.48	2.24	51.70		1.54

Table C31. Summary of frequency (freq) and cover estimates in macroplot DINO2b (Semidesert Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Loam (Wyoming Big Sagebrush) ecological site – DINO 2b macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	29.12	10.18	34.97	4.36	14.96		0.85
	1-m^2	30	100.0	19.03	13.37	70.27	4.79	25.14	34.3	0.56
	Line-point	30	100.0	54.67	20.47	37.44	7.32	13.40		1.60
ARTR2	10-m^2	30	90.5	13.24	8.49	64.13	3.63	27.43		1.37
	1-m^2	30	80.0	9.03	8.24	91.22	2.95	32.64	9.6	0.94
	Line-point	21	46.7	6.67	9.22	138.34	3.30	49.50		0.69
BRTE	10-m^2	30	95.2	10.19	6.30	61.82	2.69	26.44		0.53
	1-m^2	21	93.3	6.67	7.66	114.94	2.74	41.13	19.3	0.35
	Line-point	30	100.0	41.00	19.71	48.08	7.05	17.21		2.13
STCO4	10-m^2	21	0.0	0.00	-	-	-	-		-
	1-m^2	30	0.0	0.00	-	-	-	-	0.0	-
	Line-point	30	0.0	0.00	-	-	-	-		-
Bare soil	10-m^2	30	95.2	0.83	0.91	109.54	0.39	46.85		0.22
	1-m^2	30	66.7	1.80	3.70	205.50	1.32	73.54	3.8	0.48
	Line-point	21	46.7	8.67	10.74	123.95	3.84	44.35		2.30
Litter	10-m^2	30	100.0	36.79	14.08	38.27	6.02	16.37		0.96
	1-m^2	21	100.0	32.67	27.82	85.16	9.95	30.47	38.3	0.85
	Line-point	30	100.0	45.33	17.56	38.74	6.29	13.86		1.18
BSC	10-m^2	21	100.0	7.88	12.90	163.64	5.52	69.99		1.12
	1-m^2	30	100.0	4.50	2.16	48.04	0.77	17.19	7.0	0.64
	Line-point	30	56.7	8.67	9.73	112.29	3.48	40.18		1.24

Table C32. Summary of frequency (freq) and cover estimates in macroplot DINO3 (Semidesert Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Loam (Wyoming Big Sagebrush) ecological site – DINO 3 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	20.70	9.42	45.49	4.77	23.02		0.79
	1-m^2	15	100.0	15.47	11.33	73.23	5.73	37.06	26.3	0.59
	Line-point	15	100.0	42.67	25.49	59.73	12.90	30.23		1.62
ARTR2	10-m^2	15	93.3	9.73	10.72	110.16	5.43	55.75		1.45
	1-m^2	15	73.3	5.13	10.22	199.05	5.17	100.73	6.7	0.76
	Line-point	15	40.0	5.33	8.34	156.34	4.22	79.12		0.79
BRTE	10-m^2	15	100.0	3.87	6.05	156.43	3.06	79.17		0.46
	1-m^2	15	60.0	2.53	4.14	163.35	2.09	82.66	8.4	0.30
	Line-point	15	66.7	18.67	20.66	110.66	10.45	56.00		2.23
STCO4	10-m^2	15	73.3	1.87	1.45	77.41	0.73	39.18		1.38
	1-m^2	15	86.7	2.20	1.86	84.52	0.94	42.77	1.4	1.62
	Line-point	15	0.0	0.00	-	-	-	-		0.00
Bare soil	10-m^2	15	33.3	0.17	0.24	146.39	0.12	74.08		0.05
	1-m^2	15	13.3	0.13	0.35	263.90	0.18	133.55	3.4	0.04
	Line-point	15	73.3	10.00	8.45	84.52	4.28	42.77		2.91
Litter	10-m^2	15	93.3	14.90	9.27	62.24	4.69	31.50		0.89
	1-m^2	15	100.0	18.00	19.97	110.93	10.10	56.14	16.7	1.07
	Line-point	15	60.0	17.33	18.31	105.63	9.27	53.46		1.04
BSC	10-m^2	15	100.0	6.07	4.67	77.05	2.37	38.99		0.96
	1-m^2	15	100.0	4.87	1.77	36.32	0.89	18.38	6.3	0.77
	Line-point	15	53.3	8.00	9.41	117.64	4.76	59.53		1.27

Table C33. Summary of frequency (freq) and cover estimates in macroplot DINO4b (Semidesert Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Loam (Wyoming Big Sagebrush) ecological site – DINO 4b macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	25.67	11.30	44.03	5.72	22.28		0.95
	1-m^2	15	100.0	14.00	11.98	85.54	6.06	43.29	27.0	0.52
	Line-point	15	100.0	41.33	20.31	49.13	10.28	24.86		1.53
ARTR2	10-m^2	15	93.3	7.83	6.62	84.50	3.35	42.76		1.45
	1-m^2	15	60.0	4.40	7.41	168.51	3.75	85.27	5.4	0.81
	Line-point	15	33.3	4.00	6.32	158.11	3.20	80.02		0.74
BRTE	10-m^2	15	100.0	3.53	2.70	76.29	1.36	38.61		0.33
	1-m^2	15	100.0	2.13	1.55	72.76	0.79	36.82	10.6	0.20
	Line-point	15	93.3	26.00	16.39	63.03	8.29	31.90		2.46
STCO4	10-m^2	15	46.7	0.23	0.26	110.66	0.13	56.00		1.62
	1-m^2	15	13.3	0.20	0.56	280.31	0.28	141.85	0.1	1.38
	Line-point	15	0.0	0.00	-	-	-	-		0.00
Bare soil	10-m^2	15	73.3	0.37	0.23	62.42	0.12	31.59		0.07
	1-m^2	15	40.0	0.40	0.51	126.77	0.26	64.15	5.4	0.07
	Line-point	15	66.7	15.33	13.02	84.91	6.59	42.97		2.86
Litter	10-m^2	15	100.0	37.83	22.00	58.14	11.13	29.42		1.28
	1-m^2	15	100.0	33.80	24.97	73.89	12.64	37.39	29.7	1.14
	Line-point	15	80.0	17.33	13.35	76.99	6.75	38.96		0.58
BSC	10-m^2	15	100.0	4.27	2.15	50.28	1.09	25.45		0.48
	1-m^2	15	100.0	5.20	3.67	70.55	1.86	35.70	8.9	0.58
	Line-point	15	86.7	17.33	12.23	70.55	6.19	35.70		1.94

Table C34. Summary of frequency (freq) and cover estimates in macroplot DINO5 (Semidesert Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Loam (Wyoming Big Sagebrush) ecological site – DINO 5 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	26.23	7.87	30.01	3.98	15.18		1.04
	1-m^2	15	100.0	15.67	9.05	57.78	4.58	29.24	25.3	0.62
	Line-point	15	93.3	34.00	24.14	71.01	12.22	35.93		1.34
ARTR2	10-m^2	15	93.3	16.33	7.95	48.70	4.03	24.65		1.53
	1-m^2	15	73.3	7.73	8.40	108.68	4.25	55.00	10.7	0.72
	Line-point	15	60.0	8.00	7.75	96.82	3.92	49.00		0.75
BRTE	10-m^2	15	73.3	2.80	6.01	214.69	3.04	108.65		0.70
	1-m^2	15	33.3	1.20	3.08	256.27	1.56	129.69	4.0	0.30
	Line-point	15	40.0	8.00	14.24	178.03	7.21	90.10		2.00
STCO4	10-m^2	15	93.3	0.63	0.67	105.36	0.34	53.32		0.48
	1-m^2	15	66.7	0.67	0.49	73.19	0.25	37.04	1.3	0.50
	Line-point	15	20.0	2.67	5.94	222.61	3.00	112.65		2.02
Bare soil	10-m^2	15	86.7	0.43	0.18	40.60	0.09	20.55		0.29
	1-m^2	15	66.7	0.73	0.59	80.95	0.30	40.96	1.5	0.49
	Line-point	15	33.3	3.33	4.88	146.39	2.47	74.08		2.22
Litter	10-m^2	15	100.0	21.50	10.56	49.10	5.34	24.85		1.19
	1-m^2	15	100.0	18.07	23.82	131.82	12.05	66.71	18.1	1.00
	Line-point	15	80.0	14.67	13.02	88.77	6.59	44.92		0.81
BSC	10-m^2	15	100.0	7.63	6.81	89.25	3.45	45.16		0.57
	1-m^2	15	100.0	10.73	15.07	140.39	7.63	71.05	13.5	0.80
	Line-point	15	66.7	22.00	20.42	92.84	10.34	46.98		1.64

Table C35. Summary of frequency (freq) and cover estimates in macroplot ARCH1b (Semidesert Shallow Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site – ARCH 1b macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	18.67	5.97	31.98	2.55	13.68		1.26
	1-m^2	30	96.7	12.30	10.77	87.59	3.86	31.34	14.8	0.83
	Line-point	30	73.3	13.33	12.95	97.16	4.64	34.77		0.90
CORA	10-m^2	21	95.2	14.07	5.79	41.12	2.47	17.59		1.29
	1-m^2	30	83.3	8.30	8.45	101.80	3.02	36.43	10.9	0.76
	Line-point	30	63.3	10.33	10.98	106.26	3.93	38.03		0.95
FEOC3	10-m^2	21	23.8	0.12	0.22	183.30	0.09	78.40		1.63
	1-m^2	30	10.0	0.10	0.31	305.13	0.11	109.19	0.1	1.37
	Line-point	30	0.0	0.00	-	-	-	-		0.00
Bare soil	10-m^2	21	76.2	1.45	1.39	95.47	0.59	40.83		0.77
	1-m^2	30	50.0	1.20	2.07	172.87	0.74	61.86	1.9	0.64
	Line-point	30	16.7	3.00	7.94	264.79	2.84	94.75		1.59
Litter	10-m^2	21	100.0	2.02	3.73	184.13	1.59	78.75		0.97
	1-m^2	30	96.7	3.23	7.16	221.49	2.56	79.26	2.1	1.55
	Line-point	30	10.0	1.00	3.05	305.13	1.09	109.19		0.48
Undiffer-entiated crust	10-m^2	21	100.0	72.98	21.03	28.82	8.99	12.33		0.96
	1-m^2	30	96.7	71.90	27.11	37.70	9.70	13.49	76.3	0.94
	Line-point	30	100.0	84.00	14.29	17.01	5.11	6.09		1.10
BSC	10-m^2	21	52.4	1.60	2.80	175.81	1.20	75.19		1.11
	1-m^2	30	33.3	1.03	2.25	217.86	0.81	77.96	1.4	0.72
	Line-point	30	16.7	1.67	3.79	227.43	1.36	81.38		1.16

Table C35. Summary of frequency (freq) and cover estimates in macroplot ARCH2 (Semidesert Shallow Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site – ARCH 2 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	28.24	12.23	43.33	5.23	18.53		1.25
	1-m^2	30	100.0	24.00	14.44	60.15	5.17	21.52	22.5	1.07
	Line-point	30	83.3	15.33	12.24	79.84	4.38	28.57		0.68
CORA	10-m^2	21	100.0	22.88	11.36	49.65	4.86	21.23		1.30
	1-m^2	30	96.7	19.60	12.89	65.77	4.61	23.54	17.6	1.11
	Line-point	30	70.0	10.33	9.99	96.72	3.58	34.61		0.59
FEOC3	10-m^2	21	52.4	0.26	0.26	97.70	0.11	41.79		1.49
	1-m^2	30	26.7	0.27	0.45	168.67	0.16	60.36	0.2	1.51
	Line-point	30	0.0	0.00	-	-	-	-		0.00
Bare soil	10-m^2	21	95.2	1.86	3.95	212.70	1.69	90.97		0.45
	1-m^2	30	66.7	3.07	5.66	184.45	2.02	66.00	4.1	0.75
	Line-point	30	53.3	7.33	8.28	112.87	2.96	40.39		1.79
Litter	10-m^2	21	100.0	4.55	7.97	175.29	3.41	74.97		1.29
	1-m^2	30	100.0	4.67	5.38	115.24	1.92	41.24	3.5	1.33
	Line-point	30	6.7	1.33	5.71	428.51	2.04	153.34		0.38
Undiffer-entiated crust	10-m^2	21	100.0	70.83	14.43	20.38	6.17	8.72		0.94
	1-m^2	30	100.0	71.67	17.60	24.56	6.30	8.79	75.2	0.95
	Line-point	30	100.0	83.00	13.68	16.49	4.90	5.90		1.10
BSC	10-m^2	21	90.5	6.12	8.50	138.86	3.63	59.39		0.98
	1-m^2	30	83.3	8.27	11.61	140.39	4.15	50.24	6.2	1.32
	Line-point	30	33.3	4.33	7.28	167.98	2.60	60.11		0.69

Table C35. Summary of frequency (freq) and cover estimates in macroplot ARCH3 (Semidesert Shallow Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site – ARCH 3 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	13.73	8.68	63.24	4.39	32.00		1.33
	1-m^2	15	100.0	10.47	11.26	107.54	5.70	54.42	10.3	1.02
	Line-point	15	46.7	6.67	8.16	122.47	4.13	61.98		0.65
CORA	10-m^2	15	80.0	9.23	7.53	81.51	3.81	41.25		1.28
	1-m^2	15	86.7	8.40	10.06	119.79	5.09	60.62	7.2	1.16
	Line-point	15	40.0	4.00	5.07	126.77	2.57	64.15		0.55
FEOC3	10-m^2	15	80.0	0.40	0.21	51.75	0.10	26.19		0.86
	1-m^2	15	33.3	0.33	0.49	146.39	0.25	74.08	0.5	0.71
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		1.43
Bare soil	10-m^2	15	93.3	0.47	0.13	27.66	0.07	14.00		0.24
	1-m^2	15	66.7	0.67	0.49	73.19	0.25	37.04	1.9	0.34
	Line-point	15	33.3	4.67	8.34	178.67	4.22	90.42		2.41
Litter	10-m^2	15	100.0	2.73	4.77	174.48	2.41	88.30		1.40
	1-m^2	15	100.0	2.47	3.83	155.41	1.94	78.65	2.0	1.26
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		0.34
Undiffer-entiated crust	10-m^2	15	100.0	85.83	6.45	7.52	3.27	3.81		1.01
	1-m^2	15	100.0	86.27	9.19	10.66	4.65	5.39	84.9	1.02
	Line-point	15	100.0	82.67	13.87	16.78	7.02	8.49		0.97
BSC	10-m^2	15	93.3	3.33	2.96	88.68	1.50	44.88		0.59
	1-m^2	15	80.0	3.67	3.11	84.79	1.57	42.91	5.7	0.65
	Line-point	15	46.7	10.00	15.12	151.19	7.65	76.51		1.76

Table C38. Summary of frequency (freq) and cover estimates in macroplot ARCH4b (Semidesert Shallow Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site – ARCH 4b macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	15.87	12.88	81.15	6.52	41.07		1.38
	1-m^2	15	100.0	11.20	12.36	110.40	6.26	55.87	11.5	0.98
	Line-point	15	60.0	7.33	7.04	95.96	3.56	48.56		0.64
CORA	10-m^2	15	53.3	7.33	7.99	108.93	4.04	55.12		1.35
	1-m^2	15	80.0	4.93	4.82	97.65	2.44	49.42	5.4	0.91
	Line-point	15	40.0	4.00	5.07	126.77	2.57	64.15		0.74
FEOC3	10-m^2	15	80.0	1.53	4.42	288.38	2.24	145.94		2.30
	1-m^2	15	46.7	0.47	0.52	110.66	0.26	56.00	0.7	0.70
	Line-point	15	0.0	0.00	-	-	-	-		0.00
Bare soil	10-m^2	15	100.0	0.50	0.00	0.00	0.00	0.00		0.16
	1-m^2	15	60.0	1.13	1.41	124.19	0.71	62.85	3.2	0.35
	Line-point	15	46.7	8.00	10.14	126.77	5.13	64.15		2.49
Litter	10-m^2	15	100.0	4.40	5.62	127.79	2.85	64.67		1.01
	1-m^2	15	100.0	7.40	23.69	320.11	11.99	161.99	4.4	1.69
	Line-point	15	13.3	1.33	3.52	263.90	1.78	133.55		0.30
Undiffer-entiated crust	10-m^2	15	100.0	74.50	21.94	29.45	11.10	14.90		1.06
	1-m^2	15	93.3	76.13	21.86	28.72	11.06	14.53	70.0	1.09
	Line-point	15	100.0	59.33	22.19	37.40	11.23	18.93		0.85
BSC	10-m^2	15	100.0	4.60	5.98	129.99	3.03	65.78		0.70
	1-m^2	15	93.3	4.53	3.66	80.78	1.85	40.88	6.6	0.69
	Line-point	15	53.3	10.67	12.23	114.64	6.19	58.01		1.62

Table C39. Summary of frequency (freq) and cover estimates in macroplot ARCH5 (Semidesert Shallow Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site – ARCH 5 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	100.0	18.40	8.44	45.85	4.27	23.20		0.96
	1-m^2	15	100.0	20.67	10.17	49.23	5.15	24.91	19.2	1.07
	Line-point	15	86.7	18.67	15.52	83.16	7.86	42.08		0.97
CORA	10-m^2	15	73.3	12.83	8.01	62.42	4.05	31.59		1.12
	1-m^2	15	93.3	13.67	12.03	88.01	6.09	44.54	11.5	1.19
	Line-point	15	66.7	8.00	6.76	84.52	3.42	42.77		0.70
FEOC3	10-m^2	15	93.3	0.47	0.13	27.66	0.07	14.00		0.26
	1-m^2	15	93.3	0.93	0.26	27.66	0.13	14.00	1.8	0.52
	Line-point	15	26.7	4.00	8.28	207.02	4.19	104.76		2.22
Bare soil	10-m^2	15	100.0	0.67	0.65	96.82	0.33	49.00		0.46
	1-m^2	15	73.3	1.00	1.00	100.00	0.51	50.61	1.4	0.69
	Line-point	15	26.7	2.67	4.58	171.65	2.32	86.87		1.85
Litter	10-m^2	15	100.0	2.97	1.53	51.54	0.77	26.08		1.43
	1-m^2	15	100.0	2.60	1.40	54.00	0.71	27.33	2.1	1.25
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		0.32
Undiffer-entiated crust	10-m^2	15	100.0	87.50	0.00	0.00	0.00	0.00		1.06
	1-m^2	15	100.0	86.73	5.61	6.47	2.84	3.27	82.7	1.05
	Line-point	15	100.0	74.00	15.95	21.55	8.07	10.91		0.89
BSC	10-m^2	15	100.0	10.93	5.81	53.10	2.94	26.87		0.93
	1-m^2	15	100.0	7.07	4.50	63.62	2.27	32.19	11.8	0.60
	Line-point	15	73.3	17.33	15.34	88.49	7.76	44.78		1.47

Table C40. Summary of frequency (freq) and cover estimates in macroplot CANY3 (Semidesert Shallow Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site – CANY 3 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	20.95	15.30	73.02	6.54	31.23		0.99
	1-m^2	30	96.7	20.83	19.00	91.19	6.80	32.63	21.2	0.98
	Line-point	30	70.0	21.67	23.65	109.14	8.46	39.06		1.02
CORA	10-m^2	21	52.4	3.60	6.24	173.57	2.67	74.24		0.89
	1-m^2	30	50.0	5.20	9.65	185.65	3.45	66.43	4.0	1.29
	Line-point	30	23.3	3.33	6.61	198.27	2.36	70.95		0.82
FEOC3	10-m^2	21	90.5	0.45	0.15	33.25	0.06	14.22		0.59
	1-m^2	30	83.3	0.83	0.38	45.49	0.14	16.28	0.8	1.09
	Line-point	30	10.0	1.00	3.05	305.13	1.09	109.19		1.31
Bare soil	10-m^2	21	57.1	0.29	0.25	88.74	0.11	37.95		0.23
	1-m^2	30	26.7	0.73	1.57	214.67	0.56	76.82	1.2	0.60
	Line-point	30	16.7	2.67	6.91	259.31	2.47	92.79		2.17
Litter	10-m^2	21	100.0	13.12	18.78	143.15	8.03	61.22		1.07
	1-m^2	30	96.7	11.30	21.47	189.96	7.68	67.98	12.3	0.92
	Line-point	30	60.0	12.33	15.47	125.40	5.53	44.87		1.01
Undiffer-entiated crust	10-m^2	21	100.0	66.55	24.32	36.55	10.40	15.63		0.94
	1-m^2	30	100.0	76.80	23.12	30.11	8.27	10.77	71.0	1.08
	Line-point	30	100.0	69.67	22.66	32.53	8.11	11.64		0.98
BSC	10-m^2	21	95.2	4.33	3.52	81.13	1.50	34.70		0.51
	1-m^2	30	86.7	7.60	9.07	119.38	3.25	42.72	8.4	0.90
	Line-point	30	73.3	13.33	11.55	86.60	4.13	30.99		1.58

Table C41. Summary of frequency (freq) and cover estimates in macroplot CANY4 (Semidesert Shallow Sandy Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site – CANY 4 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	90.5	15.71	18.44	117.34	7.89	50.19		1.15
	1-m^2	30	83.3	15.13	25.08	165.70	8.97	59.29	13.6	1.11
	Line-point	30	46.7	10.00	12.87	128.65	4.60	46.04		0.73
CORA	10-m^2	21	23.8	2.40	5.49	228.49	2.35	97.72		0.70
	1-m^2	30	16.7	4.17	10.67	256.18	3.82	91.67	3.4	1.22
	Line-point	30	23.3	3.67	7.65	208.61	2.74	74.65		1.07
FEOC3	10-m^2	21	61.9	0.31	0.25	80.38	0.11	34.38		0.63
	1-m^2	30	50.0	0.50	0.51	101.71	0.18	36.40	0.5	1.02
	Line-point	30	6.7	0.67	2.54	380.56	0.91	136.18		1.35
Bare soil	10-m^2	21	100.0	1.43	1.76	123.39	0.75	52.77		0.76
	1-m^2	30	66.7	2.57	3.06	119.18	1.09	42.65	1.9	1.36
	Line-point	30	13.3	1.67	4.61	276.68	1.65	99.01		0.88
Litter	10-m^2	21	95.2	9.62	18.55	192.86	7.93	82.49		1.04
	1-m^2	30	100.0	10.00	21.41	214.06	7.66	76.60	9.2	1.09
	Line-point	30	33.3	8.00	18.08	226.00	6.47	80.87		0.87
Undiffer-entiated crust	10-m^2	21	95.2	30.60	28.69	93.78	12.27	40.11		0.78
	1-m^2	30	86.7	46.70	33.36	71.42	11.94	25.56	39.1	1.19
	Line-point	30	90.0	40.00	28.04	70.10	10.03	25.08		1.02
BSC	10-m^2	21	95.2	8.14	6.16	75.68	2.64	32.37		0.63
	1-m^2	30	90.0	12.23	11.08	90.59	3.97	32.42	12.9	0.95
	Line-point	30	63.3	18.33	17.83	97.24	6.38	34.80		1.42

Table C42. Summary of frequency (freq) and cover estimates in macroplot WUPA3 (Shallow Loamy ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes.

Shallow Loamy, 10-14" pz ecological site – WUPA 3 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	25.02	8.99	35.94	3.85	15.37		0.87
	1-m^2	30	100.0	20.50	10.66	51.98	3.81	18.60	28.8	0.71
	Line-point	30	100.0	41.00	16.05	39.15	5.74	14.01		1.42
CHLE4	10-m^2	21	100.0	3.36	2.61	77.70	1.12	33.23		0.91
	1-m^2	30	73.3	2.37	3.15	132.92	1.13	47.56	3.7	0.64
	Line-point	30	46.7	5.33	6.29	117.90	2.25	42.19		1.45
HENE5	10-m^2	21	100.0	5.02	5.52	109.95	2.36	47.03		0.83
	1-m^2	30	86.7	3.03	2.89	95.42	1.04	34.15	6.0	0.50
	Line-point	30	63.3	10.00	10.83	108.28	3.87	38.75		1.66
PLJA	10-m^2	21	100.0	6.40	4.39	68.58	1.88	29.33		0.86
	1-m^2	30	100.0	6.30	4.98	79.00	1.78	28.27	7.5	0.84
	Line-point	30	60.0	9.67	10.66	110.30	3.82	39.47		1.30
Bare soil	10-m^2	21	100.0	2.12	2.16	101.74	0.92	43.51		0.30
	1-m^2	30	100.0	4.60	8.56	186.10	3.06	66.59	7.0	0.66
	Line-point	30	70.0	14.33	14.31	99.82	5.12	35.72		2.04
Litter	10-m^2	21	90.5	5.38	4.70	87.26	2.01	37.32		0.66
	1-m^2	30	93.3	7.77	11.11	143.08	3.98	51.20	8.2	0.95
	Line-point	30	70.0	11.33	10.08	88.94	3.61	31.83		1.39

Table C43. Summary of frequency (freq) and cover estimates in macroplot WUPA4 (Shallow Loamy ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes.

Shallow Loamy, 10-14" pz ecological site – WUPA 4 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	11.55	5.79	50.14	2.48	21.44		0.89
	1-m^2	30	100.0	13.87	17.02	122.72	6.09	43.91	13.0	1.06
	Line-point	30	80.0	13.67	9.64	70.56	3.45	25.25		1.05
CHLE4	10-m^2	21	90.5	0.57	0.58	100.86	0.25	43.14		0.74
	1-m^2	30	70.0	1.07	1.23	115.30	0.44	41.26	0.8	1.39
	Line-point	30	6.7	0.67	2.54	380.56	0.91	136.18		0.87
HENE5	10-m^2	21	85.7	1.95	1.84	94.41	0.79	40.38		1.02
	1-m^2	30	76.7	1.47	1.31	89.05	0.47	31.86	1.9	0.76
	Line-point	30	23.3	2.33	4.30	184.36	1.54	65.97		1.22
PLJA	10-m^2	21	100.0	2.69	2.33	86.67	1.00	37.07		0.84
	1-m^2	30	86.7	2.30	2.12	92.16	0.76	32.98	3.2	0.71
	Line-point	30	36.7	4.67	6.81	146.02	2.44	52.25		1.45
Bare soil	10-m^2	21	100.0	1.45	1.24	85.65	0.53	36.63		0.53
	1-m^2	30	96.7	2.47	1.68	67.95	0.60	24.31	2.8	0.90
	Line-point	30	30.0	4.33	8.58	198.08	3.07	70.88		1.58
Litter	10-m^2	21	95.2	7.33	5.56	75.78	2.38	32.41		0.96
	1-m^2	30	96.7	9.27	13.28	143.33	4.75	51.29	7.6	1.21
	Line-point	30	43.3	6.33	8.90	140.51	3.18	50.28		0.83

Table C44. Summary of frequency (freq) and cover estimates in macroplot CARE3 (Upland Shallow Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Upland Shallow Loam (Pinyon-Utah Juniper) ecological site – CARE 3 macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	20.02	24.10	120.35	10.31	51.47		1.50
	1-m^2	30	93.3	10.13	19.95	196.92	7.14	70.47	13.4	0.76
	Line-point	30	46.7	10.00	13.65	136.46	4.88	48.83		0.75
CEMO2	10-m^2	21	0.0	0.00	-	-	-	-		-
	1-m^2	30	0.0	0.00	-	-	-	-	0.0	-
	Line-point	30	0.0	0.00	-	-	-	-		-
COWR2	10-m^2	21	95.2	1.76	1.81	102.95	0.78	44.03		0.66
	1-m^2	30	90.0	1.63	1.47	90.22	0.53	32.28	2.7	0.61
	Line-point	30	30.0	4.67	9.37	200.81	3.35	71.86		1.74
JUOS	10-m^2	21	42.9	8.76	17.01	194.10	7.27	83.02		1.72
	1-m^2	30	10.0	3.83	14.42	376.30	5.16	134.65	5.1	0.75
	Line-point	30	16.7	2.67	6.91	259.31	2.47	92.79		0.52
Bare soil	10-m^2	21	85.7	0.90	1.06	116.73	0.45	49.93		0.15
	1-m^2	30	80.0	1.23	1.10	89.54	0.40	32.04	5.9	0.21
	Line-point	30	73.3	15.67	14.06	89.77	5.03	32.12		2.64
Litter	10-m^2	21	100.0	16.24	25.15	154.87	10.76	66.24		1.45
	1-m^2	30	100.0	13.63	25.84	189.53	9.25	67.82	11.2	1.22
	Line-point	30	13.3	3.67	11.59	316.14	4.15	113.13		0.33
BSC	10-m^2	21	28.6	0.14	0.23	162.02	0.10	69.30		0.44
	1-m^2	30	13.3	0.17	0.46	276.68	0.17	99.01	0.3	0.51
	Line-point	30	6.7	0.67	2.54	380.56	0.91	136.18		2.05

Table C45. Summary of frequency (freq) and cover estimates in macroplot CARE4b (Upland Shallow Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Upland Shallow Loam (Pinyon-Utah Juniper) ecological site – CARE 4b macroplot, Phase 2										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	21	100.0	15.14	20.83	137.57	8.91	58.84		0.93
	1-m^2	30	96.7	20.17	30.81	152.77	11.02	54.67	16.2	1.24
	Line-point	30	60.0	13.33	15.39	115.41	5.51	41.30		0.82
CEMO2	10-m^2	21	0.0	0.00	-	-	-	-		-
	1-m^2	30	0.0	0.00	-	-	-	-	0.0	-
	Line-point	30	0.0	0.00	-	-	-	-		-
COWR2	10-m^2	21	100.0	1.33	1.21	90.57	0.52	38.74		0.66
	1-m^2	30	80.0	1.77	2.27	128.46	0.81	45.97	2.0	0.87
	Line-point	30	23.3	3.00	5.96	198.65	2.13	71.09		1.48
JUOS	10-m^2	21	28.6	5.74	11.83	206.16	5.06	88.17		1.11
	1-m^2	30	20.0	6.43	18.64	289.70	6.67	103.67	5.2	1.24
	Line-point	30	16.7	3.33	8.02	240.69	2.87	86.13		0.64
Bare soil	10-m^2	21	100.0	1.52	2.18	142.83	0.93	61.09		0.21
	1-m^2	30	86.7	2.10	2.01	95.53	0.72	34.18	7.4	0.28
	Line-point	30	76.7	18.67	19.43	104.08	6.95	37.24		2.51
Litter	10-m^2	21	100.0	16.00	22.54	140.86	9.64	60.25		1.26
	1-m^2	30	96.7	19.13	30.28	158.23	10.83	56.62	12.7	1.51
	Line-point	30	16.7	3.00	7.50	249.90	2.68	89.43		0.24
BSC	10-m^2	21	14.3	0.07	0.18	251.00	0.08	107.35		0.49
	1-m^2	30	3.3	0.03	0.18	547.72	0.07	196.00	0.1	0.23
	Line-point	30	3.3	0.33	1.83	547.72	0.65	196.00		2.28

Table C46. Summary of frequency (freq) and cover estimates in macroplot CARE8 (Upland Shallow Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Upland Shallow Loam (Pinyon-Utah Juniper) ecological site – CARE 8 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	93.3	15.97	13.00	81.40	6.58	41.19		0.98
	1-m^2	15	93.3	18.33	26.16	142.69	13.24	72.21	16.3	1.12
	Line-point	15	66.7	14.67	13.56	92.44	6.86	46.78		0.90
CEMO2	10-m^2	15	40.0	4.23	7.15	168.86	3.62	85.46		1.32
	1-m^2	15	33.3	1.40	2.85	203.47	1.44	102.97	3.2	0.44
	Line-point	15	26.7	4.00	8.28	207.02	4.19	104.76		1.25
COWR2	10-m^2	15	73.3	0.70	0.96	137.13	0.49	69.40		0.50
	1-m^2	15	60.0	0.87	0.83	96.21	0.42	48.69	1.4	0.61
	Line-point	15	26.7	2.67	4.58	171.65	2.32	86.87		1.89
JUOS	10-m^2	15	26.7	5.33	10.85	203.45	5.49	102.96		1.57
	1-m^2	15	13.3	0.87	2.64	304.86	1.34	154.28	3.4	0.25
	Line-point	15	26.7	4.00	7.37	184.20	3.73	93.21		1.18
Bare soil	10-m^2	15	100.0	1.17	1.14	98.09	0.58	49.64		0.17
	1-m^2	15	100.0	1.80	1.78	98.94	0.90	50.07	6.8	0.27
	Line-point	15	86.7	17.33	13.35	76.99	6.75	38.96		2.56
Litter	10-m^2	15	100.0	20.03	25.01	124.83	12.66	63.17		0.97
	1-m^2	15	100.0	31.00	39.47	127.32	19.97	64.43	20.6	1.51
	Line-point	15	46.7	10.67	15.34	143.79	7.76	72.77		0.52
BSC	10-m^2	15	13.3	0.07	0.18	263.90	0.09	133.55		1.50
	1-m^2	15	6.7	0.07	0.26	387.30	0.13	196.00	0.0	1.50
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C47. Summary of frequency (freq) and cover estimates in macroplot CARE9 (Upland Shallow Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Upland Shallow Loam (Pinyon-Utah Juniper) ecological site – CARE 9 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	93.3	10.23	11.25	109.94	5.69	55.63		1.39
	1-m^2	15	80.0	7.20	18.92	262.75	9.57	132.97	7.4	0.98
	Line-point	15	26.7	4.67	9.15	196.17	4.63	99.28		0.63
CEMO2	10-m^2	15	26.7	2.87	6.24	217.80	3.16	110.22		2.58
	1-m^2	15	13.3	0.47	1.36	290.52	0.69	147.02	1.1	0.42
	Line-point	15	0.0	0.00	-	-	-	-		0.00
COWR2	10-m^2	15	60.0	0.97	1.29	133.26	0.65	67.44		1.85
	1-m^2	15	40.0	0.60	0.83	138.01	0.42	69.84	0.5	1.15
	Line-point	15	0.0	0.00	-	-	-	-		0.00
JUOS	10-m^2	15	20.0	3.03	9.73	320.69	4.92	162.29		1.05
	1-m^2	15	6.7	5.00	19.36	387.30	9.80	196.00	2.9	1.72
	Line-point	15	6.7	0.67	2.58	387.30	1.31	196.00		0.23
Bare soil	10-m^2	15	93.3	0.47	0.13	27.66	0.07	14.00		0.17
	1-m^2	15	73.3	1.07	1.22	114.64	0.62	58.01	2.7	0.39
	Line-point	15	33.3	6.67	10.47	156.98	5.30	79.44		2.44
Litter	10-m^2	15	100.0	5.40	9.92	183.73	5.02	92.98		0.98
	1-m^2	15	100.0	8.53	23.33	273.39	11.81	138.35	5.5	1.54
	Line-point	15	20.0	2.67	5.94	222.61	3.00	112.65		0.48
BSC	10-m^2	15	20.0	0.10	0.21	207.02	0.10	104.76		1.80
	1-m^2	15	6.7	0.07	0.26	387.30	0.13	196.00	0.1	1.20
	Line-point	15	0.0	0.00	-	-	-	-		0.00

Table C48. Summary of frequency (freq) and cover estimates in macroplot CARE10 (Upland Shallow Loam ecological site). For line-point sampling, 10-point groups were used as subsampling units for purposes of frequency calculations. Precision is defined as one-half the width of the 95 percent confidence interval. The standardized mean was calculated as the ratio of the mean for a particular method to the among-method mean. See Appendix A for keys to species codes (BSC = biological soil crust).

Upland Shallow Loam (Pinyon-Utah Juniper) ecological site – CARE 10 macroplot, Phase 3										
				Cover						
Measure	Method	Subsample n	Freq	Mean	sd	CV	Precision	Precision % of mean	Among-method mean	Standardized mean
Total live understory canopy cover	10-m^2	15	93.3	21.23	29.29	137.92	14.82	69.80		1.09
	1-m^2	15	80.0	21.07	26.72	126.85	13.52	64.19	19.4	1.08
	Line-point	15	80.0	16.00	14.54	90.88	7.36	45.99		0.82
CEMO2	10-m^2	15	26.7	2.20	4.97	226.10	2.52	114.42		0.44
	1-m^2	15	13.3	4.67	12.32	263.90	6.23	133.55	5.0	0.94
	Line-point	15	40.0	8.00	14.24	178.03	7.21	90.10		1.61
COWR2	10-m^2	15	73.3	1.03	1.25	120.58	0.63	61.02		1.02
	1-m^2	15	46.7	0.67	0.82	122.47	0.41	61.98	1.0	0.66
	Line-point	15	13.3	1.33	3.52	263.90	1.78	133.55		1.32
JUOS	10-m^2	15	26.7	5.03	10.85	215.54	5.49	109.08		1.00
	1-m^2	15	26.7	8.00	14.24	178.03	7.21	90.10	5.0	1.60
	Line-point	15	20.0	2.00	4.14	207.02	2.10	104.76		0.40
Bare soil	10-m^2	15	100.0	1.60	2.48	154.99	1.25	78.44		0.23
	1-m^2	15	93.3	1.73	1.62	93.71	0.82	47.42	7.1	0.24
	Line-point	15	93.3	18.00	10.14	56.34	5.13	28.51		2.53
Litter	10-m^2	15	100.0	26.37	28.09	106.54	14.22	53.92		1.01
	1-m^2	15	100.0	37.67	38.01	100.90	19.23	51.06	26.0	1.45
	Line-point	15	66.7	14.00	16.39	117.06	8.29	59.24		0.54
BSC	10-m^2	15	0.0	0.00	-	-	-	-		-
	1-m^2	15	0.0	0.00	-	-	-	-	0.0	-
	Line-point	15	0.0	0.00	-	-	-	-		-

Appendix D—Among-Macroplot Variation in Selected Cover Measures by Ecological Site

Ecological site	Table	Page
Brushy Loam	D1	128
Desert Sand (Sand Sagebrush)	D2	129
Limy Upland, 6-10" pz	D3	130
Loamy Hills, 25-33" pz	D4	131
Loamy Hills, Cold, 25-33" pz	D5	132
Loamy Mesa Top PJ	D6	133
Semidesert Alkali Sandy Loam (Alkali Sacaton)	D7	134
Semidesert Loam (Wyoming Big Sagebrush)	D8	135
Semidesert Shallow Sandy Loam PJ	D9	136
Shallow Loamy, 10-14" pz	D10	137
Upland Shallow Loam (Pinyon-Utah Juniper)	D11	138

Table D1. Among-macroplot variation in selected cover measures for five Brushy Loam macroplots in Mesa Verde National Park, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Brushy Loam ecological site, n = 5 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	49.7	16.0	28.4	71.2	42.8	32.2	42	13	1.1
	1-m^2	43.4	13.7	25.8	62.6	36.8	31.6	42	13	1.9
	Line-point	52.8	3.3	48.7	56.0	7.3	6.2	4	3	7.3
AMUT	10-m^2	6.5	5.6	1.4	15.5	14.1	85.7	286	74	2.4
	1-m^2	3.2	4.4	0.0	10.8	10.8	138.9	727	184	1.9
	Line-point	5.2	3.8	0.7	10.3	9.7	72.3	206	54	3.1
POFE	10-m^2	9.6	13.2	0.0	30.4	30.3	136.9	720	183	1.1
	1-m^2	7.6	9.5	0.0	20.9	20.8	125.4	605	154	1.7
	Line-point	8.8	9.1	0.0	20.7	20.7	103.1	409	105	1.7
QUGA	10-m^2	14.5	16.8	1.2	37.4	36.2	115.3	511	131	1.8
	1-m^2	16.2	16.5	0.7	37.1	36.5	102.0	400	103	2.3
	Line-point	14.5	15.7	0.7	33.0	32.3	108.2	451	115	1.7
Bare soil	10-m^2	14.3	11.0	6.7	32.3	25.6	76.9	228	60	1.1
	1-m^2	16.8	14.8	4.2	40.9	36.7	88.0	298	77	1.8
	Line-point	41.3	26.4	8.0	78.0	70.0	63.9	160	42	1.2
Litter	10-m^2	70.4	16.2	44.2	84.2	40.0	23.0	23	8	1.1
	1-m^2	75.4	16.6	49.0	91.1	42.1	22.1	22	8	1.3
	Line-point	52.3	26.2	17.3	87.0	69.7	50.0	99	27	1.0
BSC	10-m^2	0.2	0.2	0.0	0.4	0.4	121.4	588	151	1.8
	1-m^2	0.1	0.2	0.0	0.4	0.4	170.0	1111	278	2.2
	Line-point	0.2	0.3	0.0	0.7	0.7	149.1	865	217	3.1

Table D2. Among-macroplot variation in selected cover measures for two Desert Sand (Sand Sagebrush) macroplots in Canyonlands National Park, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Desert Sand (Sand Sagebrush) ecological site, n = 2 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	13.4	0.4	13.1	13.7	0.6	3.3	3	3	8.5
	1-m^2	12.3	0.3	12.1	12.5	0.4	2.3	3	3	27.0
	Line-point	11.7	0.0	11.7	11.7	0.0	0.0	2	2	-
ATCA2	10-m^2	1.5	0.5	1.1	1.8	0.8	37.1	56	16	4.6
	1-m^2	1.7	0.1	1.6	1.7	0.2	7.1	5	3	59.8
	Line-point	1.3	0.9	0.7	2.0	1.3	70.7	194	51	4.4
HIJA	10-m^2	1.7	0.8	1.2	2.3	1.1	45.8	83	23	3.2
	1-m^2	1.1	0.1	1.0	1.2	0.2	10.9	8	4	17.9
	Line-point	1.2	0.2	1.0	1.3	0.3	20.2	19	7	18.2
STHY6	10-m^2	0.6	0.6	0.2	1.1	0.9	99.5	381	98	1.2
	1-m^2	0.5	0.6	0.1	0.9	0.8	114.0	501	128	1.7
	Line-point	1.8	2.1	0.3	3.3	3.0	115.7	514	131	3.0
Litter	10-m^2	6.9	1.2	6.0	7.7	1.6	16.9	14	6	3.7
	1-m^2	6.6	1.3	5.6	7.5	1.9	20.4	19	7	3.8
	Line-point	8.3	2.8	6.3	10.3	4.0	33.9	47	14	3.2
Undifferentiated crust	10-m^2	67.6	6.3	63.1	72.0	8.9	9.3	6	4	2.4
	1-m^2	79.1	2.5	77.4	80.9	3.5	3.2	3	3	4.2
	Line-point	81.5	4.5	78.3	84.7	6.3	5.5	4	3	3.3
BSC	10-m^2	4.3	4.6	1.0	7.5	6.5	107.6	446	114	0.8
	1-m^2	4.8	5.1	1.1	8.4	7.2	107.7	445	114	1.1
	Line-point	6.7	7.1	1.7	11.7	10.0	106.1	432	111	1.5

Table D3. Among-macroplot variation in selected cover measures for five Limy Upland macroplots in Wupatki National Monument, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes.

Limy Upland, 6-10" pz ecological site, n = 5 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	23.6	6.7	18.0	34.4	16.4	28.3	34	11	0.9
	1-m^2	16.0	3.5	11.7	20.1	8.4	21.6	21	7	1.5
	Line-point	26.7	4.4	21.3	31.3	10.0	16.5	13	6	3.6
CHLE4	10-m^2	5.1	4.0	1.1	10.7	9.6	76.8	227	60	1.2
	1-m^2	3.5	2.5	0.7	6.6	5.9	72.1	202	53	1.3
	Line-point	3.6	3.4	0.0	8.0	8.0	95.6	351	91	1.9
HENE5	10-m^2	3.7	3.4	0.6	9.0	8.4	90.6	317	82	1.4
	1-m^2	2.8	2.5	0.3	5.7	5.4	87.5	293	76	1.7
	Line-point	6.5	5.8	0.0	15.3	15.3	88.7	303	79	1.5
PLJA	10-m^2	4.4	3.8	0.5	9.6	9.1	86.8	290	75	1.7
	1-m^2	2.3	2.0	0.3	5.5	5.2	89.0	305	79	1.5
	Line-point	6.7	5.6	0.3	14.0	13.7	83.7	270	70	2.7
Bare soil	10-m^2	7.3	7.4	1.2	16.1	15.0	101.1	393	101	0.7
	1-m^2	7.3	6.9	1.9	16.7	14.8	94.8	346	89	0.9
	Line-point	16.3	16.7	4.0	40.7	36.7	102.3	403	103	1.1
Litter	10-m^2	6.6	1.7	3.9	8.4	4.5	25.7	28	9	2.5
	1-m^2	7.1	1.5	4.8	8.5	3.7	20.7	19	7	3.2
	Line-point	3.6	5.1	0.0	11.0	11.0	142.5	781	198	0.8

Table D4. Among-macroplot variation in selected cover measures for five Loamy Hills macroplots in Grand Canyon National Park, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, 25-33" pz ecological site, n = 5 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	19.7	11.6	5.6	35.2	29.5	58.9	136	36	1.3
	1-m^2	23.8	20.9	5.1	57.5	52.4	87.8	297	77	1.4
	Line-point	16.9	7.1	8.0	24.3	16.3	42.2	71	20	2.1
POFE	10-m^2	0.5	0.5	0.0	1.1	1.1	99.6	377	97	2.3
	1-m^2	0.4	0.4	0.0	1.1	1.1	109.9	465	119	2.0
	Line-point	1.5	1.4	0.0	3.3	3.3	94.3	344	89	3.0
POTR5	10-m^2	2.6	2.4	0.2	5.7	5.5	92.9	332	86	1.9
	1-m^2	4.1	3.3	0.1	8.0	7.8	81.1	254	66	3.2
	Line-point	1.8	1.8	0.0	4.7	4.7	101.1	393	101	2.5
UNGRCA1 (*Carex* sp.)	10-m^2	1.4	0.8	0.1	1.9	1.9	54.4	117	31	2.6
	1-m^2	1.2	0.7	0.1	1.9	1.8	53.9	114	31	3.3
	Line-point	6.5	4.2	0.0	10.0	10.0	64.3	162	43	1.9
Bare soil	10-m^2	1.5	0.3	1.2	2.0	0.8	20.0	19	7	6.4
	1-m^2	1.9	0.5	1.5	2.7	1.2	25.4	27	9	6.2
	Line-point	14.9	11.1	4.7	28.7	24.0	74.4	213	56	1.9
Litter	10-m^2	74.8	11.4	61.3	84.2	22.9	15.2	12	5	1.1
	1-m^2	80.1	7.3	73.9	89.5	15.6	9.1	6	4	2.2
	Line-point	69.3	7.9	60.0	78.0	18.0	11.3	8	4	2.9
BSC	10-m^2	0.7	0.9	0.0	1.9	1.9	130.2	656	167	2.1
	1-m^2	0.6	0.8	0.0	1.4	1.4	126.9	617	157	2.3
	Line-point	0.3	0.4	0.0	1.0	1.0	163.0	997	251	2.9

Table D5. Among-macroplot variation in selected cover measures for two Loamy Hills, Cold, macroplots in Grand Canyon National Park, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Hills, Cold, 25-33" pz ecological site, n = 2 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	48.8	7.4	43.6	54.0	10.5	15.2	12	5	4.3
	1-m^2	57.3	28.2	37.4	77.3	39.9	49.2	96	26	1.6
	Line-point	25.7	2.8	23.7	27.7	4.0	11.0	8	4	6.8
ABCO	10-m^2	8.6	12.2	0.0	17.2	17.2	141.4	769	195	1.1
	1-m^2	12.9	18.2	0.0	25.7	25.7	141.4	769	195	0.8
	Line-point	4.5	6.4	0.0	9.0	9.0	141.4	768	195	0.9
PIEN	10-m^2	6.9	5.5	3.0	10.8	7.8	80.4	249	65	3.9
	1-m^2	8.3	11.7	0.0	16.5	16.5	141.4	769	195	1.1
	Line-point	4.2	4.9	0.7	7.7	7.0	118.8	543	138	3.0
POTR5	10-m^2	4.7	1.4	3.7	5.7	2.0	29.6	37	11	6.3
	1-m^2	6.2	2.7	4.3	8.1	3.8	43.1	74	21	4.9
	Line-point	1.0	0.5	0.7	1.3	0.7	47.1	88	24	6.8
Bare soil	10-m^2	2.5	0.2	2.3	2.7	0.3	9.4	7	4	17.0
	1-m^2	1.8	0.7	1.3	2.3	1.0	39.3	63	18	4.7
	Line-point	4.0	1.9	2.7	5.3	2.7	47.1	89	24	4.8
Litter	10-m^2	70.2	0.8	69.6	70.8	1.2	1.2	3	2	18.1
	1-m^2	80.4	2.0	79.0	81.8	2.8	2.5	3	3	6.7
	Line-point	81.3	0.5	81.0	81.7	0.7	0.6	3	2	35.8
BSC	10-m^2	1.1	0.8	0.5	1.6	1.1	75.4	220	58	1.8
	1-m^2	1.2	0.7	0.7	1.7	1.0	61.7	149	39	5.1
	Line-point	1.0	1.4	0.0	2.0	2.0	141.4	764	194	1.7

Table D6. Among-macroplot variation in selected cover measures for five Loamy Mesa Top PJ macroplots in Mesa Verde National Park, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Loamy Mesa Top PJ ecological site, n = 5 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	32.7	15.2	20.9	55.7	34.8	46.5	86	24	3.4
	1-m^2	29.6	12.7	13.2	43.7	30.5	42.7	73	21	4.7
	Line-point	20.7	3.5	17.3	26.7	9.3	17.0	14	6	7.8
JUOS	10-m^2	7.7	4.1	3.3	12.2	8.9	52.9	110	30	3.1
	1-m^2	9.8	7.5	2.7	20.1	17.4	76.7	227	59	2.8
	Line-point	3.4	1.3	2.0	5.3	3.3	39.5	63	18	4.6
PIED	10-m^2	12.4	8.8	5.4	26.2	20.8	70.4	193	50	1.8
	1-m^2	10.9	4.0	4.6	15.4	10.8	37.2	56	16	5.6
	Line-point	7.3	3.0	2.7	10.0	7.3	40.3	65	19	3.7
POFE	10-m^2	7.0	5.2	0.5	13.1	12.6	74.2	212	56	0.8
	1-m^2	4.7	2.9	0.5	8.0	7.6	61.7	149	40	1.7
	Line-point	7.7	4.6	2.0	12.7	10.7	60.2	142	38	2.1
Bare soil	10-m^2	2.1	1.7	0.7	4.2	3.5	82.0	259	67	0.8
	1-m^2	2.3	2.4	0.6	6.3	5.7	105.4	428	110	1.0
	Line-point	7.1	4.7	2.7	14.0	11.3	66.2	171	45	1.1
Litter	10-m^2	47.2	7.2	38.2	58.5	20.3	15.3	12	5	4.1
	1-m^2	50.5	13.0	36.4	69.7	33.3	25.7	28	9	2.8
	Line-point	47.5	15.2	34.7	69.3	34.7	32.0	42	13	1.6
BSC	10-m^2	3.9	1.3	1.8	5.2	3.4	34.1	47	14	2.9
	1-m^2	5.4	3.2	1.9	9.1	7.2	58.9	136	36	2.2
	Line-point	7.4	4.5	4.7	15.3	10.7	60.5	143	38	2.5

Table D7. Among-macroplot variation in selected cover measures for five Semidesert Alkali Sandy Loam macroplots in Capitol Reef National Park, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Alkali Sandy Loam (Alkali Sacaton) ecological site, n = 5 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	20.3	10.3	7.3	35.5	28.2	50.9	102	28	0.9
	1-m^2	18.1	6.6	7.1	24.6	17.5	36.5	54	16	2.0
	Line-point	25.4	10.1	11.3	37.3	26.0	40.0	64	18	1.8
ATCO	10-m^2	2.6	1.8	0.6	4.6	4.0	69.5	188	49	2.0
	1-m^2	2.5	2.6	0.7	7.1	6.4	104.9	424	109	1.8
	Line-point	3.1	2.0	0.0	5.7	5.7	66.7	175	46	3.1
GIIN2	10-m^2	0.3	0.1	0.2	0.4	0.3	39.3	61	17	2.4
	1-m^2	0.4	0.2	0.2	0.6	0.4	44.6	77	22	3.1
	Line-point	0.3	0.6	0.0	1.3	1.3	173.2	1166	291	2.3
ORHY	10-m^2	0.5	0.2	0.3	0.7	0.4	29.5	37	12	2.9
	1-m^2	0.6	0.1	0.3	0.7	0.4	25.2	28	9	4.0
	Line-point	1.2	1.3	0.0	3.3	3.3	106.9	438	112	2.9
Bare soil	10-m^2	0.8	0.4	0.3	1.3	1.0	44.1	76	21	3.7
	1-m^2	1.2	0.7	0.3	2.1	1.8	62.2	152	40	2.9
	Line-point	4.3	2.6	0.7	8.0	7.3	60.6	143	38	3.3
Litter	10-m^2	9.7	5.2	1.3	15.6	14.3	53.9	114	31	1.4
	1-m^2	10.6	5.9	1.7	18.2	16.5	55.9	123	33	2.5
	Line-point	5.5	2.9	0.7	8.0	7.3	52.7	110	30	3.5
BSC	10-m^2	1.8	2.0	0.3	5.3	5.0	110.0	466	119	0.9
	1-m^2	1.5	1.1	0.3	3.2	2.9	74.3	215	56	1.7
	Line-point	3.3	3.5	0.0	8.0	8.0	107.6	446	114	2.2

Table D8. Among-macroplot variation in selected cover measures for five Semidesert Loam macroplots in Dinosaur National Monument, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Loam (Wyoming Big Sagebrush) ecological site, n = 5 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	32.2	15.5	20.7	59.4	38.7	48.0	92	25	0.8
	1-m^2	20.2	9.4	14.0	36.6	22.6	46.6	86	24	1.5
	Line-point	53.8	24.9	34.0	96.3	62.3	46.3	85	24	1.0
ARTR2	10-m^2	9.6	5.9	0.7	16.3	15.6	62.0	150	40	1.5
	1-m^2	5.3	3.4	0.1	9.0	8.9	65.1	166	44	3.4
	Line-point	4.8	3.1	0.0	8.0	8.0	63.9	160	42	2.1
BRTE	10-m^2	11.9	15.5	2.8	39.2	36.4	130.4	653	166	0.9
	1-m^2	7.3	9.4	1.2	23.7	22.5	130.3	653	166	1.1
	Line-point	30.1	19.2	8.0	57.0	49.0	63.8	159	42	1.4
STCO4	10-m^2	2.5	4.1	0.0	9.7	9.7	164.6	1040	260	0.6
	1-m^2	1.3	1.5	0.0	3.4	3.4	113.2	492	126	1.2
	Line-point	4.2	8.0	0.0	18.3	18.3	190.1	1387	347	0.9
Bare soil	10-m^2	0.7	0.6	0.2	1.8	1.6	89.1	301	78	1.0
	1-m^2	1.1	0.9	0.1	2.3	2.1	86.5	286	74	1.8
	Line-point	10.5	5.0	3.3	15.3	12.0	47.4	89	25	2.3
Litter	10-m^2	34.2	17.5	14.9	60.1	45.2	51.1	103	28	0.9
	1-m^2	35.0	22.2	18.0	72.2	54.2	63.5	158	42	1.3
	Line-point	29.8	18.6	14.7	54.3	39.7	62.4	152	40	1.1
BSC	10-m^2	5.5	2.6	1.8	7.9	6.1	46.2	85	23	1.9
	1-m^2	5.5	3.1	2.4	10.7	8.4	56.2	124	33	1.2
	Line-point	12.1	7.3	4.3	22.0	17.7	60.7	144	38	1.8

Table D9. Among-macroplot variation in selected cover measures for seven Semidesert Shallow Sandy Loam macroplots in Arches and Canyonlands National Parks, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Semidesert Shallow Sandy Loam (PJ) ecological site, n = 7 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	18.8	4.8	13.7	28.2	14.5	25.5	28	9	2.6
	1-m^2	16.4	5.4	10.5	24.0	13.5	33.1	45	14	2.9
	Line-point	13.3	5.7	6.7	21.7	15.0	42.7	73	21	2.4
CORA	10-m^2	10.3	7.0	2.4	22.9	20.5	68.0	181	47	1.6
	1-m^2	9.2	5.6	4.2	19.6	15.4	61.1	146	39	2.1
	Line-point	6.2	3.2	3.3	10.3	7.0	51.4	105	28	2.6
FEOC3	10-m^2	0.5	0.5	0.1	1.5	1.4	92.6	332	86	1.2
	1-m^2	0.5	0.3	0.1	0.9	0.8	61.3	147	39	2.1
	Line-point	0.9	1.4	0.0	4.0	4.0	157.3	946	237	2.0
Bare soil	10-m^2	1.0	0.6	0.3	1.9	1.6	64.6	161	42	1.4
	1-m^2	1.5	0.9	0.7	3.1	2.4	63.7	158	42	2.2
	Line-point	4.3	2.5	1.7	8.0	6.3	57.9	132	35	3.4
Litter	10-m^2	5.6	4.1	2.0	13.1	11.1	73.7	209	55	2.0
	1-m^2	6.0	3.6	2.5	11.3	8.8	61.2	147	39	3.0
	Line-point	3.6	4.7	0.7	12.3	11.7	128.6	635	161	2.4
Undifferentiated crust	10-m^2	69.8	18.9	30.6	87.5	56.9	27.1	31	10	1.1
	1-m^2	73.7	13.4	46.7	86.7	40.0	18.2	16	6	1.6
	Line-point	70.4	16.1	40.0	84.0	44.0	22.9	23	8	1.3
BSC	10-m^2	5.6	3.1	1.6	10.9	9.3	56.2	124	33	1.9
	1-m^2	6.3	3.6	1.0	12.2	11.2	57.3	129	34	2.0
	Line-point	10.8	6.2	1.7	18.3	16.7	57.5	130	35	2.3

Table D10. Among-macroplot variation in selected cover measures for two Shallow Loamy macroplots in Wupatki National Monument, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes.

Shallow Loamy, 10-14" pz ecological site, n = 2 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	18.3	9.5	11.5	25.0	13.5	52.1	107	29	0.8
	1-m^2	17.2	4.7	13.9	20.5	6.6	27.3	32	10	3.2
	Line-point	27.3	19.3	13.7	41.0	27.3	70.7	195	51	0.8
CHLE4	10-m^2	2.0	2.0	0.6	3.4	2.8	100.3	387	100	0.9
	1-m^2	1.7	0.9	1.1	2.4	1.3	53.5	113	31	2.3
	Line-point	3.0	3.3	0.7	5.3	4.7	110.0	465	119	2.3
HENE5	10-m^2	3.5	2.2	2.0	5.0	3.1	62.3	152	40	1.6
	1-m^2	2.3	1.1	1.5	3.0	1.6	49.2	96	26	1.9
	Line-point	6.2	5.4	2.3	10.0	7.7	87.9	297	77	1.7
PLJA	10-m^2	4.5	2.6	2.7	6.4	3.7	57.8	131	35	1.3
	1-m^2	4.3	2.8	2.3	6.3	4.0	65.8	169	45	1.3
	Line-point	7.2	3.5	4.7	9.7	5.0	49.3	97	26	2.6
Bare soil	10-m^2	1.8	0.5	1.5	2.1	0.7	26.4	30	10	3.5
	1-m^2	3.5	1.5	2.5	4.6	2.1	42.7	73	21	3.0
	Line-point	9.3	7.1	4.3	14.3	10.0	75.8	221	58	2.0
Litter	10-m^2	6.4	1.4	5.4	7.3	2.0	21.7	21	8	3.8
	1-m^2	8.5	1.1	7.8	9.3	1.5	12.5	9	4	11.5
	Line-point	8.8	3.5	6.3	11.3	5.0	40.0	65	18	2.9

Table D11. Among-macroplot variation in selected cover measures for two Upland Shallow Loam macroplots in Capitol Reef National Park, macroplot sample sizes required to achive 10 and 20% precision in estimates of ecological-site-level means, and ratios of within-to-among CV values. See Appendix A for keys to species codes (BSC = biological soil crust).

Upland Shallow Loam (Pinyon-Utah Juniper) ecological site, n = 5 macroplots										
Measure	Method	Mean cover	Among-macroplot variation in cover estimates					Sample size (by precision)		CV ratio (within:among)
			sd	Min	Max	Range	CV	10%	20%	
Total live understory canopy cover	10-m^2	16.5	4.4	10.2	21.2	11.0	26.4	30	10	4.4
	1-m^2	15.4	6.3	7.2	21.1	13.9	40.9	67	19	4.3
	Line-point	11.7	4.5	4.7	16.0	11.3	38.7	60	17	3.3
CEMO2	10-m^2	1.9	1.8	0.0	4.2	4.2	99.4	381	98	2.1
	1-m^2	1.3	2.0	0.0	4.7	4.7	150.3	864	217	1.7
	Line-point	2.4	3.6	0.0	8.0	8.0	149.1	855	214	1.3
COWR2	10-m^2	1.2	0.4	0.7	1.8	1.1	35.0	51	15	3.3
	1-m^2	1.1	0.6	0.6	1.8	1.2	49.9	98	27	2.3
	Line-point	2.3	1.8	0.0	4.7	4.7	75.6	219	58	2.8
JUOS	10-m^2	5.6	2.1	3.0	8.8	5.7	36.9	55	16	6.2
	1-m^2	4.8	2.7	0.9	8.0	7.1	56.1	124	33	5.5
	Line-point	2.5	1.3	0.7	4.0	3.3	50.6	101	27	5.1
Bare soil	10-m^2	1.1	0.5	0.5	1.6	1.1	41.1	69	20	2.6
	1-m^2	1.6	0.4	1.1	2.1	1.0	26.8	31	10	3.7
	Line-point	15.3	4.9	6.7	18.7	12.0	32.3	43	13	3.0
Litter	10-m^2	16.8	7.6	5.4	26.4	21.0	45.4	82	23	3.1
	1-m^2	22.0	12.1	8.5	37.7	29.1	55.0	119	32	3.1
	Line-point	6.8	5.2	2.7	14.0	11.3	76.5	225	59	2.7
BSC	10-m^2	0.1	0.1	0.0	0.1	0.1	68.6	169	45	3.2
	1-m^2	0.1	0.1	0.0	0.2	0.2	93.5	309	81	4.3
	Line-point	0.2	0.3	0.0	0.7	0.7	149.1	865	217	3.1

Appendix E—Mean Species-Area and Compositional Curves by Ecological Site

Ecological site	Figure	Page
Brushy Loam	E1	140
Desert Sand (Sand Sagebrush)	E2	141
Limy Upland, 6-10" pz	E3	142
Loamy Hills, 25-33" pz	E4	143
Loamy Hills, Cold, 25-33" pz	E5	144
Loamy Mesa Top PJ	E6	145
Semidesert Alkali Sandy Loam (Alkali Sacaton)	E7	146
Semidesert Loam (Wyoming Big Sagebrush)	E8	147
Semidesert Shallow Sandy Loam PJ	E9	148
Shallow Loamy, 10-14" pz	E10	149
Upland Shallow Loam (Pinyon-Utah Juniper)	E11	150

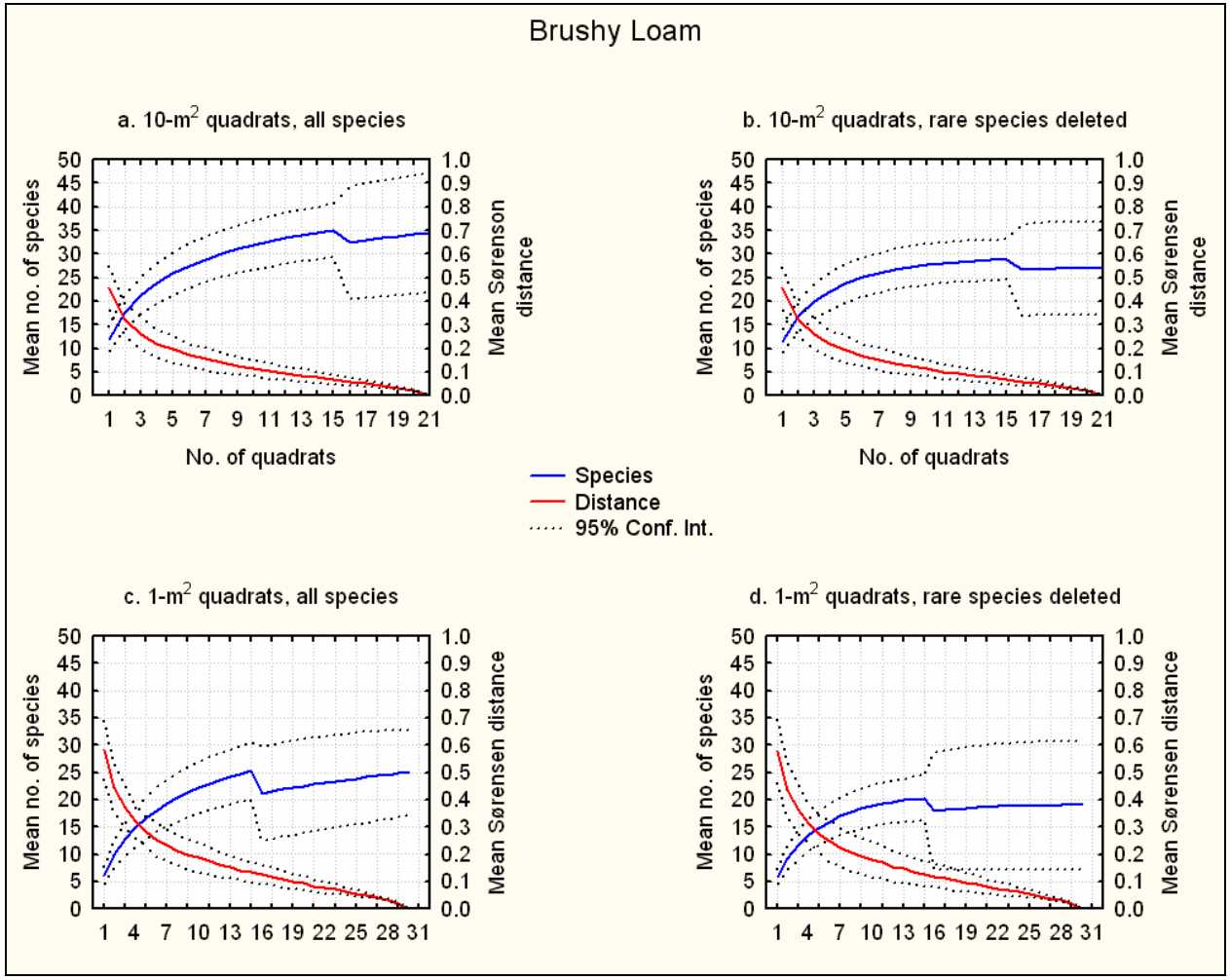

Figure E1. Mean species-area and compositional curves (mean Sørensen distances) for the Brushy Loam ecological site at Mesa Verde National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from five macroplots for quadrats 1-15 and two macroplots for quadrats > 15. Compositional curves are based on data from two macroplots.

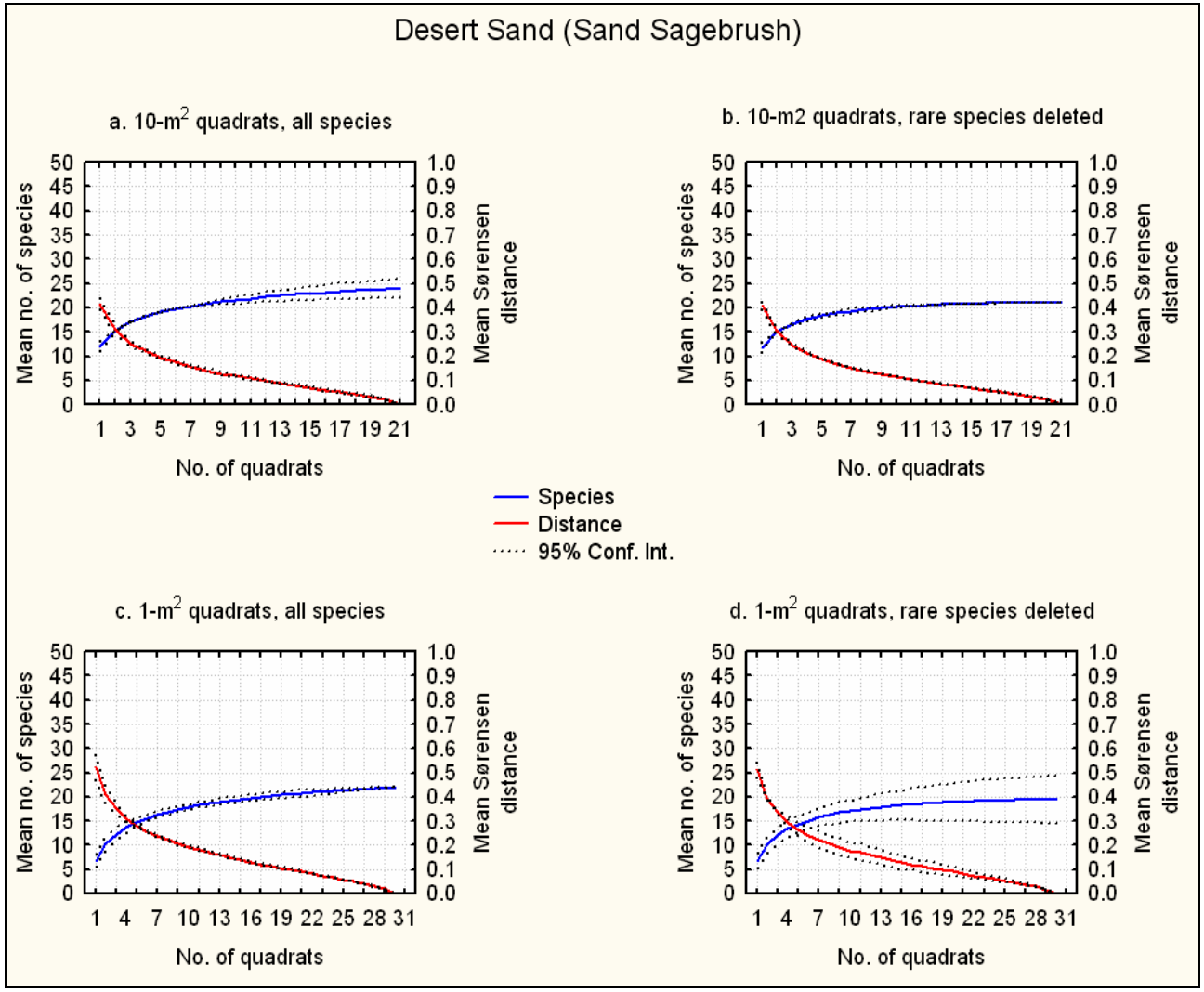

Figure E2. Mean species-area and compositional curves (mean Sørensen distances) for the Desert Sand ecological site at Canyonlands National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. All curves are based on data from two macroplots.

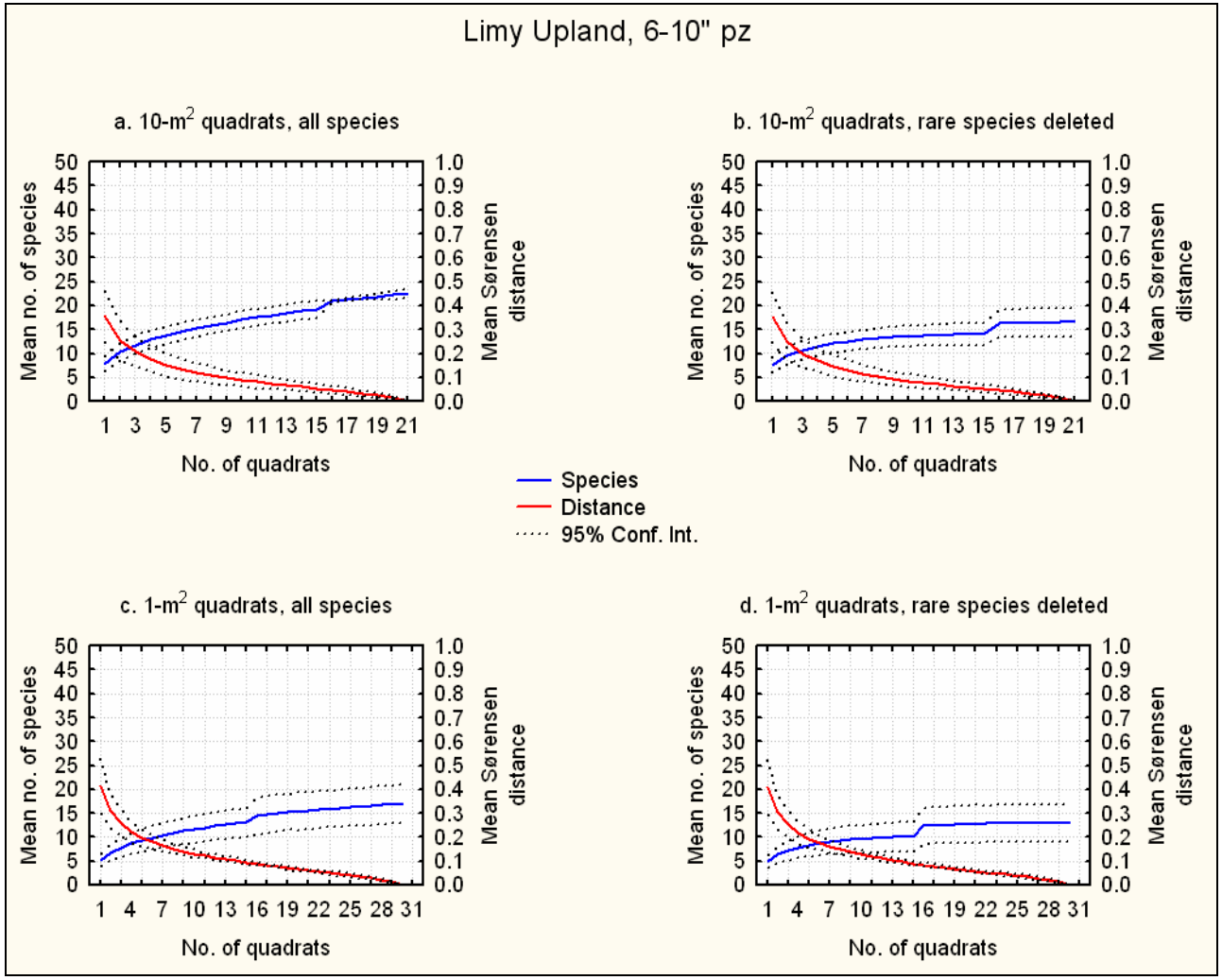

Figure E3. Mean species-area and compositional curves (mean Sørensen distances) for the Limy Upland ecological site at Mesa Verde National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from five macroplots for quadrats 1-15 and two macroplots for quadrats > 15. Compositional curves are based on data from two macroplots.

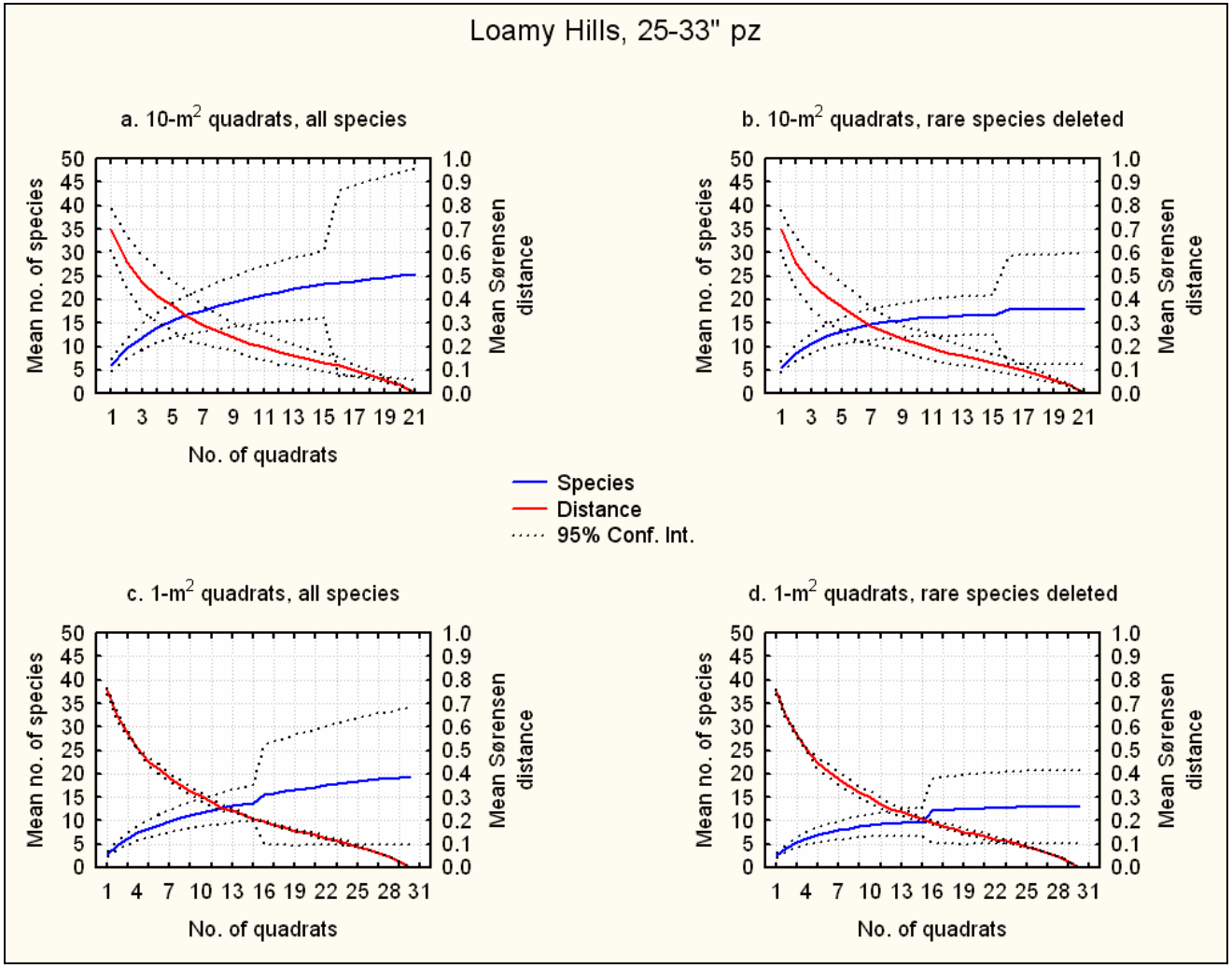

Figure E4. Mean species-area and compositional curves (mean Sørensen distances) for the Loamy Hills ecological site at Grand Canyon National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from five macroplots for quadrats 1-15 and two macroplots for quadrats > 15. Compositional curves are based on data from two macroplots.

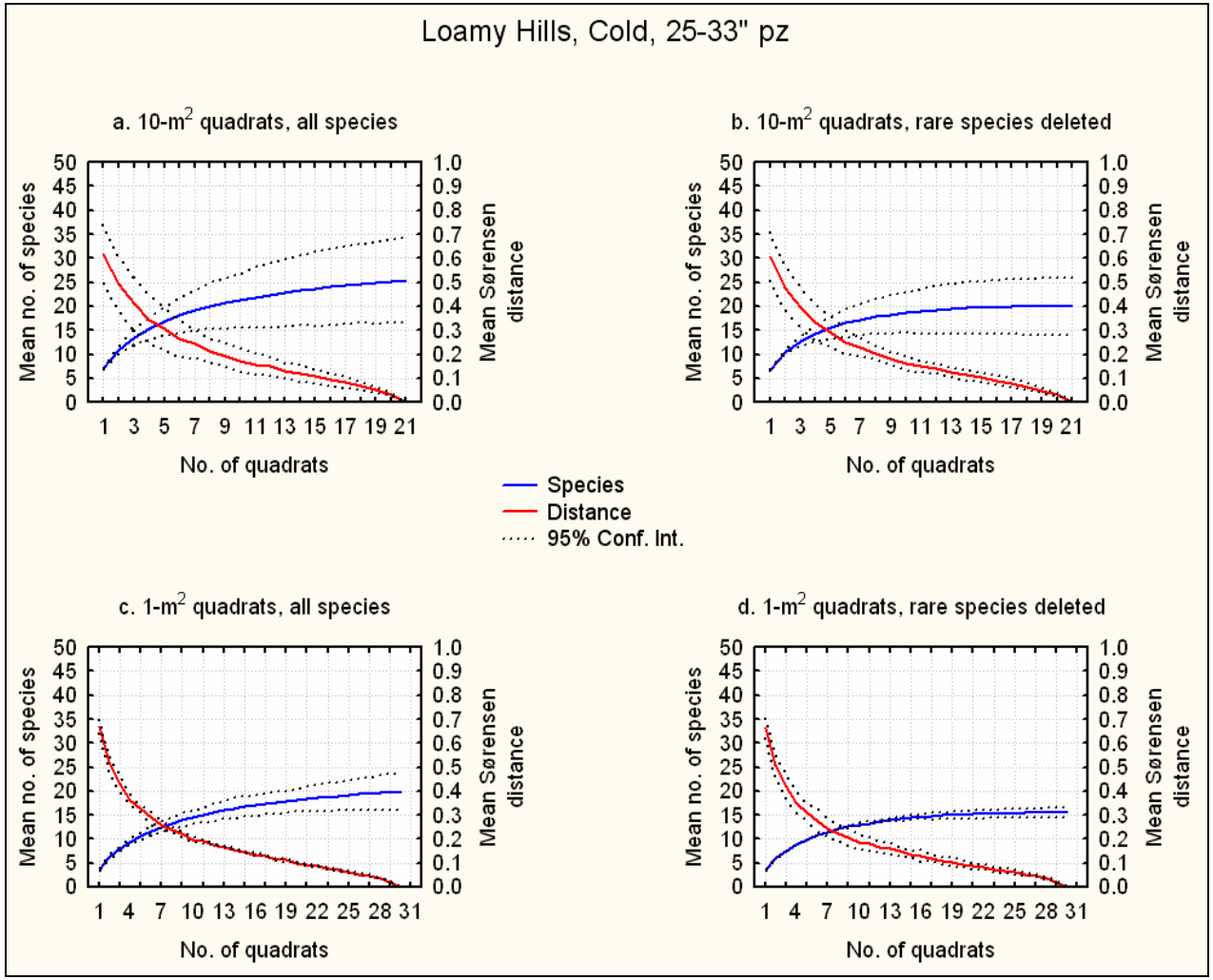

Figure E5. Mean species-area and compositional curves (mean Sørensen distances) for the Loamy Hills, Cold, ecological site at Grand Canyon National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from five macroplots for quadrats 1-15 and two macroplots for quadrats > 15. Compositional curves are based on data from two macroplots.

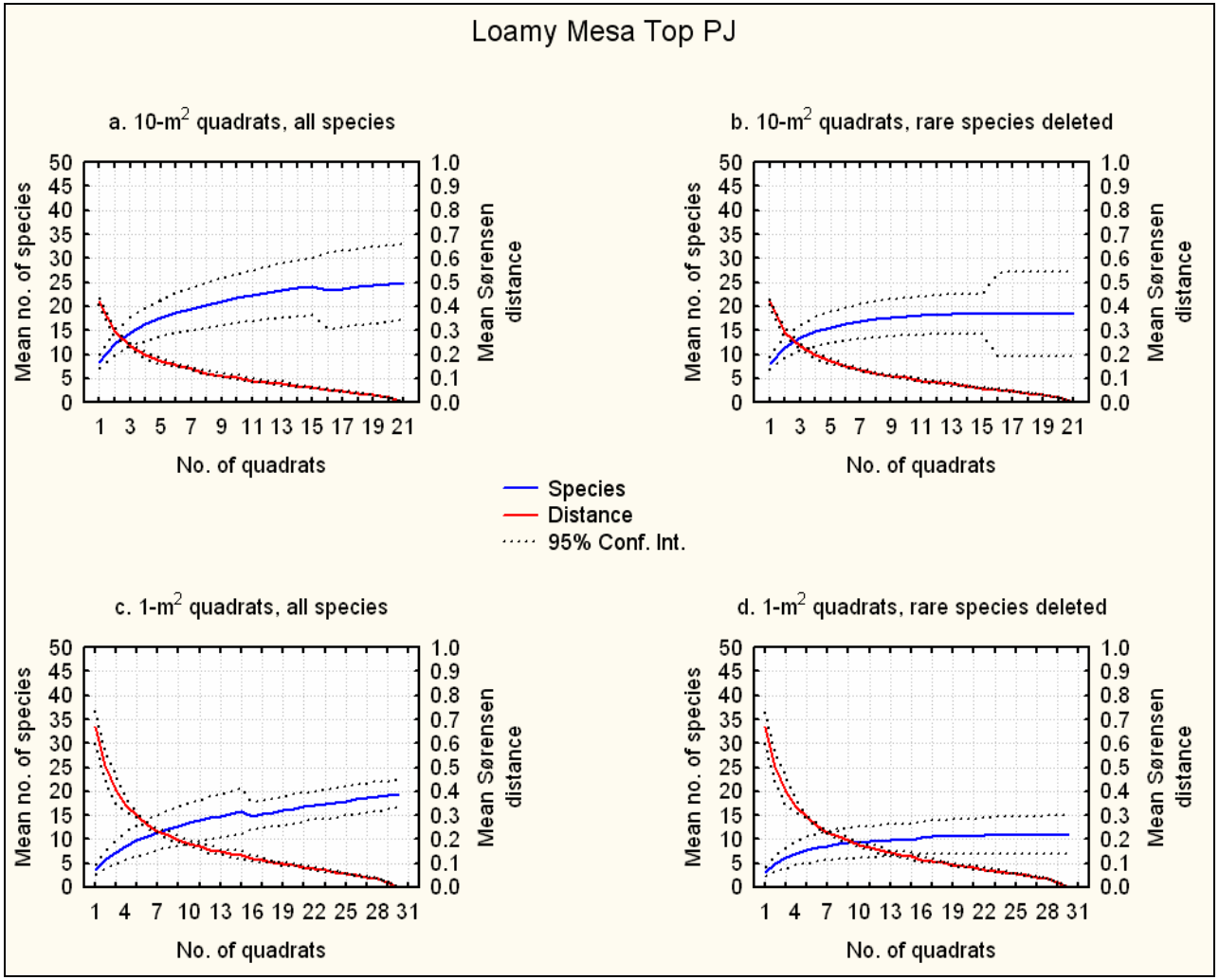

Figure E6. Mean species-area and compositional curves (mean Sørensen distances) for the Loamy Mesa Top PJ ecological site at Mesa Verde National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from five macroplots for quadrats 1-15 and two macroplots for quadrats > 15. Compositional curves are based on data from two macroplots.

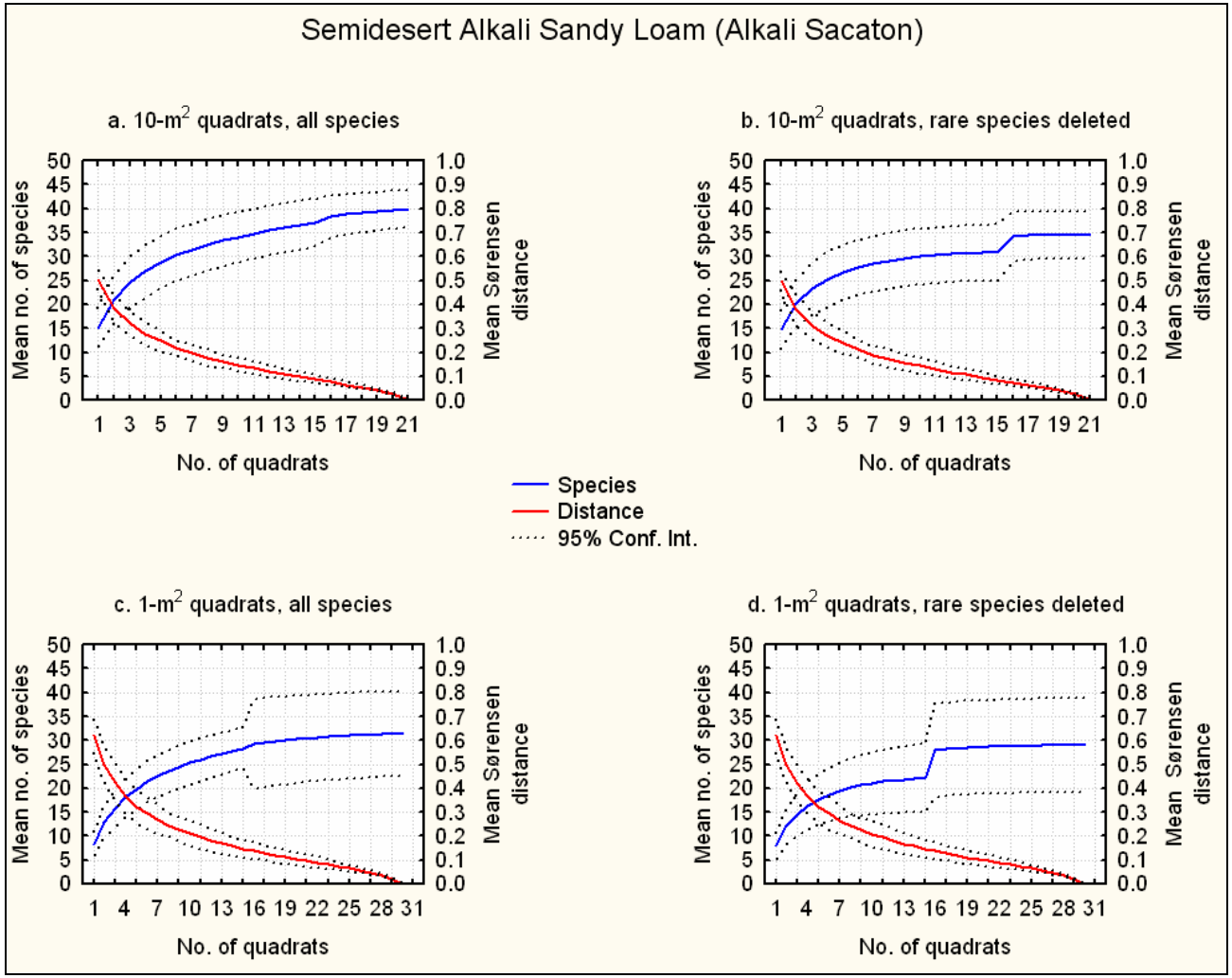

Figure E7. Mean species-area and compositional curves (mean Sørensen distances) for the Semidesert Alkali Sandy Loam ecological site at Capitol Reef National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from five macroplots for quadrats 1-15 and two macroplots for quadrats > 15. Compositional curves are based on data from two macroplots.

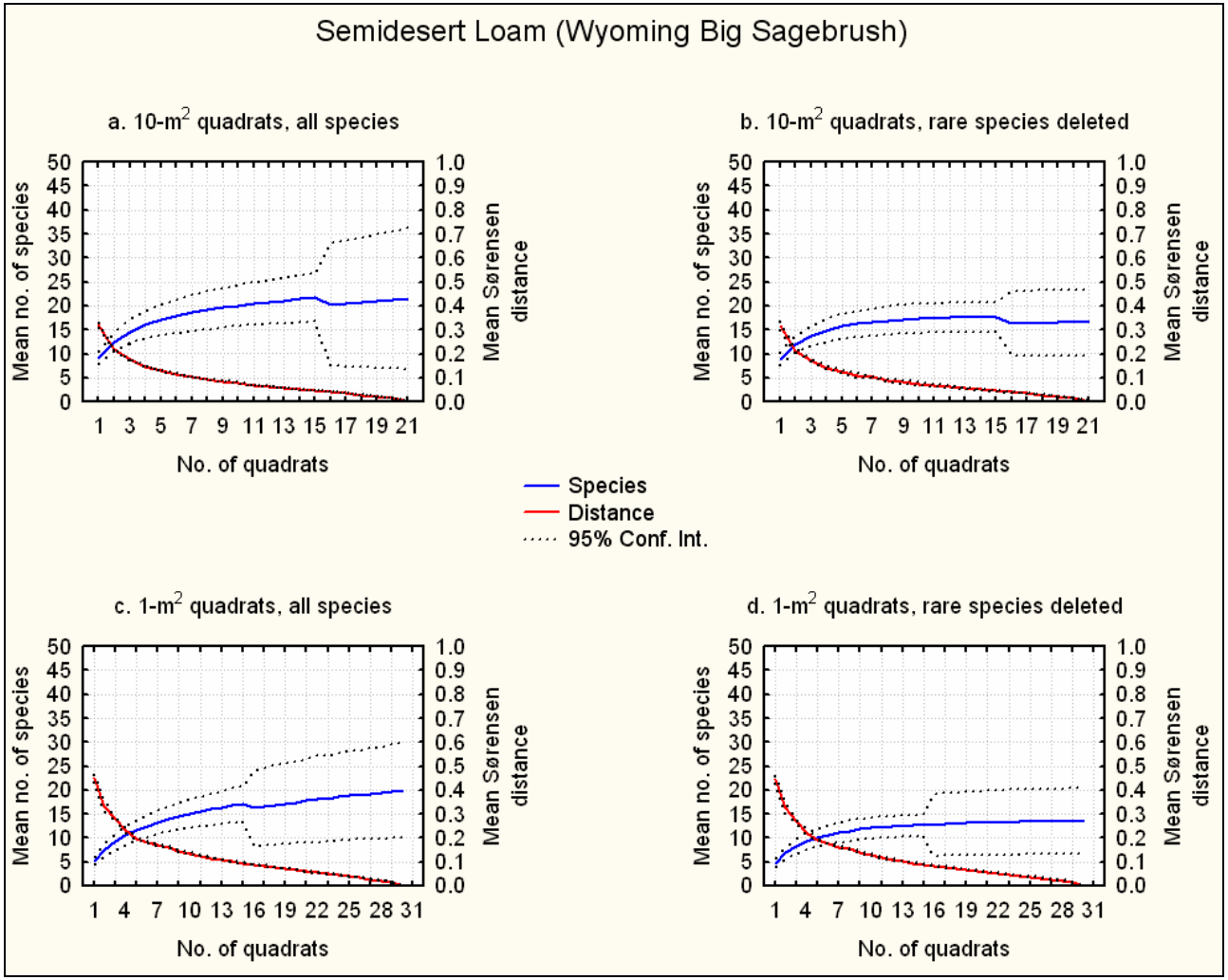

Figure E8. Mean species-area and compositional curves (mean Sørensen distances) for the Semidesert Loam ecological site at Dinosaur National Monument for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from five macroplots for quadrats 1-15 and two macroplots for quadrats > 15. Compositional curves are based on data from two macroplots.

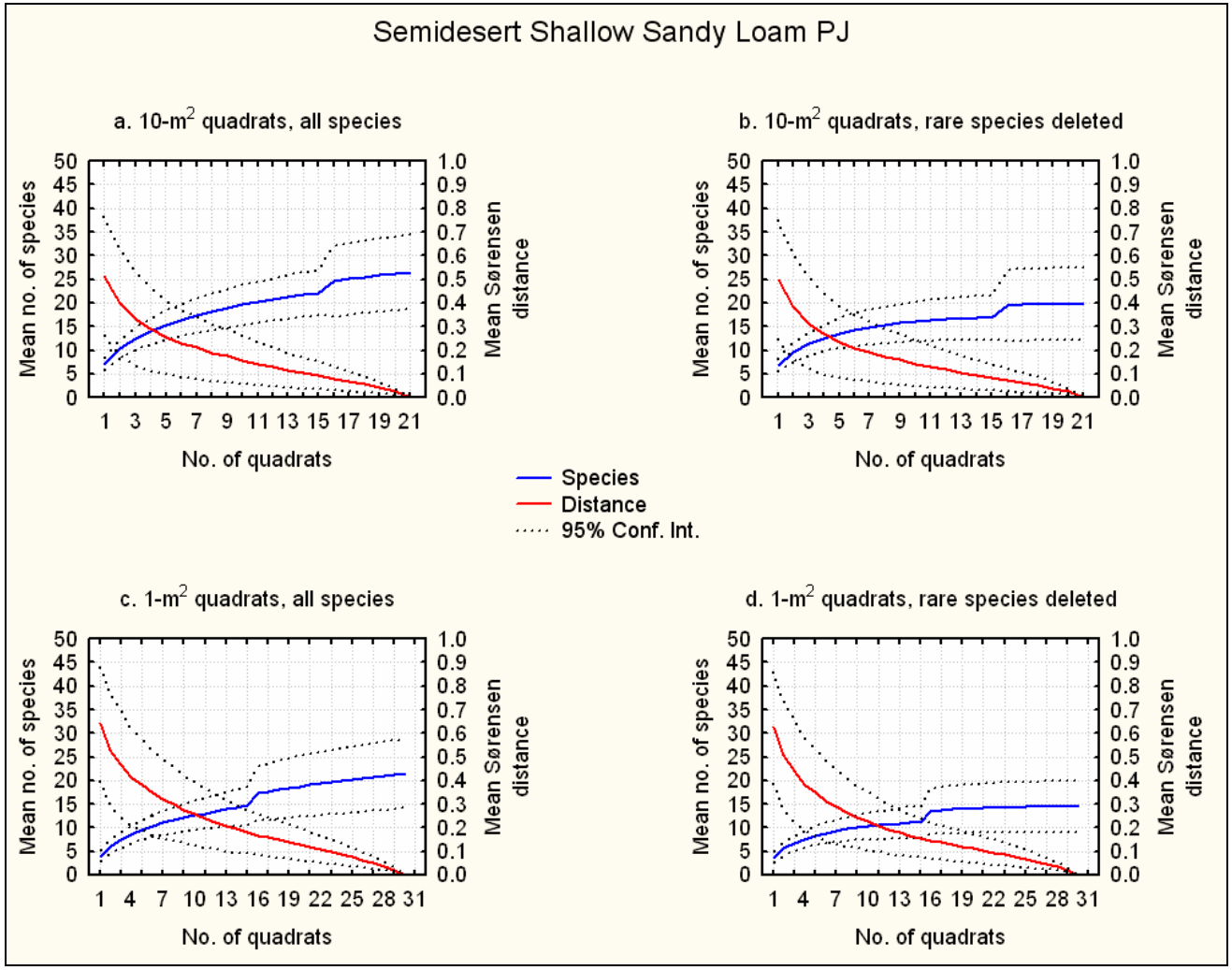

Figure E9. Mean species-area and compositional curves (mean Sørensen distances) for the Semidesert Shallow Sandy Loam ecological site at Arches and Canyonlands National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from seven macroplots for quadrats 1-15 and four macroplots for quadrats > 15. Compositional curves are based on data from four macroplots.

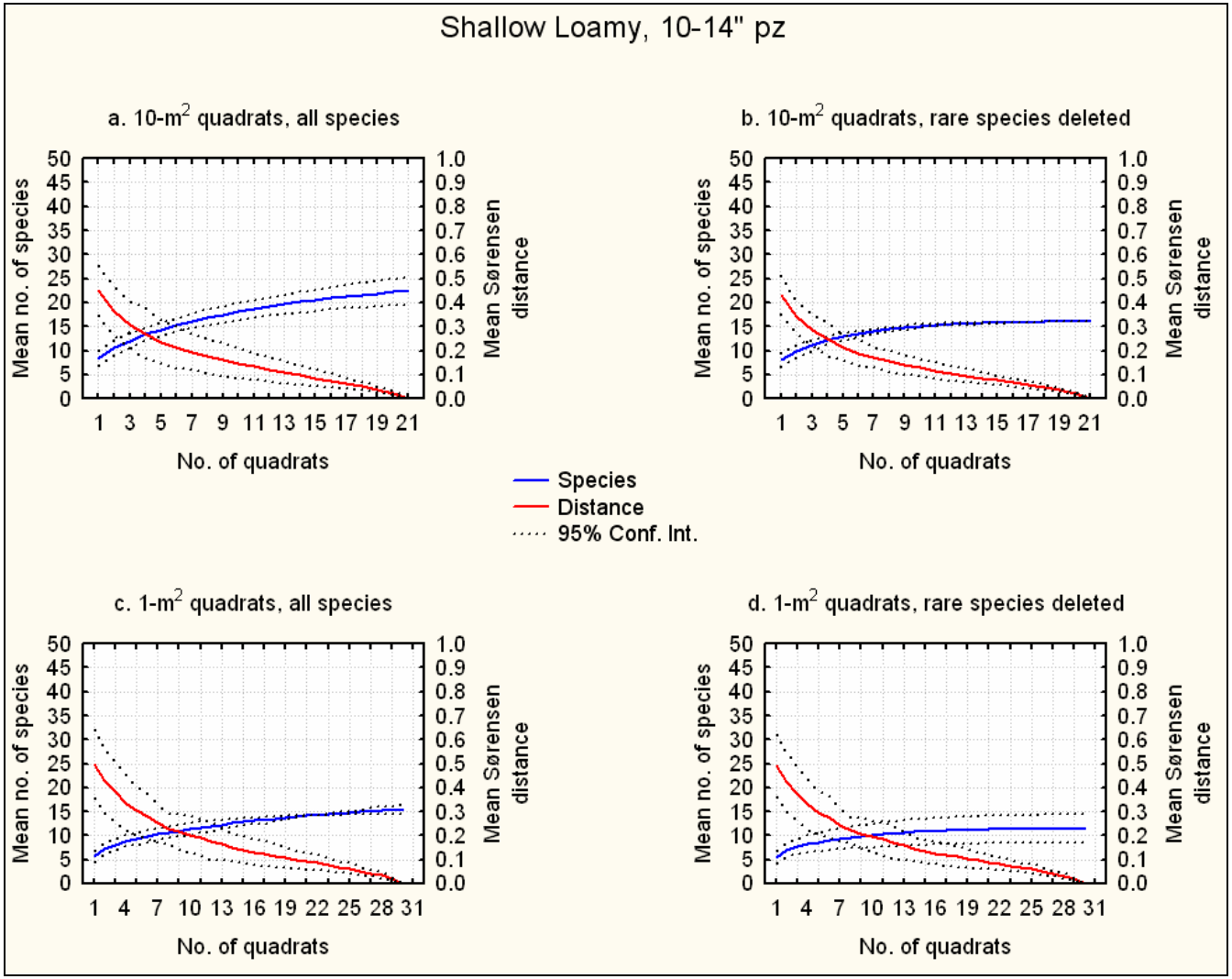

Figure E10. Mean species-area and compositional curves (mean Sørensen distances) for the Shallow Loamy ecological site at Wupatki National Monument for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. All curves are based on data from two macroplots.

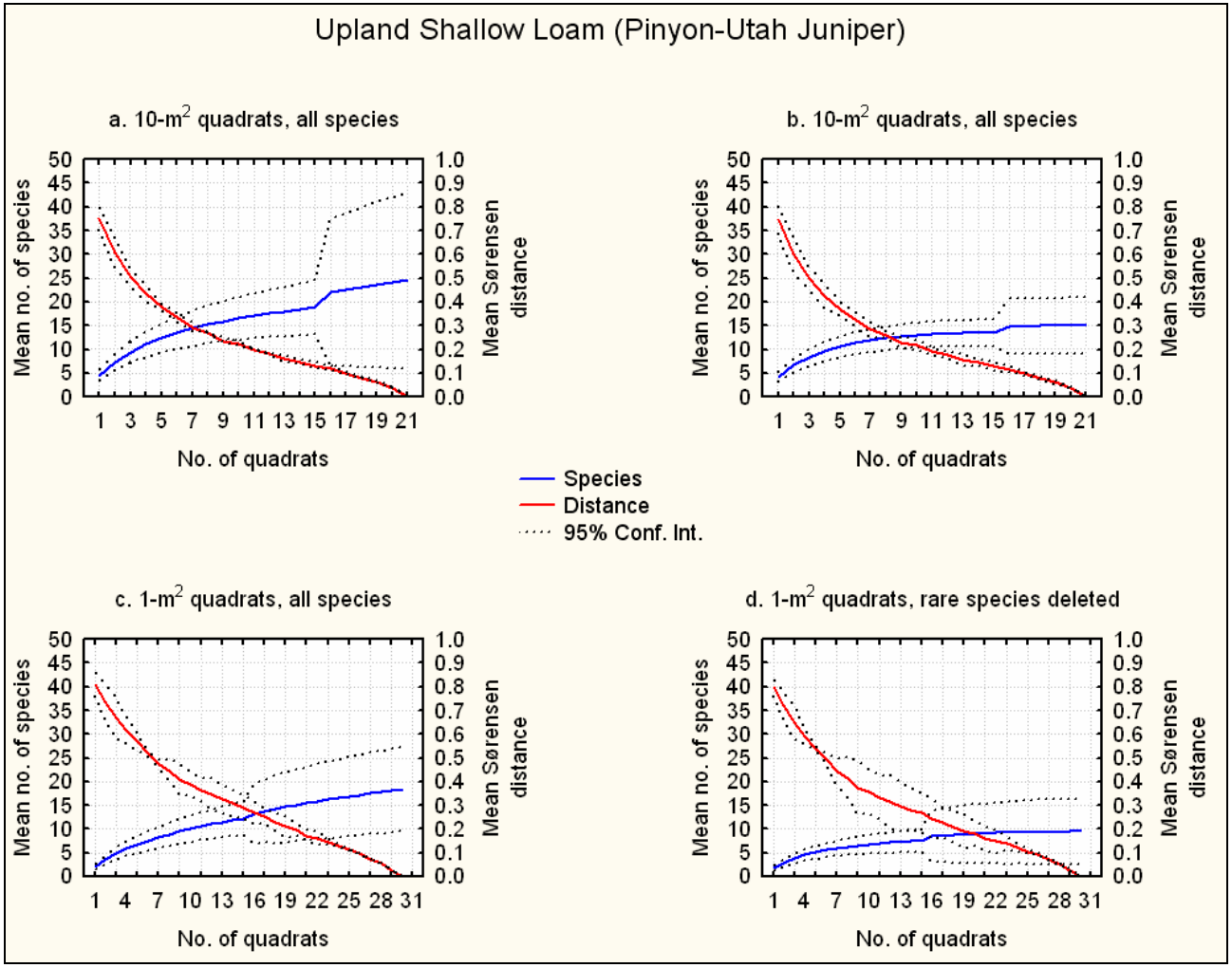

Figure E11. Mean species-area and compositional curves (mean Sørensen distances) for the Upland Shallow Loam ecological site at Capitol Reef National Park for (a) 10-m^2 quadrats, including all species; (b) 10-m^2 quadrats, exluding rare (infrequent) species that occurred in only one subsample quadrat; (c) 1-m^2 quadrats, including all species; and (d) 1-m^2 quadrats, excluding rare species. Species-area curves are based on data from five macroplots for quadrats 1-15 and two macroplots for quadrats > 15. Compositional curves are based on data from two macroplots.

Appendix F—Between-Observer Differences in Estimates of Cover and Density

Table F1. Mean estimates of plant cover (%) by sampling method (10-m^2 quadrats, 1-m^2 quadrats, and line-point intercept) and observer (Obs. 1 and Obs. 2) at Colorado Plateau ecological sites sampled during Phase 3, absolute between-observer differences, and differences expressed as percent of the mean of both observations. See Appendix A for key to species codes associated with cover measures.

		10-m^2 quadrats				1-m^2 quadrats				Line-point			
Ecological site	**Cover measure**	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**
Brushy Loam	QUGA	1.2	1.5	0.3	22.2	1.3	1.2	0.1	8.0	1.5	1.5	0.0	0.0
	POFE	12.0	9.8	2.2	20.2	8.6	6.0	2.6	35.6	17.9	16.9	1.0	5.7
	SYOR2	2.9	4.4	1.5	41.1	1.5	1.1	0.4	30.8	5.0	5.0	0.0	0.0
	Total live understory	45.3	43.3	2.0	4.5	34.9	29.6	5.3	16.4	64.6	76.4	11.8	16.7
	Mean % diff			**1.5**	**22.0**			**2.1**	**22.7**			**3.2**	**5.6**
Limy Upland, 6-10" pz	CHLE4	4.3	2.9	1.4	38.9	3.4	2.4	1.0	34.5	2.4	2.2	0.2	8.7
	HENE5	3.8	3.3	0.5	14.1	2.7	2.1	0.6	25.0	5.6	7.2	1.6	25.0
	PLJA	3.3	3.1	0.2	6.2	1.6	2.3	0.7	35.9	5.5	6.5	1.0	16.7
	Total live understory	19.9	16.5	3.4	18.7	13.9	12.8	1.1	8.2	26.9	31.2	4.3	14.8
	Mean % diff			**1.4**	**19.5**			**0.9**	**25.9**			**1.8**	**16.3**
Loamy Hills, 25-33" pz	POFE	0.9	0.8	0.1	11.8	0.5	0.5	0.0	0.0	2.0	0.4	1.6	133.3
	POTR5	1.1	1.2	0.1	8.7	1.1	0.9	0.2	20.0	1.3	1.3	0.0	0.0
	UNGRCA1 (*Carex* sp.)	1.7	2.2	0.5	25.6	1.4	1.4	0.0	0.0	8.5	9.2	0.7	7.9
	Total live understory	12.7	11.7	1.0	8.2	9.8	8.9	0.9	9.6	18.7	21.4	2.7	13.5
	Mean % diff			**0.4**	**13.6**			**0.3**	**7.4**			**1.3**	**38.7**
Loamy Mesa Top PJ	JUOS	5.5	6.0	0.5	8.7	3.3	2.3	1.0	35.7	3.1	2.3	0.8	29.6
	PIED	7.9	7.4	0.5	6.5	5.7	3.6	2.1	45.2	7.3	7.9	0.6	7.9
	POFE	3.5	2.8	0.7	22.2	2.6	2.3	0.3	12.2	7.2	6.2	1.0	14.9
	Total live understory	26.1	24.7	1.4	5.5	20.0	15.3	4.7	26.6	23.8	25.9	2.1	8.5
	Mean % diff			**0.8**	**10.7**			**2.0**	**29.9**			**1.1**	**15.2**
Semidesert Alkali Sandy Loam (Alkali Sacaton)	ATCO	1.2	0.8	0.4	40.0	0.9	0.8	0.1	11.8	0.6	0.6	0.0	0.0
	GIIN2	0.3	0.3	0.0	0.0	0.4	0.3	0.1	28.6	0.1	0.1	0.0	0.0
	ORHY	0.4	0.5	0.1	22.2	0.5	0.5	0.0	0.0	0.2	0.2	0.0	0.0
	Total live understory	14.2	12.9	1.3	9.6	14.6	12.9	1.7	12.4	19.6	22.3	2.7	12.9
	Mean % diff			**0.5**	**18.0**			**0.5**	**13.2**			**0.7**	**3.2**
Semidesert Loam (Wyoming Big Sagebrush)	ARTR2	10.8	9.7	1.1	10.7	5.0	5.4	0.4	7.7	5.5	7.9	2.4	35.8
	BRTE	2.9	1.7	1.2	52.2	1.4	1.4	0.0	0.0	16.7	18.9	2.2	12.4
	STCO4	0.8	0.7	0.1	13.3	0.7	0.7	0.0	0.0	1.6	1.2	0.4	28.6
	Total live understory	26.2	23.4	2.8	11.3	14.5	14.2	0.3	2.1	43.6	48.4	4.8	10.4
	Mean % diff			**1.3**	**21.9**			**0.2**	**2.4**			**2.5**	**21.8**
Semidesert Shallow Sandy Loam (PJ)	CORA	13.4	12.3	1.1	8.6	8.3	10.3	2.0	21.5	5.5	9.6	4.1	54.3
	FEOC3	0.6	0.5	0.1	18.2	0.5	0.7	0.2	33.3	0.6	0.4	0.2	40.0
	STLO4	0.5	0.5	0.0	0.0	0.6	0.7	0.1	15.4	0	0.3	0.3	200.0
	Total live understory	19.7	18.5	1.2	6.3	13.6	15.8	2.2	15.0	10.7	15.5	4.8	36.6
	Mean % diff			**0.6**	**8.3**			**1.1**	**21.3**			**2.4**	**82.7**
Upland Shallow Loam (Pinyon-Utah Juniper)	CEMO2	3.2	2.1	1.1	41.5	1.4	0.9	0.5	43.5	2	1.5	0.5	28.6
	COWR2	0.8	0.8	0.0	0.0	0.6	0.6	0.0	0.0	0.7	1	0.3	35.3
	JUOS	7.7	5.5	2.2	33.3	2.1	0.9	1.2	80.0	1.4	0.7	0.7	66.7
	Total live understory	22.2	16.6	5.6	28.9	14.1	11.4	2.7	21.2	10.5	10.4	0.1	1.0
	Mean % diff			**2.2**	**25.9**			**1.1**	**36.2**			**0.4**	**32.9**

Table F2. Mean estimates of biological soil crust cover (%) by sampling method (10-m^2 quadrats, 1-m^2 quadrats, and line-point intercept) and observer (Obs. 1 and Obs. 2) at Colorado Plateau ecological sites sampled during Phase 3, absolute between-observer differences, and differences expressed as percent of the mean of both observations.

		1-m^2 quadrats				10-m^2 quadrats				Line-point			
Ecological site	**Cover measure**	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**
Loamy Mesa Top PJ	Undifferentiated crust	46.2	45.1	1.1	2.4	43.8	45.8	2.0	4.5	43.6	38.9	4.7	11.4
	Cyanobacteria	1.8	2.2	0.4	20.0	1.3	2.2	0.9	51.4	4.4	5.6	1.2	24.0
	Lichen	0.7	1.2	0.5	52.6	0.9	0.8	0.1	11.8	1.1	1.3	0.2	16.7
	Moss	1.0	3.0	2.0	100.0	2.8	1.0	1.8	94.7	3.1	3.3	0.2	6.2
	Mean % diff			**1.0**	**43.8**			**1.2**	**40.6**			**1.6**	**14.6**
Semidesert Alkali Sandy Loam (Alkali Sacaton)	Undifferentiated crust	83.6	85.3	1.7	2.0	82.4	83.6	1.2	1.4	84.4	78.2	6.2	7.6
	Cyanobacteria	1.8	1.5	0.3	18.2	1.1	1.8	0.7	48.3	2.9	3.1	0.2	6.7
	Lichen	0.4	0.6	0.2	40.0	0.5	0.4	0.1	22.2	0.2	0.9	0.7	127.3
	Moss	0.1	0.2	0.1	66.7	0.0	0.2	0.2	200.0	0.0	0.2	0.2	200.0
	Mean % diff			**0.6**	**31.7**			**0.5**	**68.0**			**1.8**	**85.4**
Semidesert Loam (Wyoming Big Sagebrush)	Undifferentiated crust	60.9	65.4	4.5	7.1	61.3	65.2	3.9	6.2	54.0	52.2	1.8	3.4
	Cyanobacteria	0.5	0.9	0.4	57.1	0.8	0.6	0.2	28.6	1.1	1.8	0.7	48.3
	Lichen	1.1	1.3	0.2	16.7	1.1	0.7	0.4	44.4	1.6	2.2	0.6	31.6
	Moss	4.4	7.2	2.8	48.3	5.1	4.8	0.3	6.1	13.1	15.3	2.2	15.5
	Mean % diff			**2.0**	**32.3**			**1.2**	**21.3**			**1.3**	**24.7**
Semidesert Shallow Sandy Loam (PJ)	Undifferentiated crust	82.6	80.3	2.3	2.8	83.0	78.2	4.8	6.0	72.0	68.7	3.3	4.7
	Cyanobacteria	0.8	1.5	0.7	60.9	1.2	1.4	0.2	15.4	2.4	4.0	1.6	50.0
	Lichen	0.5	0.9	0.4	57.1	0.9	0.5	0.4	57.1	0.0	0.4	0.4	200.0
	Moss	5.0	5.8	0.8	14.8	3.1	6.5	3.4	70.8	10.2	11.6	1.4	12.8
	Mean % diff			**1.1**	**33.9**			**2.2**	**37.3**			**1.7**	**66.9**
Upland Shallow Loam (Pinyon-Utah Juniper)	Undifferentiated crust	6.3	9.8	3.5	43.5	4.9	5.5	0.6	11.5	14.9	25.6	10.7	52.8
	Cyanobacteria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Lichen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Moss	0.1	0.2	0.1	66.7	0.0	0.2	0.2	200.0	0.0	0.4	0.4	200.0
	Mean % diff			**0.9**	**27.5**			**0.2**	**52.9**			**2.8**	**63.2**

Table F3. Mean estimates of biological soil crust cover (%) based on the characterization of soil darkness (see table 10 and fig. 5 in main body of report) in 25 cm x 25 cm BSC frames for two observers (Obs. 1 and Obs. 2) at Colorado Plateau ecological sites sampled during Phase 3, absolute between-observer differences, and differences expressed as percent of the mean of both observations.

Ecological site	Biological soil crust cover measure (Soil-surface category)	Obs. 1	Obs. 2	Abs diff	Diff % of mean
Loamy Mesa Top PJ	Darkness 1	0.4	0.9	0.5	76.9
	Darkness 2	17.9	18.2	0.3	1.7
	Darkness 3	8.8	9.2	0.4	4.4
	Darkness 4	2.9	3.5	0.6	18.8
	Darkness 5	1.4	1.7	0.3	19.4
	Total	31.4	33.5	2.1	6.5
	Mean % diff			**0.7**	**21.3**
Semidesert Alkali Sandy Loam (Alkali Sacaton)	Darkness 1	13.5	11.3	2.2	17.7
	Darkness 2	44.0	45.8	1.8	4.0
	Darkness 3	8.5	11.4	2.9	29.1
	Darkness 4	0.0	0.0	0.0	0.0
	Darkness 5	0.0	0.0	0.0	0.0
	Total	66.1	68.5	2.4	3.6
	Mean % diff			**1.6**	**9.1**
Semidesert Loam (Wyoming Big Sagebrush)	Darkness 1	0.0	0.1	0.1	200.0
	Darkness 2	29.4	18.7	10.7	44.5
	Darkness 3	22.1	28.9	6.8	26.7
	Darkness 4	0.0	0.4	0.4	200.0
	Darkness 5	0.0	0.0	0.0	0.0
	Total	51.5	48.0	3.5	7.0
	Mean % diff			**3.6**	**79.7**
Semidesert Shallow Sandy Loam (PJ)	Darkness 1	8.7	6.4	2.3	30.5
	Darkness 2	37.2	40.1	2.9	7.5
	Darkness 3	16.6	22.8	6.2	31.5
	Darkness 4	0.4	0.0	0.4	200.0
	Darkness 5	0.0	0.0	0.0	0.0
	Total	62.9	69.4	6.5	9.8
	Mean % diff			**3.1**	**46.5**
Upland Shallow Loam (Pinyon-Utah Juniper)	Darkness 1	5.9	5.4	0.5	8.8
	Darkness 2	0.2	1.2	1.0	142.9
	Darkness 3	0.0	0.0	0.0	0.0
	Darkness 4	0.0	0.0	0.0	0.0
	Darkness 5	0.0	0.0	0.0	0.0
	Total	6.1	6.6	0.5	7.9
	Mean % diff			**0.3**	**26.6**

Table F4. Mean estimates of litter cover (%) by sampling method (10-m^2 quadrats, 1-m^2 quadrats, and line-point intercept) and observer (Obs. 1 and Obs. 2) at Colorado Plateau ecological sites sampled during Phase 3, absolute between-observer differences, and differences expressed as percent of the mean of both observations.

	10-m^2 quadrats				1-m^2 quadrats				Line-point			
Ecological site	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**	**Obs. 1**	**Obs. 2**	**Abs diff**	**Diff % of mean**
Brushy Loam	77.8	78.9	1.1	1.4	82.0	79.4	2.6	3.2	73.0	78.3	5.3	7.0
Limy Upland, 6-10" pz	5.9	4.1	1.8	36.0	6.8	5.1	1.7	28.6	33.8	34.6	0.8	2.3
Loamy Hills, 25-33"pz	83.3	80.9	2.4	2.9	84.6	84.7	0.1	0.1	88.8	94.1	5.3	5.8
Loamy Mesa Top PJ	43.6	44.7	1.1	2.5	43.4	42.2	1.2	2.8	54.6	50.9	3.7	7.0
Semidesert Alkali Sandy Loam (Alkali Sacaton)	6.6	6.0	0.6	9.5	8.7	6.8	1.9	24.5	15.2	17.8	2.6	15.8
Semidesert Loam (Wyoming Big Sagebrush)	23.9	21.0	2.9	12.9	21.6	19.1	2.5	12.3	40.5	44.4	3.9	9.2
Semidesert Shallow Sandy Loam (PJ)	2.9	3.5	0.6	18.8	3.3	3.9	0.6	16.7	13.3	16.5	3.2	21.5
Upland Shallow Loam (Pinyon-Utah Juniper)	15.5	16.6	1.1	6.9	23.4	23.4	0.0	0.0	23.4	26.2	2.8	11.3
			1.5	**11.4**			**1.3**	**11.0**			**3.5**	**10.0**

Table F5. Mean estimates of shrub density (counts per quadrat) by species, height class, and observer (Obs. 1 and Obs. 2) at Colorado Plateau ecological sites sampled during Phase 3, absolute between-observer differences, and differences expressed as percent of the mean of both observations.

Species	Ecological site	Size class	Obs. 1	Obs. 2	Mean	Abs. Diff	Diff % of Mean
Amerlanchier utahensis (AMUT)	Brushy Loam	0-10 cm	0	0.11	0.055	0.110	200.0
		10-25 cm	0.04	0.18	0.110	0.140	127.3
		25-50 cm	0.56	0.78	0.670	0.220	32.8
		50 cm - 1 m	2.4	2.4	2.400	0.000	0.0
		1-2 m	0.8	0.89	0.845	0.090	10.7
		>2 m	0.13	0.11	0.120	0.020	16.7
						mean diff	**64.6**
	Upland Shallow Loam (Pinyon-Utah Juniper)	0-10 cm	0.04	0.02	0.030	0.020	66.7
		10-25 cm	0.02	0.07	0.045	0.050	111.1
		25-50 cm	0.04	0	0.020	0.040	200.0
		50 cm - 1 m	0.04	0.09	0.065	0.050	76.9
		1-2 m	0.31	0.29	0.300	0.020	6.7
		>2 m	0	0.02	0.010	0.020	200.0
						mean diff	**110.2**
Artemisia bigelovii (ARBI3)	Brushy Loam	0-10 cm	1.6	1.3	1.450	0.300	20.7
		10-25 cm	0.09	0.09	0.090	0.000	0.0
		25-50 cm	0.02	0.07	0.045	0.050	111.1
		50 cm - 1 m	0.02	0.02	0.020	0.000	0.0
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**33.0**
Artemisia tridentata (ARTR2)	Loamy Mesa Top PJ	0-10 cm	0.29	0.38	0.335	0.090	26.9
		10-25 cm	0.13	0.36	0.245	0.230	93.9
		25-50 cm	0.33	0.62	0.475	0.290	61.1
		50 cm - 1 m	0.76	0.64	0.700	0.120	17.1
		1-2 m	0.13	0.16	0.145	0.030	20.7
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**43.9**
	Semidesert Loam (Wyoming Big Sagebrush)	0-10 cm	42.8	67	54.900	24.200	44.1
		10-25 cm	1.4	1.3	1.350	0.100	7.4
		25-50 cm	3.9	4.3	4.100	0.400	9.8
		50 cm - 1 m	3.1	3.2	3.150	0.100	3.2
		1-2 m	0.11	0.11	0.110	0.000	0.0
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**12.9**

Table F5.—Continued

Species	Ecological site	Size class	Obs. 1	Obs. 2	Mean	Abs. Diff	Diff % of Mean
Atriplex canescens (ATCA2)	Semidesert Alkali Sandy Loam (Alkali Sacaton)	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0	0	0.000	0.000	n/a
		25-50 cm	0.07	0.07	0.070	0.000	0.0
		50 cm - 1 m	0.11	0.09	0.100	0.020	20.0
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**10.0**
Atriplex confertifolia (ATCO)	Semidesert Alkali Sandy Loam (Alkali Sacaton)	0-10 cm	2	2.9	2.450	0.900	36.7
		10-25 cm	0.69	0.69	0.690	0.000	0.0
		25-50 cm	0.62	0.82	0.720	0.200	27.8
		50 cm - 1 m	0	0	0.000	0.000	n/a
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**21.5**
	Semidesert Loam (Wyoming Big Sagebrush)	0-10 cm	0.24	0.24	0.240	0.000	0.0
		10-25 cm	0.18	0.16	0.170	0.020	11.8
		25-50 cm	0.11	0.16	0.135	0.050	37.0
		50 cm - 1 m	0.02	0.02	0.020	0.000	0.0
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**12.2**
Berberis fremontii (BEFR)	Upland Shallow Loam (Pinyon-Utah Juniper)	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0.02	0	0.010	0.020	200.0
		25-50 cm	0	0	0.000	0.000	n/a
		50 cm - 1 m	0.04	0.07	0.055	0.030	54.5
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**127.3**
Chrysothamnus nauseosus (CHNA2)	Limy Upland, 6-10" pz	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0.04	0.02	0.030	0.020	66.7
		25-50 cm	0.58	0.6	0.590	0.020	3.4
		50 cm - 1 m	0.02	0.02	0.020	0.000	0.0
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**23.4**
	Semidesert Alkali Sandy Loam (Alkali Sacaton)	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0	0	0.000	0.000	n/a
		25-50 cm	0	0	0.000	0.000	n/a
		50 cm - 1 m	0.04	0.04	0.040	0.000	0.0
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**0.0**

Table F5.—Continued

Species	Ecological site	Size class	Obs. 1	Obs. 2	Mean	Abs. Diff	Diff % of Mean
Chrysothamnus nauseosus (CHNA2)	Semidesert Loam (Wyoming Big Sagebrush)	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0	0.02	0.010	0.020	200.0
		25-50 cm	0.09	0.11	0.100	0.020	20.0
		50 cm - 1 m	0.27	0.22	0.245	0.050	20.4
		1-2 m	0.04	0.02	0.030	0.020	66.7
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**76.8**
Coleogyne ramosissima (CORA)	Semidesert Shallow Sandy Loam PJ	0-10 cm	0.09	0.11	0.100	0.020	20.0
		10-25 cm	0.58	0.82	0.700	0.240	34.3
		25-50 cm	4.6	5.1	4.850	0.500	10.3
		50 cm - 1 m	1	0.9	0.950	0.100	10.5
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**18.8**
Purshia mexicana (PUME)	Upland Shallow Loam (Pinyon-Utah Juniper)	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0	0	0.000	0.000	n/a
		25-50 cm	0.02	0.02	0.020	0.000	0.0
		50 cm - 1 m	0.04	0.07	0.055	0.030	54.5
		1-2 m	0.07	0.07	0.070	0.000	0.0
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**18.2**
Purshia tridentata (PUTR2)	Upland Shallow Loam (Pinyon-Utah Juniper)	0-10 cm	0.02	0.02	0.020	0.000	0.0
		10-25 cm	0	0	0.000	0.000	n/a
		25-50 cm	0	0	0.000	0.000	n/a
		50 cm - 1 m	0.02	0	0.010	0.020	200.0
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**100.0**
	Brushy Loam	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0	0	0.000	0.000	n/a
		25-50 cm	0.02	0.02	0.020	0.000	0.0
		50 cm - 1 m	0	0	0.000	0.000	n/a
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**0.0**
	Loamy Mesa Top PJ	0-10 cm	0.04	0.04	0.040	0.000	0.0
		10-25 cm	0	0	0.000	0.000	n/a
		25-50 cm	0	0.09	0.045	0.090	200.0
		50 cm - 1 m	0.09	0.02	0.055	0.070	127.3
		1-2 m	0	0	0.000	0.000	n/a
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**109.1**

Table F5.—Continued

Species	Ecological site	Size class	Obs. 1	Obs. 2	Mean	Abs. Diff	Diff % of Mean
Sarcobatus vermiculatus (SAVE4)	Semidesert Alkali Sandy Loam (Alkali Sacaton)	0-10 cm	0.02	0	0.010	0.020	200.0
		10-25 cm	0.07	0.04	0.055	0.030	54.5
		25-50 cm	0.29	0.4	0.345	0.110	31.9
		50 cm - 1 m	0.58	0.62	0.600	0.040	6.7
		1-2 m	0.02	0.02	0.020	0.000	0.0
		>2 m	0	0.02	0.010	0.020	200.0
						mean diff	**82.2**
	Semidesert Loam (Wyoming Big Sagebrush)	0-10 cm	2.8	3.2	3.000	0.400	13.3
		10-25 cm	0.04	0.04	0.040	0.000	0.0
		25-50 cm	0.04	0.02	0.030	0.020	66.7
		50 cm - 1 m	0.22	0.27	0.245	0.050	20.4
		1-2 m	0.11	0.09	0.100	0.020	20.0
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**24.1**
Shepherdia rotundifolia (SHRO)	Upland Shallow Loam (Pinyon-Utah Juniper)	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0	0	0.000	0.000	n/a
		25-50 cm	0.02	0.02	0.020	0.000	0.0
		50 cm - 1 m	0.02	0.02	0.020	0.000	0.0
		1-2 m	0.02	0.02	0.020	0.000	0.0
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**0.0**
Symphoricarpos oreophilus (SYOR2)	Brushy Loam	0-10 cm	0	0	0.000	0.000	n/a
		10-25 cm	0.07	0.07	0.070	0.000	0.0
		25-50 cm	0.78	0.53	0.655	0.250	38.2
		50 cm - 1 m	1.6	1.7	1.650	0.100	6.1
		1-2 m	0.78	0.73	0.755	0.050	6.6
		>2 m	0	0	0.000	0.000	n/a
						mean diff	**12.7**

Table F6. Mean estimates of tree density (counts per quadrat) by species, size class, and observer (Obs. 1 and Obs. 2) at Colorado Plateau ecological sites sampled during Phase 3, absolute between-observer differences, and differences expressed as percent of the mean of both observations.

Species	Ecological site	Size class	Obs. 1	Obs. 2	Mean	Abs. Diff	Diff % of Mean
Abies concolor (ABCO)	Loamy Hills, 25-33" pz	Seedling	0.04	0.04	0.040	0.000	0.0
		Pole	0	0	0.000	0.000	n/a
		Overstory	0	0	0.000	0.000	n/a
						mean diff	**0.0**
Juniperus osteosperma (JUOS)	Semidesert Shallow Sandy Loam PJ	Seedling	0.02	0.02	0.020	0.000	0.0
		Pole	0	0	0.000	0.000	n/a
		Overstory	0	0	0.000	0.000	n/a
						mean diff	**0.0**
	Upland Shallow Loam (Pinyon-Utah Juniper)	Seedling	0.02	0.02	0.020	0.000	0.0
		Pole	0.04	0.02	0.030	0.020	66.7
		Overstory	0.09	0.13	0.110	0.040	36.4
						mean diff	**34.3**
	Semidesert Loam (Wyoming Big Sagebrush)	Seedling	0.04	0.13	0.085	0.090	105.9
		Pole	0.04	0.04	0.040	0.000	0.0
		Overstory	0	0	0.000	0.000	n/a
						mean diff	**52.9**
	Loamy Mesa Top PJ	Seedling	1.1	1	1.050	0.100	9.5
		Pole	0.29	0.33	0.310	0.040	12.9
		Overstory	0.18	0.22	0.200	0.040	20.0
						mean diff	**14.1**
Pinus edulis (PIED)	Upland Shallow Loam (Pinyon-Utah Juniper)	Seedling	0.07	0.04	0.055	0.030	54.5
		Pole	0.07	0.07	0.070	0.000	0.0
		Overstory	0	0	0.000	0.000	n/a
						mean diff	**27.3**
	Loamy Mesa Top PJ	Seedling	1.4	1.3	1.350	0.100	7.4
		Pole	0.36	0.38	0.370	0.020	5.4
		Overstory	0.04	0.04	0.040	0.000	0.0
						mean diff	**4.3**
	Brushy Loam	Seedling	0.02	0.02	0.020	0.000	0.0
		Pole	0	0	0.000	0.000	n/a
		Overstory	0	0	0.000	0.000	n/a
						mean diff	**0.0**
Picea engelmannii (PIEN)	Loamy Hills, 25-33" pz	Seedling	0.02	0.02	0.020	0.000	0.0
		Pole	0.07	0.07	0.070	0.000	0.0
		Overstory	0	0	0.000	0.000	n/a
						mean diff	**0.0**
Pinus ponderosa (PIPO)	Loamy Hills, 25-33" pz	Seedling	0	0	0.000	0.000	n/a
		Pole	0.04	0.02	0.030	0.020	66.7
		Overstory	0.18	0.16	0.170	0.020	11.8
						mean diff	**39.2**

Table F6.—Continued

Species	Ecological site	Size class	Obs. 1	Obs. 2	Mean	Abs. Diff	Diff % of Mean
Populus tremuloides (POTR5)	Loamy Hills, 25-33" pz	Seedling	3.4	3.2	3.300	0.200	6.1
		Pole	0.29	0.29	0.290	0.000	0.0
		Overstory	0.02	0.02	0.020	0.000	0.0
						mean diff	**2.0**
Pseudotsuga menziesii (PSME)	Loamy Hills, 25-33" pz	Seedling	0.02	0.02	0.020	0.000	0.0
		Pole	0	0	0.000	0.000	n/a
		Overstory	0	0	0.000	0.000	n/a
						mean diff	**0.0**
Quercus gambelii (QUGA)	Brushy Loam	Seedling	4.3	5.2	4.750	0.900	18.9
		Pole	0.02	0	0.010	0.020	200.0
		Overstory	0	0	0.000	0.000	n/a
						mean diff	**109.5**

Appendix G—Nested Frequency Data by Ecological Site

Ecological site	Table	Page
Brushy Loam	G1	162
	G2	164
Desert Sand (Sand Sagebrush)	G3	166
Limy Upland, 6-10" pz	G4	167
	G5	168
Loamy Hills, 25-33" pz	G6	169
	G7	170
Loamy Hills, Cold, 25-33" pz	G8	171
Loamy Mesa Top PJ	G9	172
	G10	173
Semidesert Alkali Sandy Loam (Alkali Sacaton)	G11	174
	G12	176
Semidesert Loam (Wyoming Big Sagebrush)	G13	178
	G14	179
Semidesert Shallow Sandy Loam PJ	G15	180
	G16	182
	G17	184
Shallow Loamy, 10-14" pz	G18	186
Upland Shallow Loam (Pinyon-Utah Juniper)	G19	187
	G20	188

Table G1. Frequency (%) of plant species in different-sized quadrats at three macroplots (MEVE1, MEVE2, and MEVE3) associated with the Brushy Loam ecological site at Mesa Verde National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	MEVE1				MEVE2				MEVE5			
Species code	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**
ACMI2	0	0	0	10	13	13	37	94	13	23	43	80
AGCR	0	0	0	0	0	0	0	0	7	13	17	17
ALAC4	0	3	10	24	0	0	23	42	0	0	0	0
AMUT	3	3	37	70	0	7	13	47	3	7	13	47
ARBI3	0	0	0	0	0	0	0	0	0	0	7	7
ARDR4	0	0	0	0	0	0	0	0	0	0	0	3
BASA3	0	0	0	0	0	0	0	5	0	0	0	0
BRTE	0	0	0	0	3	3	7	16	0	0	0	7
CANU3	0	0	0	0	0	0	3	8	0	0	0	0
CANU4	0	0	0	0	0	0	10	48	0	0	0	0
CEMO2	0	0	3	22	0	0	0	0	0	0	0	0
CHAL7	0	0	0	0	0	7	27	79	0	0	0	0
CHLE4	0	0	0	0	0	0	0	0	0	0	7	17
CHVI8	0	0	0	0	0	0	7	16	0	0	0	0
COUM	0	0	0	5	0	0	0	10	0	0	0	0
DEPI	0	0	0	5	0	0	0	5	0	0	0	7
ELEL5	0	0	0	5	3	3	10	29	13	40	73	83
ERUM	0	0	0	0	0	0	0	0	0	0	3	7
FERU	0	0	3	18	0	0	0	0	0	0	0	3
HECO26	0	0	0	0	0	0	0	0	0	0	3	17
IPAG	0	3	3	13	0	0	0	0	0	0	0	0
JUOS	0	0	0	10	0	0	0	0	0	0	0	0
KOMA	0	0	0	0	0	0	0	0	0	0	13	47
LATA	0	0	0	0	10	33	70	89	0	0	0	0
LUCA	0	3	10	24	0	0	0	0	7	7	57	80
MARE11	0	0	0	5	0	7	13	23	0	0	0	13
PAMY	0	0	3	8	0	0	0	0	0	0	0	0
PASM	0	0	0	0	0	0	0	5	3	20	27	47
PEPU7	0	0	0	5	0	0	0	5	0	7	40	63
PHHE2	0	0	0	0	0	0	0	0	0	0	7	23
PIED	0	0	13	61	0	0	0	0	0	0	0	7
POFE	0	7	33	62	0	0	3	8	43	63	80	87
PUTR2	0	0	0	0	0	0	0	0	0	0	0	0
QUGA	20	43	70	94	17	23	50	100	0	0	10	17
SIAL2	0	0	0	0	0	0	3	13	0	0	0	0

Table G1.—Continued

Species code	Frequency (%) by macroplot and quadrat size											
	MEVE1				MEVE2				MEVE5			
	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
SPCO	0	0	0	0	0	0	0	0	0	0	0	0
STLO4	3	3	20	34	0	0	0	0	0	0	0	0
SYOR2	0	13	40	69	3	10	20	39	0	0	13	83
WYAR	0	0	0	0	0	3	10	24	0	0	17	43
YUBA	0	3	3	8	0	0	0	0	0	0	0	0

Table G2. Frequency (%) of plant species in different-sized quadrats at two Brushy Loam macroplots (MEVE6 and MEVE7) and combined frequency values for all five macroplots associated with the Brushy Loam ecological site at Mesa Verde National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	MEVE6				MEVE7b				All macroplots combined (n = 5)			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ACMI2	0	10	27	43	10	20	53	93	7	13	32	64
AGCR	0	0	0	0	0	0	0	0	1	3	3	3
ALAC4	0	0	0	0	0	0	0	0	0	1	7	13
AMUT	0	3	3	13	0	13	43	93	1	7	22	54
ARBI3	0	0	7	17	0	0	0	0	0	0	3	5
ARDR4	0	0	0	0	0	0	0	23	0	0	0	5
BASA3	0	0	0	0	0	0	0	0	0	0	0	1
BRTE	0	0	10	30	0	3	27	50	1	1	9	21
CANU3	0	0	0	0	0	3	3	3	0	1	1	2
CANU4	0	7	13	13	0	0	13	50	0	1	7	22
CEMO2	0	0	0	0	0	0	0	0	0	0	1	4
CHAL7	0	0	0	0	0	0	0	0	0	1	5	16
CHLE4	10	27	50	53	0	0	0	7	2	5	11	15
CHVI8	0	0	0	0	0	0	0	0	0	0	1	3
COUM	0	0	0	0	0	0	0	0	0	0	0	3
DEPI	0	0	0	0	0	0	0	0	0	0	0	3
ELEL5	27	50	80	87	3	13	33	47	9	21	39	50
ERUM	0	0	3	23	0	0	0	7	0	0	1	7
FERU	0	0	0	0	0	0	0	0	0	0	1	4
HECO26	10	20	27	30	0	0	0	0	2	4	6	9
IPAG	0	0	0	0	0	0	0	0	0	1	1	3
JUOS	0	0	0	0	0	0	0	0	0	0	0	2
KOMA	7	13	30	80	0	3	17	47	1	3	12	35
LATA	0	0	0	3	0	0	0	0	2	7	14	18
LUCA	0	3	23	70	3	3	40	63	2	3	26	48
MARE11	0	0	0	0	0	0	0	0	0	1	3	8
PAMY	0	0	0	0	0	0	0	0	0	0	1	2
PASM	7	7	7	17	0	0	0	0	2	5	7	14
PEPU7	23	27	67	80	0	0	0	27	5	7	21	36
PHHE2	0	0	0	0	0	0	13	30	0	0	4	11

Table G2.—Continued

Species code	Frequency (%) by macroplot and quadrat size											
	MEVE6				MEVE7b				All macroplots combined (n = 5)			
	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
PIED	0	0	0	0	0	0	0	0	0	0	3	14
POFE	13	47	70	80	80	87	100	100	27	41	57	67
PUTR2	0	0	0	7	0	0	0	0	0	0	0	1
QUGA	0	0	7	20	7	13	27	30	9	16	33	52
SIAL2	0	0	0	0	0	0	0	0	0	0	1	3
SPCO	0	0	0	0	0	0	0	7	0	0	0	1
STLO4	0	0	0	0	0	0	0	0	1	1	4	7
SYOR2	0	0	3	37	17	27	40	87	4	10	23	63
WYAR	0	0	17	53	0	0	13	23	0	1	11	29
YUBA	0	0	0	0	0	0	0	0	0	1	1	2

Table G3. Frequency (%) of plant species in different-sized quadrats at two Desert Sand macroplots (CANY1 and CANY2b) and combined frequency values for both macroplots associated with the Desert Sand ecological site at Canyonlands National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	CANY1				CANY2b				Both macroplots combined (n = 2)			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ABFR2	0	0	0	0	0	3	7	11	0	2	3	6
ARPU9	0	0	3	3	0	0	0	0	0	0	2	2
ATCA2	0	0	10	53	0	3	10	29	0	2	10	41
BRTE	0	0	0	0	0	3	3	3	0	2	2	2
CELA4	0	0	0	0	0	0	0	10	0	0	0	5
CHAL7	0	0	13	28	0	0	0	0	0	0	7	14
CHST	0	0	0	0	0	0	0	5	0	0	0	2
CORA	0	0	0	0	0	0	0	5	0	0	0	2
EPVI	0	0	0	5	0	0	0	0	0	0	0	2
ERCE2	0	0	3	8	0	0	0	0	0	0	2	4
FEOC3	10	30	63	78	0	13	47	90	5	22	55	84
GAPI	0	17	40	88	7	27	70	99	3	22	55	93
HIJA	3	17	23	33	7	10	43	86	5	13	33	60
LAOC3	0	13	50	83	20	77	100	100	10	45	75	92
LIAR3	0	3	43	72	0	13	40	69	0	8	42	70
MACA2	0	0	3	3	0	10	37	84	0	5	20	44
MEAL6	3	3	20	63	3	10	40	92	3	7	30	78
OEPA	0	0	0	14	0	0	7	16	0	0	3	15
OPPO	0	0	0	10	0	0	0	0	0	0	0	5
PLPA2	7	37	60	89	10	27	57	80	8	32	58	85
SAPA8	0	3	27	84	0	0	3	3	0	2	15	44
SAPE10	3	7	20	68	0	0	17	55	2	3	18	61
SPCO	0	0	0	0	0	3	7	11	0	2	3	6
SPGR2	3	30	70	94	10	43	77	100	7	37	73	97
STEX	0	3	17	36	0	10	30	40	0	7	23	38
STHY6	0	7	10	39	3	27	70	100	2	17	40	69
STLO4	0	0	0	0	0	0	10	29	0	0	5	15
TOAN	0	10	27	46	0	0	10	15	0	5	18	30

Table G4. Frequency (%) of plant species in different-sized quadrats at three macroplots (WUPA1, WUPA2, and WUPA5) associated with the Limy Upland ecological site at Wupatki National Monument. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	WUPA1				WUPA2				WUPA5			
Species code	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**
ACHY	0	0	0	10	0	0	0	0	0	0	0	0
ARPU9	0	0	0	0	0	0	0	5	0	0	0	0
BOER4	7	53	90	95	3	20	47	94	0	0	0	0
BOGR2	0	0	0	0	0	0	0	0	0	0	0	0
BRTE	0	0	0	0	0	0	0	0	0	0	0	0
CHLE4	17	77	100	100	0	3	27	74	33	80	93	100
CHNA2	0	3	7	50	3	7	40	92	0	0	3	63
CRCI3	0	7	10	20	0	0	0	0	0	0	0	0
DEPI	3	3	23	76	3	3	7	30	0	7	23	23
ELEL5	0	0	0	0	0	0	0	0	0	0	3	13
GIIN2	37	83	93	100	0	7	27	41	30	70	93	100
HENE5	7	17	53	100	0	20	73	92	0	0	7	37
LAOC3	0	0	0	0	0	0	0	0	0	0	0	0
MEAL6	20	50	83	98	3	27	60	89	23	43	67	87
OPER	0	0	0	0	0	0	0	0	0	0	0	13
PHCR	0	0	0	0	0	0	0	0	0	0	10	43
PLJA	0	7	13	23	33	67	100	100	47	73	100	100
PSSP	0	0	0	5	0	0	0	0	0	0	0	7
SAKA	3	3	23	52	0	0	0	5	0	0	0	0
SPAI	0	0	0	0	0	0	0	5	0	0	0	0
SPHA	0	0	0	0	0	0	0	14	0	0	0	0
SPPA2	0	3	13	51	0	0	0	0	0	0	0	0
ZIGR	0	0	3	3	0	7	7	7	0	0	0	0

Table G5. Frequency (%) of plant species in different-sized quadrats at two Limy Upland macroplots (WUPA6 and WUPA7) and combined frequency values for all five macroplots associated with the Limy Upland ecological site at Wupatki National Monument. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	WUPA6				WUPA7				All macroplots combined (n = 5)			
Species code	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**
ACHY	0	0	0	0	0	0	0	0	0	0	0	2
ARPU9	0	0	0	0	0	0	0	0	0	0	0	1
BOER4	3	23	80	90	10	20	57	87	5	23	55	73
BOGR2	0	0	0	3	0	0	0	0	0	0	0	1
BRTE	0	0	3	3	0	0	0	3	0	0	1	1
CHLE4	43	83	100	100	30	57	77	100	25	60	79	95
CHNA2	0	0	0	0	0	0	10	60	1	2	12	53
CRCI3	0	0	0	0	0	0	0	0	0	1	2	4
DEPI	3	17	70	93	0	0	0	10	2	6	25	47
ELEL5	0	0	0	0	0	0	0	0	0	0	1	3
GIIN2	10	50	93	97	0	0	3	17	15	42	62	71
HENE5	17	43	97	100	0	0	0	0	5	16	46	66
LAOC3	0	0	0	7	0	0	0	0	0	0	0	1
MEAL6	0	0	0	0	0	0	0	0	9	24	42	55
OPER	0	0	0	0	0	0	0	0	0	0	0	3
PHCR	0	0	0	3	0	0	0	0	0	0	2	9
PLJA	7	10	43	63	17	53	93	100	21	42	70	77
PSSP	0	0	0	0	0	0	0	0	0	0	0	2
SAKA	0	0	20	53	0	0	0	23	1	1	9	27
SPAI	0	0	0	0	0	0	0	0	0	0	0	1
SPHA	0	0	0	0	0	0	0	0	0	0	0	3
SPPA2	0	0	57	90	0	0	17	53	0	1	17	39
ZIGR	0	0	3	10	0	0	0	7	0	1	3	5

Table G6. Frequency (%) of plant species in different-sized quadrats at three macroplots (GRCA3, GRCA4, and GRCA5) associated with the Loamy Hills ecological site at Grand Canyon National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	GRCA3				GRCA4				GRCA5			
Species code	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**
ABCO	0	0	13	28	0	3	23	90	0	0	0	7
ABLA	0	0	0	29	0	0	3	37	0	0	0	0
ACMI2	0	0	0	0	3	3	10	24	0	0	7	13
ANPA5	0	0	0	0	0	0	0	0	0	0	0	7
BRIN2	0	0	0	0	0	0	3	22	0	3	7	7
BRTE	0	0	0	0	0	0	0	0	0	0	3	7
CHAL7	0	0	0	0	0	0	0	0	7	20	30	30
ELEL5	0	0	0	0	0	3	3	13	0	3	17	30
EPAN	0	0	3	3	0	0	0	0	0	0	0	0
FRVI	0	0	0	5	0	3	10	29	0	0	0	0
GECA3	0	0	0	0	0	7	10	24	0	0	0	0
GOOB2	3	3	23	38	0	0	0	0	0	0	0	0
JUCO6	0	0	0	5	0	0	0	0	0	0	0	0
LUAR3	0	0	0	0	0	0	0	0	0	0	0	0
MARE11	0	3	3	13	3	7	13	23	0	0	0	23
PIEN	0	0	0	38	0	3	7	40	0	0	0	0
PIPO	0	0	0	0	0	0	0	5	0	0	0	7
POFE	0	0	0	0	0	0	7	11	3	13	27	43
POTR5	0	7	37	89	0	0	10	58	0	13	63	80
PSME	0	3	20	44	0	0	7	40	0	0	0	0
PTAQ	0	0	0	0	0	3	3	3	0	0	0	0
PYCH	0	0	0	10	0	0	0	0	0	0	0	0
SEMU3	0	0	0	0	0	0	0	0	3	3	43	70
SYOR2	0	0	0	0	0	0	3	22	0	0	0	0
THFE	0	0	0	0	0	0	0	0	0	0	0	0
UNGRCA1	0	0	7	11	23	63	80	94	10	33	53	93

Table G7. Frequency (%) of plant species in different-sized quadrats at two Loamy Hills macroplots (GRCA6 and GRCA7) and combined frequency values for all five macroplots associated with the Loamy Hills ecological site at Grand Canyon National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	GRCA6				GRCA7				All macroplots combined (n = 5)			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ABCO	0	0	7	7	0	0	0	0	0	1	9	26
ABLA	0	0	0	0	0	0	0	0	0	0	1	13
ACMI2	0	0	0	0	0	0	0	0	1	1	3	8
ANPA5	0	7	10	17	0	0	0	0	0	1	2	5
BRIN2	0	7	17	40	0	0	0	0	0	2	5	14
BRTE	0	0	0	0	0	0	0	0	0	0	1	1
CHAL7	0	0	0	0	0	0	0	0	1	4	6	6
ELEL5	0	0	10	50	0	7	17	40	0	3	9	27
EPAN	0	0	0	0	0	0	0	0	0	0	1	1
FRVI	0	0	0	0	0	0	0	0	0	1	2	7
GECA3	0	0	0	0	0	0	0	0	0	1	2	5
GOOB2	0	0	0	0	0	0	0	0	1	1	5	8
JUCO6	0	0	0	7	0	0	0	0	0	0	0	2
LUAR3	0	0	0	0	3	20	27	47	1	4	5	9
MARE11	0	0	0	0	0	0	7	27	1	2	5	17
PIEN	0	0	0	20	0	0	0	0	0	1	1	20
PIPO	0	0	0	30	0	0	0	20	0	0	0	12
POFE	7	13	27	73	7	33	70	93	3	12	26	44
POTR5	0	3	13	33	0	0	13	20	0	5	27	56
PSME	0	0	0	7	0	0	0	0	0	1	5	18
PTAQ	0	3	37	67	0	0	0	0	0	1	8	14
PYCH	0	0	0	0	0	0	0	0	0	0	0	2
SEMU3	0	0	7	33	0	0	0	0	1	1	10	21
SYOR2	0	0	0	0	0	0	0	0	0	0	1	4
THFE	0	0	0	13	0	0	0	0	0	0	0	3
UNGRCA1	37	63	70	100	10	43	60	87	16	41	54	77

Table G8. Frequency (%) of plant species in different-sized quadrats at two Loamy Hills, Cold, macroplots (GRCA1 and GRCA2) and combined frequency values for both macroplots associated with the Loamy Hills, Cold, ecological site at Grand Canyon National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	GRCA1				GRCA2				Both macroplots combined (n = 2)			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ABCO	0	0	0	0	0	3	37	84	0	2	18	42
ABLA	0	0	10	43	0	0	0	0	0	0	5	22
ACMI2	0	0	0	0	0	10	10	20	0	5	5	10
ANPA5	3	3	7	7	0	0	0	5	2	2	3	6
BRIN2	0	10	23	66	0	7	13	37	0	8	18	52
ELEL5	0	0	10	24	0	0	3	8	0	0	7	16
ERFO3	0	3	10	24	3	7	7	11	2	5	8	18
FRVI	0	0	10	24	7	10	27	46	3	5	18	35
GECA3	0	3	3	13	0	3	17	26	0	3	10	20
GOOB2	0	3	13	47	0	0	0	14	0	2	7	30
JUCO6	0	0	17	40	0	0	0	0	0	0	8	20
MARE11	0	3	10	29	0	0	27	60	0	2	18	45
PIED	0	0	0	0	0	0	3	8	0	0	2	4
PIEN	0	0	20	68	0	0	0	5	0	0	10	36
PIPO	0	0	0	14	0	0	0	5	0	0	0	10
POFE	0	3	7	26	3	13	17	31	2	8	12	28
POTR5	3	7	33	81	3	7	7	50	3	7	20	65
PSME	0	7	37	75	0	3	17	55	0	5	27	65
PTAQ	0	0	0	0	0	0	7	16	0	0	3	8
PYCH	0	0	0	0	0	0	3	3	0	0	2	2
SEMU3	0	0	0	5	3	10	13	18	2	5	7	11
SISC7	0	0	0	5	0	0	0	10	0	0	0	7
UNGRCA1	3	20	37	70	10	17	53	77	7	18	45	74

Table G9. Frequency (%) of plant species in different-sized quadrats at three macroplots (MEVE3, MEVE4, and MEVE8) associated with the Loamy Mesa Top PJ ecological site at Mesa Verde National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	MEVE3				MEVE4				MEVE8			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ARTR2	0	0	0	0	0	0	0	0	0	0	0	0
BRTE	0	0	0	0	0	0	0	0	0	0	3	20
CANU3	0	0	0	0	0	0	3	3	0	0	0	0
CANU4	0	0	0	0	0	0	0	0	0	0	7	53
CHAL7	0	0	0	5	0	0	3	13	0	0	0	0
CHLE4	0	0	0	0	0	0	0	0	0	0	0	0
COWR2	0	0	0	0	0	0	0	0	0	0	13	73
DEPI	0	0	0	0	0	0	0	0	0	0	0	0
ELEL5	0	0	0	0	0	0	0	10	0	0	0	0
ERUM	0	0	13	37	0	0	0	0	0	0	0	0
ESVI2	0	0	0	0	0	0	0	5	0	0	0	0
GUSA2	0	0	0	0	0	0	0	0	0	0	0	0
HECO26	0	0	0	0	0	0	0	5	0	0	0	0
JUOS	0	0	10	48	0	3	33	86	3	20	27	87
KOMA	0	0	0	0	0	0	0	5	0	0	0	0
LAOC3	0	0	0	0	0	0	0	0	0	0	0	0
LATA	0	0	0	0	0	0	0	0	0	0	10	47
LEPE2	0	0	3	3	0	0	0	0	0	0	0	0
LEPU	0	7	37	84	0	0	0	0	0	0	0	0
LEPU	0	0	0	0	3	10	27	50	0	0	0	0
LUCA	0	0	3	8	0	0	0	10	0	0	0	0
OPER	0	0	7	78	0	0	3	65	0	0	7	47
PEPU7	0	0	3	13	0	0	0	0	0	0	0	0
PIED	0	0	23	61	0	0	23	80	0	0	27	47
POFE	10	57	97	100	20	57	97	100	27	60	100	100
PUTR2	0	3	20	72	0	0	0	10	0	0	0	20
RATE	0	0	0	0	0	0	3	3	0	0	3	3
SEMU3	0	0	0	0	0	0	0	0	0	0	0	0
SPCO	0	0	0	0	0	0	0	5	0	0	0	0
STHY6	0	0	0	0	0	0	0	0	0	0	0	7
STLO4	0	0	0	5	3	3	3	27	0	0	0	30
YUBA	0	0	3	8	0	3	7	30	0	0	0	17

Table G10. Frequency (%) of plant species in different-sized quadrats at two Loamy Mesa Top PJ macroplots (MEVE9 and MEVE10) and combined frequency values for all five macroplots associated with the Loamy Mesa Top PJ ecological site at Mesa Verde National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	MEVE9				MEVE10				All macroplots combined (n = 5)			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ARTR2	0	0	0	0	7	13	67	97	1	3	13	19
BRTE	0	0	3	17	0	7	20	33	0	1	5	14
CANU3	0	0	0	0	0	0	0	0	0	0	1	1
CANU4	0	0	0	17	0	0	0	3	0	0	1	15
CHAL7	0	0	0	0	0	0	7	10	0	0	2	6
CHLE4	0	0	0	3	0	0	0	3	0	0	0	1
COWR2	0	10	33	77	0	0	43	83	0	2	18	47
DEPI	0	0	0	0	0	0	7	17	0	0	1	3
ELEL5	0	0	0	7	0	0	13	37	0	0	3	11
ERUM	0	0	0	0	0	0	0	0	0	0	3	7
ESVI2	0	0	0	0	0	0	0	0	0	0	0	1
GUSA2	0	0	0	0	0	0	0	30	0	0	0	6
HECO26	0	0	0	0	3	7	7	13	1	1	1	4
JUOS	0	17	20	63	7	7	13	70	2	9	21	71
KOMA	0	0	0	0	0	0	0	0	0	0	0	1
LAOC3	0	0	0	0	0	0	3	10	0	0	1	2
LATA	0	0	13	13	0	0	0	10	0	0	5	14
LEPE2	0	0	0	0	0	0	0	0	0	0	1	1
LEPU	0	0	0	0	0	0	0	0	0	1	7	17
LEPU	0	0	0	33	0	0	0	0	1	2	5	17
LUCA	0	0	3	10	0	0	7	10	0	0	3	8
OPER	0	0	13	67	0	0	33	67	0	0	13	65
PEPU7	0	0	0	0	0	0	0	0	0	0	1	3
PIED	0	3	17	50	0	0	20	63	0	1	22	60
POFE	13	30	87	100	3	10	53	87	15	43	87	97
PUTR2	0	0	7	13	0	0	0	0	0	1	5	23
RATE	0	0	0	0	0	7	13	27	0	1	4	7
SEMU3	0	0	0	10	0	0	0	0	0	0	0	2
SPCO	0	0	0	0	0	0	0	10	0	0	0	3
STHY6	0	0	0	0	0	0	0	0	0	0	0	1
STLO4	0	7	7	17	0	0	13	20	1	2	5	20
YUBA	0	3	7	53	0	0	0	7	0	1	3	23

Table G11. Frequency (%) of plant species in different-sized quadrats at three macroplots (CARE1, CARE2b, and CARE5) associated with the Semidesert Alkali Sandy Loam ecological site at Capitol Reef National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	CARE1				CARE2b				CARE5			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
AMAC2	0	3	33	48	0	0	3	3	0	0	7	20
ARBI3	0	0	0	0	0	0	0	10	0	0	0	0
ARDR4	0	0	0	0	0	0	0	0	0	0	0	7
ARFI2	0	0	0	0	0	0	0	5	0	0	0	0
ARTR2	0	0	0	0	0	0	0	10	0	0	0	0
ATCA2	0	0	0	0	0	0	0	0	0	0	10	33
ATCO	0	3	30	97	3	13	50	98	0	7	30	57
BOER4	3	10	13	18	0	0	0	0	0	0	0	0
BOGR2	3	3	23	57	3	7	10	29	0	0	0	7
BRIN2	0	0	0	0	0	0	0	0	0	3	3	7
BRTE	0	0	0	5	0	0	0	5	0	3	7	43
CELA4	0	3	17	50	0	0	7	21	0	0	7	33
CHAL7	7	13	20	63	7	37	47	80	0	10	20	50
CHLE4	0	13	33	67	0	0	0	0	7	10	37	67
CHNA2	0	0	0	0	0	0	0	0	0	0	0	0
CHST	0	0	0	0	0	0	0	5	0	20	60	90
COWR2	0	0	0	0	0	0	0	0	0	0	7	13
DEPI	0	0	0	0	0	0	0	14	0	0	0	10
ERCE2	17	40	73	100	0	10	30	44	3	10	23	50
ERIN4	0	0	0	0	0	0	0	0	0	0	0	0
GIIN2	0	10	33	48	0	3	20	44	3	20	50	80
GUSA2	0	3	43	96	0	3	37	70	0	3	7	33
HAGL	0	0	0	0	0	0	0	0	0	0	0	0
HIJA	0	7	7	21	7	10	10	15	0	0	7	30
LAOC3	0	7	17	45	0	3	3	18	3	37	70	90
LIAR3	0	0	0	0	0	0	7	11	0	0	0	0
MACA2	0	3	13	51	0	0	7	11	0	3	7	23
MATA2	3	7	17	36	0	10	30	68	0	7	30	80
MEAL6	0	3	3	18	0	0	0	0	0	33	67	93
MUSQ	0	0	0	0	0	0	0	5	0	0	0	0
OECE2	0	0	0	10	0	0	0	0	0	0	0	0
OEPA	0	0	0	0	0	0	0	10	0	0	0	7
OPER	3	17	57	100	0	13	37	75	0	0	0	7
ORHY	0	10	53	100	7	20	53	100	3	23	67	90
PHCR	0	0	0	0	0	0	0	0	0	0	0	10

Table G11.—Continued

Species code	Frequency (%) by macroplot and quadrat size											
	CARE1				CARE2b				CARE5			
	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
PLPA2	40	80	100	100	47	70	83	93	0	3	30	63
SAIB	13	57	80	90	0	0	0	0	53	77	93	100
SAPA8	0	0	0	0	3	23	63	73	0	0	0	0
SAVE4	0	7	17	55	0	0	10	72	0	0	17	53
SIHY	0	3	7	73	0	0	3	22	0	0	0	7
SPAI	0	0	3	3	0	0	0	0	0	0	0	3
SPCO	0	0	20	49	0	7	13	56	0	0	0	13
SPCO4	37	57	87	96	7	17	57	80	3	7	13	27
SPCR	0	0	0	0	0	3	10	10	0	0	0	0
SPPA2	0	0	0	0	0	0	0	0	3	7	10	63
STLO4	0	0	0	0	0	0	0	0	0	0	0	0
TESP2	0	0	0	5	0	0	0	0	0	0	0	0
THSU	0	0	0	0	0	0	0	10	0	0	0	0
VUOC	0	3	10	29	0	0	0	10	10	23	63	90

Table G12. Frequency (%) of plant species in different-sized quadrats at two Semidesert Alkali Sandy Loam macroplots (CARE6 and CARE7) and combined frequency values for all five macroplots associated with the Semidesert Alkali Sandy Loam ecological site at Capitol Reef National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	CARE6				CARE7				All macroplots combined (n = 5)			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
AMAC2	0	0	7	23	7	13	47	70	1	3	19	33
ARBI3	0	0	0	0	0	0	0	0	0	0	0	2
ARDR4	0	0	0	0	0	0	0	0	0	0	0	1
ARFI2	0	0	0	0	0	0	0	0	0	0	0	1
ARTR2	0	0	0	0	0	0	0	0	0	0	0	2
ATCA2	0	0	0	0	0	0	0	0	0	0	2	7
ATCO	0	7	20	47	0	3	60	100	1	7	38	80
BOER4	0	0	0	0	0	0	0	0	1	2	3	4
BOGR2	0	0	0	0	0	0	0	0	1	2	7	18
BRIN2	0	0	0	0	0	0	0	0	0	1	1	1
BRTE	0	0	0	0	3	3	7	33	1	1	3	17
CELA4	0	0	0	0	7	10	17	23	1	3	9	26
CHAL7	0	0	0	0	0	0	0	0	3	12	17	39
CHLE4	0	0	0	0	0	7	13	23	1	6	17	31
CHNA2	0	0	0	7	0	0	0	0	0	0	0	1
CHST	0	0	0	0	0	3	3	3	0	5	13	20
COWR2	0	0	0	0	0	0	0	0	0	0	1	3
DEPI	0	0	0	0	0	0	7	7	0	0	1	6
ERCE2	0	3	7	20	0	0	23	47	4	13	31	52
ERIN4	0	0	0	0	0	0	0	20	0	0	0	4
GIIN2	3	17	27	33	3	20	43	83	2	14	35	58
GUSA2	0	10	17	17	0	7	13	37	0	5	23	50
HAGL	0	0	0	0	7	13	33	47	1	3	7	9
HIJA	7	23	30	63	0	3	27	57	3	9	16	37
LAOC3	0	10	30	60	17	70	93	100	4	25	43	63
LIAR3	0	0	0	0	0	0	0	0	0	0	1	2
MACA2	0	3	3	10	0	0	0	0	0	2	6	19
MATA2	0	0	0	0	0	0	0	0	1	5	15	37
MEAL6	0	0	0	3	0	0	33	63	0	7	21	36
MUSQ	0	0	0	0	0	0	0	0	0	0	0	1
OECE2	0	0	0	0	0	0	0	0	0	0	0	2
OEPA	0	0	0	0	0	0	0	0	0	0	0	3
OPER	0	0	7	13	0	0	0	47	1	6	20	48
ORHY	0	10	33	63	0	3	60	93	2	13	53	89
PHCR	0	0	0	0	0	0	0	0	0	0	0	2

Table G12.—Continued

Species code	Frequency (%) by macroplot and quadrat size											
	CARE6				CARE7				All macroplots combined (n = 5)			
	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
PLPA2	0	0	7	13	0	23	87	100	17	35	61	74
SAIB	0	0	0	13	20	73	93	97	17	41	53	60
SAPA8	0	0	0	0	0	0	0	0	1	5	13	15
SAVE4	0	0	0	7	0	3	23	50	0	2	13	47
SIHY	0	0	7	7	0	0	0	7	0	1	3	23
SPAI	0	3	20	60	0	0	0	13	0	1	5	16
SPCO	0	0	0	7	0	0	0	7	0	1	7	26
SPCO4	0	0	0	0	0	0	0	0	9	16	31	41
SPCR	0	0	0	0	0	0	0	0	0	1	2	2
SPPA2	0	0	7	7	0	0	3	10	1	1	4	16
STLO4	0	0	0	0	0	0	7	63	0	0	1	13
TESP2	0	0	0	0	0	0	0	0	0	0	0	1
THSU	0	0	0	0	0	0	0	0	0	0	0	2
VUOC	0	0	0	0	0	0	3	7	2	5	15	27

Table G13. Frequency (%) of plant species in different-sized quadrats at three macroplots (DINO1, DINO2b, and DINO3) associated with the Semidesert Loam ecological site at Dinosaur National Monument. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	DINO1				DINO2b				DINO3			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
AGSM	0	13	33	52	0	0	0	0	0	0	0	10
ARTR2	0	0	3	41	7	23	70	99	30	57	73	100
ASMO7	0	0	0	0	0	0	0	0	0	0	0	0
ATCA2	0	0	0	5	0	0	0	0	0	0	0	0
ATCO	0	0	0	10	0	0	3	51	0	0	3	37
BRTE	73	97	100	100	87	93	93	93	27	60	67	100
CANU3	0	7	27	70	0	0	0	0	0	0	0	0
CANU3	0	0	0	0	0	0	0	0	0	0	0	0
CELA4	0	0	0	0	0	0	0	0	0	0	3	7
CHLE4	0	0	0	0	0	0	0	0	0	3	3	7
CHNA2	0	0	0	0	0	0	0	0	0	0	0	0
DEPI	0	7	30	82	0	7	23	52	0	7	37	87
ERCE2	0	0	0	0	0	0	0	0	0	0	7	13
GIIN2	0	0	33	67	0	0	0	0	0	0	7	10
GUSA2	0	0	3	3	0	7	20	63	0	0	0	0
HIJA	7	7	7	11	3	3	13	23	7	17	37	53
JUOS	0	0	0	0	0	0	0	0	0	0	0	0
LAOC3	0	0	0	0	0	0	0	0	0	0	17	33
LARE	0	3	20	30	10	30	70	94	0	0	0	0
LASE	0	0	0	5	0	0	0	0	0	0	0	0
LEPU	0	0	0	0	0	0	0	0	0	0	0	7
OPER	0	0	3	18	0	3	3	3	0	0	7	60
ORHY	0	3	7	21	0	0	0	0	0	0	0	37
PLPA2	0	0	3	27	0	0	0	0	0	0	0	0
POSE	0	10	23	52	0	0	0	0	0	0	20	40
RATE	0	0	0	0	0	0	0	0	0	0	0	0
SAIB	0	0	0	0	0	0	3	8	0	0	10	17
SAVE4	0	0	3	8	0	0	0	0	0	0	0	0
SIAL2	0	0	0	0	0	0	3	46	0	0	0	0
SIHY	0	0	3	3	3	20	47	99	0	3	17	53
SPCO	0	20	57	80	0	0	0	38	0	10	37	77
STCO4	17	37	73	88	0	0	0	0	3	23	77	93
STLO4	0	0	0	0	0	0	0	0	0	0	0	0
VUOC	77	97	97	97	3	7	13	23	0	0	0	0
ZIPA2	0	0	0	5	0	0	0	0	0	0	0	0

Table G14. Frequency (%) of plant species in different-sized quadrats at two Semidesert Loam macroplots (DINO4b and DINO5) and combined frequency values for all five macroplots associated with the Semidesert Loam ecological site at Dinosaur National Monument. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	DINO4b				DINO5				All macroplots combined (n = 5)			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
AGSM	0	0	0	0	3	17	30	47	1	6	13	22
ARTR2	0	10	43	100	10	13	67	100	9	21	51	88
ASMO7	0	0	0	7	0	0	0	0	0	0	0	1
ATCA2	0	0	0	0	0	0	0	0	0	0	0	1
ATCO	0	0	0	13	0	0	0	0	0	0	1	22
BRTE	87	100	100	100	30	43	53	83	61	79	83	95
CANU3	0	0	0	0	0	0	0	0	0	1	5	14
CANU3	0	0	0	0	3	10	23	73	1	2	5	15
CELA4	0	0	0	0	7	13	27	57	1	3	6	13
CHLE4	0	0	0	0	0	0	0	0	0	1	1	1
CHNA2	0	0	0	33	0	0	0	0	0	0	0	7
DEPI	0	3	7	47	0	0	0	10	0	5	19	56
ERCE2	0	0	0	0	0	0	0	0	0	0	1	3
GIIN2	0	0	7	13	0	0	0	3	0	0	9	19
GUSA2	3	7	53	83	0	0	0	20	1	3	15	34
HIJA	0	0	7	20	7	20	20	23	5	9	17	26
JUOS	0	0	0	23	0	0	0	17	0	0	0	8
LAOC3	0	0	0	3	0	0	0	0	0	0	3	7
LARE	0	0	0	0	0	0	0	0	2	7	18	25
LASE	0	0	0	3	0	0	0	0	0	0	0	2
LEPU	0	0	0	0	0	0	7	30	0	0	1	7
OPER	0	0	7	43	0	0	20	60	0	1	8	37
ORHY	0	0	0	0	0	0	0	7	0	1	1	13
PLPA2	0	0	0	0	10	20	33	63	2	4	7	18
POSE	3	10	20	67	43	73	100	100	9	19	33	52
RATE	3	10	20	37	0	0	0	0	1	2	4	7
SAIB	0	0	0	0	0	0	0	0	0	0	3	5
SAVE4	0	0	7	67	0	0	0	0	0	0	2	15
SIAL2	0	0	0	0	0	0	0	0	0	0	1	9
SIHY	0	0	3	13	0	0	0	7	1	5	14	35
SPCO	3	7	7	17	7	13	30	67	2	10	26	56
STCO4	0	3	17	50	7	17	77	97	5	16	49	66
STLO4	3	3	3	10	0	0	0	0	1	1	1	2
VUOC	13	40	63	83	10	27	87	97	21	34	52	60
ZIPA2	0	0	0	0	0	0	0	0	0	0	0	1

Table G15. Frequency (%) of plant species in different-sized quadrats at three macroplots (ARCH1b, ARCH2, and ARCH3) associated with the Semidesert Shallow Sandy Loam ecological site at Arches National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	ARCH1b				ARCH2				ARCH3			
Code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ARFI2	0	0	0	0	0	0	0	0	0	0	0	3
ASMA10	0	0	0	10	0	0	0	0	0	0	0	0
ASMO7	0	0	0	0	0	0	0	0	0	0	0	0
ATCA2	0	0	0	0	0	0	0	0	0	0	0	0
BRTE	0	0	0	0	0	0	0	5	0	0	7	10
CANU3	0	0	0	0	0	0	0	0	0	0	0	0
CHAL7	0	0	0	0	0	0	0	0	0	0	0	0
CHST	0	0	0	0	0	0	0	0	0	3	20	40
CHVI8	0	0	7	35	0	0	0	0	0	0	0	0
CORA	3	20	77	100	17	47	97	100	0	10	67	100
COWR2	0	0	0	0	0	0	0	0	0	0	0	0
DAFL	0	3	20	53	0	0	0	0	0	0	0	0
DEPI	0	0	0	0	0	0	0	5	0	0	0	20
ELEL5	0	0	0	0	0	0	0	0	0	0	0	0
EPVI	0	3	7	64	0	0	13	47	0	7	7	17
ERCE2	0	0	0	0	0	0	0	0	0	0	0	0
ERCO14	0	0	0	0	0	0	0	0	0	0	0	0
ERIN4	0	3	7	11	0	0	0	0	0	0	0	0
ERMI4	0	0	3	8	0	0	0	0	0	0	0	0
EUFE2	3	10	23	52	0	0	0	0	0	0	0	0
FEOC3	0	7	10	24	0	3	27	46	10	30	50	83
FRAN2	0	0	0	0	0	0	0	0	0	0	0	0
GIIN2	0	0	10	15	0	3	37	56	0	3	3	7
GUSA2	0	0	0	0	0	0	0	0	0	0	0	0
HIJA	3	10	53	77	0	0	0	0	0	0	0	10
JUOS	0	0	0	5	0	0	0	5	0	0	0	7
LAOC3	0	0	0	0	3	7	33	48	0	0	0	0
LEMO2	0	0	0	0	0	0	0	0	0	0	0	0
LEPE2	0	0	0	0	0	0	0	0	0	0	0	0
MAFR3	0	0	0	0	0	0	0	0	0	0	0	0
MEAL6	0	0	3	3	0	0	3	8	0	0	0	0
OECE2	0	0	0	5	0	0	0	0	0	0	0	0
OPER	0	0	0	0	3	10	47	70	0	3	23	53
OPPO	0	0	0	0	0	0	0	0	0	0	0	0
PEPU7	0	0	0	0	0	0	0	5	0	0	0	0

Table G15.—Continued

	Frequency (%) by macroplot and quadrat size											
	ARCH1b				ARCH2				ARCH3			
Code	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**
PHCR	0	0	0	0	0	0	3	13	0	0	0	7
PIED	0	0	0	0	0	0	0	0	0	0	0	0
PLPA2	0	0	0	0	0	0	0	0	0	0	0	0
PUME	0	0	0	0	0	0	0	0	0	0	0	7
SAPE10	0	0	0	0	0	0	0	0	0	0	0	0
SCWH	0	0	0	0	0	0	0	0	0	0	0	0
SEMU3	0	0	0	0	0	0	0	0	0	0	0	0
SPCO	0	0	0	0	0	0	0	0	0	0	0	0
STEX	0	0	0	0	0	0	0	0	0	0	0	0
STHY6	0	0	3	8	0	0	0	5	0	0	0	0
STLO4	0	7	13	18	3	23	83	93	23	37	80	93
YUHA	0	0	0	5	0	0	0	0	0	0	0	7
ZIPA2	0	0	0	0	0	0	0	0	0	0	0	0

Table G16. Frequency (%) of plant species in different-sized quadrats at three macroplots (ARCH4b, ARCH5, and CANY3) associated with the Semidesert Shallow Sandy Loam ecological site at Arches and Canyonlands National Parks. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	ARCH4b				ARCH5				CANY3			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ARFI2	0	0	0	0	0	0	0	0	0	0	0	0
ASMA10	0	0	0	0	0	0	0	0	0	0	0	0
ASMO7	0	0	0	0	0	0	0	0	0	0	0	10
ATCA2	0	0	0	0	0	0	0	0	0	0	0	5
BRTE	0	0	3	7	0	3	23	50	0	7	43	72
CANU3	0	0	0	0	0	0	0	0	0	0	0	0
CHAL7	0	0	0	0	0	0	0	0	0	0	3	3
CHST	0	0	7	47	3	43	83	97	0	0	3	3
CHVI8	0	0	0	0	0	0	0	0	0	3	3	3
CORA	0	10	43	97	3	7	73	100	3	7	40	73
COWR2	0	0	0	0	0	0	0	0	0	13	53	100
DAFL	0	0	0	0	0	0	0	0	0	0	0	0
DEPI	0	0	7	23	0	0	0	0	0	10	17	55
ELEL5	0	0	0	0	0	0	0	0	0	0	3	8
EPVI	0	0	13	27	0	10	33	40	0	3	7	11
ERCE2	0	0	0	0	0	0	0	0	0	0	0	5
ERCO14	0	0	0	0	0	0	0	0	0	0	13	47
ERIN4	0	0	0	0	0	0	0	0	0	0	0	0
ERMI4	0	0	0	0	0	0	0	0	0	0	0	0
EUFE2	0	0	3	10	0	0	7	13	3	10	13	13
FEOC3	13	13	53	90	27	77	97	97	3	30	83	83
FRAN2	0	0	0	0	0	0	0	0	0	0	0	0
GIIN2	3	3	47	87	30	60	80	87	3	13	47	80
GUSA2	0	0	0	7	0	0	0	0	0	3	13	42
HIJA	0	0	0	0	0	0	0	0	0	0	0	0
JUOS	0	0	0	0	0	0	0	0	0	0	0	10
LAOC3	0	0	0	17	7	17	27	57	0	10	23	33
LEMO2	0	0	0	0	0	0	0	0	0	0	17	50
LEPE2	0	0	30	43	0	0	0	0	0	0	0	0
MAFR3	0	0	0	0	0	0	0	0	0	0	0	10
MEAL6	0	0	0	13	0	0	0	0	0	0	0	0
OECE2	0	0	0	0	0	0	0	0	0	0	0	0
OPER	3	3	7	13	3	17	77	100	0	0	0	0
OPPO	0	0	0	0	0	0	0	0	3	3	17	40
PEPU7	0	0	0	0	0	0	0	0	0	0	0	0

Table G16.—Continued

Species code	Frequency (%) by macroplot and quadrat size											
	ARCH4b				ARCH5				CANY3			
	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
PHCR	20	43	67	80	0	0	0	0	0	0	3	3
PIED	0	0	0	0	0	0	0	0	0	0	0	5
PLPA2	0	0	0	0	0	0	0	13	0	0	0	0
PUME	0	0	0	0	0	0	0	0	0	0	0	0
SAPE10	0	0	3	13	0	0	0	0	0	0	0	0
SCWH	0	0	0	0	0	0	0	0	0	0	0	5
SEMU3	0	0	0	0	0	0	0	0	0	0	3	8
SPCO	0	0	0	3	0	0	3	3	0	0	0	0
STEX	0	0	0	0	0	0	0	0	0	0	0	5
STHY6	0	0	0	0	0	0	0	0	0	0	7	26
STLO4	0	13	30	100	37	50	93	100	0	0	7	21
YUHA	0	0	0	0	0	0	0	0	0	0	0	0
ZIPA2	0	0	0	0	0	0	0	0	0	0	0	0

Table G17. Frequency (%) of plant species in different-sized quadrats at one Semidesert Shallow Sandy Loam macroplot (CANY4) at Canyonlands National Park and combined frequency values for all seven macroplots associated with the Semidesert Shallow Sandy Loam ecological site at Arches and Canyonlands National Parks. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size							
	CANY4				All macroplots combined (n = 7)			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
ARFI2	0	0	0	0	0	0	0	0.5
ASMA10	0	0	0	0	0	0	0	1
ASMO7	0	0	10	34	0	0	1	6
ATCA2	0	0	0	0	0	0	0	1
BRTE	0	3	7	30	0	2	12	25
CANU3	0	3	3	8	0	0.5	0.5	1
CHAL7	0	0	0	10	0	0	0.5	2
CHST	0	0	3	22	0.5	7	17	30
CHVI8	0	0	0	0	0	0.5	1	6
CORA	0	3	17	31	4	15	59	86
COWR2	3	13	33	62	0.5	4	12	23
DAFL	0	0	0	0	0	0.5	3	8
DEPI	0	0	20	49	0	1	6	22
ELEL5	0	3	10	10	0	0.5	2	3
EPVI	0	3	10	24	0	4	13	33
ERCE2	0	0	0	0	0	0	0	1
ERCO14	0	0	0	0	0	0	2	7
ERIN4	0	0	0	0	0	0.5	1	2
ERMI4	0	0	0	0	0	0	0.5	1
EUFE2	0	0	0	0	1	3	7	13
FEOC3	3	13	50	69	8	25	53	70
FRAN2	0	0	3	3	0	0	0.5	0.5
GIIN2	0	10	37	70	5	13	37	57
GUSA2	0	0	3	13	0	0.5	2	9
HIJA	0	0	0	0	0.5	1	8	12
JUOS	0	0	0	0	0	0	0	4
LAOC3	3	3	7	16	2	5	13	24
LEMO2	0	0	0	0	0	0	2	7
LEPE2	0	0	0	0	0	0	4	6
MAFR3	0	0	0	0	0	0	0	1

Table G17.—Continued

Species code	Frequency (%) by macroplot and quadrat size							
	CANY4				All macroplots combined (n = 7)			
	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
MEAL6	0	0	0	0	0	0	1	4
OECE2	0	0	0	0	0	0	0	1
OPER	0	0	0	0	1	5	22	34
OPPO	0	3	7	35	0.5	1	3	11
PEPU7	0	0	0	0	0	0	0	1
PHCR	0	0	0	0	3	6	10	15
PIED	0	0	0	10	0	0	0	2
PLPA2	0	0	0	0	0	0	0	2
PUME	0	0	0	0	0	0	0	1
SAPE10	0	0	0	0	0	0	0.5	2
SCWH	0	0	0	0	0	0	0	1
SEMU3	0	3	3	22	0	0.5	1	4
SPCO	0	0	0	0	0	0	0.5	1
STEX	0	0	3	18	0	0	0.5	3
STHY6	3	3	17	26	0.5	0.5	4	9
STLO4	0	0	10	43	9	19	45	67
YUHA	0	0	0	14	0	0	0	4
ZIPA2	0	0	3	8	0	0	0.5	1

Table G18. Frequency (%) of plant species in different-sized quadrats at two Shallow Loamy macroplots (WUPA3 and WUPA4) and combined frequency values for both macroplots associated with the Shallow Loamy ecological site at Wupatki National Monument. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	WUPA3				WUPA4				Both macroplots combined (n = 2)			
Species code	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**
ACHY	0	0	0	0	0	0	0	33	0	0	0	17
ATCA2	0	0	0	0	0	0	0	10	0	0	0	5
BOER4	7	7	47	90	0	3	13	18	3	5	30	54
CHLE4	7	40	77	91	10	30	70	99	8	35	73	95
CHNA2	0	0	7	16	0	0	3	22	0	0	5	19
CRCI3	0	0	0	5	0	0	0	0	0	0	0	2
DEPI	0	0	17	69	0	0	7	7	0	0	12	38
ELEL5	0	0	0	0	0	0	3	13	0	0	2	6
EPVI	0	0	0	0	0	3	7	16	0	2	3	8
GACO5	0	0	0	5	0	0	0	0	0	0	0	2
GIIN2	47	87	100	100	0	33	77	86	23	60	88	93
HENE5	17	50	87	100	10	33	80	99	13	42	83	100
MEAL6	10	23	60	84	13	43	83	100	12	33	72	92
OPER	0	0	0	5	0	0	0	0	0	0	0	2
PLJA	23	57	97	97	10	53	87	100	17	55	92	98
SAKA	0	0	3	3	0	0	0	5	0	0	2	4
SPAI	0	3	10	15	0	0	10	10	0	2	10	12
SPPA2	0	0	0	0	0	0	3	13	0	0	2	6
STPI	0	0	0	0	0	0	0	5	0	0	0	2

Table G19. Frequency (%) of plant species in different-sized quadrats at three macroplots (CARE3, CARE4b, and CARE8) associated with the Upland Shallow Loam ecological site at Capitol Reef National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	CARE3				CARE4b				CARE8			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
AMUT	0	0	0	0	0	3	3	13	0	0	0	0
BEFR	0	0	0	5	0	0	0	0	0	0	3	17
BRTE	0	0	0	0	0	0	0	0	0	0	0	7
CEMO2	0	0	0	0	0	0	0	0	0	0	3	37
CHAL7	0	0	0	0	0	0	0	0	0	0	0	3
CHVI8	0	0	3	3	0	0	0	0	0	0	0	0
COME5	0	0	0	0	0	3	3	3	0	0	0	0
COWR2	17	53	90	95	17	47	80	99	3	7	60	80
CRFL5	0	0	7	30	0	0	7	35	0	0	3	40
DEPI	0	3	10	20	0	0	20	25	0	3	33	57
EPVI	0	0	0	14	0	0	0	5	0	3	13	30
ERCE2	0	0	0	5	0	0	0	0	0	0	0	0
ERMI4	0	0	7	21	0	0	3	3	0	0	0	0
FRAN2	0	0	0	5	0	0	0	0	0	0	0	0
GIIN2	0	10	17	21	0	0	0	0	0	7	20	43
GUSA2	0	0	0	5	0	0	0	0	0	3	7	30
HIJA	0	0	7	30	0	0	0	0	0	0	0	0
JUOS	0	0	0	14	0	0	0	5	0	3	3	23
ORHY	0	0	0	14	0	0	0	10	0	7	7	10
PEPU7	0	0	0	0	0	0	0	14	0	0	0	7
PIED	0	0	0	19	0	0	3	18	0	0	0	7
POFE	0	3	3	3	0	0	0	0	0	0	0	0
POSA12	0	0	3	3	0	0	0	0	0	0	0	0
PUME	0	0	0	0	0	0	0	0	0	0	0	7
PUTR2	0	0	0	0	0	0	0	0	0	0	0	0
SHRO	0	0	0	5	3	3	3	3	0	0	0	3
SIHY	3	3	3	3	0	0	0	0	0	0	0	0
STPI	0	0	7	30	0	0	3	22	0	0	0	7

Table G20. Frequency (%) of plant species in different-sized quadrats at two Upland Shallow Loam macroplots (CARE9 and CARE10) and combined frequency values for all five macroplots associated with the Upland Shallow Loam ecological site at Capitol Reef National Park. See Appendix A for key to species codes.

	Frequency (%) by macroplot and quadrat size											
	CARE9				CARE10				Ecological Site Mean			
Species code	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2	0.01 m^2	0.1 m^2	1 m^2	10 m^2
AMUT	0	0	0	0	0	0	0	0	0	1	1	3
BEFR	0	0	0	0	0	0	0	0	0	0	1	4
BRTE	0	0	0	0	0	0	0	0	0	0	0	1
CEMO2	0	0	7	13	0	3	10	27	0	1	4	15
CHAL7	0	0	0	0	0	0	0	0	0	0	0	1
CHVI8	0	0	0	0	0	0	0	0	0	0	1	1
COME5	0	0	0	0	0	0	0	0	0	1	1	1
COWR2	20	37	47	67	17	33	47	80	15	35	65	84
CRFL5	0	0	0	0	0	0	7	43	0	0	5	30
DEPI	0	3	20	53	7	13	20	23	1	5	21	36
EPVI	0	0	0	7	0	0	17	37	0	1	6	18
ERCE2	0	0	0	0	0	0	0	0	0	0	0	1
ERMI4	0	0	0	0	0	0	0	0	0	0	2	5
FRAN2	0	0	0	0	0	0	0	0	0	0	0	1
GIIN2	0	0	0	13	0	0	0	0	0	3	7	16
GUSA2	0	0	10	20	0	0	0	7	0	1	3	12
HIJA	0	0	0	0	0	0	0	0	0	0	1	6
JUOS	0	0	0	0	0	0	0	27	0	1	1	14
ORHY	0	0	0	3	0	0	7	10	0	1	3	9
PEPU7	0	0	0	13	0	0	0	0	0	0	0	7
PIED	0	0	0	0	0	0	3	23	0	0	1	13
POFE	0	0	0	0	0	0	0	0	0	1	1	1
POSA12	0	0	0	0	0	0	0	0	0	0	1	1
PUME	0	0	0	30	0	0	0	0	0	0	0	7
PUTR2	0	0	0	10	0	0	0	0	0	0	0	2
SHRO	0	0	0	7	0	0	0	10	1	1	1	6
SIHY	0	0	0	0	0	0	0	0	1	1	1	1
STPI	0	0	0	0	0	0	0	0	0	0	2	12