Long-term Ecological Monitoring Program

Evaluation of a Study Design for Detecting Ecological Change in Denali National Park and Preserve at Multiple Scales

Volume 2: Tables and Figures

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Preface

The text and figures for the Minigrid Report were placed into a separate volume to facilitate review of the document. This was necessary due the large number of data tables and figures contained herein. The tables are presented in the first section, followed by the figures.

Note: Where shown, error bars represent ± 1 standard error of the mean value.

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Table 2.1. Summary of National Park Service recommendations for designing long-term monitoring sampling plans.

1. A probability sample should always be taken to avoid bias. Judgment sampling using representative sites selected by experts should be avoided.

2. Since the NPS's mission is to protect resources in the entire park, sampling should be designed so that robust inferences can be made to the entire park and not some easily accessible portion of it. Areas of the park that are too inaccessible or unsafe to sample can be excluded from the program, but then no inference can be made about resources in these areas. Design-based inferences can only be made to areas that have a chance of being included in a sample.

3. As a starting point, samples should be spread out over the entire park or target population using some sort of grid or cell design, or a tessellation procedure. Sample intensity can be increased in areas of special interest.

4. Areas of special interest, such as riparian or alpine areas, can be defined based on physical characteristics such as terrain. These can be used judiciously to define strata, or areas to sample with higher probability.

5. A design based on stratification of the park based on habitats derived from vegetation maps is not recommended because stratum boundaries change over time.

6. Permanent plots are recommended. Revisiting the same plots removes plot-to-plot differences from the change estimates, increasing the precision.

7. Determine the sample size needed to detect changes of interest. Taking too few samples puts resources at risk because important changes are missed or detected too late; taking too many samples wastes time and resources.

8. Be sensitive to the spatial integrity of the sample. Is there adequate coverage of areas of interest?

9. Precision increases with the number of years of sampling.

10. It is not necessary to visit all sites every year. A rotating panel design can be used. Data analysis of these designs can be complex and needs to be considered when the design is put together.

11. Collocation of sampling is recommended to allow comparisons among components.

Table 3.1. Cross reference table showing the extensive-scale objectives for the Denali vegetation monitoring program and the specific field procedures we have designed to meet each objective.

Objective	**Field procedures that provide data to meet objectives**
#1 Vegetation structure	Cover transects Tree mensuration Quadrat observations
# 2 Vegetation species composition	Cover transects Quadrat observations Tree mensuration
#3 Density of tree species	Tree mensuration Quadrat measurements for seedling density
#4 Annual growth of spruce	Increment coring Tree mensuration
#5 Forest insect damage	Tree mensuration Photo documentation
#6 Human use of landscape	Plot descriptive data Photo documentation
#7 Soil attributes	Soil field observations and sampling
#8 Active layer depth	Soil depth measurements Soil field observations
#9 Fuels	Cover transects Quadrat observations Photo documentation
#10 Landscape appearance	Photo documentation Plot descriptive data

Table 3.2. Spatial scales at which values for vegetation parameters may be estimated using the minigrid design, and therefore scales at which change in these parameters may be detected.

Type of change and spatial scale at which change may be observed (domain of statistical inference)**	**An Example…**	**Values required for parameter estimate at given scale**	**Statistical comparisons of interest for detecting change**	**Methods to "Scale up" observations within the design**
Change in the mean value of vegetation parameter at one individual plot between two sample iterations (*****200 square meter plot***)	Percent cover of *Betula nana* increased by 32 percent during 1 sample interval in a given plot	Parameter estimates (e.g. mean and variance in cover values) for an individual plot at two separate sample iterations	**compare mean cover values at time 1 vs. time 2**; [Analyze species frequency data (quadrats) to determine if *frequency* of *B. nana* has increased; inspect plot photos from two sample iterations to determine if change is apparent; inspect vertical distribution of cover of *B. nana* at two sample intervals to assess this facet of change]	The number of individual plots in which the given change was observed can be tallied and compared to numbers of plots that did not exhibit given change; this would allow for an estimate of the frequency of the observed change at the 200m patch size across the larger areas of interest (both within and among minigrid samples)
Change in the distribution or pattern of abundance of given vegetation parameter observed among the plots *within* a single minigrid sample (*****2.5 x 2.5 kilometer minigrid study area (6.25 km^2***)	Percent cover of *B. nana* increased in high elevation plots within a grid, where it appears to have displaced dwarf scrub species, but decreased in cover in low elevation plots where it has apparently been displaced by an increased in cover by tree species	Parameter estimates for each of 25 plots within a minigrid; Measurements of independent predictive physical variables for these plots. ALSO: Gradient analysis or regression equation showing relationship between plot elevation and *Betula nana* cover for this sample	**Test for difference in slope of regression line predicting *B. nana* abundance based on plot elevation. Simultaneous comparisons of mean cover values for separate elev. gradient segments at T_1 vs. T_2; Nonparametric tests of ranked cover data relative to elevation;**	The number and spatial distribution of minigrid samples showing the same pattern of change may be determined: Did all minigrids north of the Alaska Range crest show the same pattern, or is it restricted to particular *kinds* or *locations* of minigrid samples?
Change in the mean value, or degree of variation of a vegetation parameter for one	Mean basal area (m^2 / Ha) of white spruce increased by 3 m^2 / Ha within a minigrid	Parameter estimates for white spruce basal area across all 25 plots in a minigrid sample	**compare mean basal area values across entire sample at T_1 vs. T_2;, (**tally the	Examine the number and spatial distribution of minigrid samples in which

Type of change and spatial scale at which change may be observed (domain of statistical inference)**	**An Example…**	**Values required for parameter estimate at given scale**	**Statistical comparisons of interest for detecting change**	**Methods to "Scale up" observations within the design**
entire minigrid sample between two sample iterations [****2.5 x 2.5 kilometer minigrid study area (6.25 km^2)**]	sample during a given sample interval	for two separate sample iterations	number of individual plots that showed an increase in basal area of spruce; examine the size-class structure of trees in sample to identify where increase in BA occurred (i.e. through recruitment vs. growth of existing trees); compare mean diameter statistics of sampled trees at T_1 vs. T_2; compare cover data for white spruce at T_1 vs. T_2	similar changes were observed over the sample interval; form a single stratum consisting of all plots in these samples and perform statistical test to determine whether observed changes at minigrid scale are statistically significant at this larger spatial scale, based on more extensive dataset
Change in vegetation parameter mean or variability *among* multiple sets of entire minigrid samples ***(**inference domain would be variable, depending upon data included in analyses)***	Mean density of white spruce for all plots located within the park road corridor increased by an average of 20 stems per hectare during a sample interval	Parameter estimates derived for pooled data from all plots that fall within the specified area of interest	**Compare mean density across all plots within park road corridor at T_1 vs. T_2** (Examine frequency data for spruce, examine cover data for spruce, examine basal area and size-class distribution data for spruce**)**	Compare results of this analysis to other discrete regions of the park: are the same changes observed in data from other regions?
Change in observed values and/or pattern of variation for vegetation parameter within an ecoregion (or other geographic subsection of the park) **(*****The area within the ecoregion boundary*)	Active layer depth has increased by an average of 5 cm within the heavily permafrosted Toklat Basin ecoregion subsection during a sample interval	Parameter estimates for all plots that fall in a given ecoregion (ecoregion becomes a stratum, formed subsequent to data collection)	**Compare mean depth of active layer (quantified with soil depth measurements) across all plots in Toklat Basin subsection at T_1 vs. T_2**	

Type of change and spatial scale at which change may be observed (_domain of statistical inference_)**	**An Example…**	**Values required for parameter estimate at given scale**	**Statistical comparisons of interest for detecting change**	**Methods to "Scale up" observations within the design**
Change in the mean response, or distribution, of a vegetation parameter along an important ecological gradient at the regional to park-wide scale **(**_Inference domain would be variable – depending upon how many minigrids contribute data to the gradient analysis, how many and the spatial arrangement of those grids_**)	The observed relationship between mean shrub cover and elevation for areas north of the Alaska Range crest changed significantly during a sample interval: average shrub cover across all plots located between 1200 and 1800 m in elevation increased by an estimated 25 %, whereas no changes in shrub cover were observed in plots in any of the other elevation strata (i.e. 0-600 m, 600-1200 m, and >1800 m)	Separate parameter estimates for each of multiple strata formed based on observed values for plot elevation (ALSO: Gradient analysis or regression equation showing relationship between plot elevation and shrub cover for this sample).	**Compare mean shrub cover across all plots in each of several elevation strata at T_1 vs. T_2; (multiple comparisons)**	
Change in the mean or distribution of a vegetation parameter at a park-wide scale. **(**_entire park_)**	Frequency of occurrence of species "**X**" (dominant, exotic, keystone, or otherwise) increased by an estimated 10 percent among all plots measured in the park during a sample interval	Parameter estimates for species frequency for all plots measured in the park during one entire sample iteration.	**Compare frequency estimates derived from observations in first and second sample iterations**.	(Compare to frequency estimates derived during same period for other park units in the Central Alaska Network???)

Table 4.1. Summary of vegetation sampling completed during 2001 - 2003, Minigrid Pilot Study, Denali National Park and Preserve, Alaska.

Minigrid	Type	Dates Surveyed	Access Method	# of Points Surveyed	Comments
2001					
Rock Creek	Transitional	June 20 to June 28, 2001	Foot travel from park road (day trips)	25	High topographic relief
Wigand Creek	Boreal	July 3 to July 9, 2001	Helicopter	25	Very tussocky terrain, difficult travel conditions
Upper Savage River	Alpine	July 30 to August 3, 2001	Foot travel from park road (backpack in and camp)	25	High topographic relief
2002					
Lower Stony Creek	Transitional	June 27 to July 6, 2002	Helicopter	25	High topographic relief and dense brushy areas
East Chitsia	Boreal	June 27 to July 5, 2002	Helicopter	20	Due to a combination of factors – extreme weather, dense brush and steep slopes,the crew was able to sample only 20 of 25 points.
Primrose	Alpine	July 12 to July 19, 2002	Foot travel from park road (backpack in and camp)	25	
Gorge Creek	Alpine	July 12 to July 20, 2002	Foot travel from park road (backpack in and camp)	18	We could only access 18 points due to topography.
East Toklat	Boreal	July 25 to August 1, 2002	Helicopter	25	
West Toklat	Boreal	July 25 to 1 August 2002	Helicopter	25	
2003					
Upper Wigand Cr.	Boreal	June 30 to July 7, 2003	Helicopter	25	
Tributary Cr.	Alpine	July 14 to July 23, 2003	Foot travel from park road (backpack in and camp)	24	One point was located in inaccessible terrain.
Lower East Fork	Boreal	July 28 to August 4, 2003	Helicopter	25	

Table 4.2. Values observed for plot physical variables from a cross-section of plots in the Lower Stony minigrid.

Plot #	Elevation (m)	Slope	Aspect	Equivalent latitude	% Rock (± se)	% Gravel (± se)	% Bare ground (± se)
01	822	2°	218	61.99°	0	0	0
02	829	18°	357	81.52°	0	0	0
09	944	19°	328	75.85°	0.13 (± 0.07)	0	1 (± 0.58)
11	816	2°	308	64.78°	0	0	0
15	1086	6°	350	69.48°	0.06 (± 0.06)	0	0
19	1007	11°	268	61.20°	0	0	0
23	898	14°	62	66.87°	0	0	0
24	985	22°	198	42.23°	4.5 (± 2.10)	0	0

Table 4.3. Physical descriptors recorded in eight selected plots in the Lower Stony minigrid.

Plot #	Slope Position	Landform Descriptor	Drainage Code	Wind Exposure	Slope Type	Evidence of Fire	Parent material	Frost Action code
01	Valley bottom - stream terrace	Alluvial delta	Impeded	Exposed	Simple	none	Alluvium	Low
02	Toe slope	Valley slope broken by benches	Impeded	Moderate	Complex	none	Bedrock residuum	None
09	Toe slope	Sloping gully	Rapid, runoff	Sheltered	Complex	none	Colluvium	None
11	Valley bottom - stream terrace	Stream terrace	Rapid, permeable	Protected	Simple	none	Alluvium	Low
15	Ridgetop	Broad, flat ridge	Rapid, permeable	Exposed	Complex	none	Bedrock residuum	Moderate
19	Toe slope	Base of valley slope	Impeded	Sheltered	Complex	none	Bedrock residuum	Moderate
23	Middle 1/3 slope	Swale on valley slope	Rapid, runoff	Protected	Complex	none	Bedrock residuum	None
24	Upper 1/3 slope	Valley slope	Rapid, runoff	Moderate	Complex	none	Bedrock residuum	None

Table 4.4. Field soil observations recorded at eight selected plots in the Lower Stony minigrid.

Plot #	Soil depth (cm) (± se)	Soil temp. (° C)	Air temp (°C)	Litter depth (cm)	Living Mat Depth (cm)	Organic Mat Depth (cm)	Max. Vertical Microrelief (dm)	Max. Horizontal Microrelief (dm)
01	17 (± 3)	0.93 (±0.3)	11.9	0.3 (± 0)	4 (± 0.7)	19 (± 1.5)	0	0
02	32 (± 4)	2.98 (±1.2)	11.5	0.3 (± 0.1)	7.5 (± 1.3)	12.3 (± 4.3)	0.75	2
09	33 (± 3)	2.68 (± 0.7)	18.9	1.7 (± 1.4)	4 (± 1.4)	15 (± 0.4)	5	50
11	35 (± 4)	2.88 (±0.4)	11.2	0.9 (± 0.1)	5 (± 2.1)	16.3 (± 1.9)	22.5	200
15	54 (± 9)	5.12 (±0.5)	6.6	0.2 (± 0.1)	2.5 (± 0.6)	5 (± 1.2)	0	0
19	27 (± 2)	0.80 (0.2)	10.5	0.2 (± 0.1)	4 (± 0.6)	18.8 (± 2.1)	50	150
23	39 (± 10)	3.68 (±0.4)	11.2	2.6 (± 1.8)	0.7 (± 0.3)	7.7 (± 0.3)	0	0
24	35 (± 6)	6.87 (±0.4)	6.7	0.1 (± 0.1)	8.25 (± 1.6)	10.3 (± 3.3)	20	40

Table 4.5. Results of laboratory soil analyses from soil samples taken at eight selected plots in the Lower Stony minigrid. Values were calculated as a mean of four observation from points surrounding the permanent vegetation monitoring plot.

Plot #	% Fine fraction (> 2mm)	% Soil moisture	pH	% Sand	% Silt	% Clay	% Soil Carbon	% Soil Nitrogen
01	72.3	32.8	4.99	66.8	20.8	14.4	1.5	0.09
02	92.1	21.4	4.68	40.8	48.8	10.4	4.55	0.24
09	44.5	24.3	4.44	-99	-99	-99	4.76	0.33
11	72.2	16.9	7.01	64.8	24.8	10.4	1.87	0.11
15	40.8	38.3	4.27	60.8	28.8	10.4	2.27	0.14
19	82.2	25.6	4.21	52.8	36.8	10.4	7.78	0.39
23	83.8	23.8	4.11	37.2	48.8	14	4.39	0.34
24	41.1	23.8	4.36	-99	-99	-99	7.21	0.40

The value “-99” indicates missing values for the parameter in question

Table 4.6. Transect cover summary table for eight selected points in the Lower Stony minigrid.

Plot #	Total # species "hit"	# species per point	Variance in # species per point	# total "hits" per point	Variance in # "hits" per point	Mean # "hits" > 30 cm per point	Variance in # "hits" > 30 cm per point
01	8	1.119	0.555	3.119	1.520	0.322	0.395
02	10	1.034	0.344	3.322	1.601	0.475	0.461
09	14	1.169	0.385	2.932	1.168	1.017	0.672
11	7	0.797	0.406	3.559	5.458	1.695	4.802
15	12	0.373	0.272	1.949	0.566	0.000	0.000
19	11	1.169	0.971	3.085	1.493	0.034	0.033
23	16	1.797	1.406	3.559	2.389	1.186	1.534
24	10	1.220	0.382	3.085	1.148	0.627	0.445

Table 4.7. Table showing frequency of occurrence in the 1 m^2, 4 m^2, and entire plot (200 m^2) for all vascular plant species observed in Rock Creek minigrid point #19.

Species	1 m^2	4 m^2	200 m^2
Aconitum delphinifolium	1	1	1
Adoxa moschatellina	1	1	1
Alnus viridis	0.5	0.75	1
Anemone richardsonii	0	0.25	1
Artemisia tilesii	0	0.25	1
Boykinia richardsonii	0	0	1
Calamagrostis canadensis	0.25	0.5	1
Carex scirpoidea	0.5	0.75	1
Cardamine umbellata	0	0	1
Cystopteris fragilis	0.25	0.25	1
Cystopteris montana	0.25	0.25	1
Dryopteris inexpansa	0	0	1
Epilobium angustifolium	0	0.5	1
Equisetum arvense	0.25	0.75	1
Heracleum maximum	0	0.75	1
Lycopodium annotinum	0.25	0.25	1
Mertensia paniculata	1	1	1
Petasites frigidus	0.75	0.75	1
Polemonium acutiflorum	0	0	1
Ribes triste	0	0	1
Salix richardsonii	0.25	0.5	1
Sanguisorba stipulata	0.25	0.25	1
Saxifraga nelsoniana	0.25	0.5	1
Senecio lugens	0	0.25	1
Stellaria borealis	0	0	1
Valeriana captitata	0	0	1

Table 4.8. Table showing frequency of occurrence in the 1 m^2, 4 m^2, and entire plot (200 m^2) for all nonvascular plant species observed in Rock Creek minigrid point #19.

Species	Type	1 m^2	4 m^2	200 m^2
Aulacomnium palustre	bryophyte	0	0.25	1
Blepharostoma trichophyllum	bryophyte	0	0	1
Brachytheciaceae sp#1	bryophyte	0.5	0.75	1
Brachytheciaceae sp#2	bryophyte	0	0	1
Bryum sp #1	bryophyte	0	0.25	1
Cladonia sp. #1	lichen	0.25	0.25	1
Climacium dendroides	bryophyte	0	0.25	1
Distichium capillaceum	bryophyte	0.5	0.5	1
Drepanocladus sp. #1	bryophyte	0.5	0.5	1
Hylocomium splendens	bryophyte	0	0	1
Lophozia incisa	bryophyte	0.25	0.25	1
Nephroma expallidum	lichen	0	0	1
Peltigera aphthosa	lichen	0.25	0.25	1
Pellia endiviifolia	bryophyte	0.25	0.5	1
Peltigera rufescens	lichen	0.25	0.25	1
Plagiothecium sp. #1	bryophyte	0.25	0.75	1
Pleurozium schreberi	bryophyte	0	0	1
Polytrichum formosum	bryophyte	0.25	0.5	1
Pogonatum sp. #1	bryophyte	0	0	1
Preissia quadrata	bryophyte	0	0	1
Rhizomnium sp. #1	bryophyte	0.25	0.5	1
Schistidium apocarpum	bryophyte	0.25	0.25	1
Timmia norvegica	bryophyte	0	0.25	1
Unidentified liverwort	bryophyte	0	0	1
Tortula sp. #1	bryophyte	0.25	0.25	1

Table 4.9. The frequency of occurrence of vascular plant species endemic to Alaska-Yukon in the nested quadrat array for each plot in the upper Savage River minigrid sample.

Plot #	1 m^2	4 m^2	200 m^2
01	1	1	1
02	0.25	0.25	1
03	0.75	1	1
04	0.25	1	1
05	0	0	0
06	0.75	1	1
07	0	0	0
08	0.75	0.75	1
09	0	0	0
10	0	0	0
11	0	0	1
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0
16	0.25	0.5	1
17	0.25	0.25	1
18	0.25	0.25	1
19	0.5	0.75	1
20	0	0	1
21	0.25	0.5	1
22	0.75	0.75	1
23	0.75	0.75	1
24	0.25	1	1
25	0	0	1

Table 4.10. Vascular plant species richness metrics for each plot in the Upper Savage River minigrid sample.

Plot #	S^{1m}	$S^{4 m}$	$S^{200 m}$	H	D`
1	11.75	16	31	3.434	0.9677
2	14	21	40	3.689	0.9750
3	6.5	13.75	40	3.689	0.9750
4	7.25	14.5	30	3.401	0.9667
5	9	12	24	3.178	0.9583
6	6.25	13	42	3.738	0.9762
7	12	14.75	29	3.367	0.9655
8	7	13.75	40	3.689	0.9750
9	8.25	10	23	3.135	0.9565
10	5	7.5	23	3.135	0.9565
11	11.5	16.5	38	3.638	0.9737
12	11.25	14.75	36	3.584	0.9722
13	8	9.75	22	3.091	0.9545
14	8.75	10.75	15	2.708	0.9333
15	8.25	11.75	25	3.219	0.9600
16	15.75	22.25	45	3.807	0.9778
17	14.5	22.75	57	4.043	0.9825
18	9.5	15.25	37	3.611	0.9730
19	13.75	19.25	44	3.784	0.9773
20	-99	-99	41	3.714	0.9756
21	19.75	28.25	68	4.220	0.9853
22	15.25	22.5	60	4.094	0.9833
23	5.75	10.25	42	3.738	0.9762
24	3.75	14	52	3.951	0.9808
25	-99	-99	37	3.611	0.9730
Mean for minigrid	**10.1**	**15.4**	**37.6**	**3.571**	**0.9700**

S^{1m} – mean number of species in 1 m^2 quadrats;
$S^{4 m}$ = mean number of species in 4 m^2 quadrats;
$S^{200 m}$ = total number of species in plot;
H = Shannon`s diversity index;
D = Simpson`s diversity index.

Table 4.11. Tree data for trees observed in the Wigand Creek minigrid point #23. These data will be used to track condition, vigor and size of individual trees in permanent vegetation monitoring plots.

Species	DBH	Condition	Crown class	Pathogen code	Comments
Betula papyrifera	12.5	Alive	Intermediate	None	oozing black liquid from bole
Betula papyrifera	13.7	Alive	Intermediate	None	
Betula papyrifera	17.9	Alive	Intermediate	None	
Betula papyrifera	13.9	Dead	Overtopped	Dead; Conk fungi	sap rot conks, broken top at 5 m
Picea glauca	14.2	Alive	Intermediate	None	
Picea glauca	17.4	Alive	Intermediate	None	leaning
Picea glauca	17.8	Alive	Intermediate	Pitch tubes evident	half crown, pitch tubes
Picea glauca	18	Alive	Intermediate	Pitch tubes evident	half crown, pitch tubes
Picea glauca	18.1	Alive	Intermediate	Pitch tubes evident	half crown, pitch globules on bole
Picea glauca	18.8	Alive	Intermediate	None	
Picea glauca	20.0	Alive	Intermediate	None	half crown, bend @ 10 m
Picea glauca	21.1	Alive	Intermediate	None	
Picea glauca	22.3	Alive	Intermediate	None	
Picea glauca	22.4	Alive	Intermediate	None	
Picea glauca	23.4	Alive	Intermediate	Pitch tubes evident	half crown, pitch tubes
Picea glauca	27.1	Alive	Codominant	None	
Picea glauca	40.6	Alive	Dominant	None	
Picea glauca	22.4	Dead	Intermediate	Dead; Broom rust	large crack in bole at base
Picea glauca	31.6	Dead	Overtopped	Dead	bole with broken top @ 4 m

Table 4.12. Estimates of tree, sapling and seedling density calculated from field measurements of trees in Wigand Creek minigrid point #23. Units are number of stems per hectare.

Species	**Live tree density**	**Dead tree density**	**Live sapling density**	**Dead sapling density**	**Live seedling density**	**Dead seedling density**
Betula papyrifera	150	50	900	100	0	0
Picea glauca	650	100	100	0	0	0
Populus tremuloides	0	0	600	100	625	0

"tree" is defined as individual that is ≥ 12 cm diameter at breast height (dbh), "sapling" is individual that is < 12 cm dbh, but > 0 cm dbh; and "seedling" is an individual that < 0 cm dbh (e.g. shorter than 1.37 m tall).

Table 4.13. Estimates of tree, sapling and seedling basal area calculated from field measurements of trees in Wigand Creek minigrid point #23. Units are m^2 tree bole per hectare.

Species	**Live tree basal area**	**Dead tree basal area**	**Live sapling basal area**	**Dead sapling basal area**
Betula papyrifera	2.609	0.759	0.648	0.378
Picea glauca	25.922	5.892	0.346	0
Populus tremuloides	0	0	0.071	0.016

Table 4.14. Estimates of tree, sapling and seedling diameter at breast height (dbh) calculated from field measurements of trees in Wigand Creek minigrid point #23. Values are expressed in cm.

Species	**Mean live tree dbh**	**Mean dead tree dbh**	**Mean live sapling dbh**	**Mean dead sapling dbh**
Betula papyrifera	14.7 (± 1.3)	13.9 (± 0)	2.1 (±0.5)	5.8 (± 2.7)
Picea glauca	21.6 (± 1.7)	27.0 (±3.3)	6.3 (± 1.5)	N/A
Populus tremuloides	N/A	N/A	1.0 (± 0.2)	1.3 (± 0.5)

Table 5.1. Correlation matrix for pairs of physical variables measured at 25 plots in the West Toklat minigrid sample.

	elevation	slope	aspect off-180	EQ	soil depth	litter depth	o horiz. depth	% soil moisturre	% soil frag <2mm	% C	% N	Soil pH
slope angle	**0.70**	-										
aspect off-180♦	-0.17	-.05	-									
equiv. latitude (EQ)	0.23	**0.45**	**0.83**									
soil depth	**0.70**	**0.45**	-0.14	0.13								
litter depth	-0.07	**0.51**	0.29	**0.41**	-0.07							
o horiz depth	0.06	0.03	0.20	0.10	0.29	**0.46**						
soil moisture %	0.11	-0.22	-0.18	**-0.39**	0.05	-0.25	0.08					
% soil frag <2mm	**-0.57**	-0.33	**0.66**	**0.35**	**-0.37**	**0.40**	0.34	0.04				
% soil carbon (%C)	0.13	-013	-0.32	**-0.45**	0.01	-0.20	0.06	**0.96**	-0.08			
% soil nitrogen (%N)	-0.02	-0.22	-0.13	**-0.35**	-0.12	-0.12	0.04	**0.96**	0.09	**0.97**		
soil pH	-0.16	-0.04	0.18	0.23	-0.19	-0.13	**-0.47**	**-0.80**	-0.08	**-0.85**	**-0.81**	
soil temperature	0.28	**0.35**	0.02	0.20	0.33	**0.53**	**0.62**	**-0.45**	-0.15	**-0.39**	**-0.43**	0.06

Number given is coefficient of simple correlation (=r) between pair of physical parameters.♦ aspect off-180 is the absolute value of the difference between observed plot aspect and due south - it is a measure of relative southern exposure. We have bolded all correlations between pairs of variables stronger than 0.35, to allow the reader to more easily visualize strong patterns in correlation among variables.

Table 5.2. Selected scores for common species on the first ordination axis of vascular plant cover data from West Toklat minigrid.

Species	**DCA-1 score**
Salix reticulata	378
Carex podocarpa	334
Saussurea angustifolia	274
Festuca altaica	273
Boykinia richardsonii	271
Carex bigelowii	90
Eriophorum vaginatum	74
Betula nana	-18
Ledum decumbens	-49
Pedicularis labradorica	-90
Eriophorum brachycentrum	-148

Table 5.3. Correlation matrix for selected pairs of plant cover, species richness, and community composition measurements among 25 points sampled in the West Toklat minigrid. Number given is the coefficient of simple correlation between given pairs of vegetation parameters.

	Tree density	Tree BA	Seedling density	% tree cover	% shrub cover	% dwarf shrub cover	% forb cover	% gram. cover	% moss cover	% lichen cover	mean 1 m^2 VP richness	mean 4 m^2 VP richness	200 m^2 VP richness
Tree basal area	**0.45**												
Seedling density	**0.80**	0.20											
% tree cover	**0.87**	**0.50**	**0.80**										
% shrub cover	**-0.45**	-0.18	**-0.59**	**-0.47**	-								
% dwarf shrub	-0.17	0.18	-0.19	-0.04	-0.09	-							
% forb cover	0.23	**0.57**	0.06	0.21	0.16	0.21	-						
% gram. cover	-0.18	-0.08	-0.05	-0.09	-0.24	-0.08	**-0.38**	-					
% moss cover	0.27	0.19	**0.37**	0.27	**-0.71**	0.09	-0.30	**0.35**	-				
% lichen cover	-0.17	-0.11	-0.08	-0.10	-0.13	-0.10	**-0.49**	**0.42**	0.10	-			
1 m^2 richness	**0.35**	**0.42**	0.21	0.28	-0.33	0.23	**0.54**	**-0.38**	0.06	**-0.53**	-		
4 m^2 richness	**0.37**	**0.45**	0.28	**0.36**	-0.34	0.23	**0.52**	**-0.38**	0.06	**-0.52**	**0.95**	-	
200 m^2 richness	**0.41**	**0.47**	**0.40**	0.45	-0.34	0.22	**0.51**	**-0.41**	0.04	**-0.48**	**0.83**	**0.93**	-
DCA-1 ‡	**0.62**	**0.61**	**0.46**	**0.60**	**-0.44**	0.08	**0.50**	-0.20	0.30	**-0.53**	**0.71**	**0.75**	**0.71**

Tree density is the estimated total density (stems/Ha) of all tree species individuals > 1.3 m in height. "Tree BA" = Tree basal area is the total basal area of all tree individuals > 1.3 m in height within plot; seedling density is the estimated density of tree species individuals < 1.37 m in height. Cover percentages come from transect measurements, species richness values come from quadrat and plot observations of species composition. ‡ DCA-1 represents plot scores on the first two axes from a DECORANA ordination analysis of species cover percentages derived from the cover transect data.

Table 5.4 ANOVA table showing results of simple linear regression models for predicting three levels of mean species richness by equivalent latitude for a plot in the West Toklat minigrid sample.

Mean species richness 1 m^2 quadrats

Term	DF	Regression coefficient	Sum of Squares	Mean Square	F- value	Prob <F>
Equiv. latitude	1	0.191	19.93	19.93	6.68	0.0159
Residuals	23		67.62	2.94		
$r^2 = 0.23$						

Mean species richness 4 m^2 quadrats

Term	DF	Regression coefficient	Sum of Squares	Mean Square	F- value	Prob <F>
Equiv. latitude	1	0.306	51.04	51.04	7.22	0.0131
Residuals	23		162.60	7.07		
$r^2 = 0.24$						

Species richness of 200 m^2 plot

Term	DF	Regression coefficient	Sum of Squares	Mean Square	F- value	Prob <F>
Equiv. latitude	1	0.856	398.81	398.81	7.47	0.0118
Residuals	23		1228.23	53.40		
$r^2 = 0.25$						

Table 5.5. Coefficients from multiple regression models predicting three levels of mean species richness, and community composition (DCA-1) for 25 plots in West Toklat minigrid sample.

Dependent variable	Predictor variables	Regression coefficient	r^2 for model	p-value
1 m^2 richness	EQ LM depth	0.156 0.290	0.315	0.0157
4 m^2 richness	EQ LM depth	0.231 0.621	0.402	0.0035
200 m^2 richness	EQ LM depth	0.0618 1.9949	0.456	0.0012
DCA-1	EQ LM depth	4.72 13.55	0.368	0.0064

EQ=Equivalent Latitude
LM depth=Living Mat depth

Table 5.6. Correlation matrix for physical variables measured at 25 plots in the Lower Stony Creek mini-grid sample.

	elev	slope angle	aspect off-180	EQ lat	soil depth	litter depth	o horiz depth	soil moisture %	% soil frag <2mm	% C	% N	Soil pH
slope angle	0.09	-										
aspect off-180	0.22	0.10	-									
Equiv. latitude (EQ)	-0.03	-0.01	**0.86**									
soil depth	0.34	**0.53**	0.29	0.02								
litter depth	-0.16	**0.37**	0.23	0.06	**0.44**							
org. horizon depth	-0.31	**-0.49**	**-0.49**	-0.10	**-0.40**	0.07						
soil moisture %	0.33	0.31	0.00	0.00	**0.49**	-0.22	-0.24					
% soil frag < 2mm	-0.33	**-0.40**	0.25	0.34	-0.34	0.32	-0.34	**-0.51**				
% carbon	0.27	**0.38**	**0.01**	-0.17	0.21	0.31	0.25	-0.11	0.11			
% nitrogen	0.28	**0.53**	0.01	-0.14	0.32	0.32	0.14	0.04	-0.08	**0.93**		
soil pH	**-0.54**	**-0.33**	-0.03	0.01	-0.13	-0.11	0.05	-0.31	0.17	**-0.50**	**-0.55**	
soil temperature	0.27	**0.63**	0.02	-0.20	**0.68**	0.02	**-0.72**	0.24	**-0.47**	0.11	0.18	-0.09

Number given is coefficient of simple correlation (=r) between pair of physical parameters.♦ aspect off-180 is the absolute value of the difference between observed plot aspect and due south - it is a measure of relative southern exposure. We have bolded all correlations between pairs of variables stronger than 0.35, to allow the reader to more easily visualize strong patterns in correlation among variables.

Table 5.7. A comparison of the frequency of occurrence of the seven most abundant (in terms of cover) vascular plant species in the Lower Stony minigrid, with frequency values observed in the adjacent West Toklat minigrid.

Species	Frequency in West Toklat	Frequency in Lower Stony	Difference
Betula nana	87 %	79%	-12 %
Salix pulchra	61 %	45 %	-16 %
Carex bigelowii	95 %	56 %	-39 %
Vaccinium uliginosum	98 %	70 %	-28 %
Ledum decumbens	94 %	51 %	-43 %
Calamagrostis canadensis	12 %	44 %	+ 32 %
Empetrum nigrum	81 %	43 %	-38 %
Vaccinium vitis-idaea	99 %	75 %	-24 %

Table 5.8. Selected scores for common species on the first ordination axis of vascular plant cover data from Lower Stony Creek minigrid sample

Species	**DCA-1 score**
Valeriana capitata	512
Anemone parviflora	512
Picea glauca	415
Mertensia paniculata	328
Aconitum delphinifolium	326
Vaccinium vitis-idaea	-6
Pedicularis labradorica	-8
Ledum decumbens	-28
Eriophorum vaginatum	-33
Carex bigelowii	-67

Table 5.9. Correlation matrix for selected cover and species richness measurements among 25 points sampled in the Lower Stony Creek minigrid sample. Number given is the coefficient of simple correlation between given pairs of vegetation parameters.

	Tree density	Tree BA	Seedling density	% tree cover	% shrub cover	% dwarf shrub cover	% forb cover	% gram. cover	% moss cover	% lichen cover	mean $1m^2$ VP richness	mean $4\ m^2$ VP richness	200 m^2 VP richness
Tree basal area	**0.62**												
Seedling density	-0.02	0.25											
% tree cover	**0.92**	**0.88**	0.11										
% shrub cover	-0.33	**-0.39**	-0.15	**-0.40**									
% dwarf shrub	-0.24	-0.18	-0.02	-0.24	**-0.40**								
% forb cover	-0.08	0.16	-0.02	0.03	-0.11	-0.08							
% graminoid cover	-0.13	-0.24	0.30	-0.19	-0.03	-0.14	**0.42**	-					
% moss cover	0.19	0.19	-0.24	0.21	-0.03	0.14	**-0.65**	**-0.46**					
% lichen cover	-0.17	-0.20	-0.23	-0.20	**-0.41**	0.28	**-0.35**	**-0.43**	0.13				
1 m^2 richness	-0.23	-0.05	-0.10	-0.16	-0.34	**0.36**	**0.36**	0.03	-0.28	0.15			
4 m^2 richness	-0.21	-0.06	-0.12	-0.15	-0.25	0.21	**0.54**	0.01	**-0.51**	0.18	**0.87**		
200 m^2 richness	-0.05	0.13	0.01	0.03	-0.12	0.16	0.34	**-0.26**	**-0.47**	0.14	**0.70**	**0.84**	
DCA-1 ‡	**0.46**	**0.73**	0.07	**0.64**	-0.32	-0.34	**0.61**	-0.03	**-0.38**	-0.16	0.24	**0.41**	**0.46**

Tree density is the estimated total density (stems/Ha) of all tree species individuals > 1.3 m in height. "Tree BA" = Tree basal area is the total basal area of all tree individuals > 1.3 m in height; seedling density is the estimated density of tree species individuals < 1.37 m in height. Cover percentages come from transect measurements, species richness values come from quadrat and plot observations of species composition. ‡ DCA-1 represents plot scores on the axis from a DECORANA ordination analysis of species cover percentages derived from the cover transect data.

Table 5.10. Results of separate, simple linear regression analyses predicting three metrics of mean species richness, and DCA-1 by the suite of independent physical factors measured in the Lower Stony Creek minigrid sample.

Dependent variable	Predictor variables	Regression coefficient	r^2 for model	p-value
1 m^2 richness	Elevation	0.013	0.316	0.0034
	Soil depth	0.056	0.179	0.0350
	Soil temperature	0.459	0.211	0.0478
	Living mat depth	-0.313	0.123	0.0863
	O-mat depth	-0.119	0.087	0.1520
4 m^2 richness	Elevation	0.022	0.381	0.0010
	Soil depth	0.115	0.312	0.0037
	Soil temperature	0.313	0.318	0.0119
	Living mat depth	-0.646	0.218	0.0187
	O-mat depth	-0.259	0.195	0.0273
200 m^2 richness	Elevation	0.046	0.258	0.0096
	Soil depth	0.289	0.310	0.0039
	Soil temperature	3.12	0.615	0.00007
	Living mat depth	-0.904	0.067	0.2131
	O-mat depth	-0.810	0.298	0.0048
DCA-1	LM depth	-19.14	0.172	0.0394

Table 5.11. ANOVA table of results of multiple regressions of plot score on DCA-1 against a suite of environmental variables identified through stepwise regression procedure (using Cp criterion for inclusion of predictor variables).

Term	**DF**	**Regression coefficient**	**Sum of Squares**	**Mean Square**	**f - value**	**Prob <F>**
Elevation	1	-0.39	6243	277572.79	0.627	0.4372
Slope angle	1	-6.34	4762	4762	0.478	0.4967
Soil depth	1	4.52	82759	82759	8.315	0.0089
Residual	21		209015	9953		
r^2 = 0.31						

F-statistic = 3.14 on 3, 21 df; **p= 0.0469**

Table 5.12. Correlation matrix for physical variables measured at 25 plots in the Primrose Ridge minigrid sample.

	elev	slope angle	aspect off-180	EQ lat.	Soil depth	litter depth	o horiz depth	soil moisture	% soil frag <2mm	% C	% N	soil pH
slope angle	**-0.67**	-										
aspect off-180	-0.06	**0.49**	-									
equivalent latitude	**0.70**	-0.27	**0.43**									
soil depth	0.24	**-0.47**	-0.10	0.04								
litter depth	-0.27	0.19	-0.18	-0.23	0.15							
o horiz depth	-0.14	0.07	-0.12	-0.21	**0.48**	**0.65**						
soil moisture %	-0.05	0.22	-0.24	-0.33	0.03	0.27	**0.39**					
% soil frag > 2mm	-0.09	0.11	0.27	0.05	0.21	0.24	0.13	-.18				
% carbon	0.08	0.06	-0.26	-0.21	-0.32	-0.07	-0.12	**0.66**	**-0.58**			
% nitrogen	0.16	0.04	-0.25	-0.14	-0.29	-0.07	-0.10	**0.68**	**-0.59**	**0.99**		
soil pH	-0.31	0.19	0.05	**-0.35**	**0.51**	0.18	**0.45**	0.15	0.08	-0.33	-0.30	
soil temperature	-0.03	-0.02	0.24	0.19	**-0.45**	**-0.66**	**-0.78**	**-0.59**	0.10	-0.10	-0.12	-0.32

Number given is coefficient of simple correlation (=r) between pair of physical parameters.♦ aspect off-180 is the absolute value of the difference between observed plot aspect and due south - it is a measure of relative southern exposure. We have bolded all correlations between pairs of variables stronger than 0.35, to allow the reader to more easily visualize strong patterns in correlation among variables.

Table 5.13. Correlation matrix for selected cover and species richness measurements among 25 points sampled in the Primrose Ridge minigrid sample. Number given is the coefficient of simple correlation between given pairs of vegetation parameters.

	% shrub cover	% dwarf shrub cover	% forb cover	% gram. cover	% moss cover	% lichen cover	mean 1 m^2 VP richness	mean 4 m^2 VP richness	200 m^2 VP richness
% shrub cover									
% dwarf shrub	-0.05								
% forb cover	**0.62**	0.26							
% graminoid cover	**0.57**	0.15	**0.65**						
% moss cover	0.02	**0.42**	0.15	**0.27**					
% lichen cover	**-0.43**	-0.30	**-0.38**	**-0.54**	**-0.38**				
1 m^2 richness	0.09	**0.64**	**0.59**	0.27	**0.46**	**-0.73**			
4 m^2 richness	0.17	**0.54**	**0.58**	0.27	**0.43**	**-0.82**	**0.93**		
200 m^2 richness	0.26	**0.49**	**0.51**	0.15	**0.16**	**-0.65**	**0.75**	**0.85**	
DCA-1 ‡	**0.84**	0.05	**0.63**	**0.52**	0.13	**-0.54**	0.19	**0.35**	**0.45**

Cover percentages come from transect measurements, species richness values come from quadrat and plot observations of species composition. ‡ DCA-1 represent plot scores on the first axis from a DECORANA ordination analysis of species cover percentages derived from the cover transect data. Plot # 11 was identified as an extreme multivariate outlier, and was thus removed, and the ordination was re-run using twenty four plots.

Table 5.14 Mean values for physical variables calculated for plots classified in four Viereck level III vegetation types, Primrose Ridge minigrid.

Vegetation type	# points	Elev. (m)	Slope angle	Aspect 0ff-180	EQ	Soil depth	Soil temp. (° C)	Soil moisture	Soil pH	% carbon	% nitrogen
Dryas Dwarf Scrub	6	1361	8°	99°	65.17	22 cm	12.3 ° C	20.7 %	4.58	2.2 %	0.17 %
Ericaceous Dwarf Scrub	3	1158	29°	91°	53.29	34 cm	9.8 ° C	28.7 %	4.98	2.7 %	0.20 %
Willow Dwarf Scrub	6	1271	18°	89°	61.28	52 cm	7.5 ° C	34.7 %	4.90	3.7 %	0.26 %
Mesic Graminoid Herbaceous	4	1316	10°	49°	56.41	53 cm	6.6 ° C	32.0 %	4.98	2.4 %	0.18 %

Table 5.16. Results of separate simple linear regression analyses of plot species richness on physical predictor variables for 25 plots in Primrose Ridge minigrid sample.

Variable	coefficient	r-squared	F-statistic	df	p-value
Slope angle	0.802	0.407	15.8	1,23	0.0006
Elevation	-0.071	0.405	15.68	1,23	0.0006
Soil pH	17.19	0.377	12.68	1,23	0.0018

Table 5.17. ANOVA table of results of multiple regression of plot species richness against four environmental variables identified through stepwise regression procedure (using Cp criterion for inclusion of predictor variables) for the Primrose Ridge minigrid sample. *** two plots were omitted from this model because soil sample data were missing (no soils at points).

Term	**DF**	**Regression coefficient**	**Sum of Squares**	**Mean Square**	**F- value**	**Prob <F>**
Elevation	1	-0.026	1626	1626	27.48	0.000055
Slope angle	1	0.556	497	497	8.40	0.0096
Soil temperature	1	-0.938	300	300	5.06	0.0372
Soil pH	1	11.45	599	599	10.11	0.0052
Residual	18		1065	59		
r^2 = 0.739						

F-statistic = 12.76 on 4, 18 df; **p= 0.00004**

Table 5.18. Results of separate simple linear regression analyses of plot species richness on physical predictor variables for 25 plots in Primrose Ridge minigrid sample.

Variable	coefficient	r-squared	F-statistic	df	p-value
Elevation	-0.401	0.276	8.02	1,22	0.00969
O-horizon depth	10.13	0.276	8.029	1,22	0.00966
Soil temperature	-8.81	0.124	3.104	1,22	0.09198

Table 5.19. ANOVA table of results of multiple regression of plot score on DCA-1 against three environmental variables identified through stepwise regression procedure (using Cp criterion for inclusion of predictor variables) for the Primrose Ridge minigrid sample.

Term	**DF**	**Regression coefficient**	**Sum of Squares**	**Mean Square**	**F- value**	**Prob <F>**
Elevation	1	-0.471	51742	51742	12.17	0.0023
Equivalent latitude	1	3.43	10288	10288	2.42	.1355
Soil temperature	1	-13.06	46574	46574	10.95	.0035
Residuals	20		85021	4251		
r^2 = 0.739						

F-statistic = 8.52 on 3, 20 df; **p= 0.00076**

Table 6.1. Correlation matrix for physical variables measured at plots in the pilot study project.

	elev	slope angle	aspect off-180	EQ lat.	soil depth	live mat depth	o horiz depth	soil moisture	% soil frag <2mm	% C	% N	soil pH
slope angle	**0.52**											
aspect off-180	-0.10	-0.05										
equivalent latitude	-0.24	**-0.43**	**0.75**									
soil depth	0.17	0.14	-0.05	-0.03								
live mat depth	**-0.54**	-0.02	0.17	0.17	-0.10							
o horiz depth	**-0.62**	**-0.52**	0.15	0.15	-0.20	0.26						
soil moisture %	**-0.51**	-0.25	0.11	0.09	-0.05	0.20	**0.53**					
% soil frag < 2mm	**-0.65**	**-0.47**	0.15	0.16	-0.12	0.32	0.46	**0.52**				
% carbon	**-0.47**	-0.19	0.11	0.08	-0.14	0.22	**0.55**	**0.88**	**0.39**			
% nitrogen	**-0.42**	-0.15	0.07	0.01	-0.10	0.16	**0.49**	**0.87**	**0.38**			
soil pH	-0.06	0.26	0.00	0.02	0.21	-0.17	-0.17	-0.04	-0.05	-0.12	-0.04	
soil temperature	**0.65**	**0.47**	-0.06	-0.12	0.05	**-0.37**	**-0.65**	**-0.46**	**-0.49**	**-0.41**	**-0.38**	0.06

Number given is coefficient of simple correlation (=r) between pair of physical parameters.♦ aspect off-180 is the absolute value of the difference between observed plot aspect and due south - it is a measure of relative southern exposure. We have bolded all correlations between pairs of variables stronger than 0.35, to allow the reader to more easily visualize strong patterns in correlation among variables.

Table 6.2. Correlation matrix for selected pairs of plant cover and species richness measurements among 213 points sampled across all of the pilot study minigrids minigrid. Number given is the coefficient of simple correlation between given pairs of vegetation parameters.

	Tree density	Tree BA	Seedling density	% tree cover	% shrub cover	% dwarf shrub cover	% forb cover	% gram. cover	% moss cover	% lichen cover	mean 1 m^2 VP richness	mean 4 m^2 VP richness
Tree basal area	**0.47**											
Seedling density	**0.60**	**0.47**										
% tree cover	**0.69**	**0.81**	0.31									
% shrub cover	0.01	0 05	-0.04	0.00								
% dwarf shrub	-0.03	-0.18	0.02	-0.07	**-0.34**							
% forb cover	-0.04	0.27	-0.04	0.07	0.06	-0.01						
% graminoid cover	-0.20	**-0.33**	-0.02	-0.28	0.23	-0.06	-0.06					
% moss cover	0.29	0.15	0.26	0.17	0.29	0.01	-0.18	0.21				
% lichen cover	-0.09	-0.23	-0.09	-0.20	-0.30	0.27	-0.32	-0.15	-0.04			
1 m^2 richness	-0.18	-0.12	-0.04	-0.19	**-0.43**	**0.48**	**0.37**	-0.10	-0.06	0.10		
4 m^2 richness	-0.19	-0.09	-0.08	-0.17	**-0.48**	**0.39**	**0.42**	-0.19	-0.22	0.06	**0.95**	
200 m^2 richness	-0.19	-0.06	-0.09	-0.15	**-0.48**	0.25	**0.44**	**-0.35**	**-0.40**	0.02	**0.77**	**0.88**

Tree density is the estimated total density (stems/Ha) of all tree species individuals > 1.3 m in height. "Tree BA" = Tree basal area is the total basal area of all tree individuals > 1.3 m in height; seedling density is the estimated density of tree species individuals < 1.37 m in height. Cover percentages come from transect measurements, species richness values come from quadrat and plot observations of species composition.

Table 7.1. Summary of bird censuses completed at minigrids in 2001 and 2002, Denali National Park and Preserve, Alaska.

Minigrid	Type	Dates Surveyed	Crew[1]	Access Method	Number of Points Surveyed	Comments
2001						
Rock Creek	Transitional	June 10-11, 22, 27	A	Foot travel from park road (day trips)	25	
Wigand Creek	Boreal	June 19-21	A	Helicopter	25	
2002						
East Chitsia	Boreal	June 8-11	B	Helicopter	20	This minigrid was challenging due to tremendous relief and extremely thick vegetation. Inclement weather was a factor, as was crew injury (the ABO intern injured her back on this minigrid).
East Toklat	Boreal	June 8-11	C	Helicopter	25	
Upper Savage	Alpine	June 10-13	A	Foot travel from park road (camping)	20	We were constricted by time (three days) and had one day of bad weather when we could not survey.
West Toklat	Boreal	June 11-14	B	Helicopter	25	
Lower Stony	Transitional	June 11-14	C	Helicopter	25	

[1] Crew A: Carol McInytre (NPS), Laura Weaver (NPS), Karen Oakley (USGS). Crew B: Sally Andersen (NPS), Carol Erwin (ABO), Ruby Hammond (ABO); Crew C: Tim Walker (ABO), Ryan Drum (NPS), Colleen Burgess (ABO).

Table 7.1. cont'd. Summary of bird censuses completed at minigrids in 2001 and 2002, Denali National Park and Preserve, Alaska.

Cabin Creek	Transitional	June 17-21	C	Foot travel from park road (camping)	11	Cabin Creek is a challenging minigrid. The main stem of the Toklat River bisects the minigrid, the topography is extreme, and many of the smaller streams and side hills are choked with alder thickets. Grizzly bear sign is common and struggling through alders in the midst of many bear tracks leaves much to the imagination. This minigrid will require at least a week of survey time (T. Walker, pers. comm.).
Gorge Creek	Alpine	June 17-21	B	Foot travel from park road (camping)	16	We could only access 16 points due to topography, cliffs and talus slopes.
Primrose	Alpine	June 17-20	A	Foot travel from park road (camping)	9	Inclement weather (fog, rain, snow, sleet, wind, hail) settled into the area during the first morning of survey work and remained in the area for four consecutive days.

Table 7.2. Example of point count data. East Chitsia minigrid, Point #1, Denali National Park and Preserve, June 2002, 04:32 ADT.

Detection	Species	# Birds	Distance (m)	Detection Type
1	Ruby-crowned Kinglet	1	30	Singing
2	Fox Sparrow	1	40	Singing
3	Varied Thrush	1	50	Singing
4	Swainson's Thrush	1	60	Singing
5	Swainson's Thrush	1	90	Singing
6	Swainson's Thrush	1	70	Singing
7	Yellow-rumped Warbler	1	70	Singing
8	Swainson's Thrush	1	80	Singing
9	Ruby-crowned Kinglet	1	90	Singing
10	Yellow-rumped Warbler	1	60	Singing

Table 7.3. Birds observed on an alpine, transitional, and boreal minigrids, June 2001 and 2002.

An **Alpine** Minigrid: Upper Savage

Common name	Number of Detections	Frequency of Occurrence
Wilson's Warbler	35	1.842
Fox Sparrow	35	1.842
White-crowned Sparrow	29	1.526
American Tree Sparrow	26	1.368
Arctic Warbler	18	0.947
Unknown redpoll	14	0.737
Orange-crowned Warbler	12	0.632
Savannah Sparrow	11	0.579
Willow Ptarmigan	5	0.263
Golden-crowned Sparrow	4	0.211
Horned Lark	2	0.105
Gray-cheeked Thrush	2	0.105
Black-billed Magpie	1	0.053
Hermit Thrush	1	0.053
Lincoln's Sparrow	1	0.053
Lapland Longspur	1	0.053
Total Detections	197	
Number of Species	16	
Number of Points	20	

A **Transitional** Minigrid: Lower Stony

Common name	Number of Detections	Frequency of Occurrence
American Tree Sparrow	58	2.32
Savannah Sparrow	49	1.96
White-crowned Sparrow	45	1.8
Wilson's Warbler	37	1.48
Orange-crowned Warbler	18	0.72
Fox Sparrow	17	0.68
Unknown redpoll	10	0.4
Black-billed Magpie	7	0.28
Dark-eyed Junco	6	0.24
Yellow-rumped Warbler	5	0.2
Lincoln's Sparrow	5	0.2
Common Snipe	4	0.16

Table 7.3 cont'd. Birds observed on an alpine, transitional, and boreal minigrids, June 2001 and 2002

Mew Gull	4	0.16
Unknown bird	3	0.12
Willow Ptarmigan	2	0.08
Horned Lark	2	0.08
White-winged Crossbill	2	0.08
Alder Flycatcher	1	0.04
Arctic Warbler	1	0.04
Hermit Thrush	1	0.04
Varied Thrush	1	0.04
Total Detections	278	
Number of Species	20	
Number of Points	25	

A **Boreal** Minigrid: West Toklat

Common name	Number of Detections	Frequency of Occurrence
White-crowned Sparrow	78	3.12
Savannah Sparrow	45	1.8
American Tree Sparrow	43	1.72
Fox Sparrow	21	0.84
Dark-eyed Junco	20	0.8
Unknown redpoll	18	0.72
Gray-cheeked Thrush	14	0.56
Yellow-rumped Warbler	12	0.48
American Robin	9	0.36
Wilson's Warbler	9	0.36
Lincoln's Sparrow	8	0.32
Orange-crowned Warbler	5	0.2
Unknown bird	5	0.2
Gray Jay	4	0.16
Whimbrel	1	0.04
Ruby-crowned Kinglet	1	0.04
Total Detections	293	
Number of Species	15	
Number of Points	25	

Table 7.4. Frequency of occurrence of birds detected on 8-minute point counts on minigrids in 2001 and 2002, Denali National Park and Preserve, Alaska.

Species	Total number of detections	Number of minigrids	Frequency of occurrence
Horned Grebe	1	1	0.005
Northern Harrier	2	1	0.010
Golden Eagle	2	1	0.010
Willow Ptarmigan	9	3	0.045
Rock Ptarmigan	1	1	0.005
American Golden-Plover	3	1	0.015
Spotted Sandpiper	1	1	0.005
Whimbrel	10	2	0.050
Surfbird	10	1	0.050
Common Snipe	4	1	0.020
Mew Gull	6	2	0.030
Three-toed Woodpecker	1	1	0.005
Olive-sided Flycatcher	3	1	0.015
Alder Flycatcher	12	3	0.060
Gray Jay	26	7	0.130
Black-billed Magpie	10	4	0.050
Horned Lark	10	5	0.050
Black-capped Chickadee	2	1	0.010
Boreal Chickadee	9	4	0.045
Red-breasted Nuthatch	1	1	0.005
Ruby-crowned Kinglet	25	3	0.125
Arctic Warbler	20	3	0.100
Townsend's Solitaire	1	1	0.005
Gray-cheeked Thrush	44	6	0.220
Swainson's Thrush	66	5	0.330
Hermit Thrush	40	5	0.200
American Robin	30	5	0.150
Varied Thrush	49	4	0.245
American Pipit	15	3	0.075
Orange-crowned Warbler	88	7	0.440
Yellow Warbler	6	1	0.030
Yellow-rumped Warbler	72	7	0.360

Table 7.4 cont'd. Frequency of occurrence of birds detected on 8-minute point counts on minigrids in 2001 and 2002, Denali National Park and Preserve, Alaska.

Species	Total number of detections	Number of minigrids	Frequency of occurrence
Blackpoll Warbler	1	1	0.005
Wilson's Warbler	147	9	0.735
American Tree Sparrow	172	8	0.860
Savannah Sparrow	236	8	1.180
Fox Sparrow	158	9	0.790
Lincoln's Sparrow	59	6	0.295
White-crowned Sparrow	351	9	1.755
Golden-crowned Sparrow	11	5	0.055
Dark-eyed Junco	99	7	0.495
Lapland Longspur	7	3	0.035
Pine Grosbeak	1	1	0.005
White-winged Crossbill	8	3	0.040
Unknown redpoll	74	9	0.370
Unknown bird	10	3	0.050

Table 7.5. List of bird species observed on minigrids while traveling between points, but not detected during point counts, during 2001-2002 pilot study surveys of 10 minigrids, Denali National Park and Preserve.

Species	East Toklat	Gorge Creek	Lower Stony	Primrose	Rock Creek	Savage	Wigand Creek
Mallard			x				x
Green-winged teal	x		x				
Scaup sp.			x				
Canvasback			x				
Sharp-shinned hawk			x				
Lesser yellowlegs			x				
Upland sandpiper							x
Baird's sandpiper				x			
Short-eared owl			x				
Northern shrike					x		
Common raven				x			
Bohemian waxwing	x						
Snow bunting		x					
Gray-crowned rosy finch		x				x	

Table 7.6. Patterns in bird species diversity (species richness) on five completely surveyed (25 points) minigrids in Denali National Park and Preserve, Alaska, 2001-2002.

Grid	Type	Overall site diversity[1]	Site diversity[2]	Average point diversity[3]	Spatial homogeneity[4]
Rock Creek	Transitional	26	25	5.68	0.23
Wigand Creek	Boreal	24	22	4.80	0.22
East Toklat	Boreal	17	15	5.20	0.35
West Toklat	Boreal	16	16	6.28	0.39
Lower Stony	Transitional	28	21	5.80	0.28

[1] Total number of species encountered on grid during sampling period.
[2] Total number of species encountered on grid during 8-minute counts.
[3] Average number of species/ 8-minute count.
[4] Average point diversity/site diversity (average proportion of species recorded on grid observed at each point). A value of 1 = all species detected on all points.

Table 7.7. Comparison of bird detections during 8-minute point counts conducted in Rock Creek in June 2001 on the minigrid and on 2 point count routes established in 1992.

Common name	Rock Creek Minigrid	Rock Creek Point Count Routes established in 1992
Northern Goshawk	0	1
Golden Eagle	2	0
Gray Jay	4	2
Horned Lark	2	0
Black-capped Chickadee	2	0
Boreal Chickadee	6	4
Red-breasted Nuthatch	1	0
Arctic Warbler	1	0
Townsend's Solitaire	1	0
Gray-cheeked Thrush	1	0
Swainson's Thrush	15	29
Hermit Thrush	21	8
American Robin	14	9
Varied Thrush	22	18
American Pipit	1	0
Orange-crowned Warbler	17	6
Yellow-rumped Warbler	5	28
Wilson's Warbler	22	3
American Tree Sparrow	13	1
Savannah Sparrow	5	2
Fox Sparrow	32	1
Lincoln's Sparrow	1	0
White-crowned Sparrow	35	18
Golden-crowned Sparrow	1	0
Dark-eyed Junco	31	26
White-winged Crossbill	0	1
Unknown redpoll	6	5
Total points	25	24
Total birds	261	162
Total species	25	17
Birds per point	10.44	6.75
Species per point	1.00	0.71

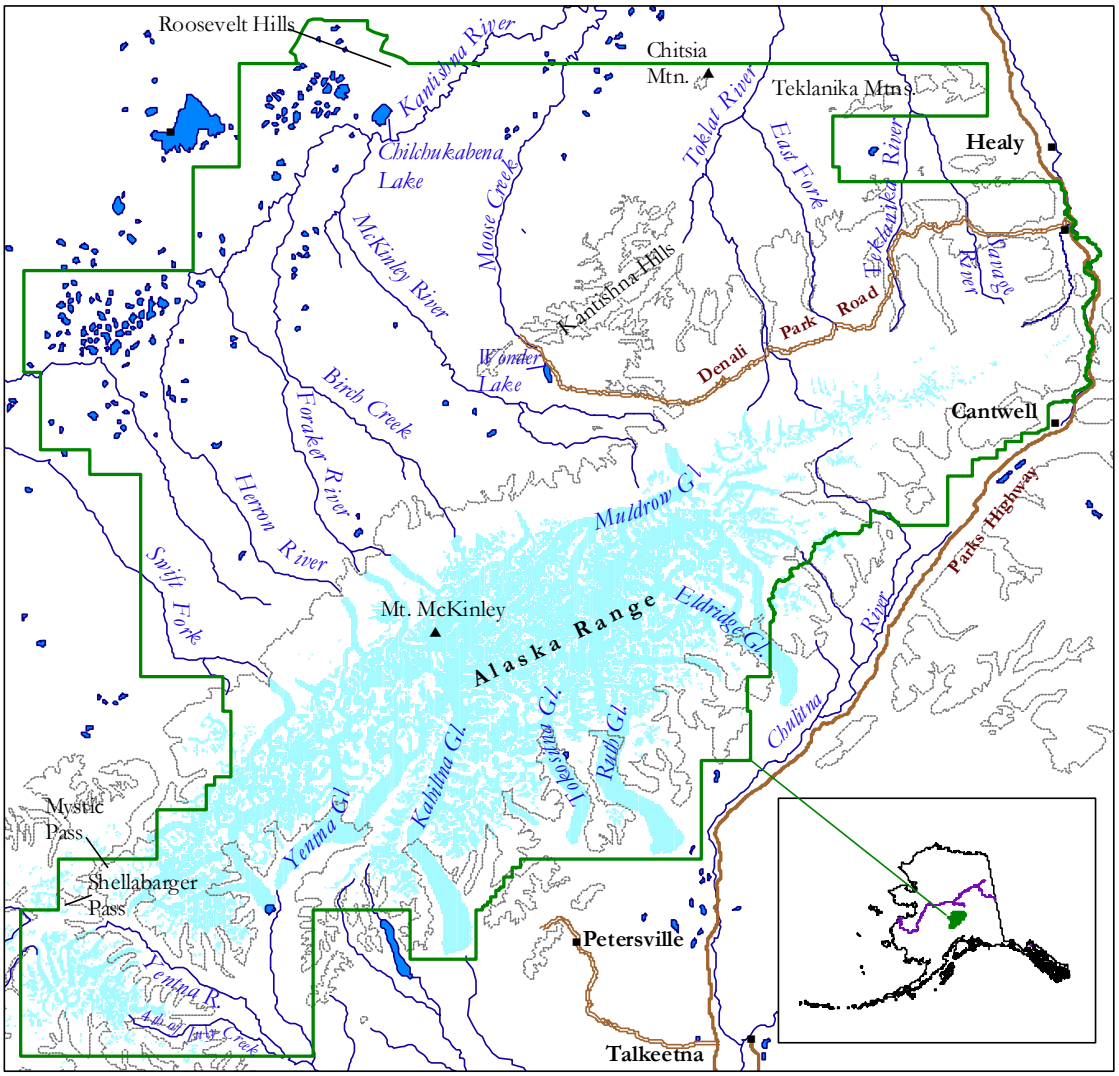

Figure I.1. Map of Denali National Park and Preserve showing important features of the landscape, with insert showing the location of the park within Alaska.

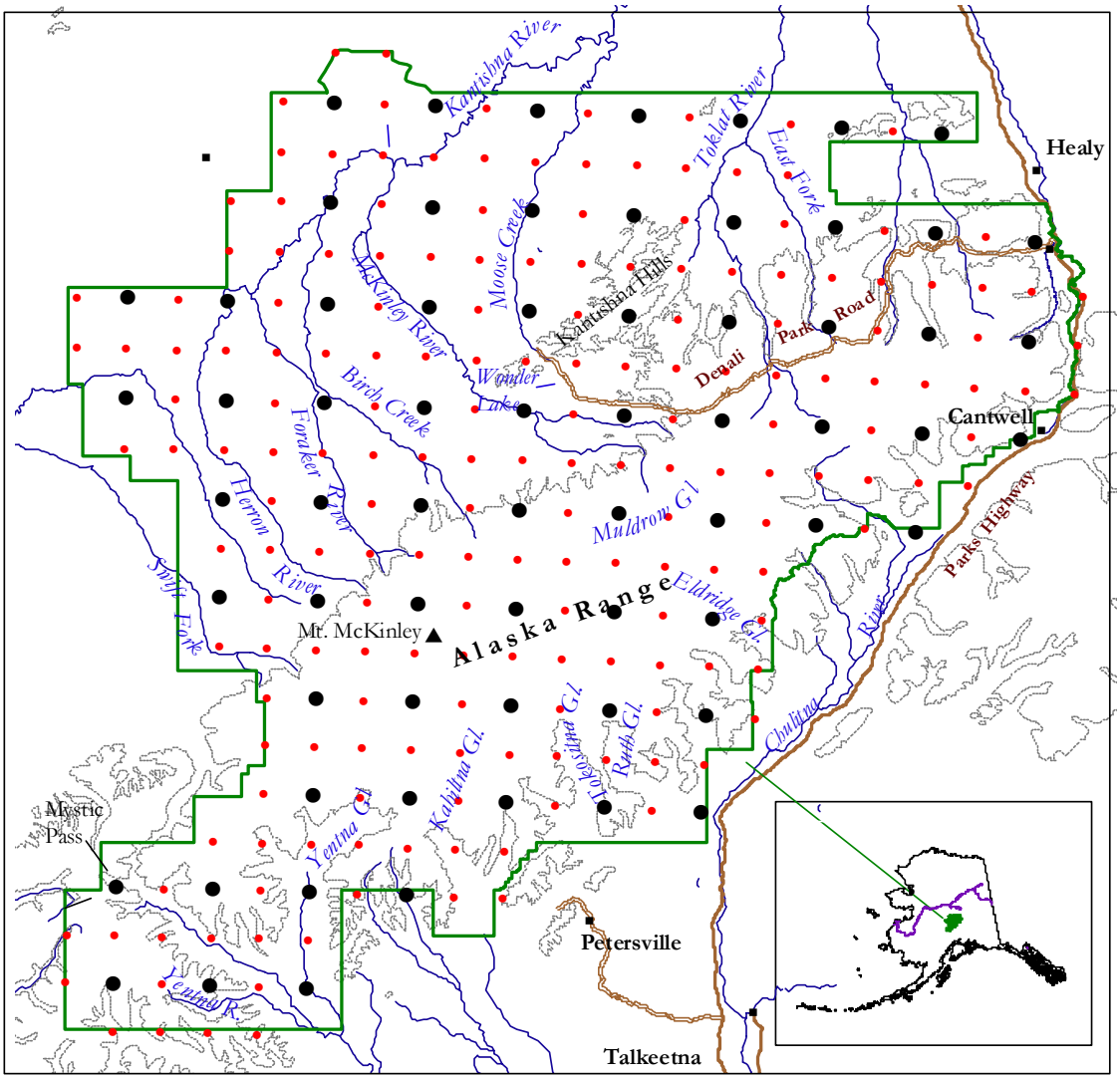

Figure I.2. Map of Denali National Park and Preserve showing the location of systematic grid points arrayed across the park landscape, with insert showing the location of the park within Alaska. Black dots show the location of 20 km grid points and red dots show the 10 km grid points.

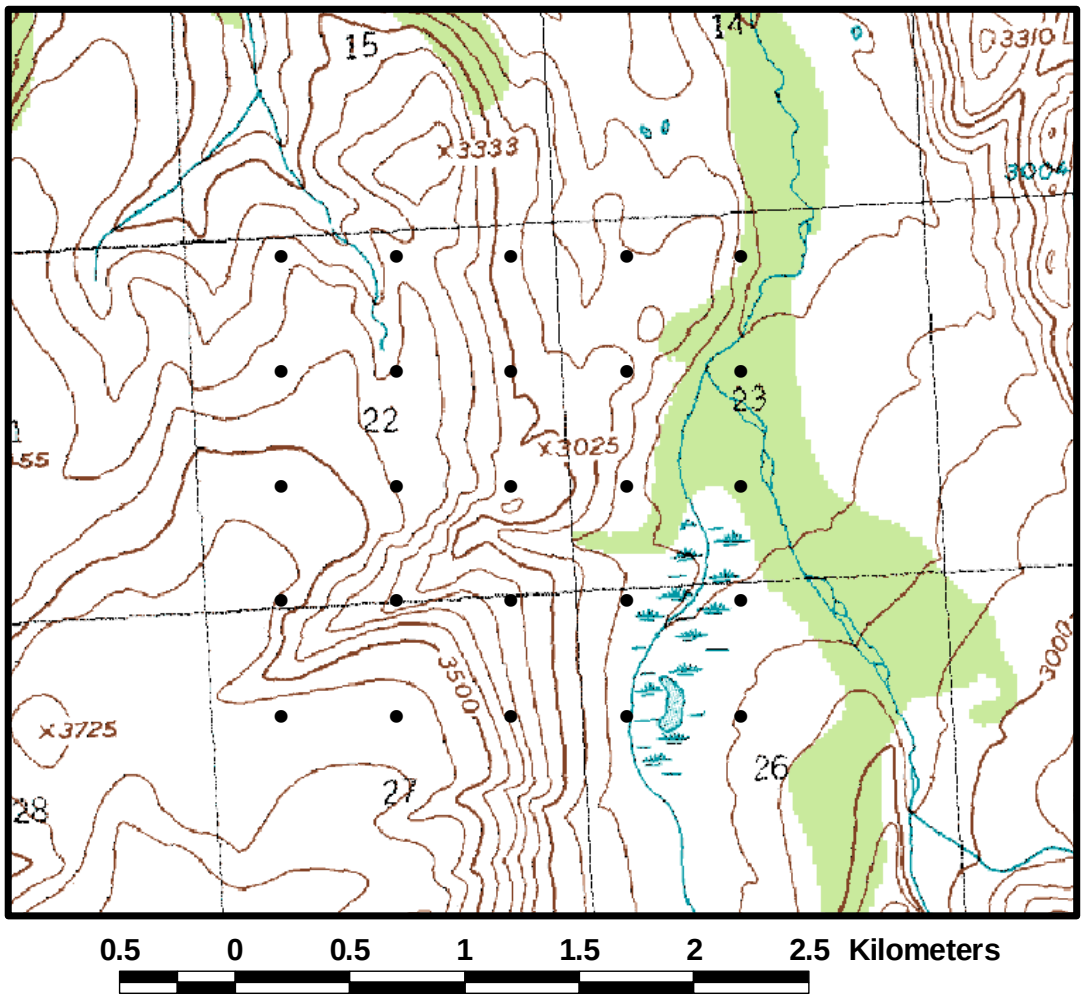

Figure I.3. An example of one minigrid sample – Lower Stony Creek minigrid, sampled during June and July, 2002. Black dots show the location of permanent monitoring plots.

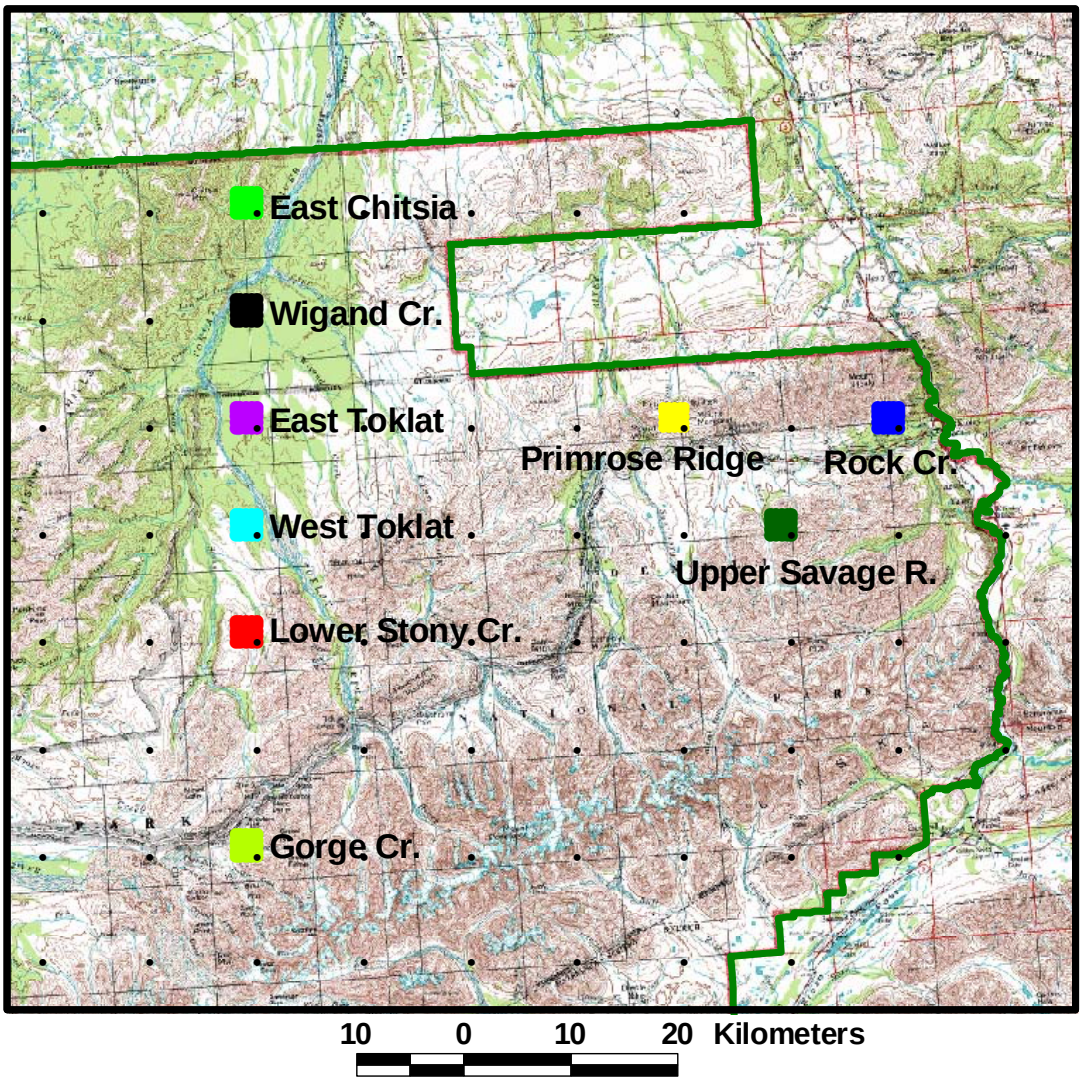

Figure I.4. Map showing the Northeastern quadrant of Denali National Park and Preserve with the nine minigrid samples that were completed during pilot study during 2001 – 2002. The locations of park-wide 10 km grid points are indicated by black dots.

Placeholder for Figure 3.1 (plot diagram)

Figure 3.2. A photograph of a vegetation plot being measured in the alpine zone of the Rock Creek drainage, showing the transects and a quadrat placement.

Placeholder for Figure 3.3. (coring diagram)

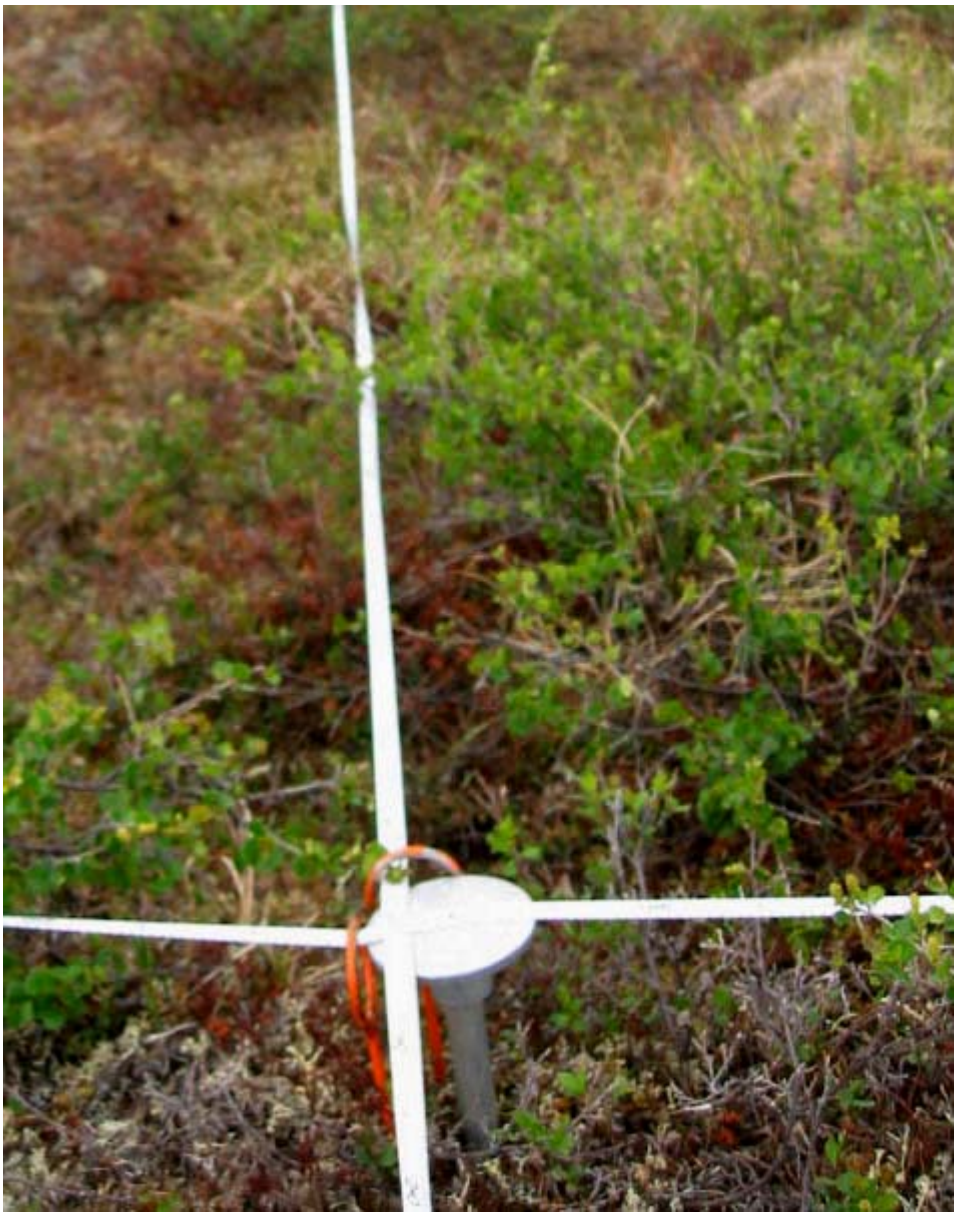

Figure 3.4. Plot monument used for marking permanent vegetation monitoring plots.

Figure 3.5. Sara Goeking (top) and Carl Roland (bottom) using cover transect sampling staff during Denali minigrid pilot study.

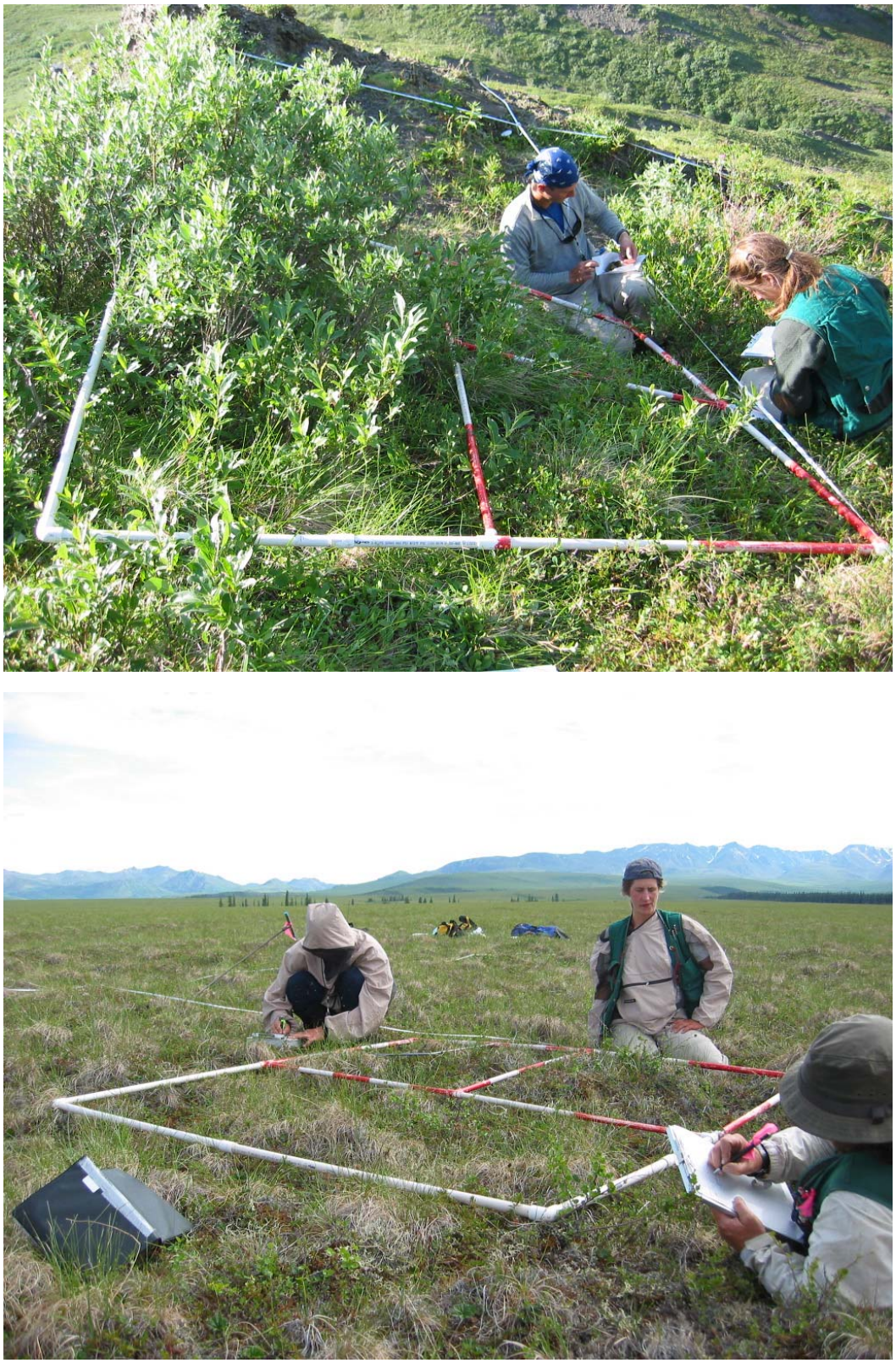

Figure 3.6. Field crew performing quadrat sampling for species composition during pilot study.

Figure 3.7
Database Design

See Foldout in pocket on inside of the back cover

Figure 4.1. Looking northeast through Lower Stony plot # 21 from perimeter.

Figure 4.2. Looking east through Lower Stony plot #21 from perimeter.

Figure 4.3. Looking south through Lower Stony plot #21 from perimeter.

Figure 4.4. Looking west through Lower Stony plot #21 from perimeter.

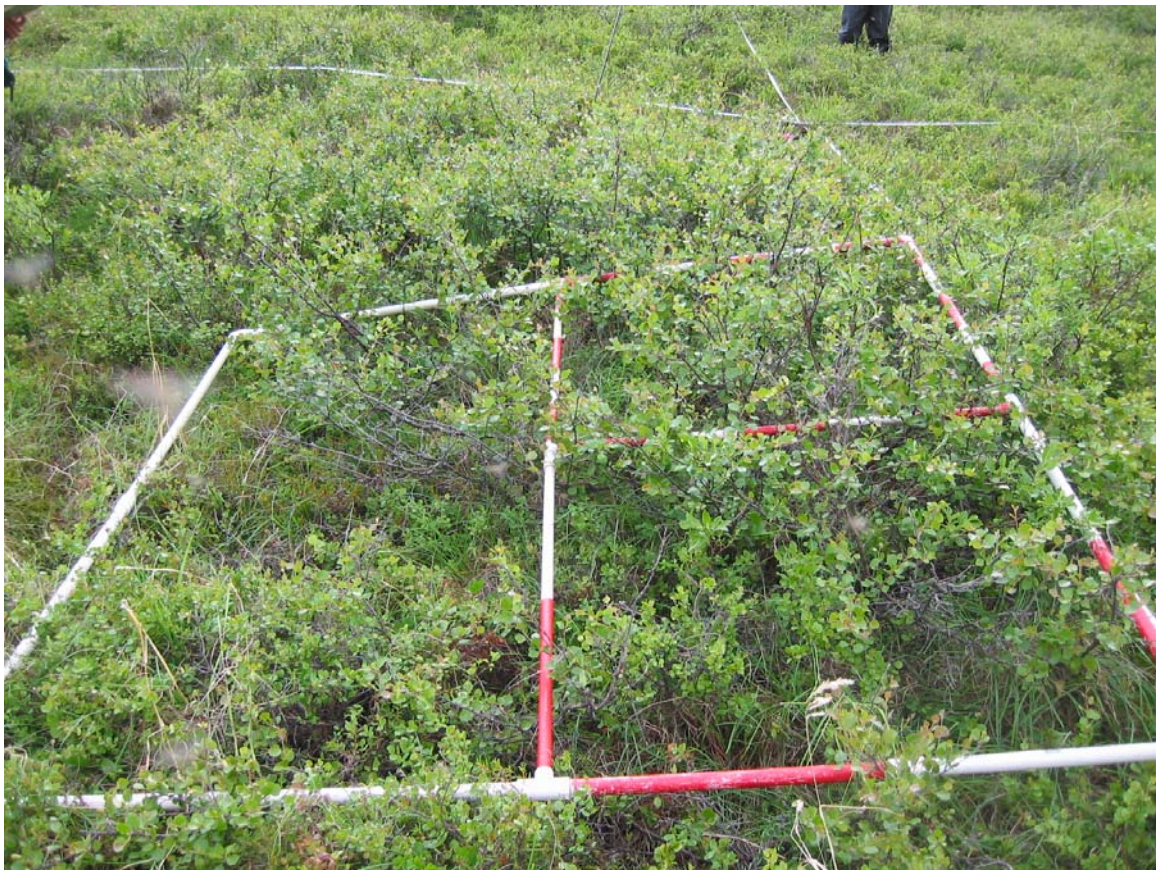

Figure 4.5. Quadrat A in Lower Stony plot #21.

Figure 4.6. Quadrat B in Lower Stony plot #21.

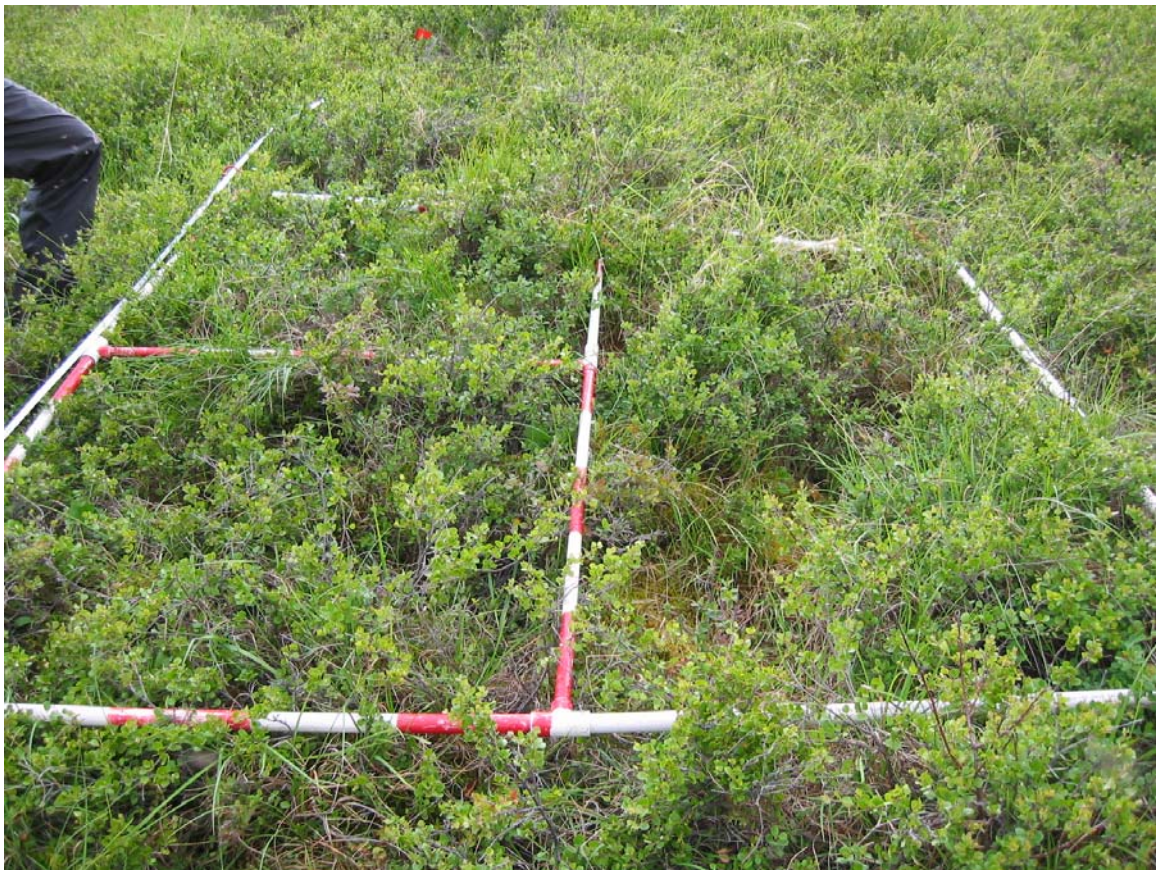

Figure 4.7. Quadrat C in Lower Stony plot #21.

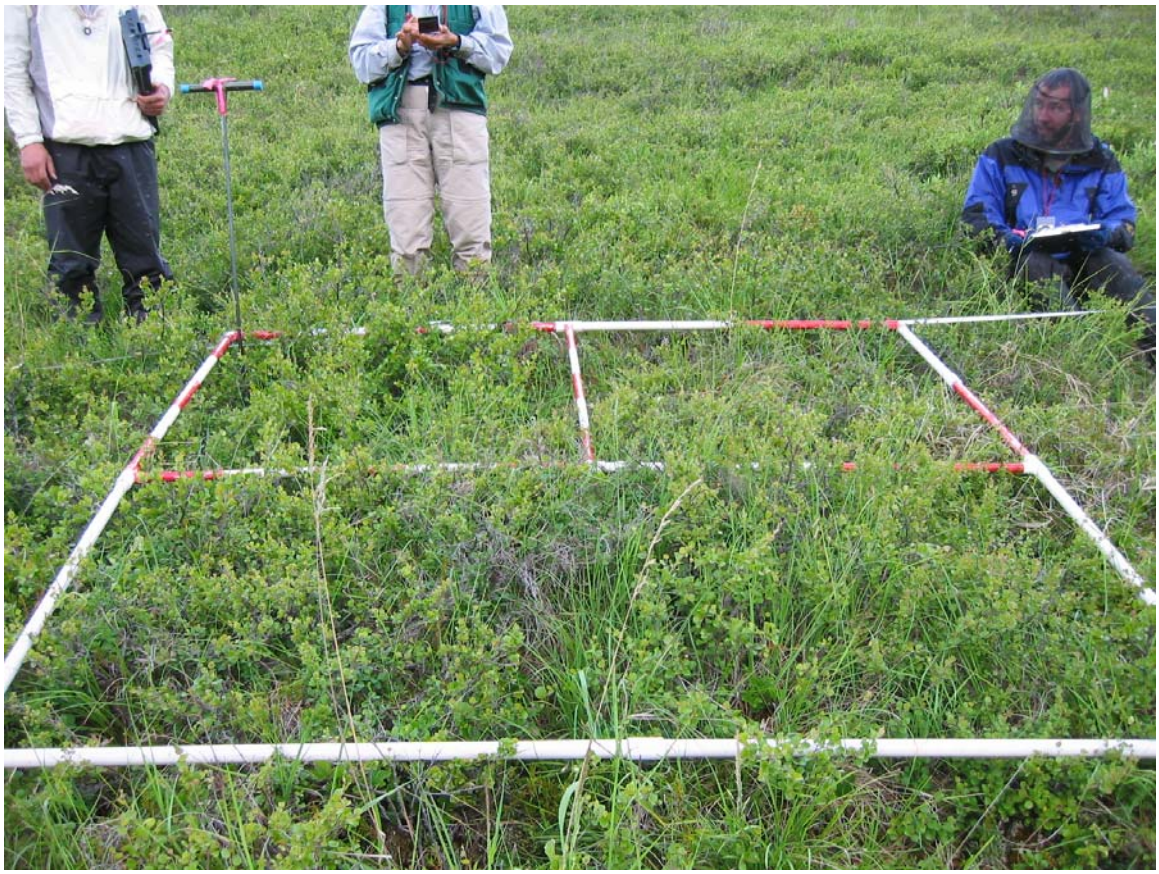

Figure 4.8. Quadrat D in Lower Stony plot #21.

Figure 4.9. Panoramic photograph showing landscape around the Lower Stony minigrid, looking eastward from above Lower Stony minigrid point #21. Note the tape measures describing cover transects in the lower left portion of the frame.

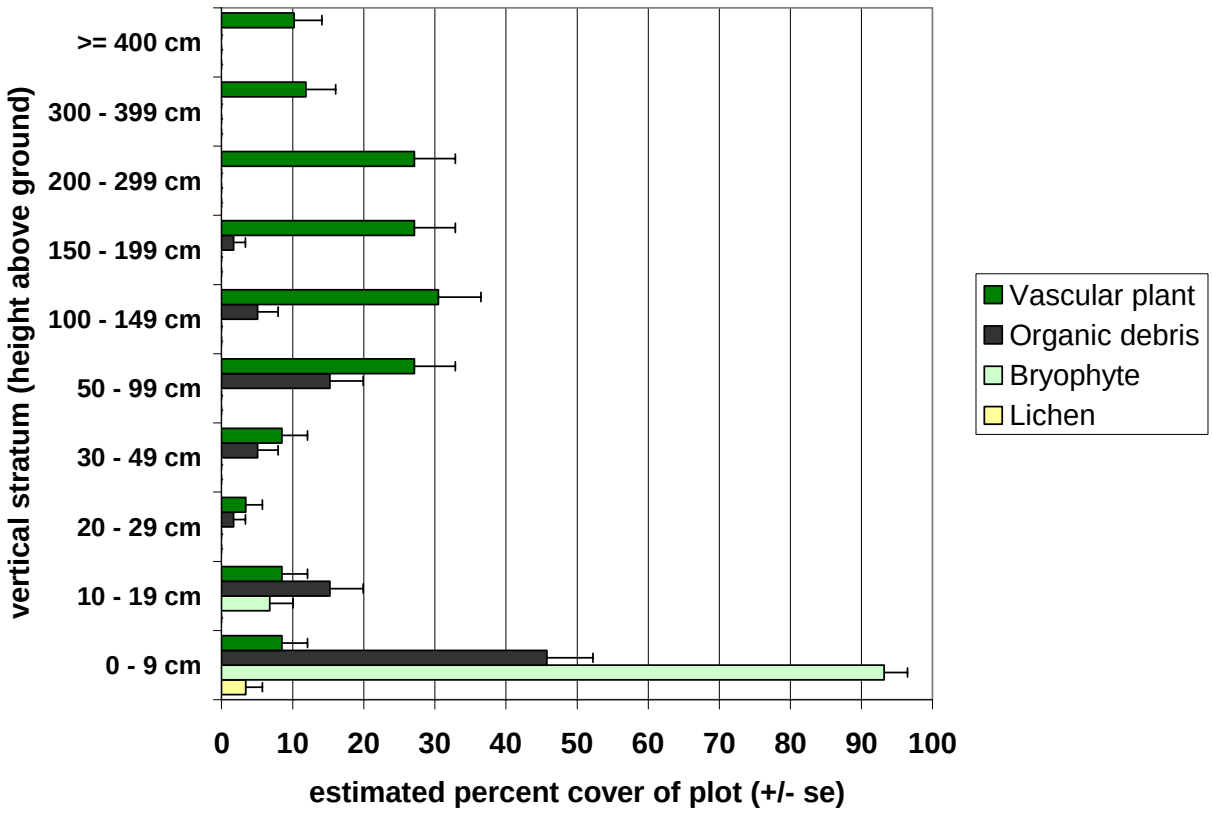

Figure 4.10. Vertical distribution of mean percent cover of Lower Stony plot # 11 of vascular plants, organic debris, bryophytes and lichens observed within the plot (± standard error).

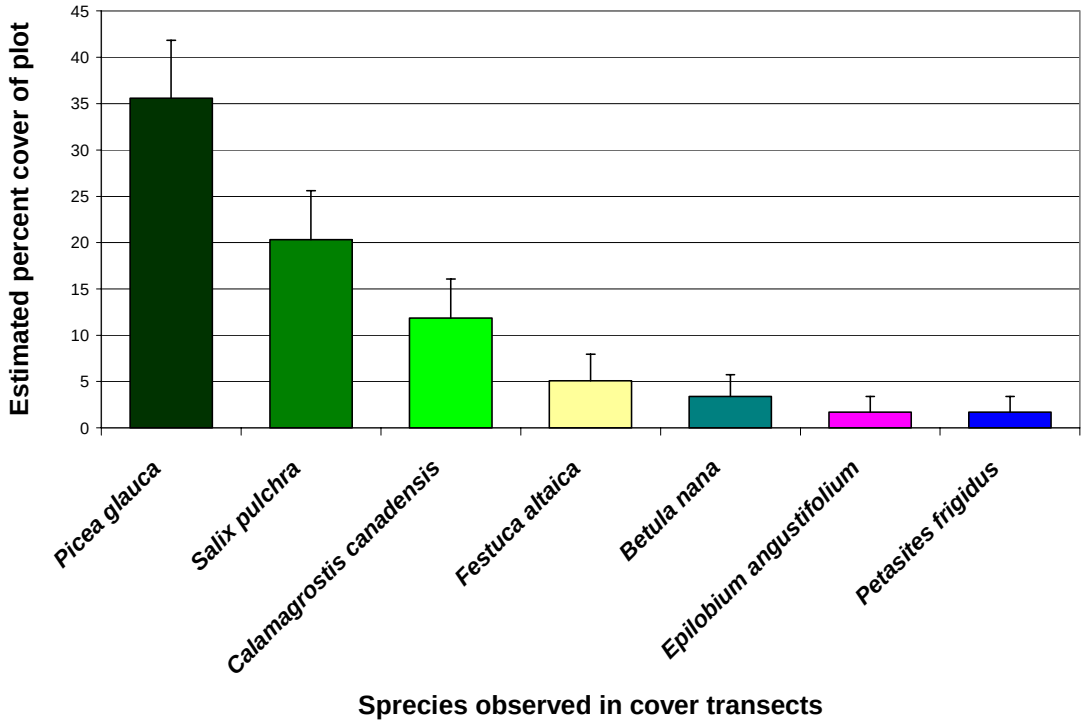

Figure 4.11. Cover values for seven vascular plant species observed in the cover transects in Lower Stony minigrid plot #11 (± standard error).

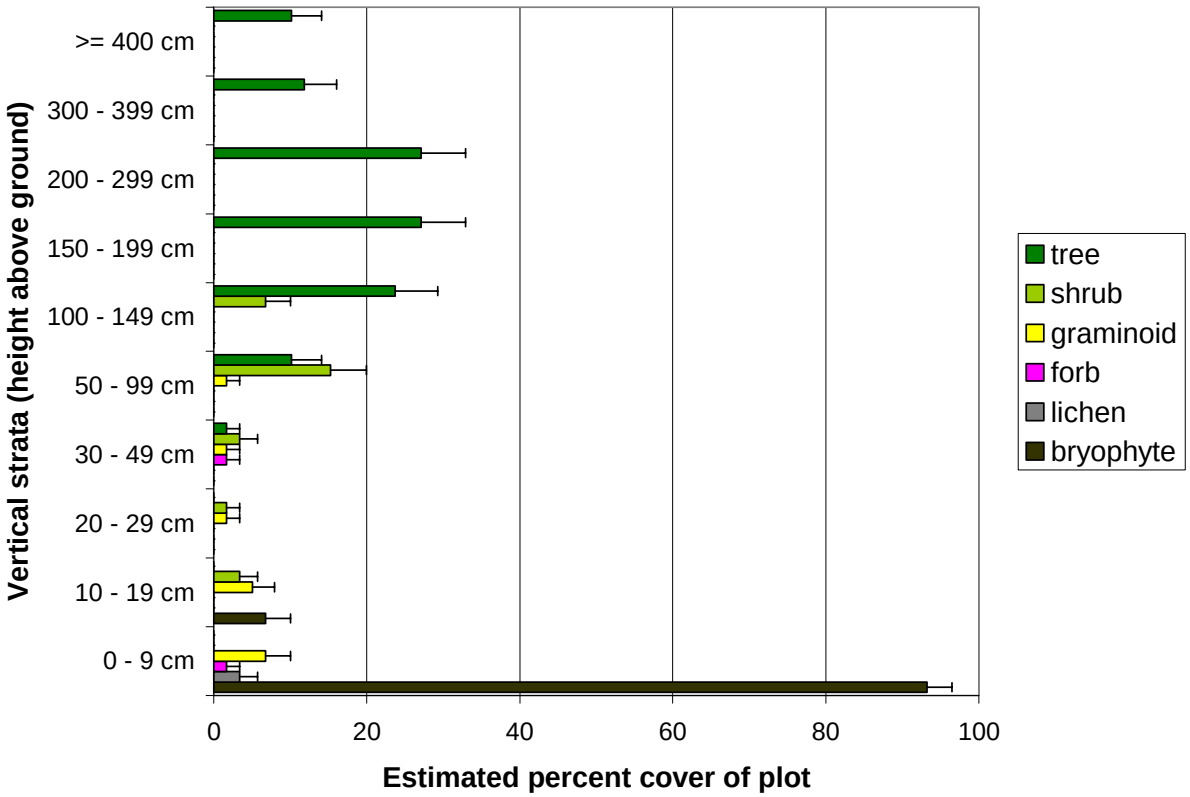

Figure 4.12. Vertical distribution of tree, shrub, graminoid, forb, lichen and bryophyte cover in of Lower Stony plot # 11

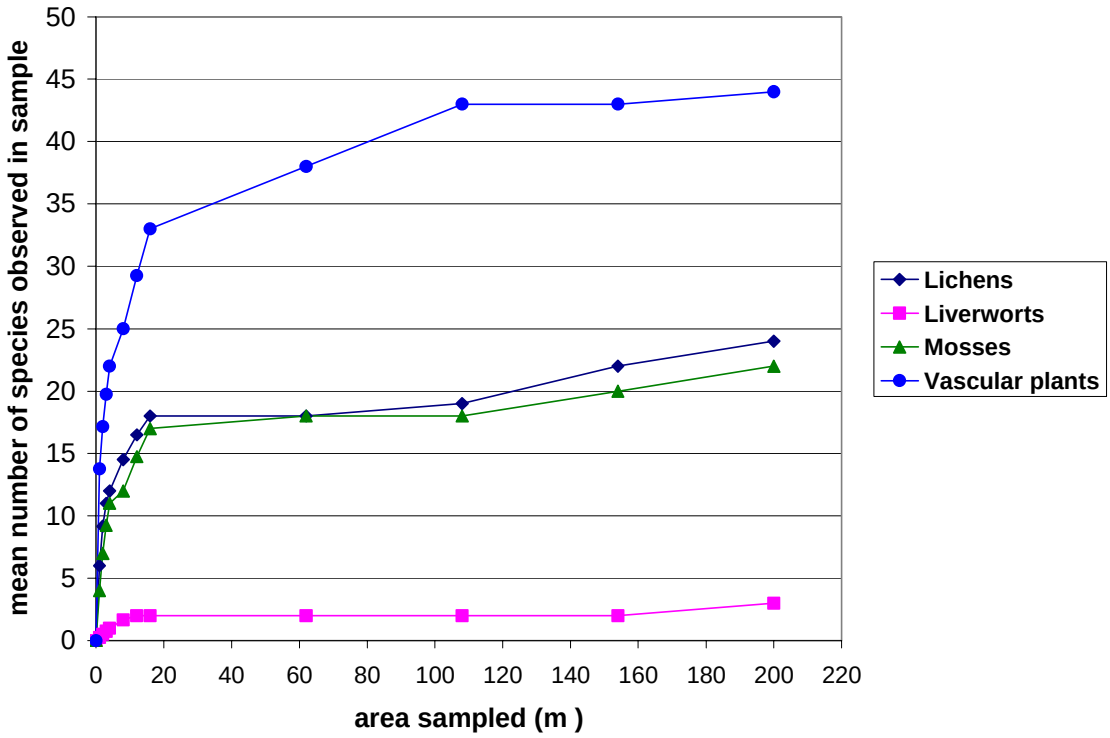

Figure 4.13. Species acquisition curves for lichens, liverworts, mosses and vascular plants recorded in species composition measurements in Upper Savage River minigrid point #19.

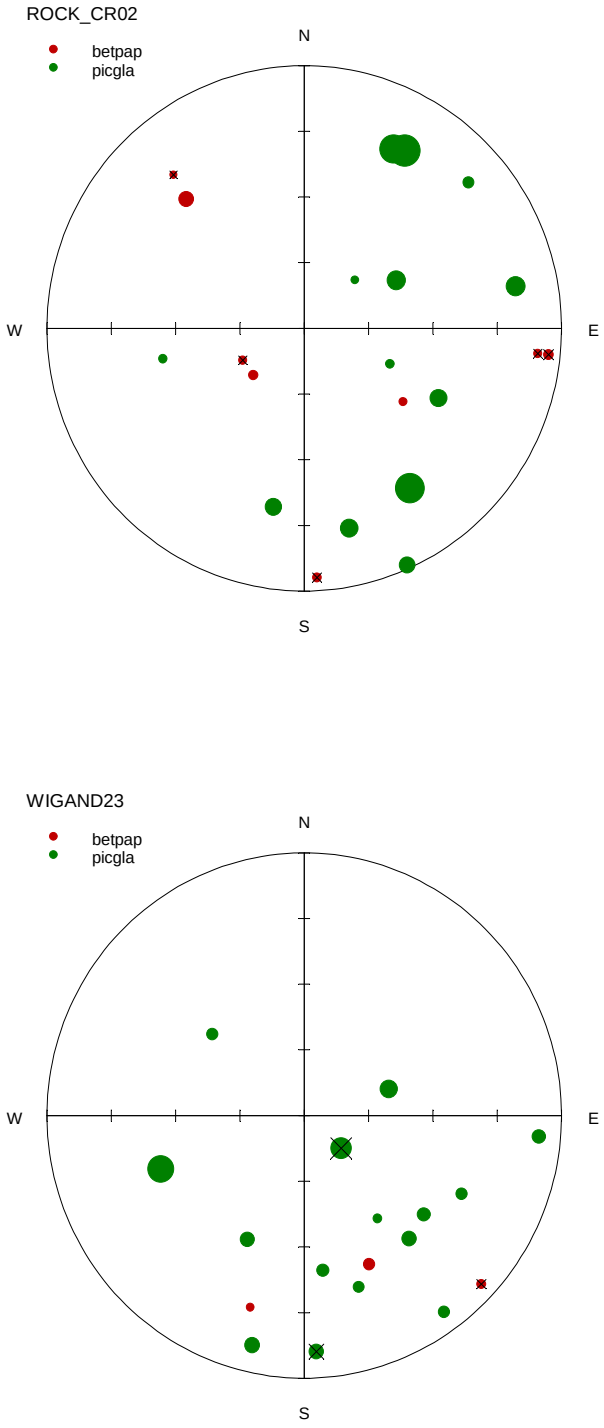

Figure 4.14. Plot maps for two plots generated by StatServer mapping routine. Maps show the location, species, relative size, and condition (live/dead) of all trees in plot (individuals > 12m dbh).

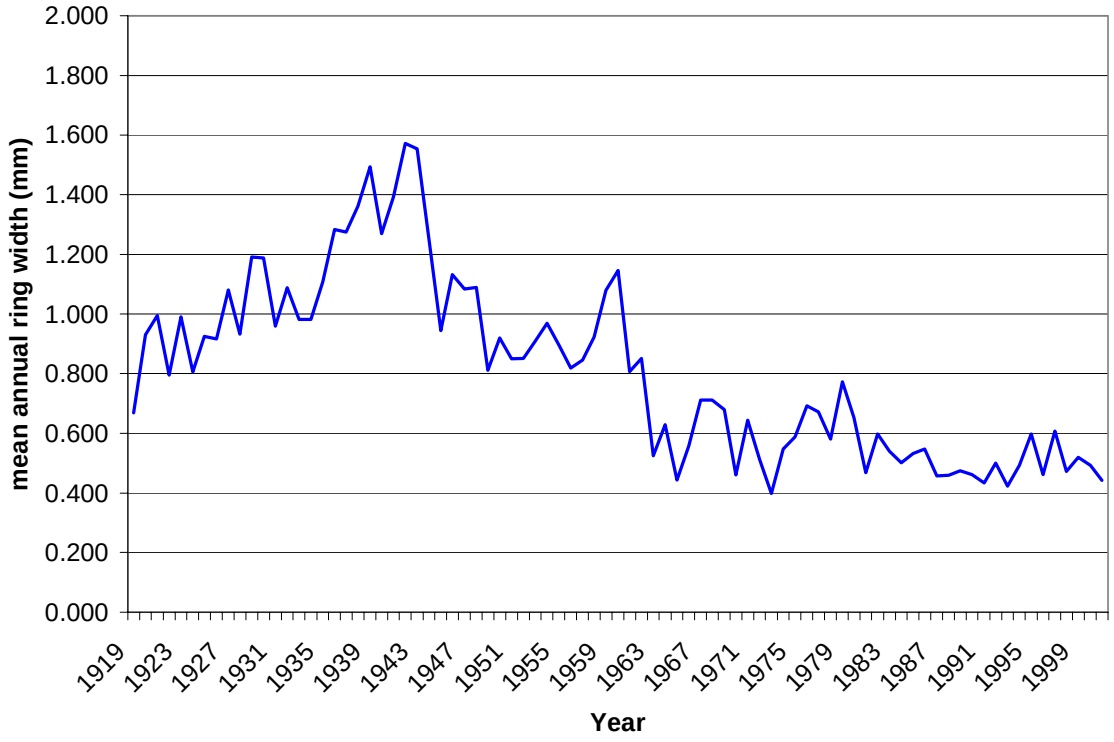

Figure 4.15. Mean annual ring width for four trees sampled at Lower Stony Creek minigrid plot #16 for the period 1919 until 2001.

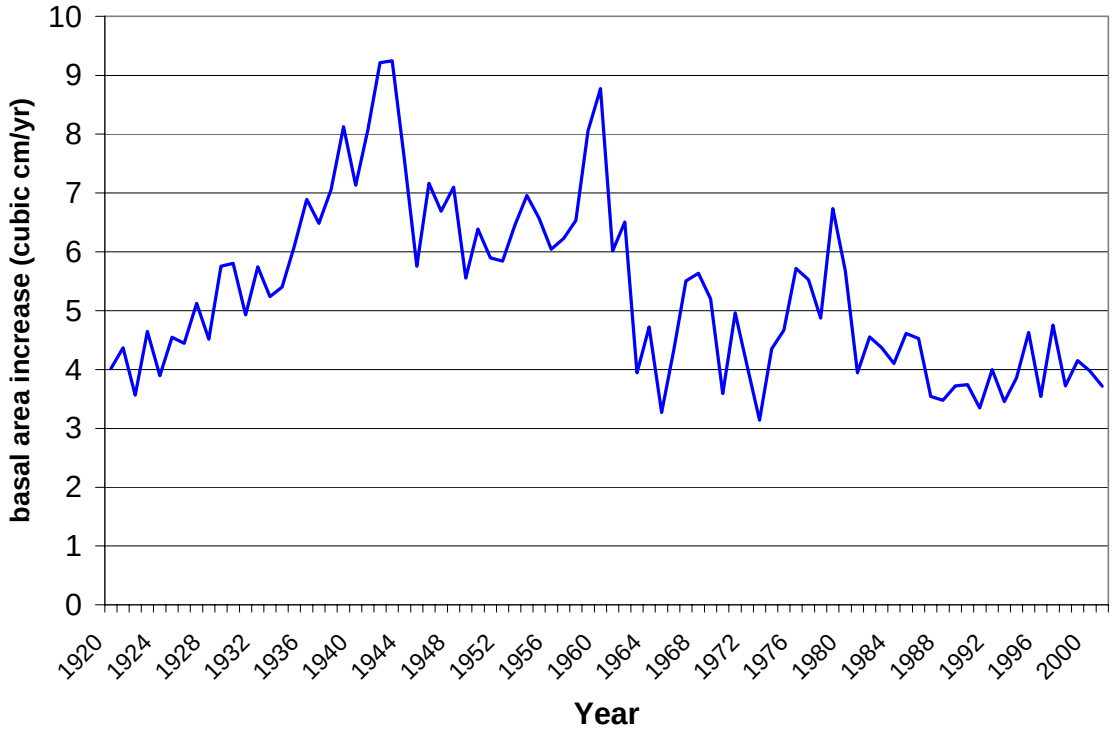

Figure 4.16. Mean annual basal area increment (cm^3/year) for four trees sampled at Lower Stony Creek minigrid plot #16 for the period 1919 until 2001.

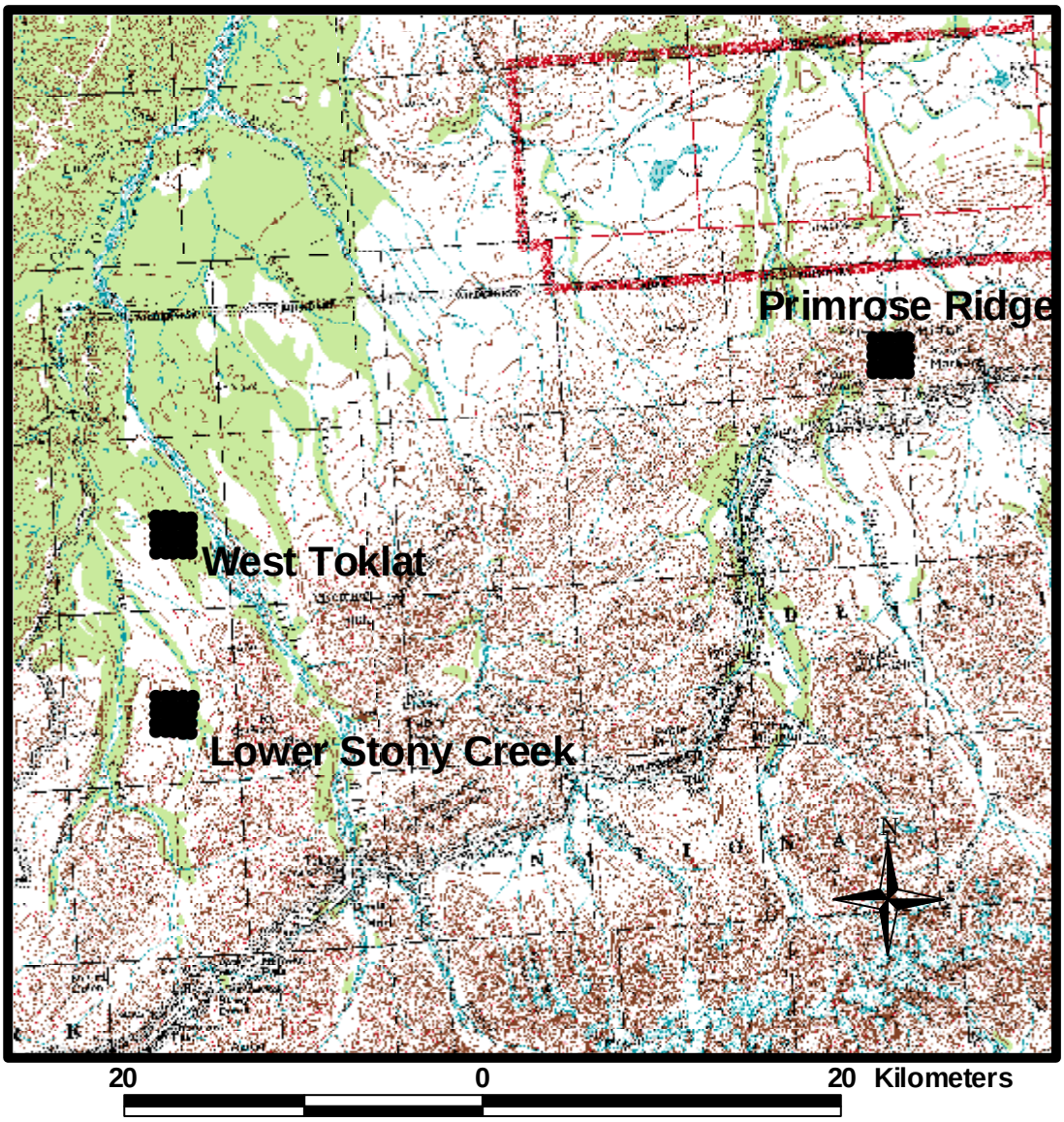

Figure 5.1. Map showing the location of three example minigrids that will be discussed in detail in this chapter of the report.

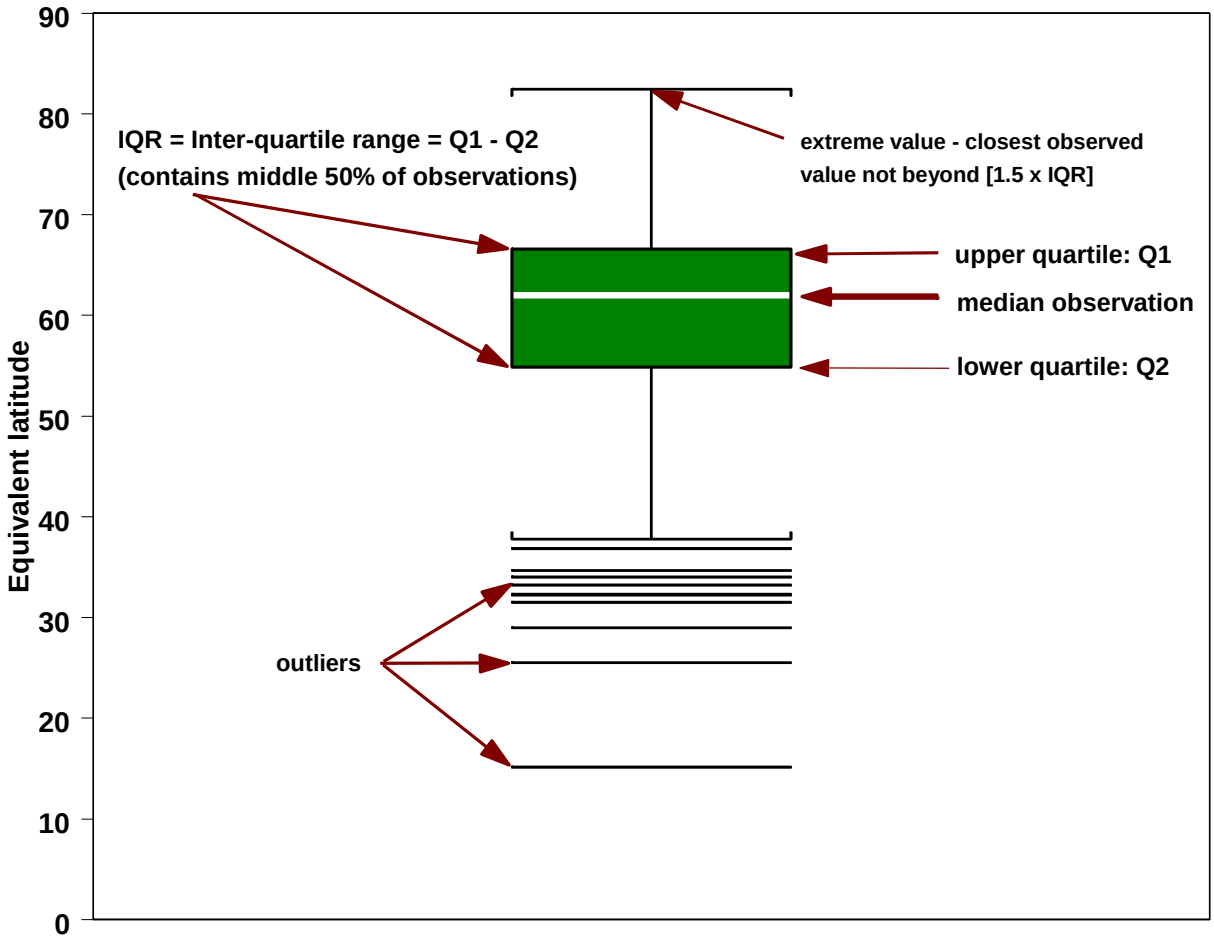

Figure 5.2. Explanation of the attributes of box and whisker plots used extensively in this report.

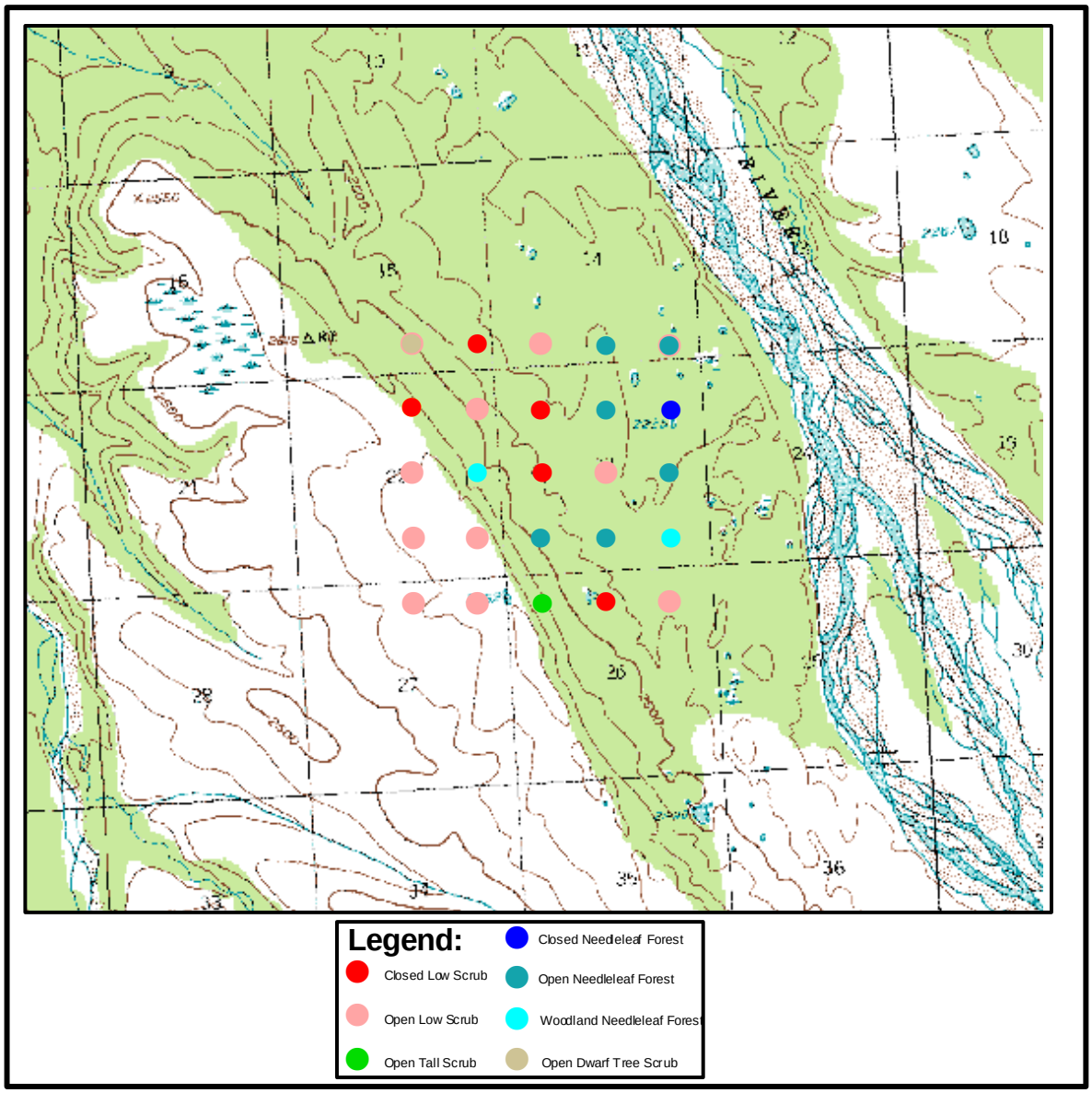

Figure 5.3. Map showing the location of 25 sample points in the West Toklat minigrid in Denali National Park, Alaska. Dots are color-coded to represent the Viereck level III vegetation types observed at each of the sample points.

Figure 5.4A. Panoramic image of the landscape of the West Toklat minigrid looking southeast from point #20. In the foreground is the top edge of the bluff and photo is looking down the slopes of the bluff toward the terrace surface below, where trees are visible. Note the absence of trees on upper edge of bluff.

Figure 5.4B. Panoramic image of the landscape of the West Toklat minigrid looking southwest from point # 17. The vegetation in this photo is typical of the low dwarf birch – ericaceous scrub that occurs on the upper surface of the bluff feature in this minigrid.

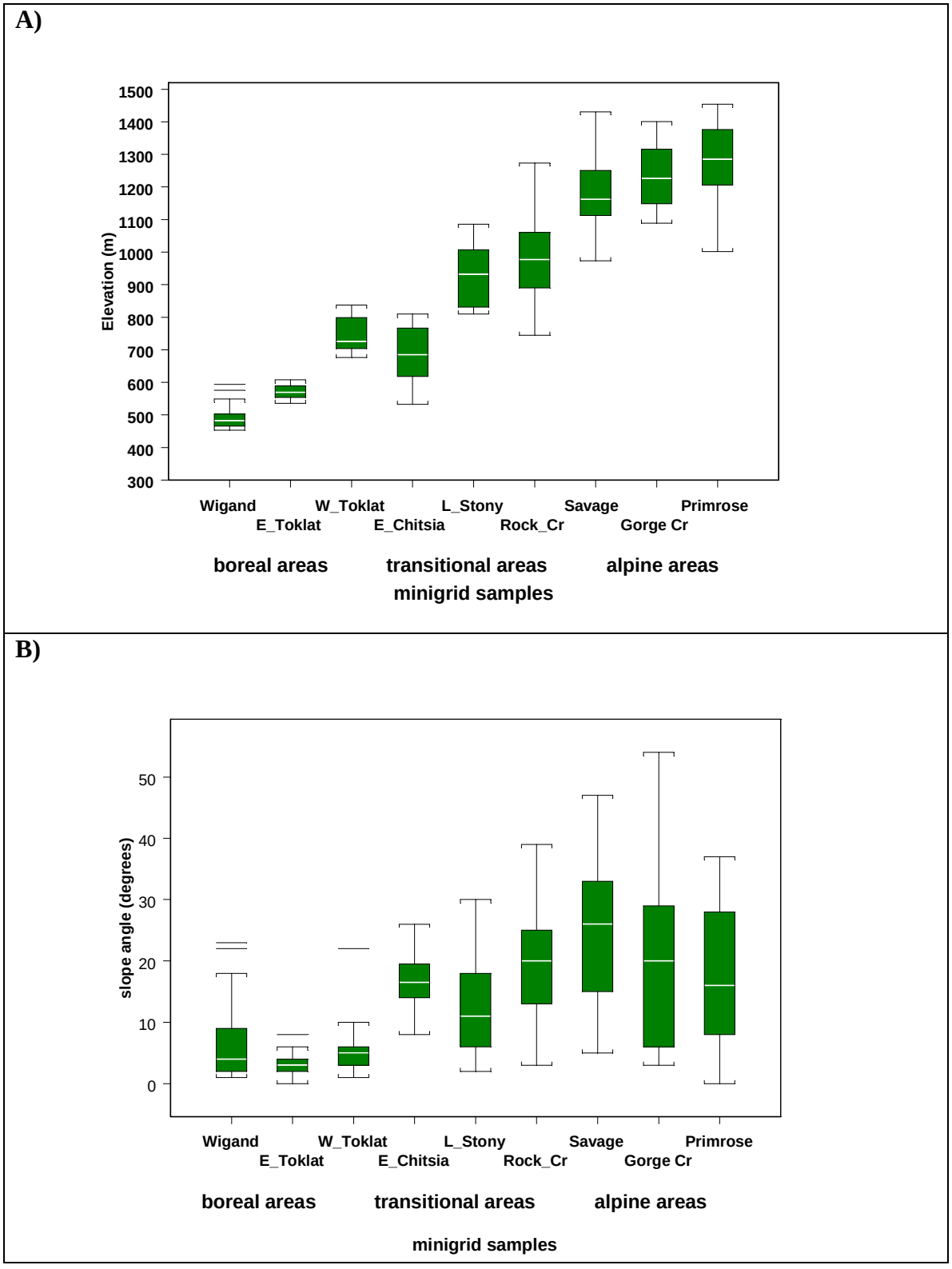

Figure 5.5. The ranges of variation in two topographic variables measured within and among nine minigrid samples in Denali National Park, Alaska: A) elevation; B) slope angle.

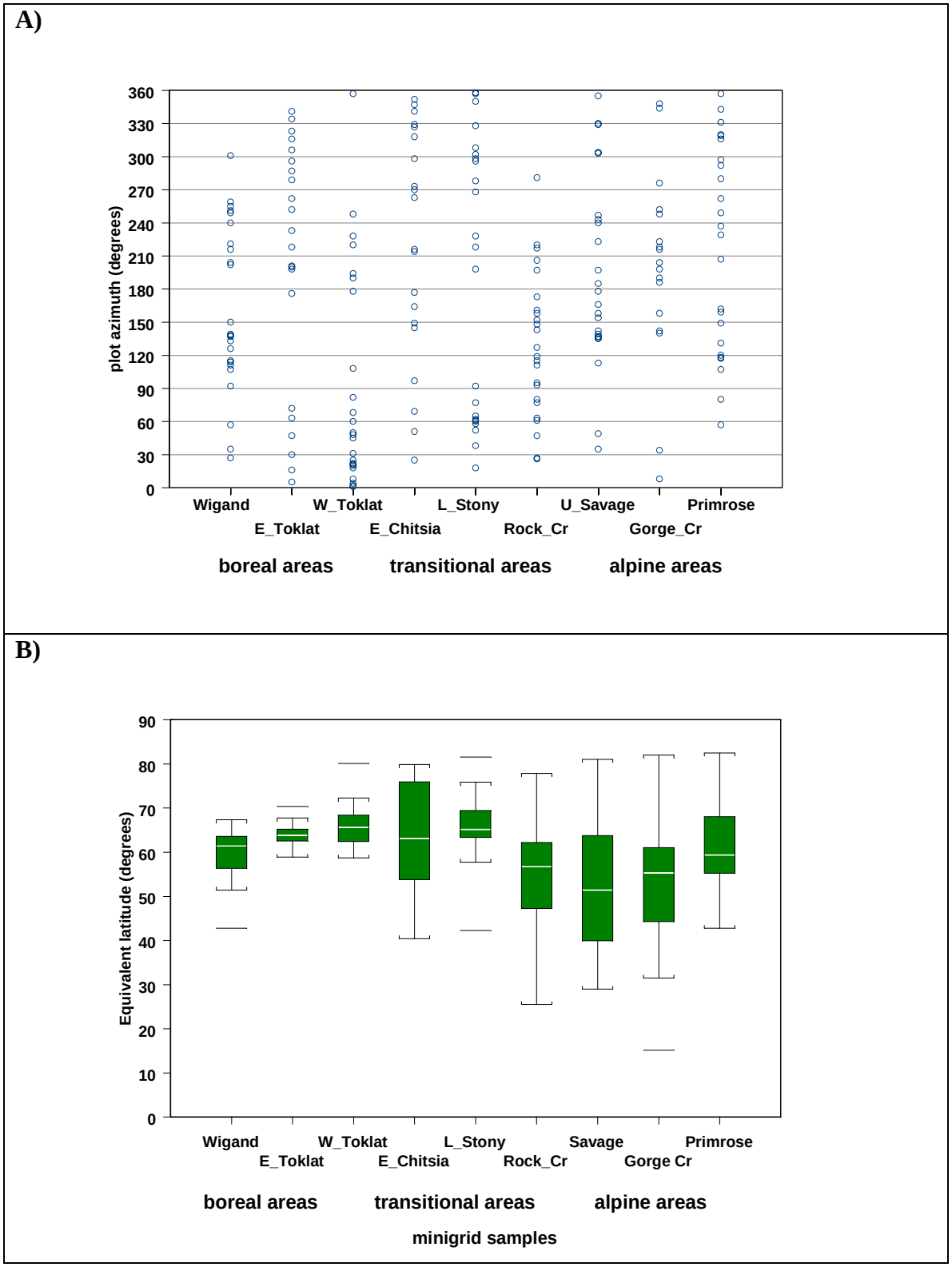

Figure 5.6. The ranges of variation in two topographic variables measured within and among nine minigrid samples in Denali National Park, Alaska: A) aspect; B) equivalent latitude.

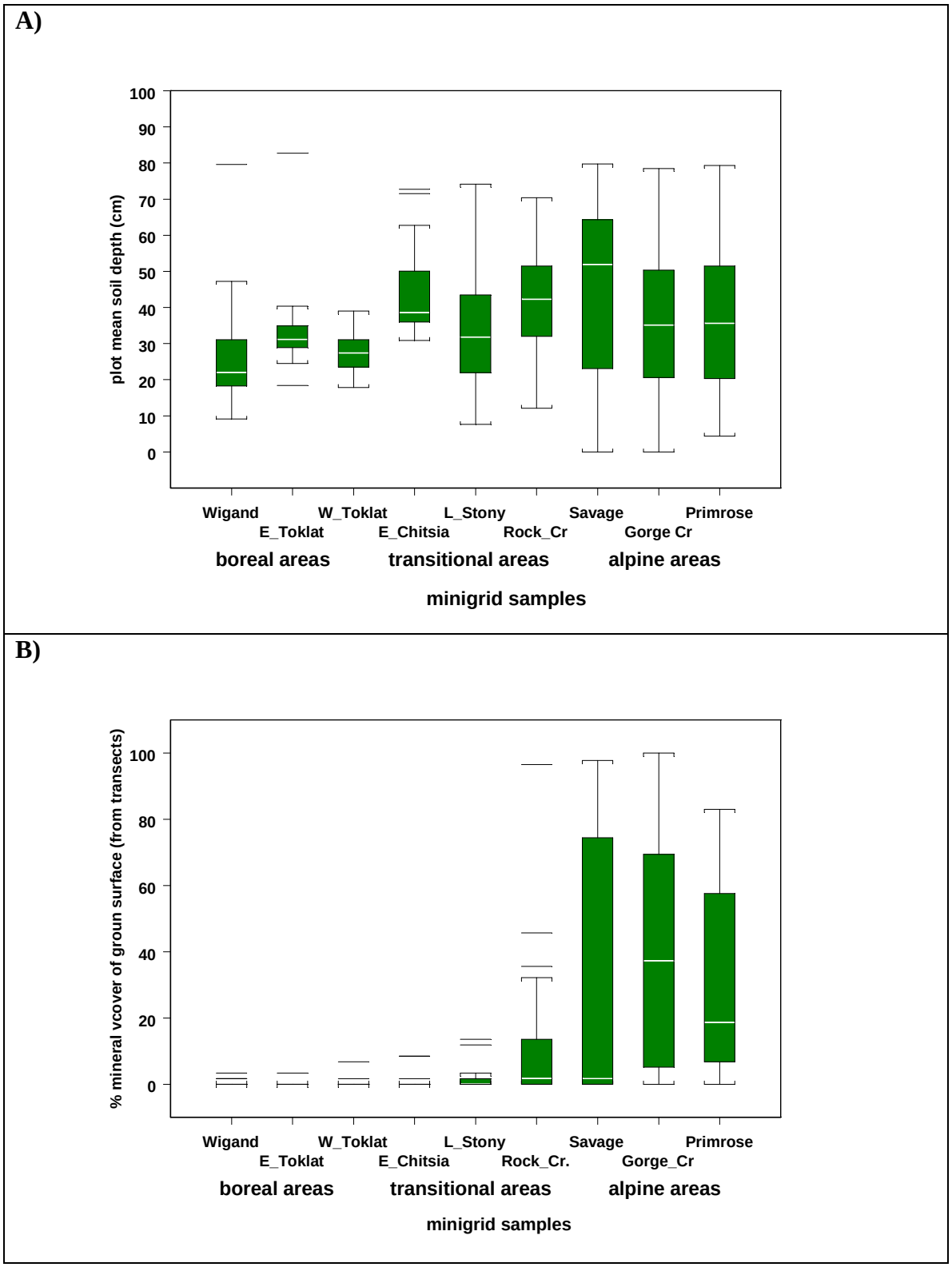

Figure 5.7. The ranges of variation in two soil related parameters observed within and among nine minigrid samples in Denali National Park, Alaska: A) soil depth; B) percent mineral cover of the ground surface.

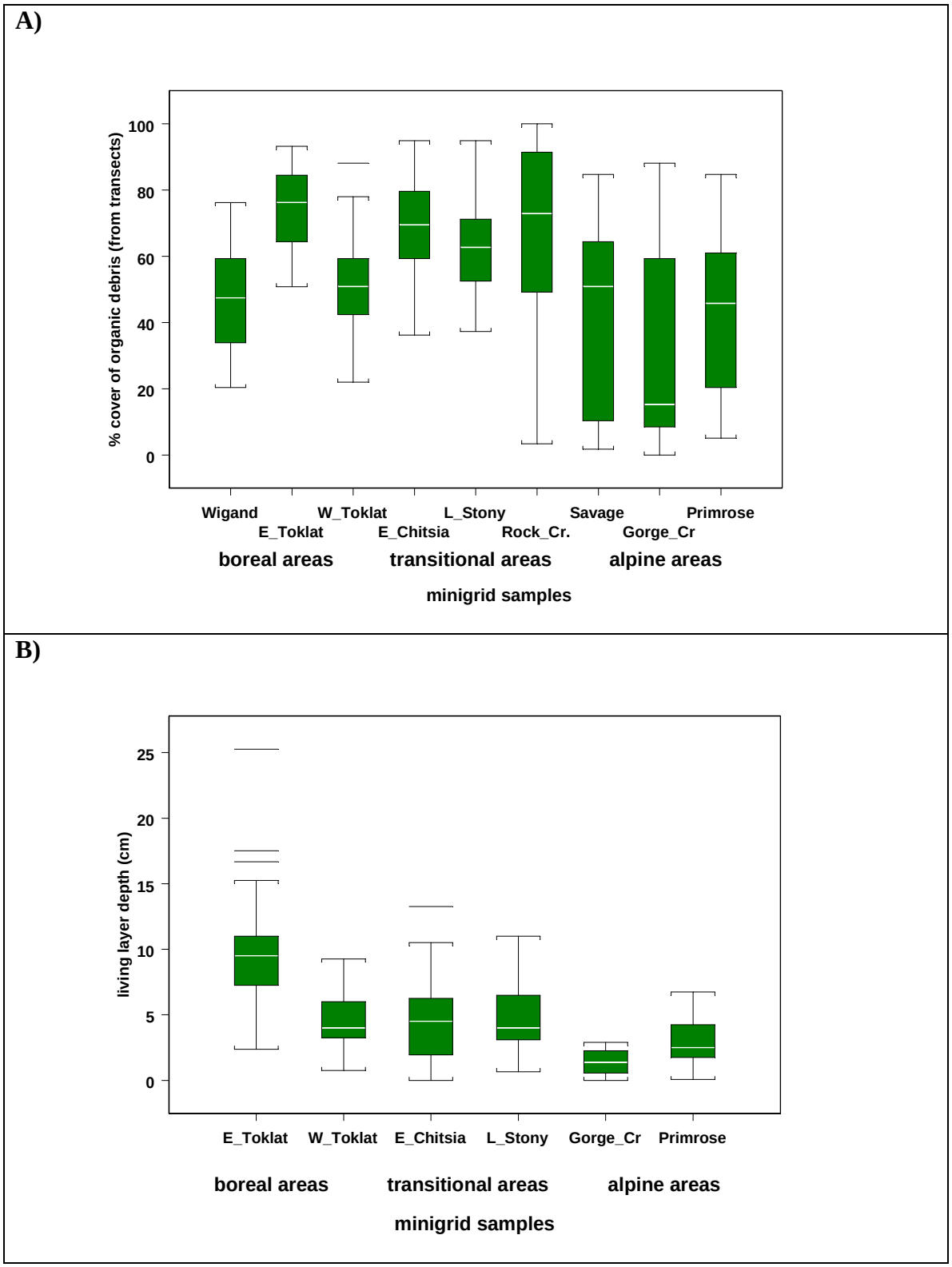

Figure 5.8. The ranges of variation in two soil related parameters observed within and among nine minigrid samples in Denali National Park, Alaska: A) percent cover of organic detritus of the ground surface; B) depth of the living layer at ground level (live mosses, lichens and vascular plants in contact with soil surface).

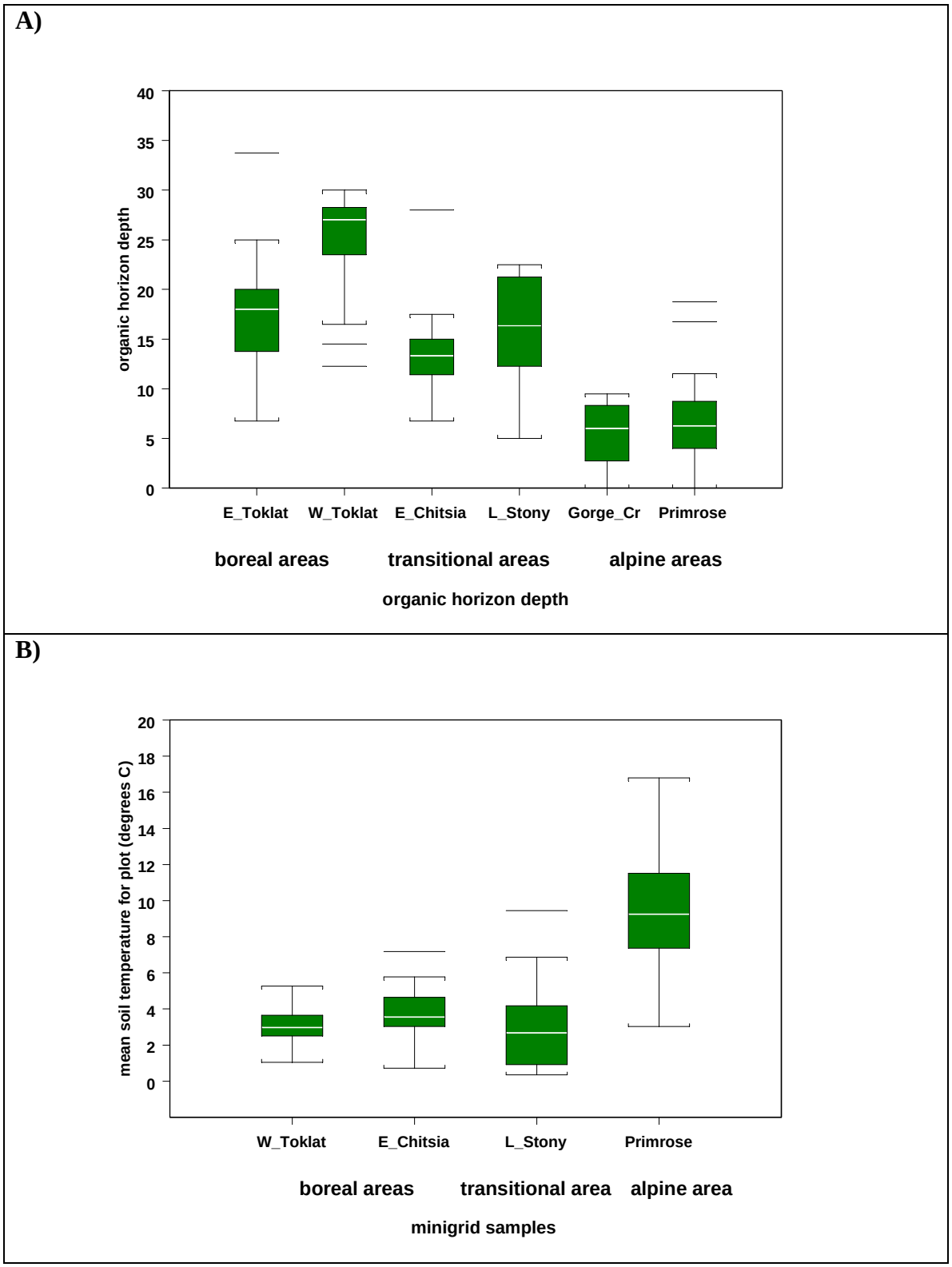

Figure 5.9. The ranges of variation in soil related parameters observed within and among groups of minigrid samples in Denali National Park, Alaska: A) mean depth of the organic soil horizon; B) mean soil temperature.

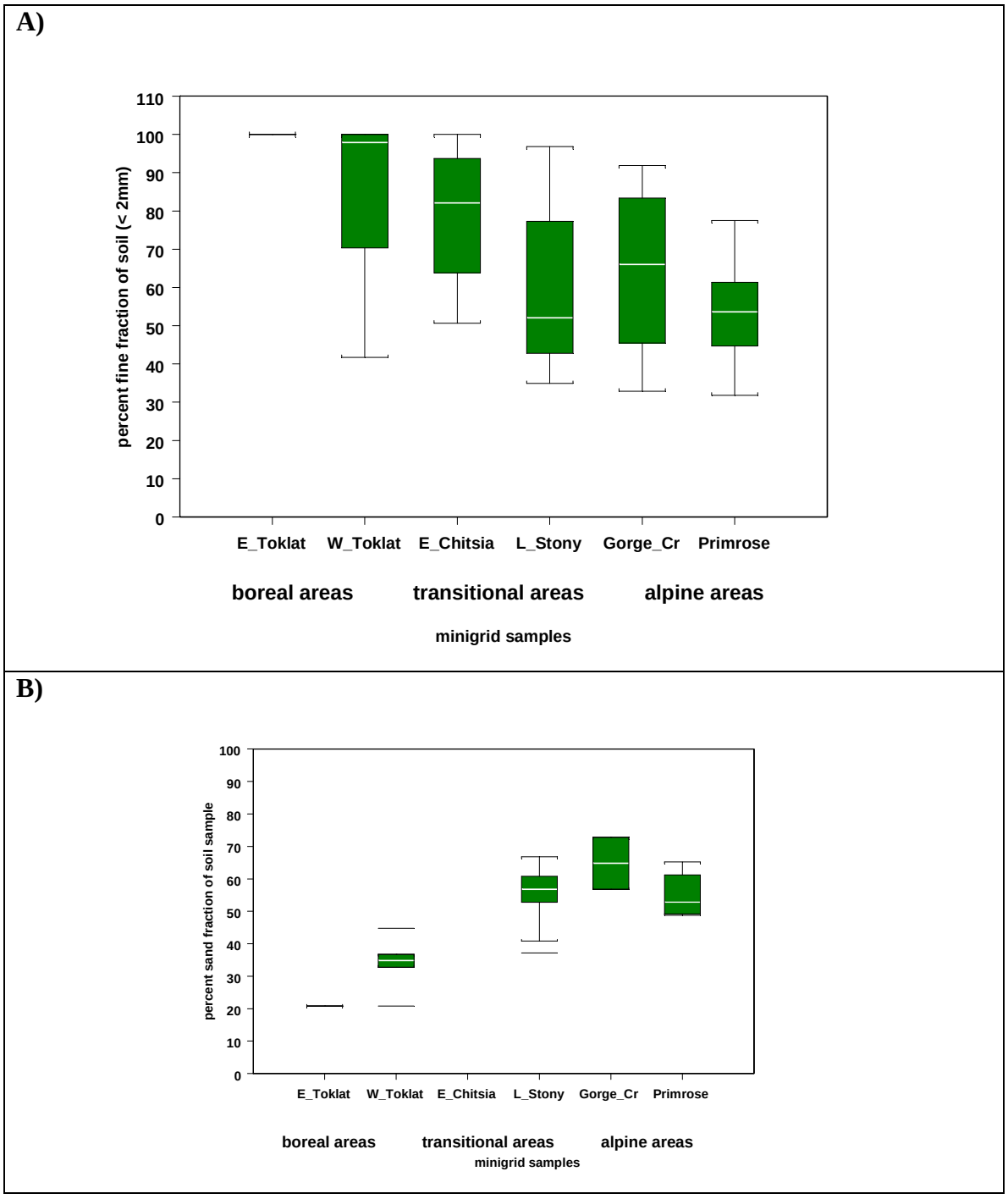

Figure 5.10. The ranges of variation in two soil parameters observed within and among six minigrid samples in Denali National Park, Alaska: A) percent fine fraction of soil samples; B) percent sand fraction of soil. Soil texture data were missing for East Chitsia minigrid due to low sample volumes.

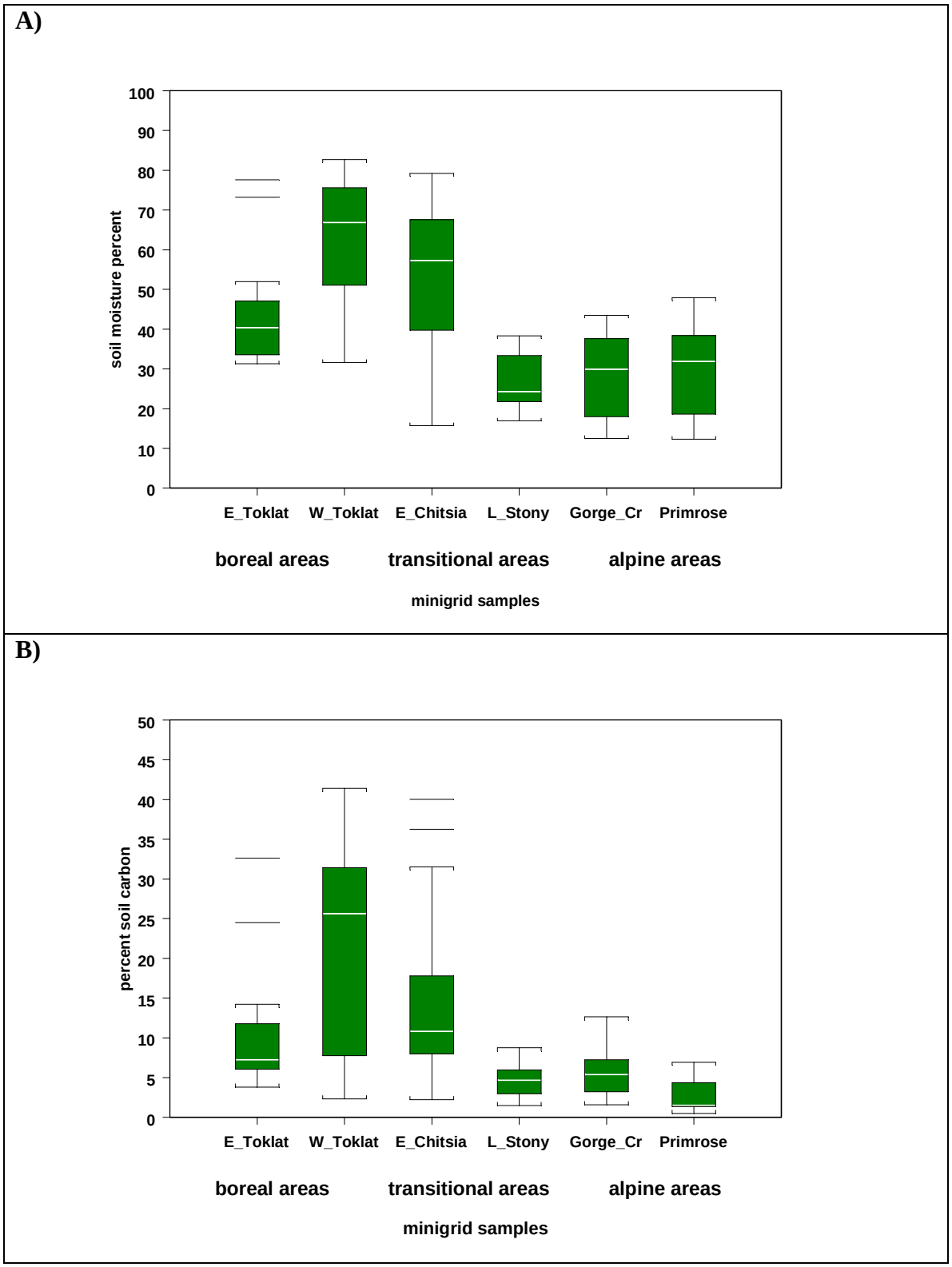

Figure 5.11. The ranges of variation in two soil parameters observed within and among six minigrid samples in Denali National Park, Alaska: A) percent moisture of soil samples; B) percent soil carbon.

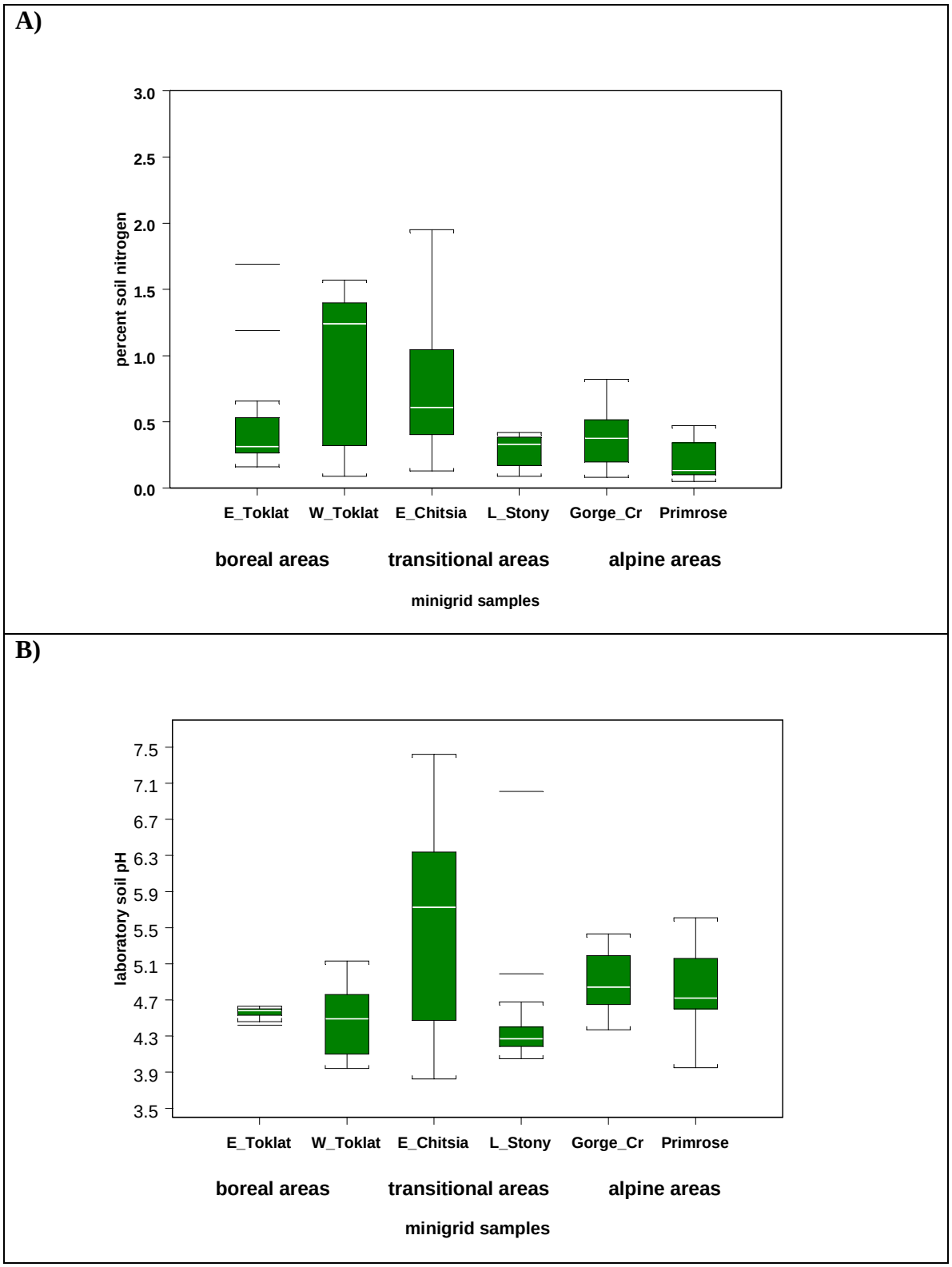

Figure 5.12. The ranges of variation in two soil parameters observed within and among six minigrid samples in Denali National Park, Alaska: A) percent soil nitrogen; B) soil pH.

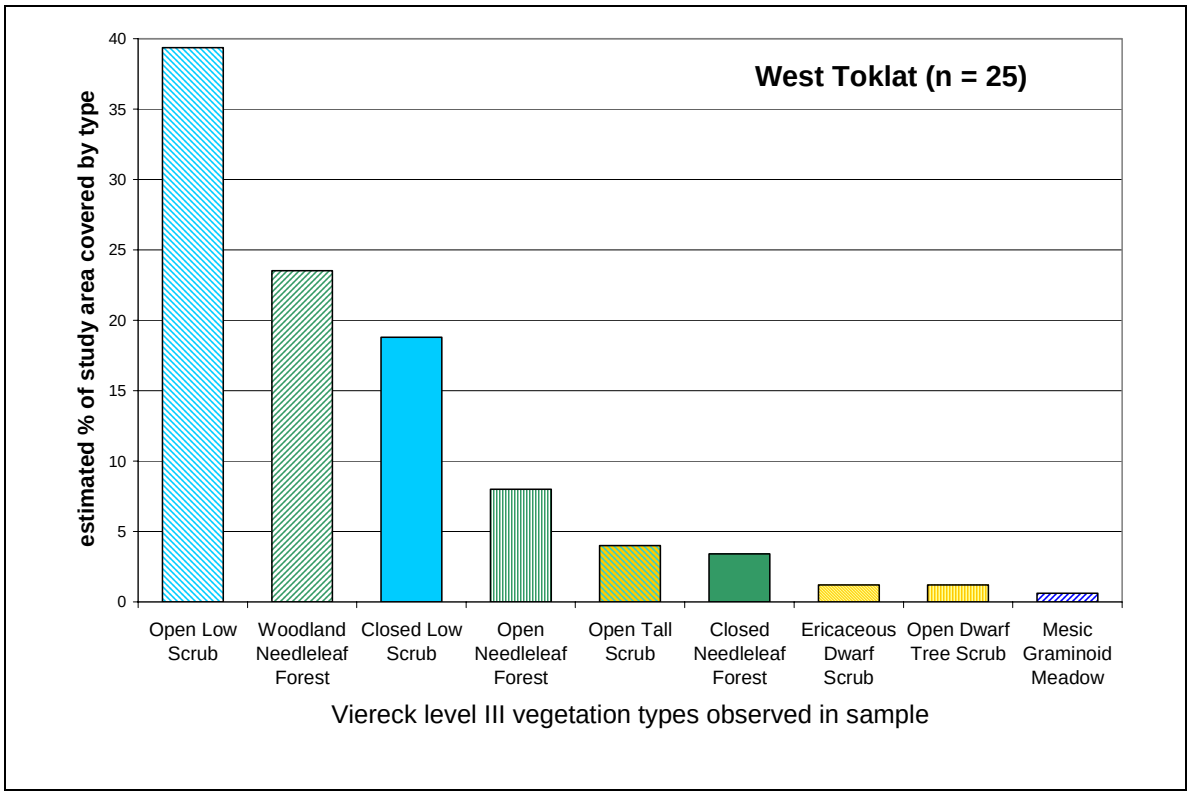

Figure 5.13. Histogram showing the estimated percentage of the West Toklat minigrid study area occupied by nine vegetation types (classified at Viereck level III) observed in the sample plots.

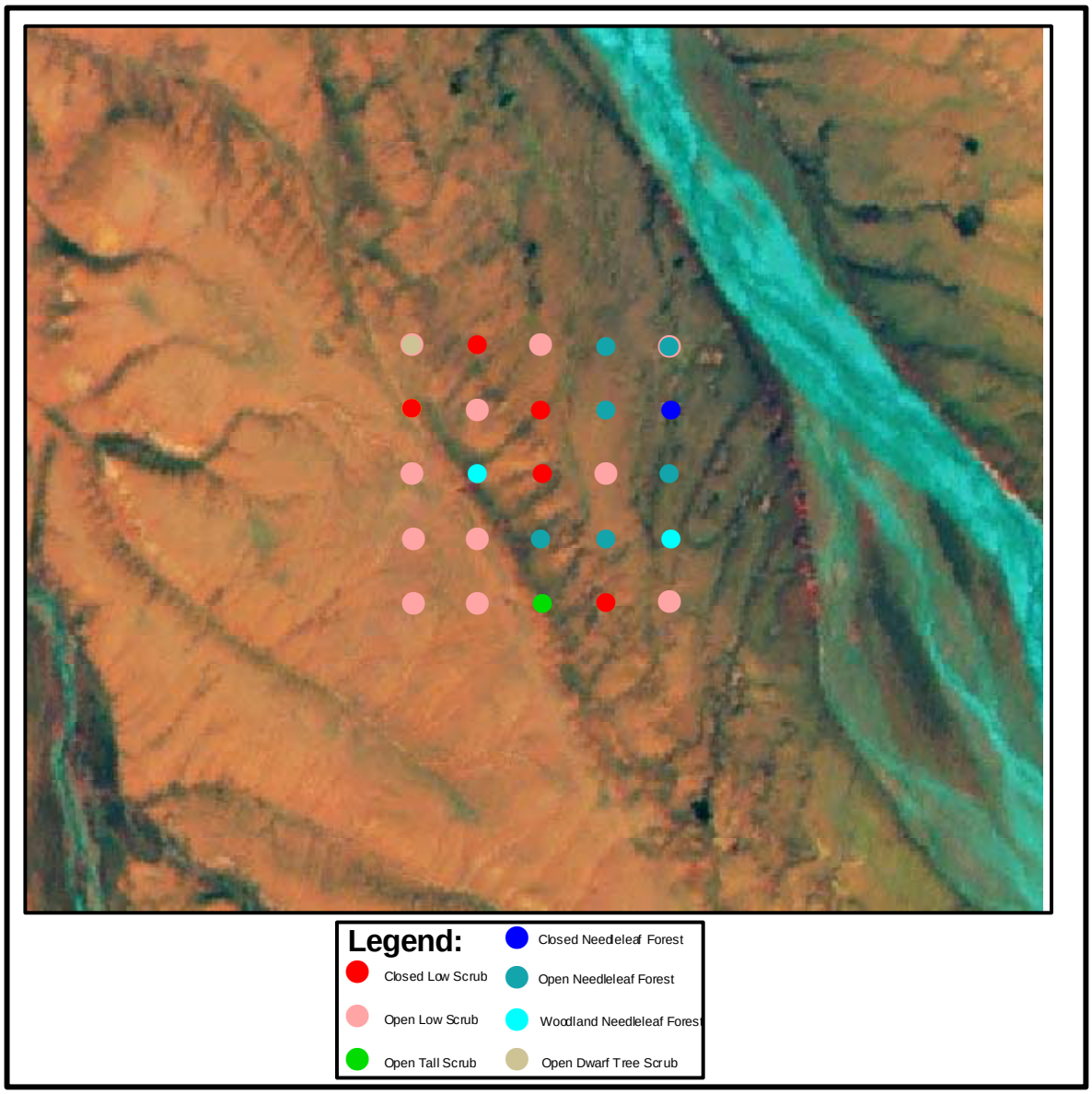

Figure 5.14. Location of 25 sample points measured in the West Toklat minigrid sample, projected onto a SPOT satellite image (faux CIR spectrum) for the area. Dots are color-coded to the Viereck level III vegetation types.

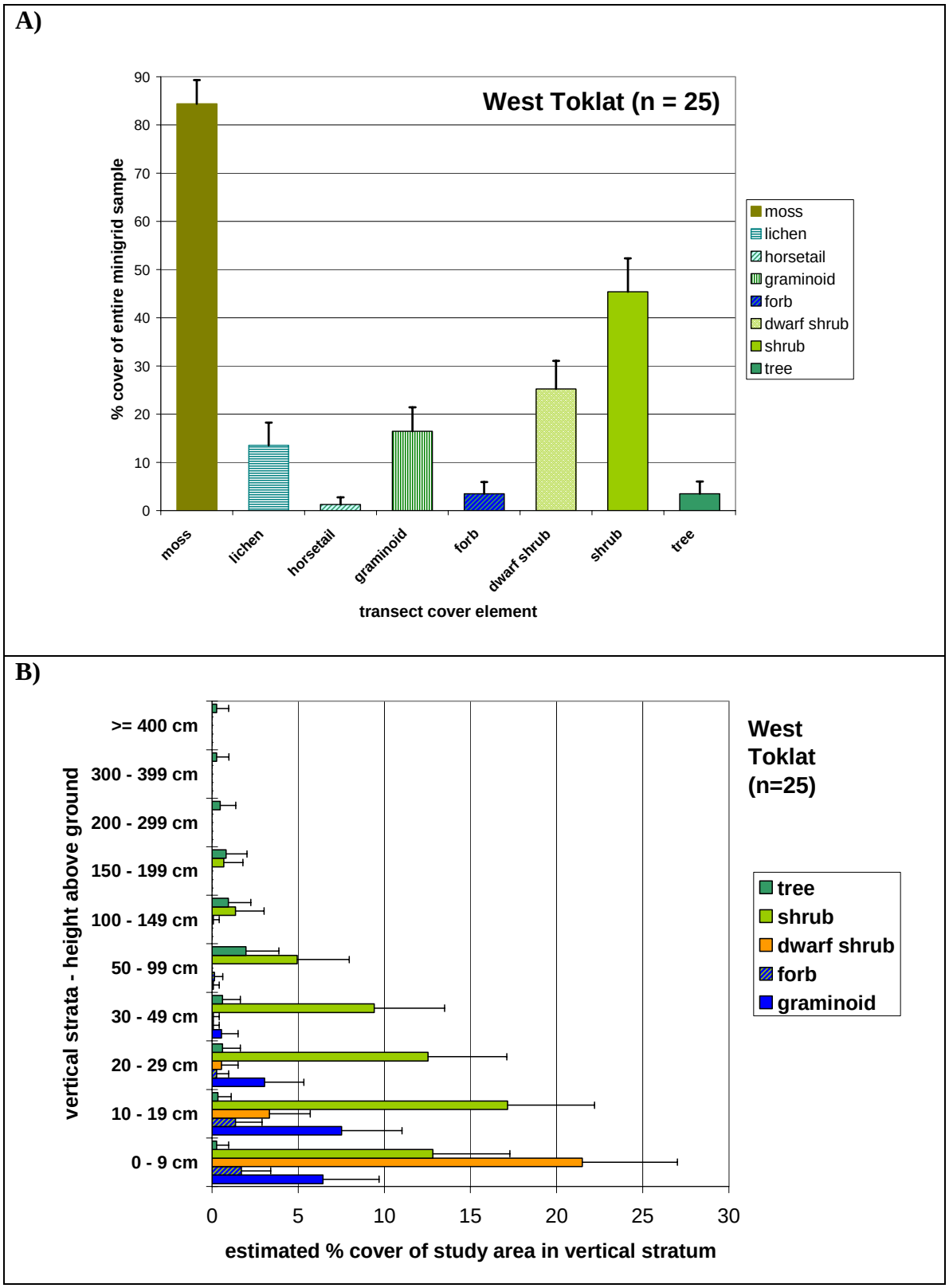

Figure 5.15. The estimated distribution of plant cover of the entire West Toklat minigrid sample: A) estimated total cover of sample by eight growth form classes in the vegetation; B) vertical arrangement of cover for the five most abundant vascular plant growth-form classes observed in the vegetation.

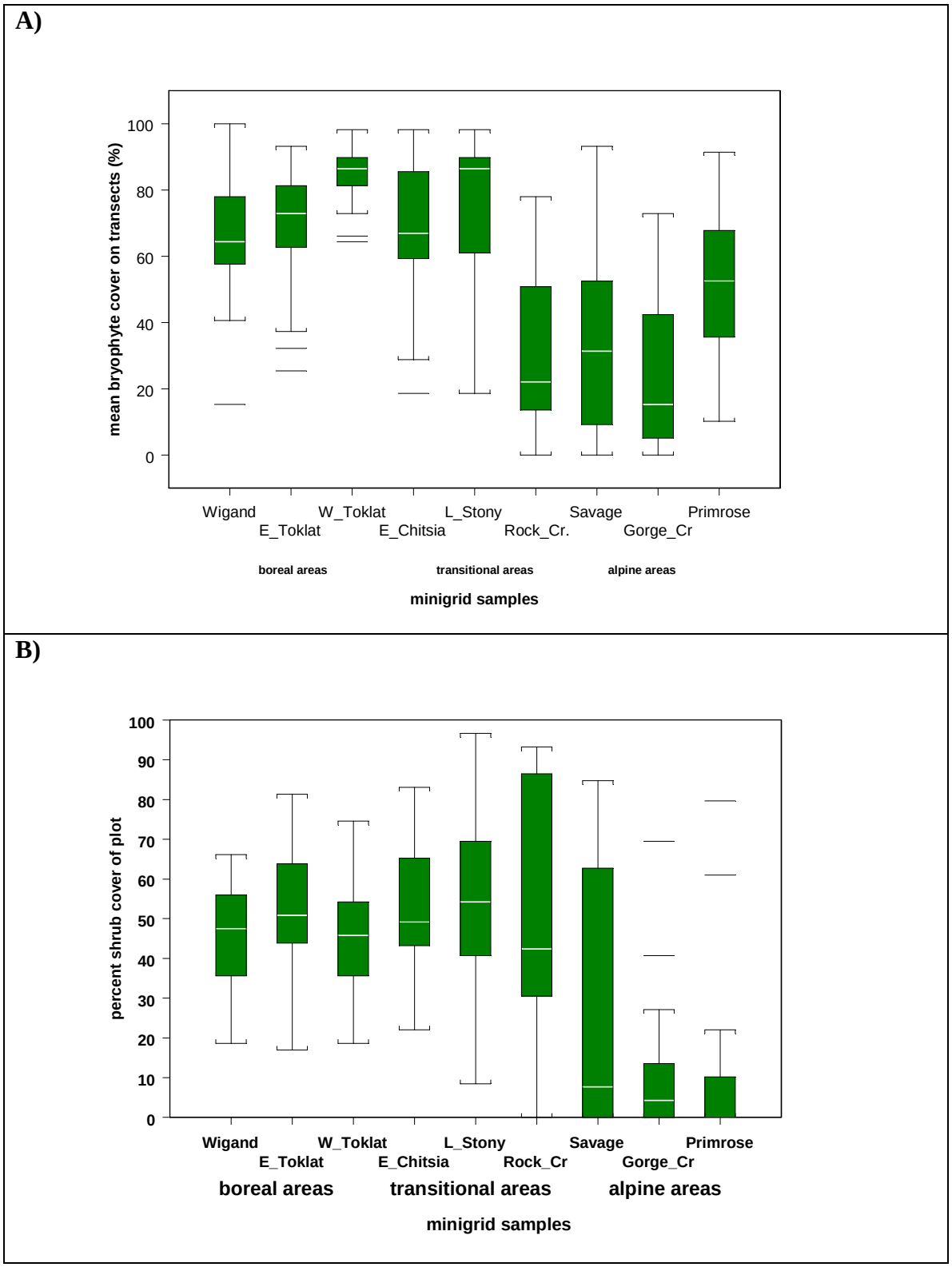

Figure 5.16. The ranges of variation in two aspects of plant cover observed within and among nine minigrid samples measured in Denali National Park, Alaska: a) percent bryophyte cover of plot; B) percent shrub cover of plot.

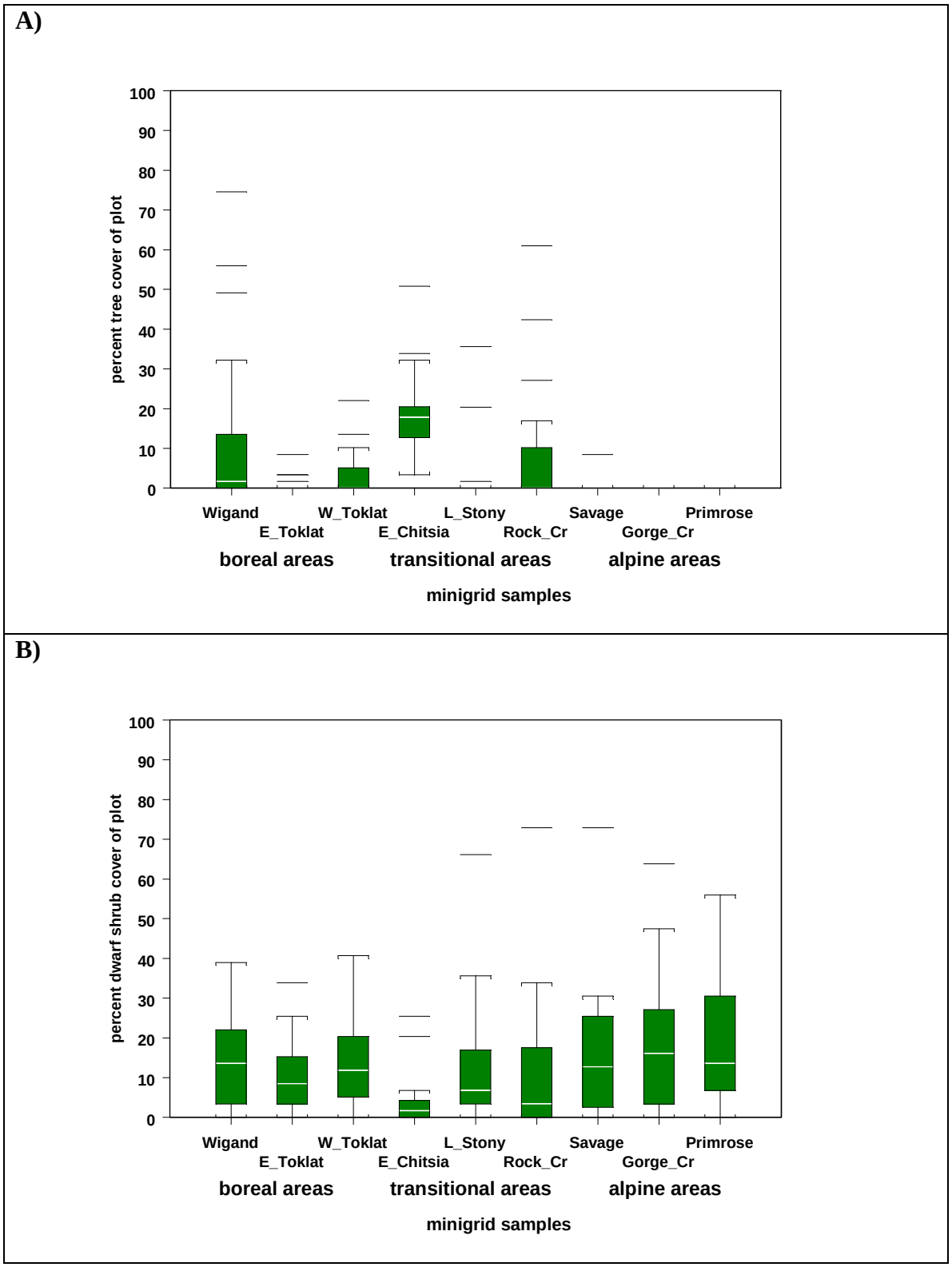

Figure 5.17. The ranges of variation in two aspects of plant cover observed within and among nine minigrid samples measured in Denali National Park, Alaska: A) percent cover of plot by trees; B) percent cover of plot by dwarf shrubs.

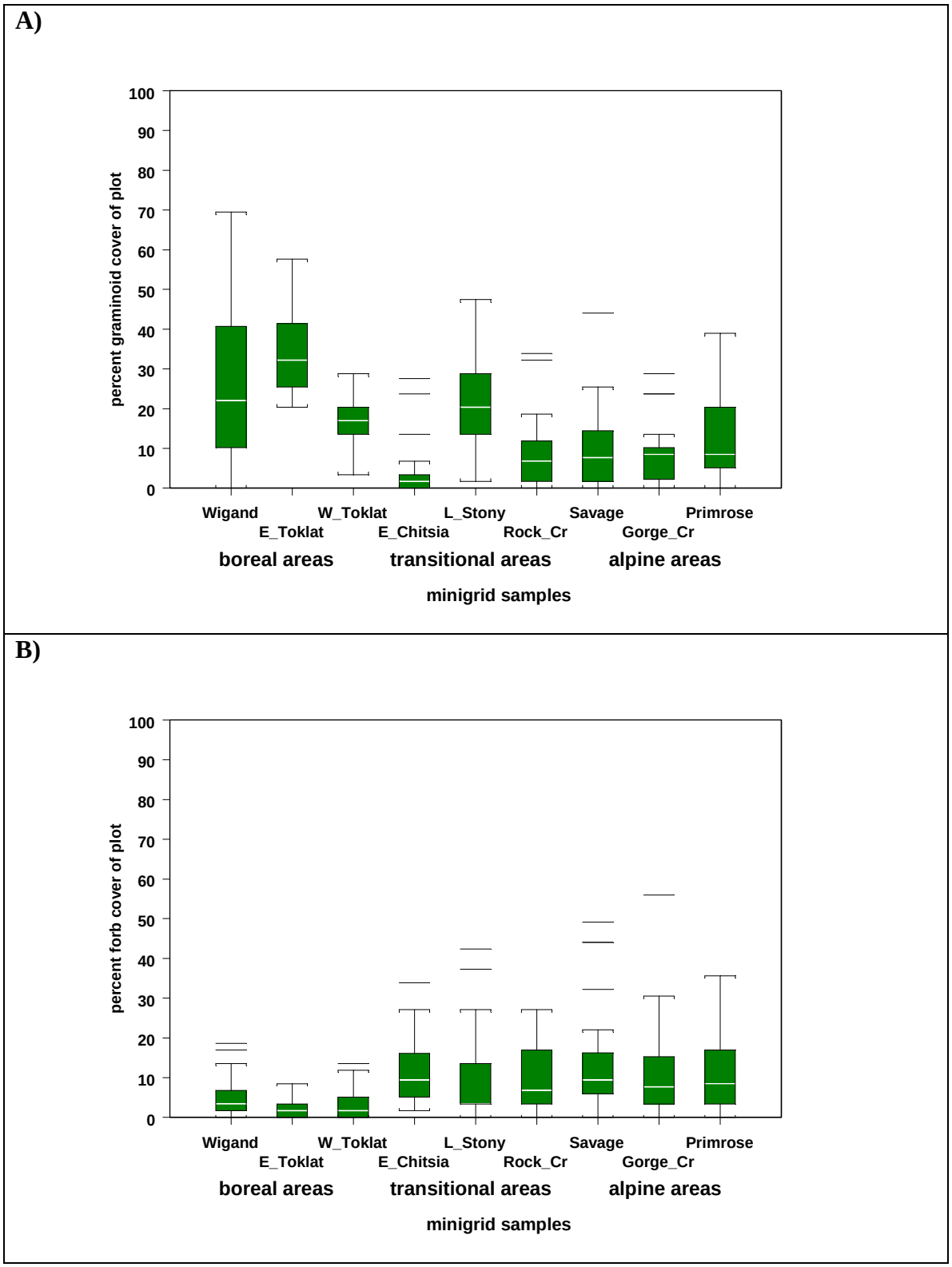

Figure 5.18. The ranges of variation in two aspects of plant cover observed within and among nine minigrid samples measured in Denali National Park, Alaska: A) percent cover of graminoids (grasses, sedges and rushes); B) percent cover of forbs (herbaceous vascular plants).

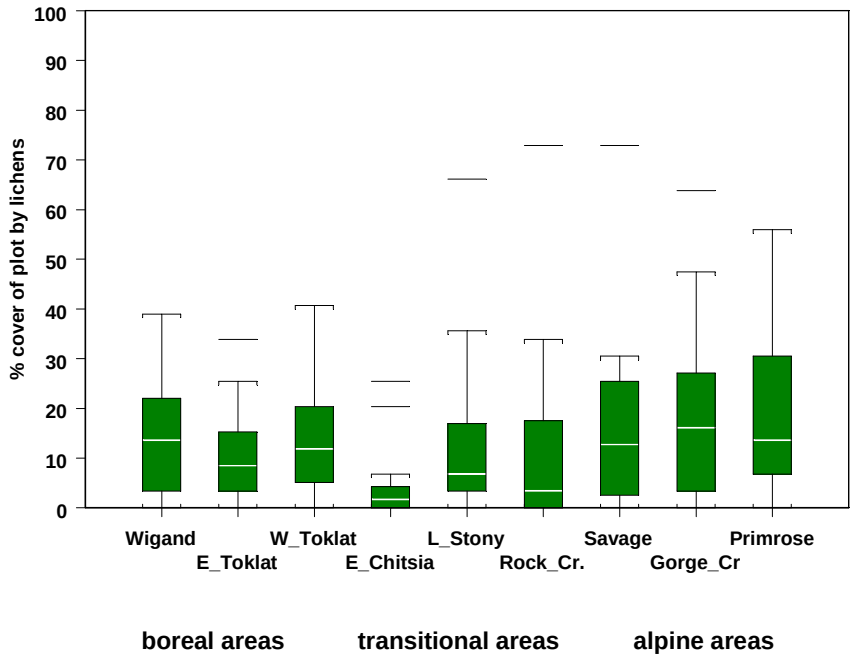

Figure 5.19a. The ranges of variation in lichen cover of plots within and among nine minigrid samples in Denali National Park, Alaska**.**

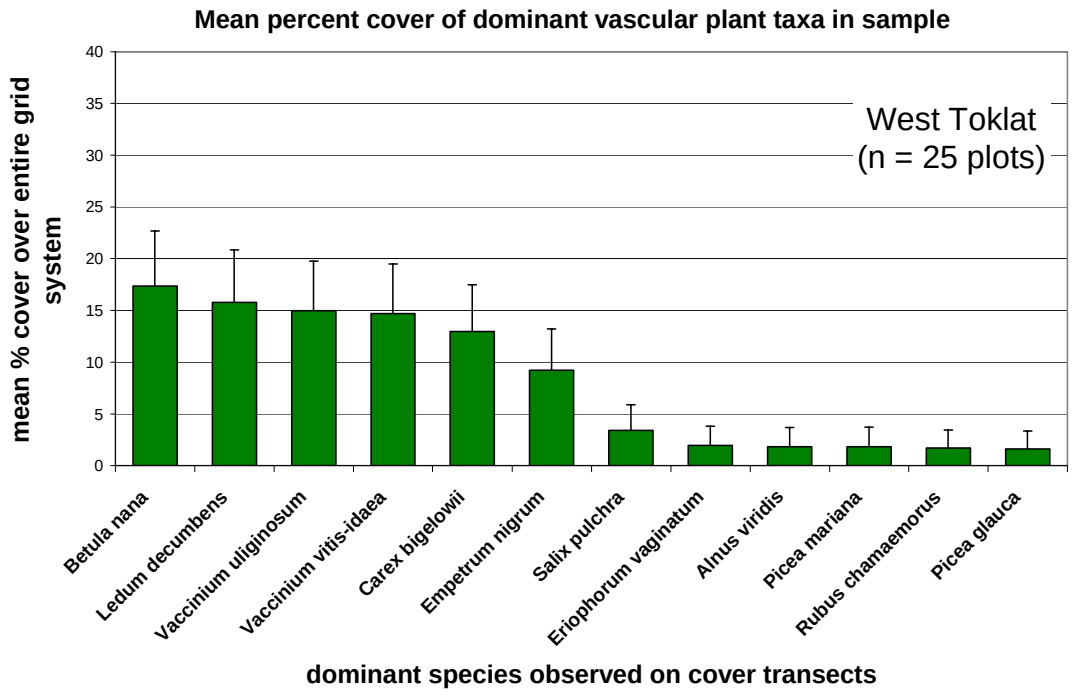

Figure 5.19b. Estimated mean percent cover of entire West Toklat minigrid by the twelve most abundant species observed in sample.

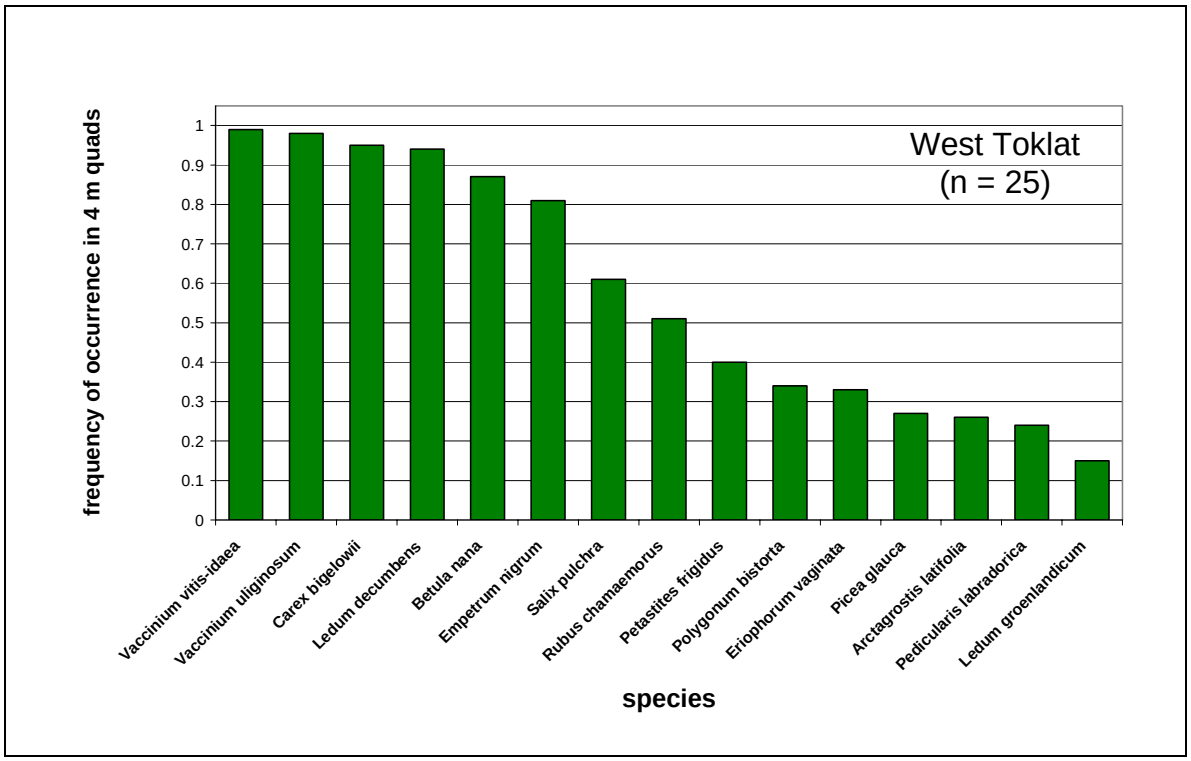

Figure 5.20A Frequency of occurrence of 15 highest frequency vascular plant taxa observed in the West Toklat minigrid sample. Value given is the proportion of 4 m^2 quadrats in which each species was observed (#observed/100 quadrats).

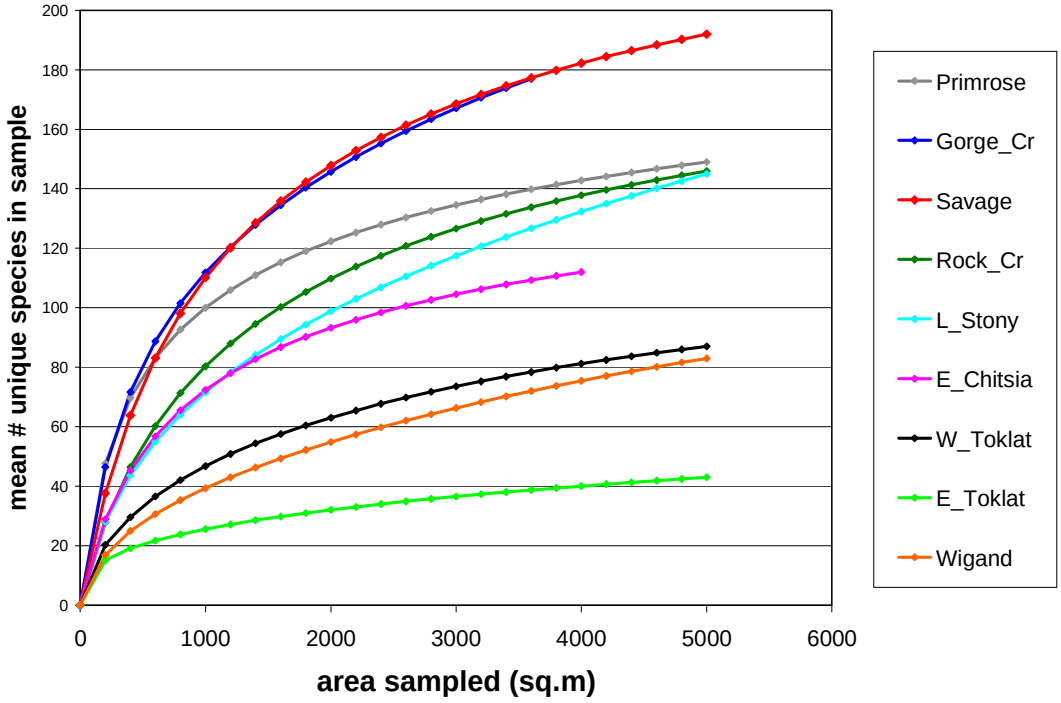

Figure 5.20B. Species accumulation curves for nine minigrid samples measured in Denali National Park, Alaska. Value at each interval is mean # of unique vascular plant taxa observed in sample for given area sampled (each increment adds one 200 m^2 plot to sample).

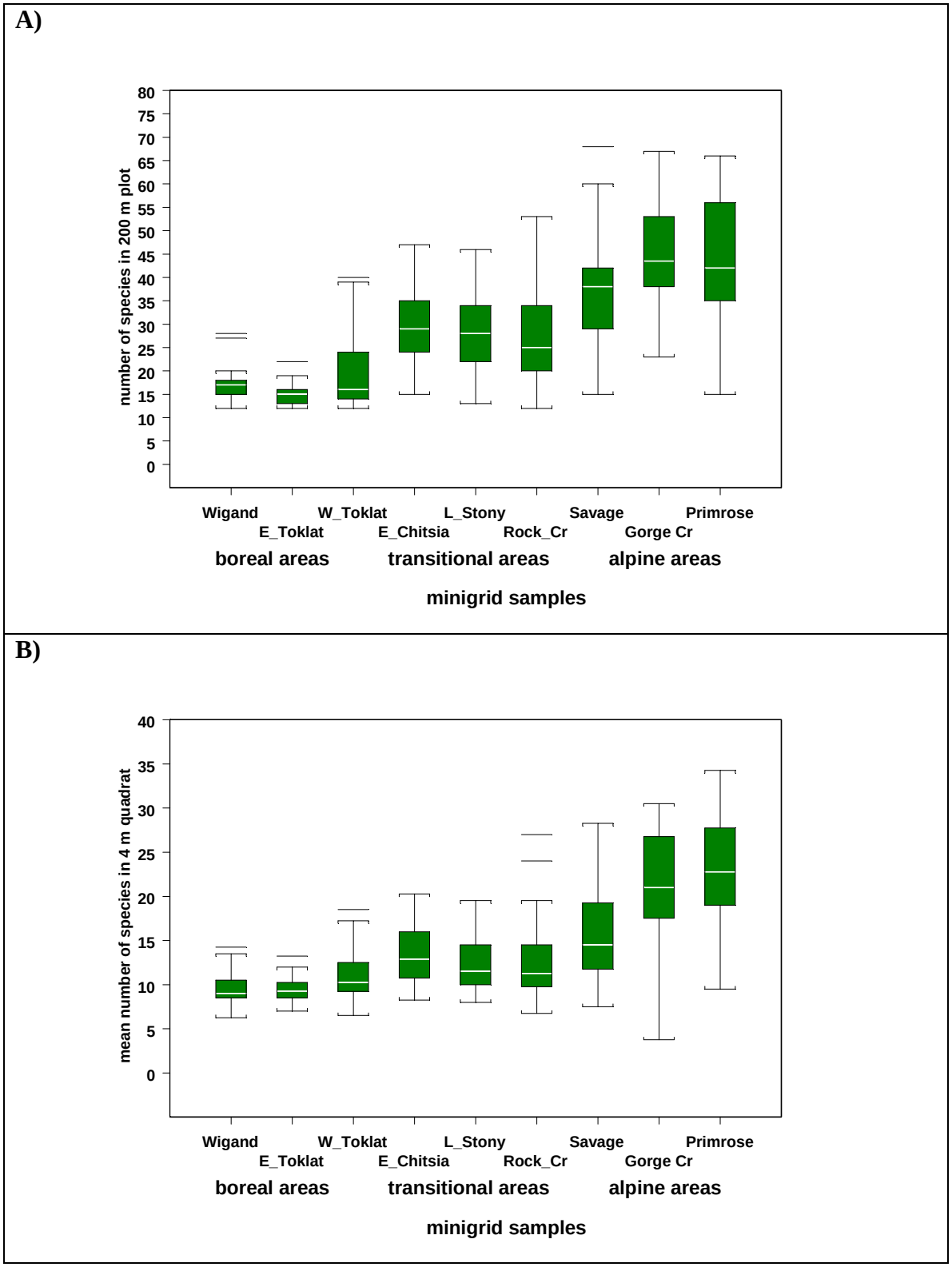

Figure 5.21. The ranges of variation in two metrics of mean vascular plant species richness within and among nine minigrid samples measured in Denali National Park, Alaska: A) mean number of species per plot (200 m^2); B) mean number of species per 4 m^2 quadrat.

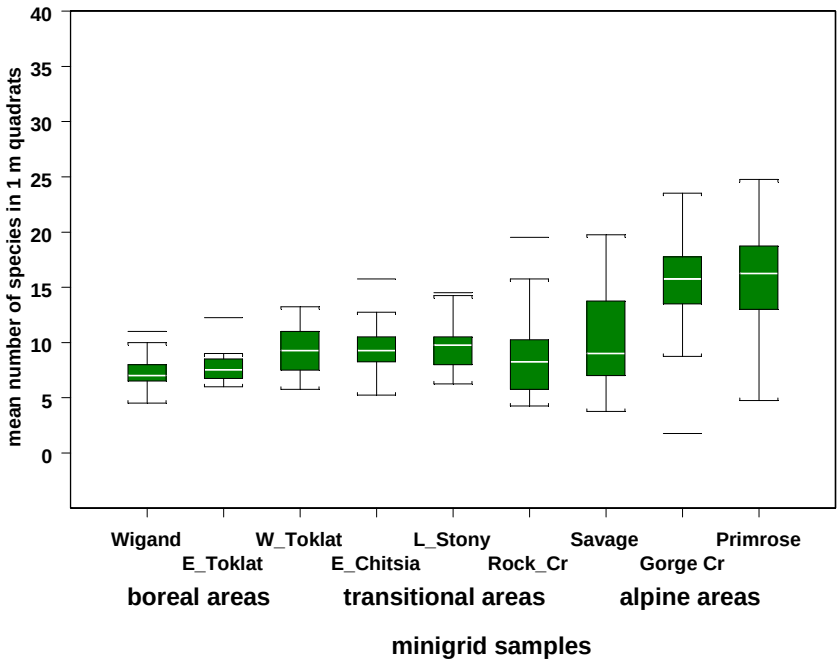

Figure 5.22A. The ranges of variation in the mean number of vascular plant species in 1 m^2 quadrats within and among nine minigrid samples measured in Denali National Park, Alaska.

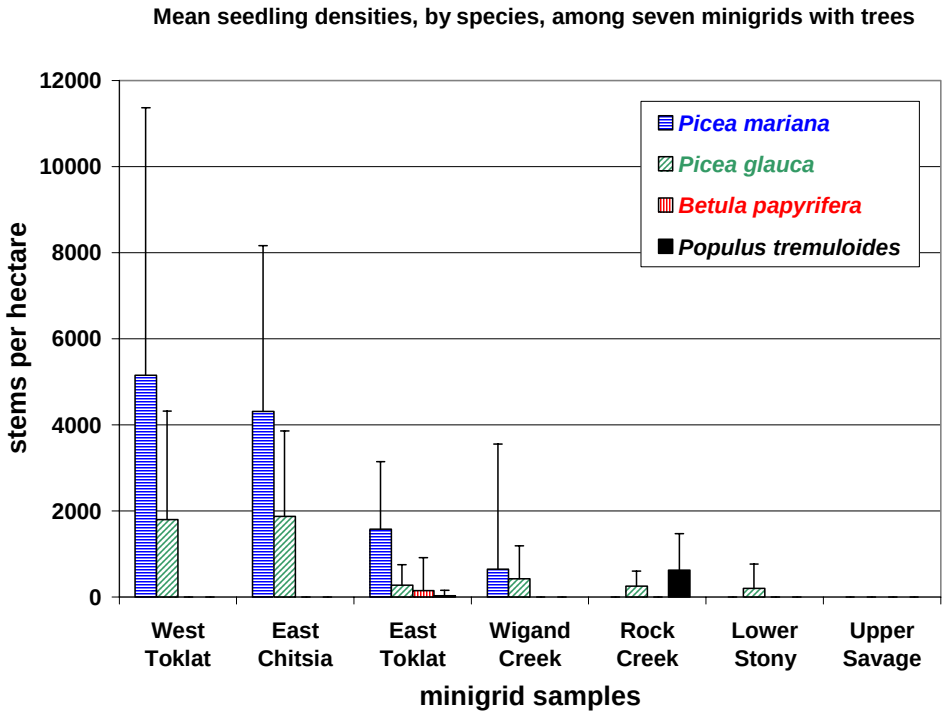

Figure 5.22B. The mean seedling densities, by species observed for each of the seven minigrid samples in which trees were observed during pilot study. Please note that minigrid samples are arranged along X axis in descending order of seedling density!!

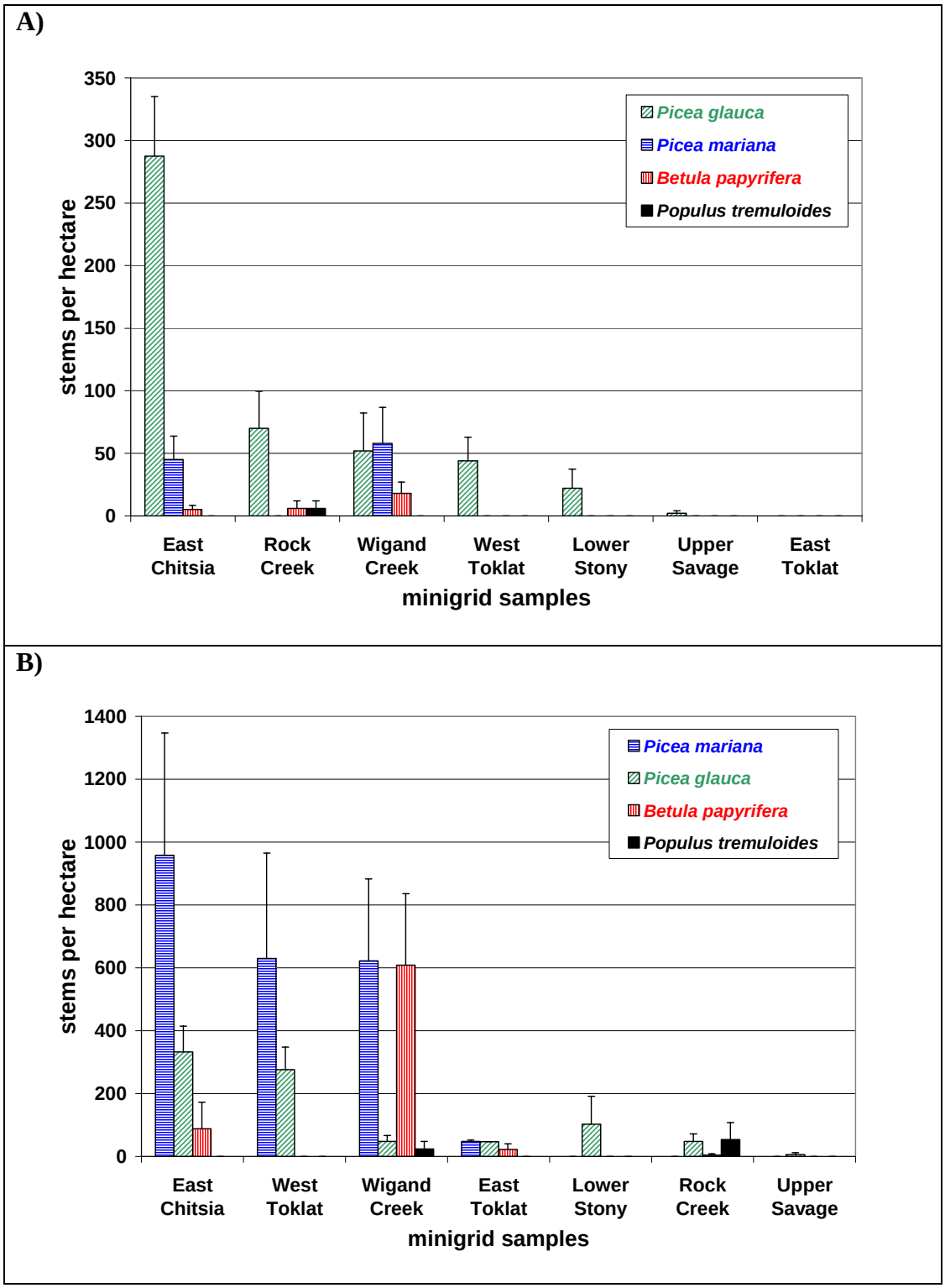

Figure 5.23. Mean densities, by species, for live individuals of four selected tree species in two different size classes measured in seven minigrid samples in Denali National Park, Alaska: A) tree density; B) sapling density. Please note that for each figure, minigrid samples are arranged on X axis in descending order of highest tree density and highest sapling density, respectively!!

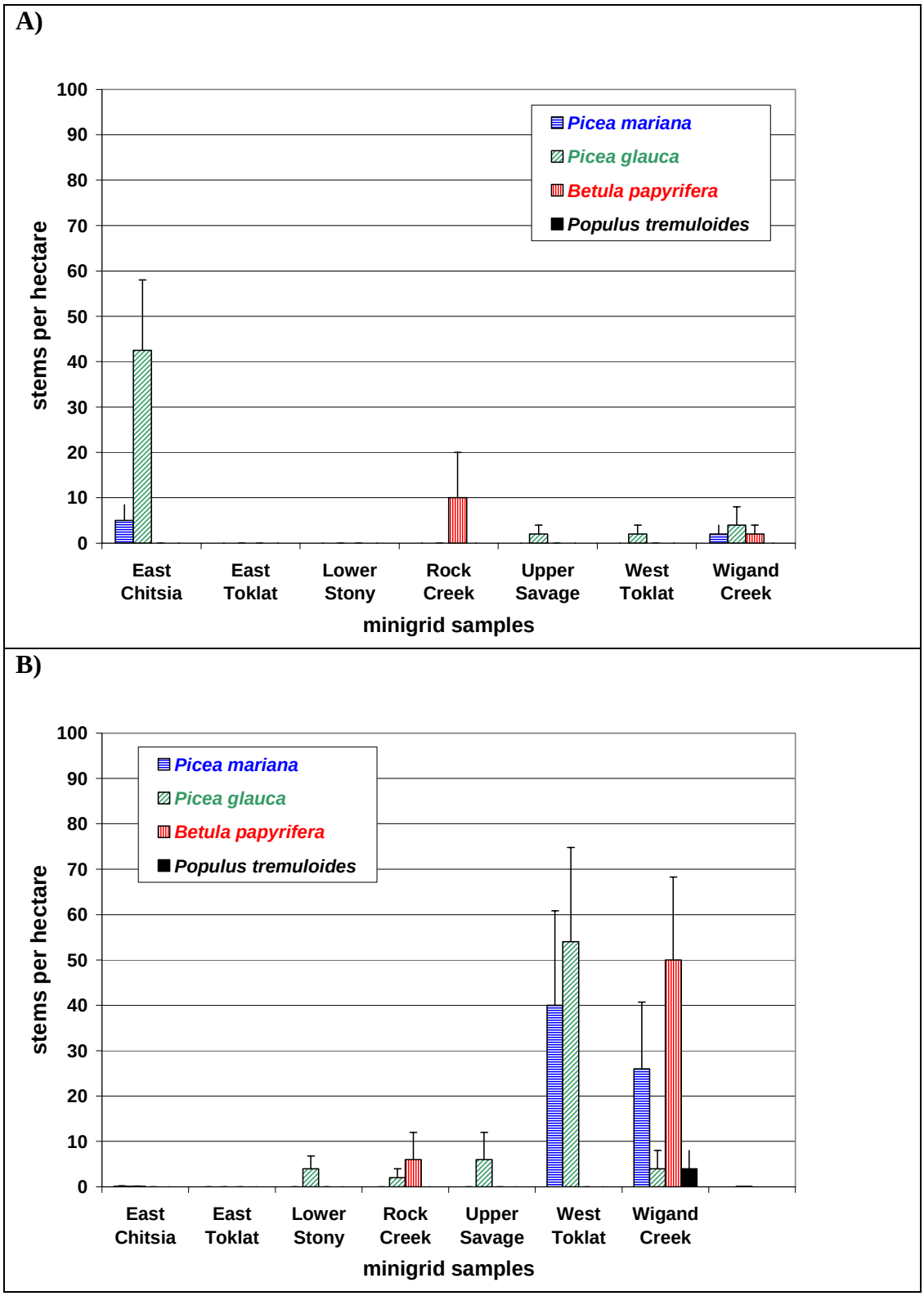

Figure 5.24. Mean densities, by species, for number of dead individuals of four tree species in two different size classes measured in 7 minigrid samples in Denali National Park, Alaska: A) tree density (>12 cm dbh); B) sapling density (<12 cm dbh). Minigrids arranged on x axis in descending order, based on the mean density of *live* trees IN SAMPLE!!

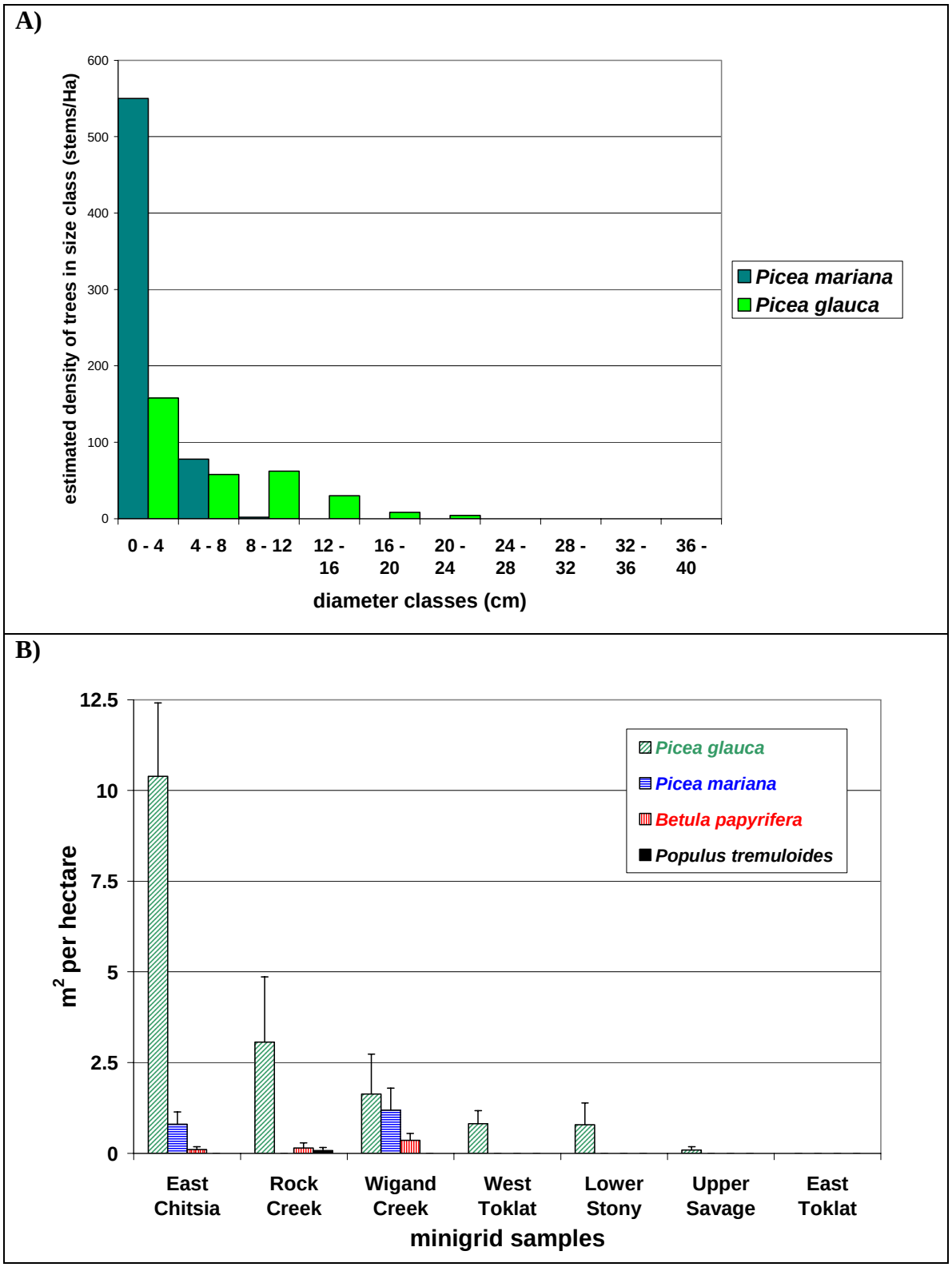

Figure 5.25. Attributes of tree size, by species, measured in Denali National Park, Alaska: A) size-class histograms for white and black spruce tree populations measured in the West Toklat minigrid sample; B) estimated mean basal area of trees, by species, for seven minigrids in Denali National Park, Alaska.

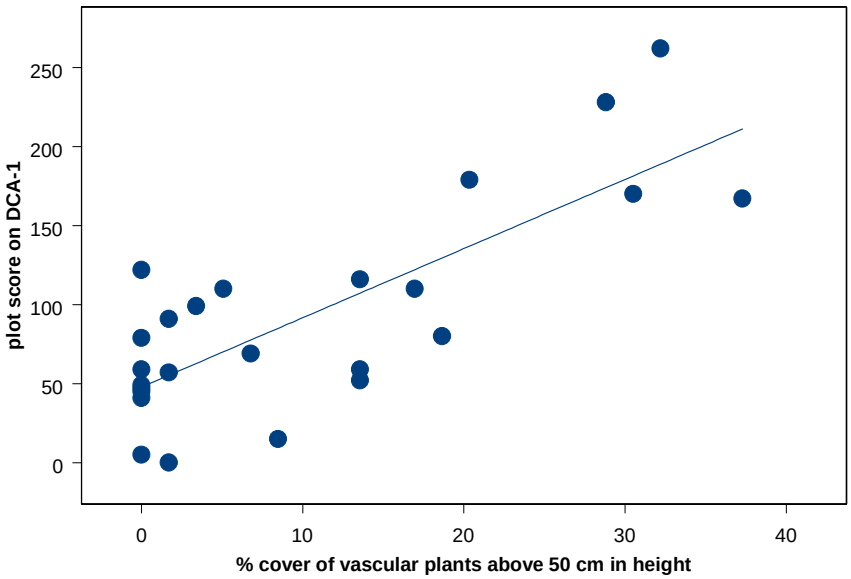

Figure 5.26. Plot score on DCA-1 was strongly correlated with the percent cover of vascular plants above 50 cm in height among the 25 plots measured in the West Toklat minigrid.

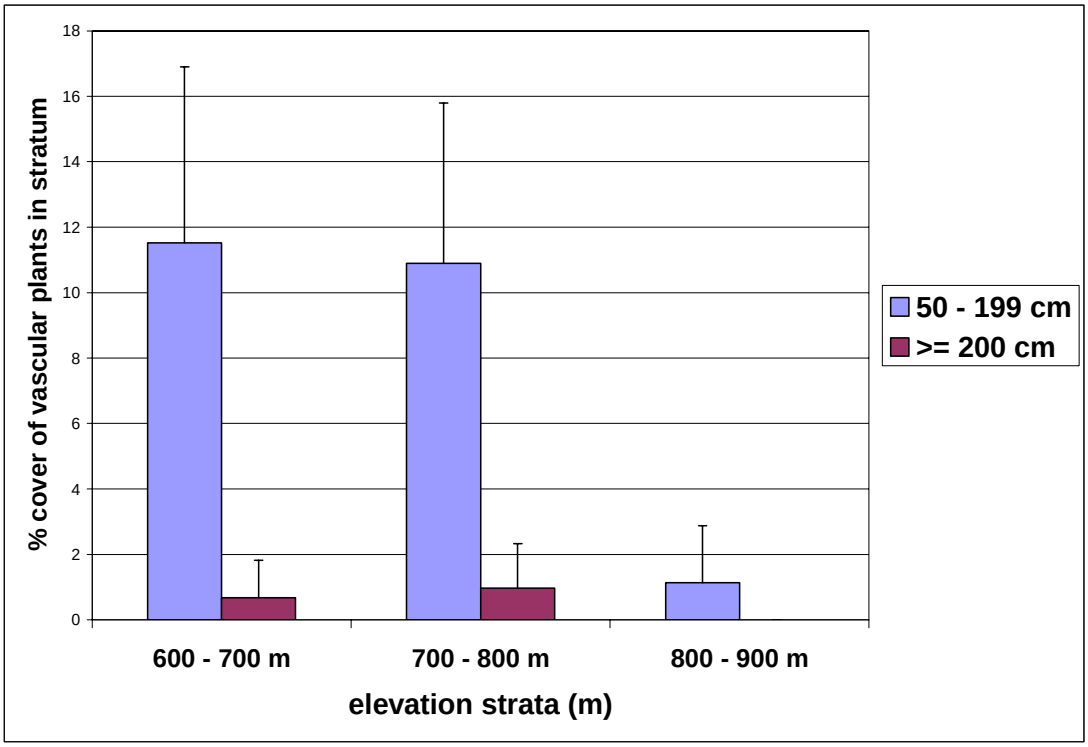

Figure 5.27. The cover of vascular plants in two vertical strata (> 2 m, and 50-199 cm) across the categories of elevation in the West Toklat minigrid sample.

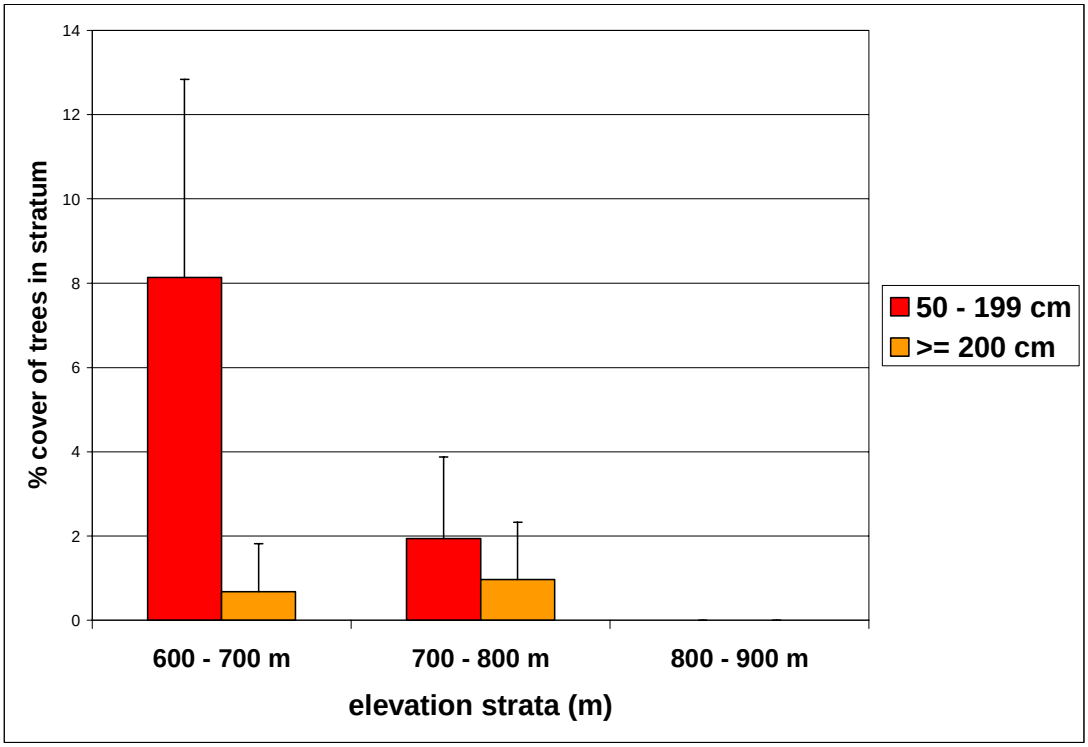

Figure 5.28. Mean percent cover of trees in each of three strata of elevation defined for the West Toklat minigrid sample.

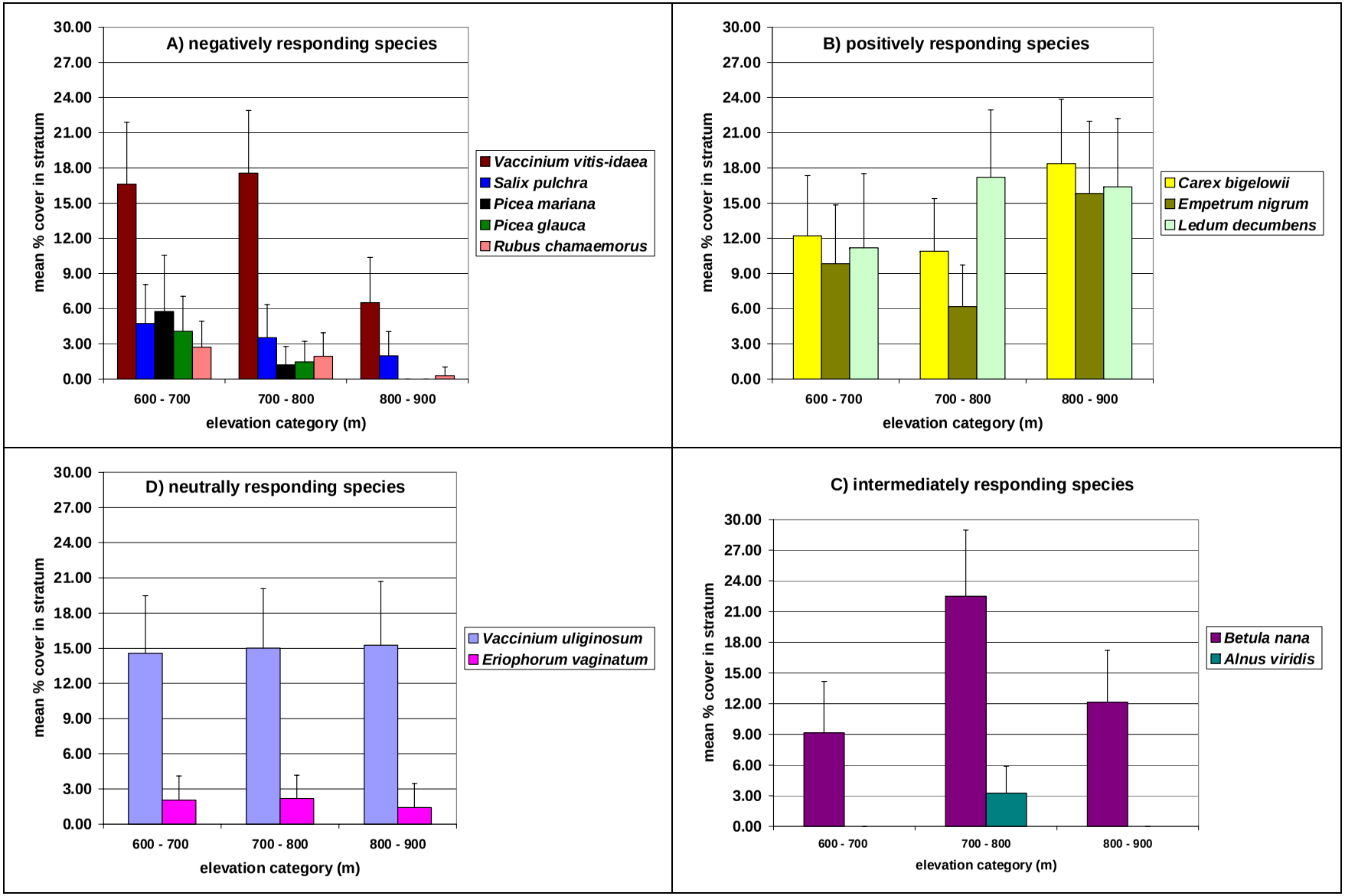

Figure 5.29. Gradient analyses of cover of 12 dominant plant species within the West Toklat minigrid sample revealed differences in the response of cover percentages across the three elevation zones identified within this sample, clockwise from upper left: A) species that generally decreased in cover in the highest elevation stratum; B) species that generally increased in cover in the highest elevation stratum; C) species that had highest cover in intermediate elevation stratum; D) species that were apparently neutral across this environmental gradient.

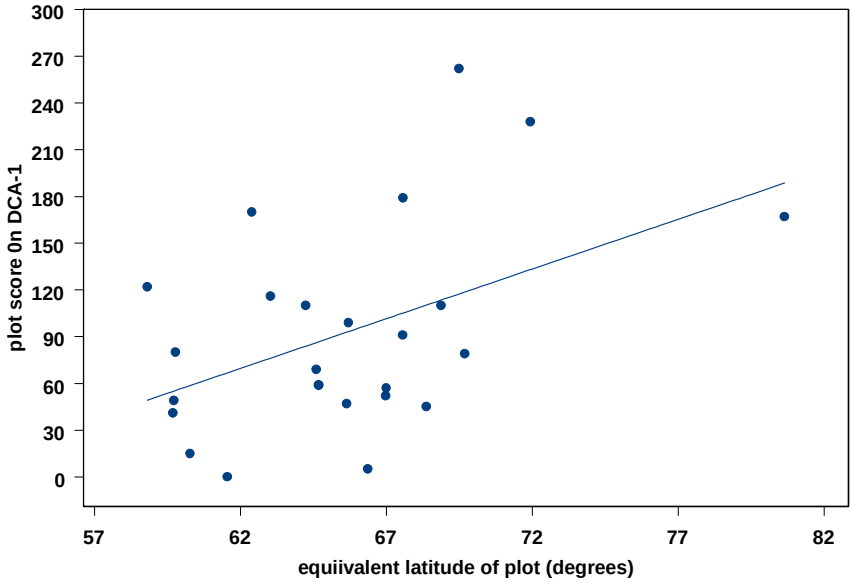

Figure 5.30. The relationship between equivalent latitude of a plot and plot vegetation score on DCA-1 for 25 points measured in the West Toklat minigrid sample (line is fitted least squares regression).

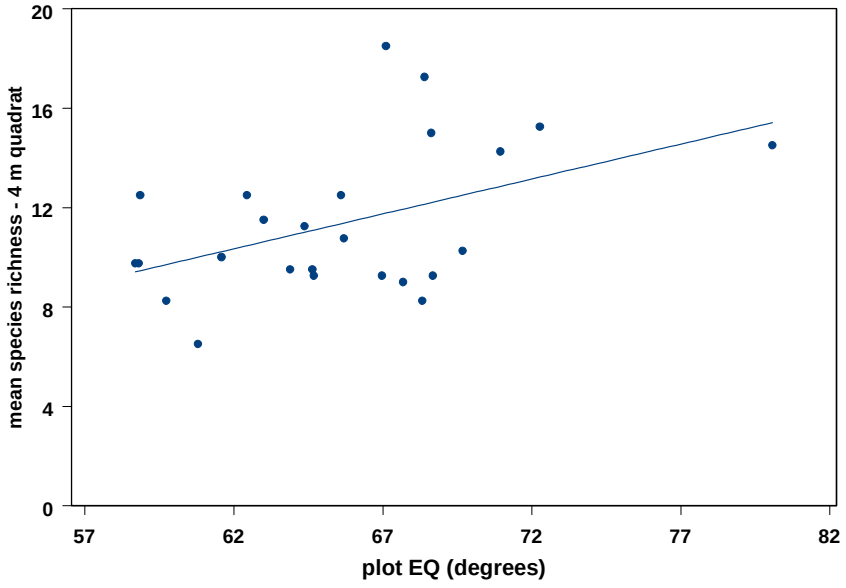

Figure 5.31. The relationship between equivalent latitude of a plot and mean species richness in 4 m^2 quadrats for 25 points measured in the West Toklat minigrid sample (line is fitted least squares regression).

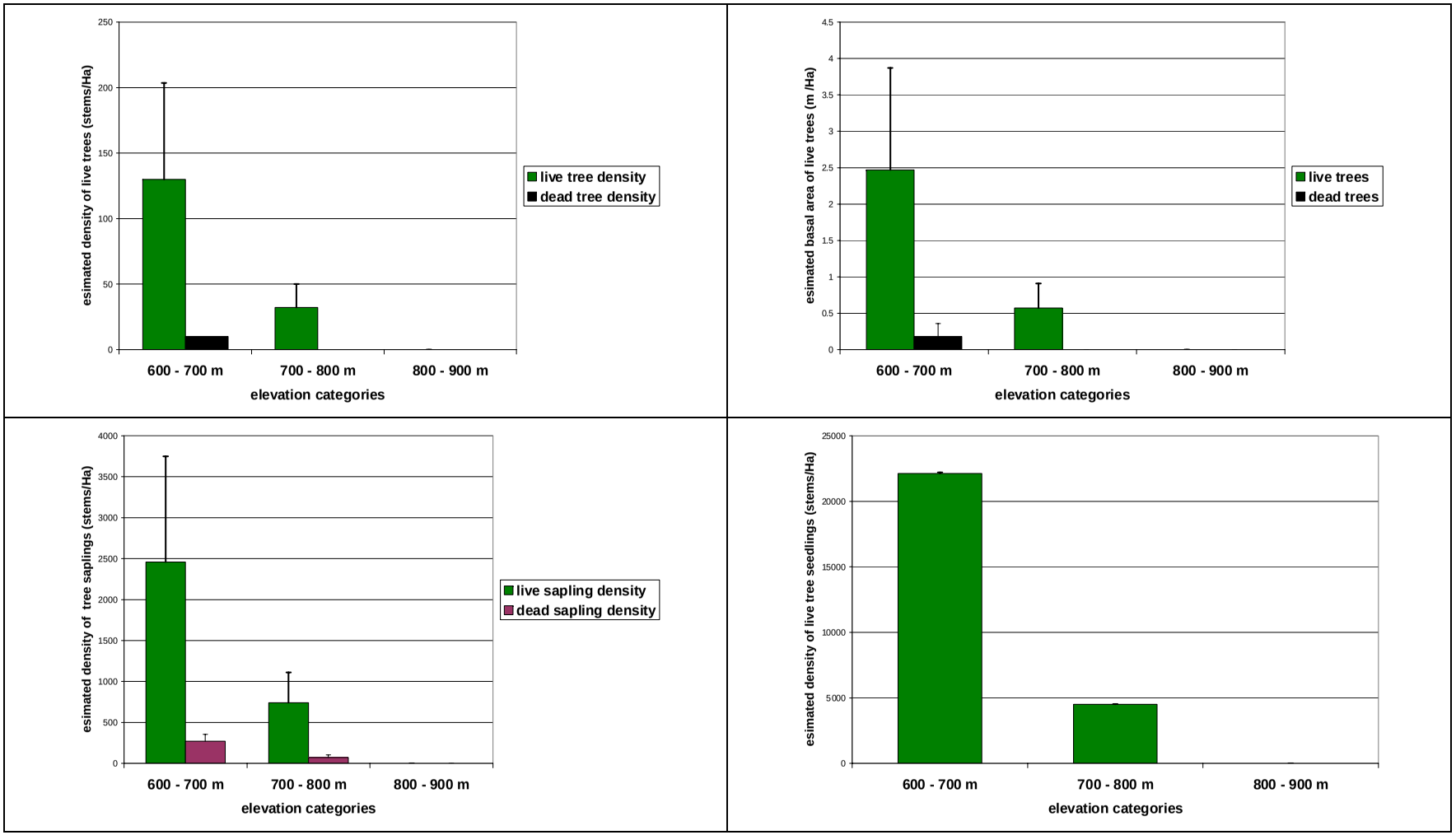

Figure 5.32. Gradient analyses of all aspects of tree density and basal area showed a decrease in tree abundance with increasing elevation within the West Toklat minigrid sample, clockwise from upper left: A) estimated density of live and dead trees in three strata of elevation; B) estimated basal area of live and dead trees in three strata of elevation; C) estimated density of live seedlings in three strata of elevation; D) estimated density of live and dead saplings in three strata of elevation.

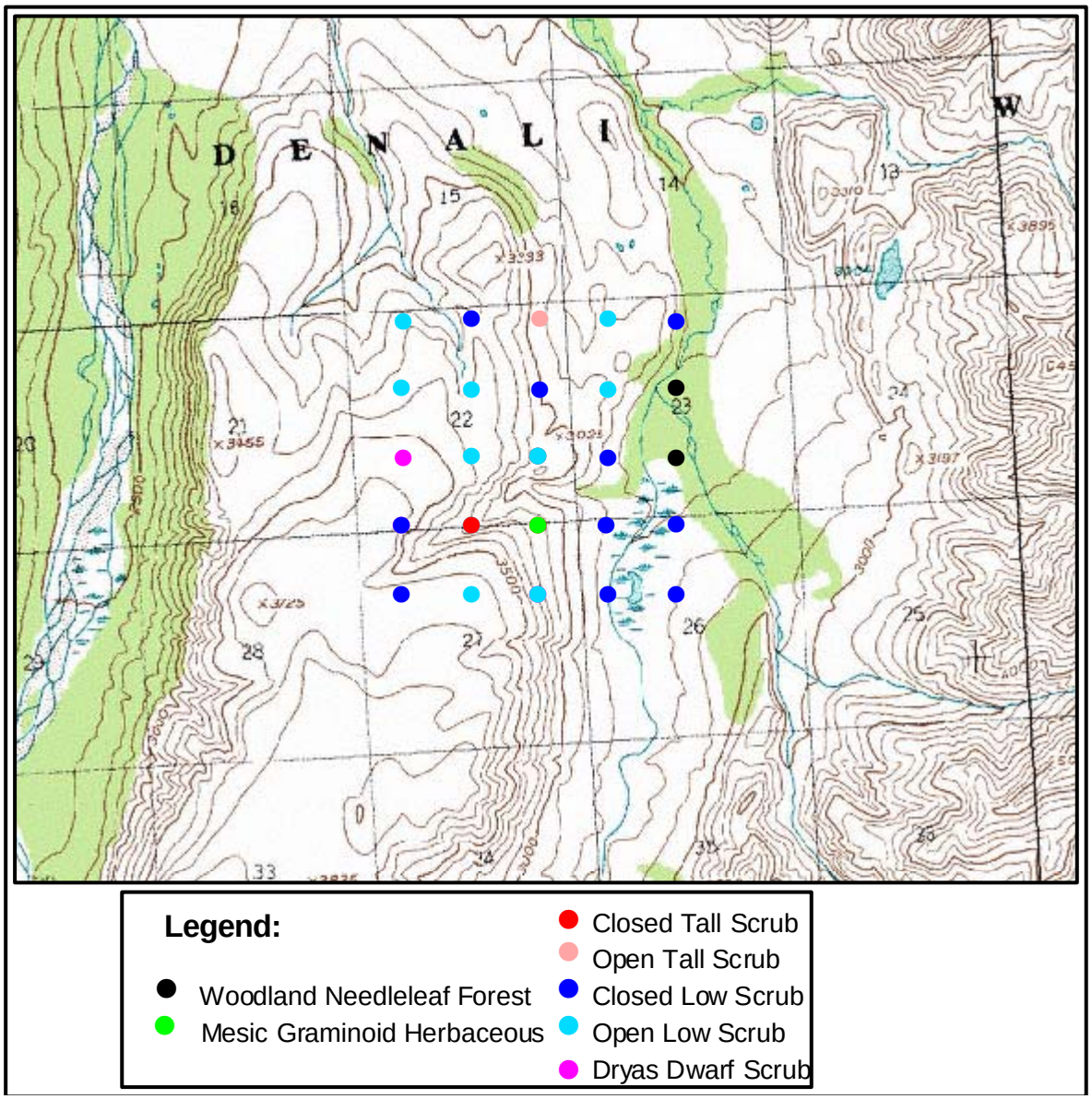

Figure 5.33: Map showing the location of the sample points in the Lower Stony Creek minigrid sample – dots are color-coded to represent the primary Viereck level III vegetation classes observed at each of the points.

Figure 5.34A. Panoramic image looking northwest at landscape of Lower Stony Creek minigrid sample from point #1. The majority of the minigrid is visible from this point.

Figure 5.34B. Panoramic image looking northeast at landscape of Lower Stony Creek minigrid sample from point #3. This photograph shows alpine area of the sample in the foreground.

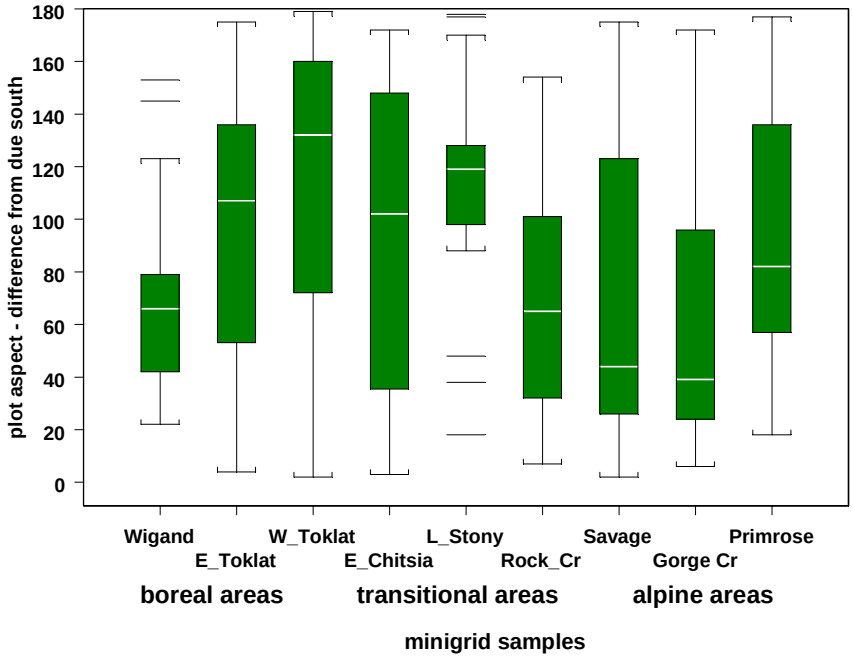

Figure 5.35. Range of observations in difference of plot aspect from due south (= absolute value of [plot aspect -180 degrees]) within and among nine minigrid samples measured in Denali National Park, Alaska.

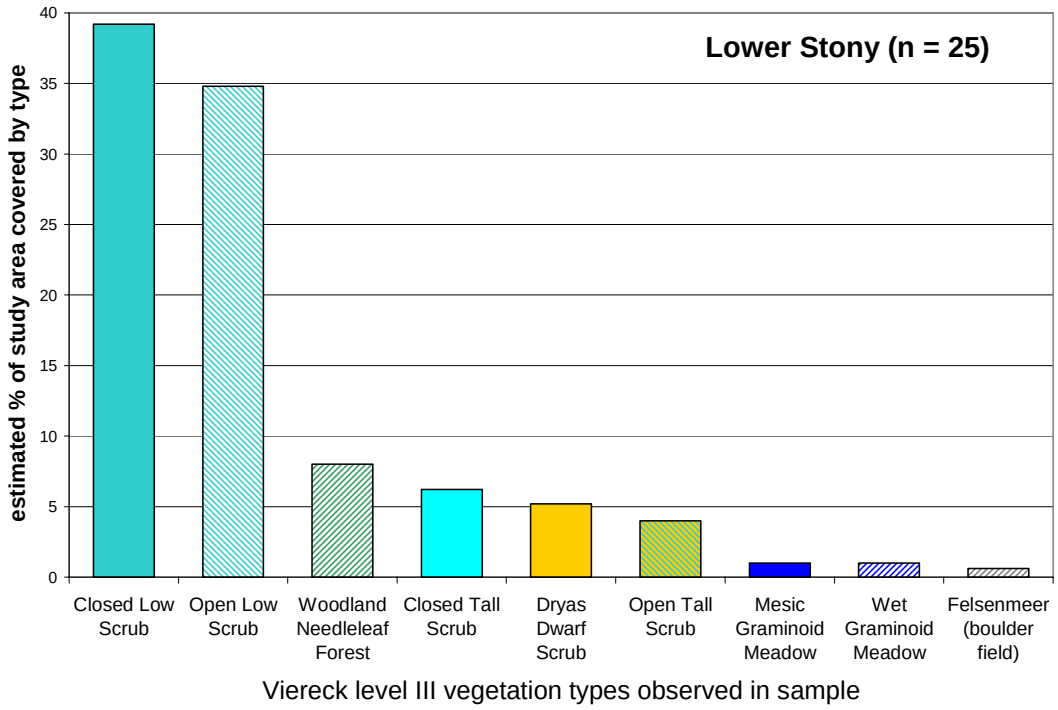

Figure 5.36. Estimated percentage of the Lower Stony Creek minigrid study area occupied by nine vegetation types (classified at Viereck level III) observed in the sample plots.

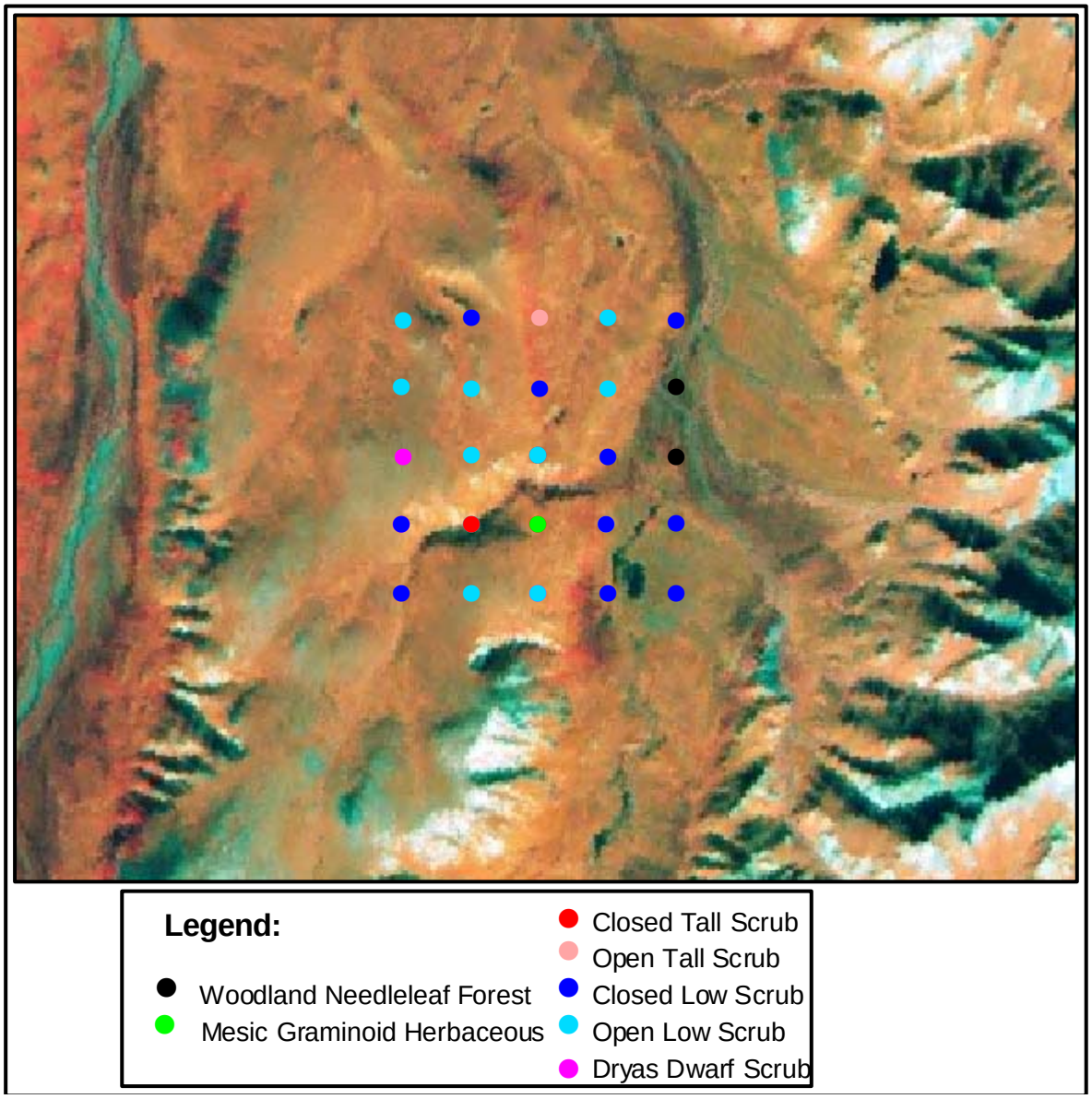

Figure 5.37. Location of 25 sample points measured in the Lower Stony minigrid sample, projected over the SPOT satellite image (color IR spectrum) for the area. Dots are color-coded to the Viereck level III vegetation classifications made by the field crew. (NOTE: some plots have two vegetation types within them, in these instances the predominant type is shown in the above figure).

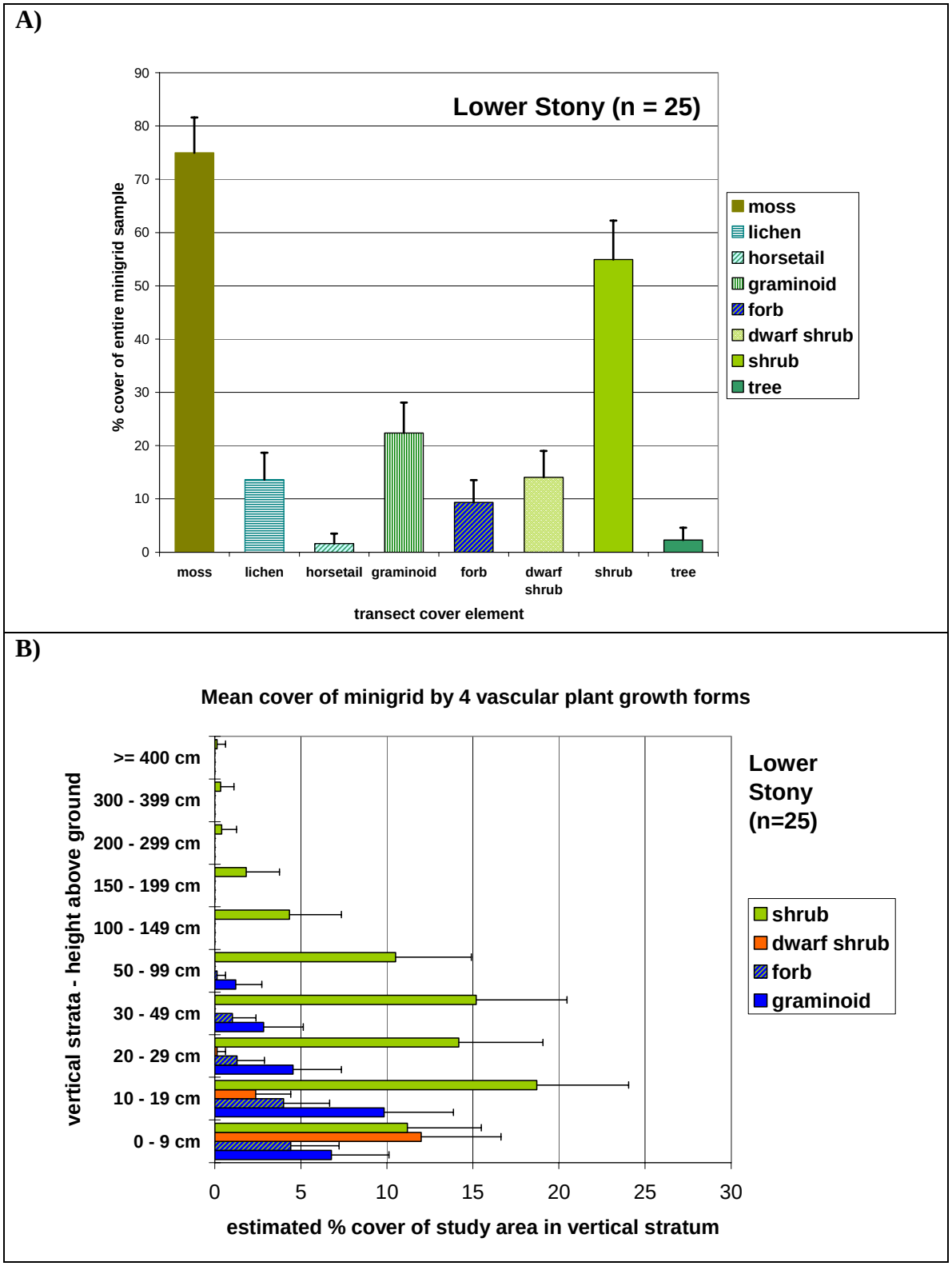

Figure 5.38. Percent of the entire Lower Stony minigrid sample by different aspects of the vegetation cover: A) percent cover of the minigrid by eight transect cover elements; B) vertical distribution of plant cover by four dominant vascular plant growth forms.

A)

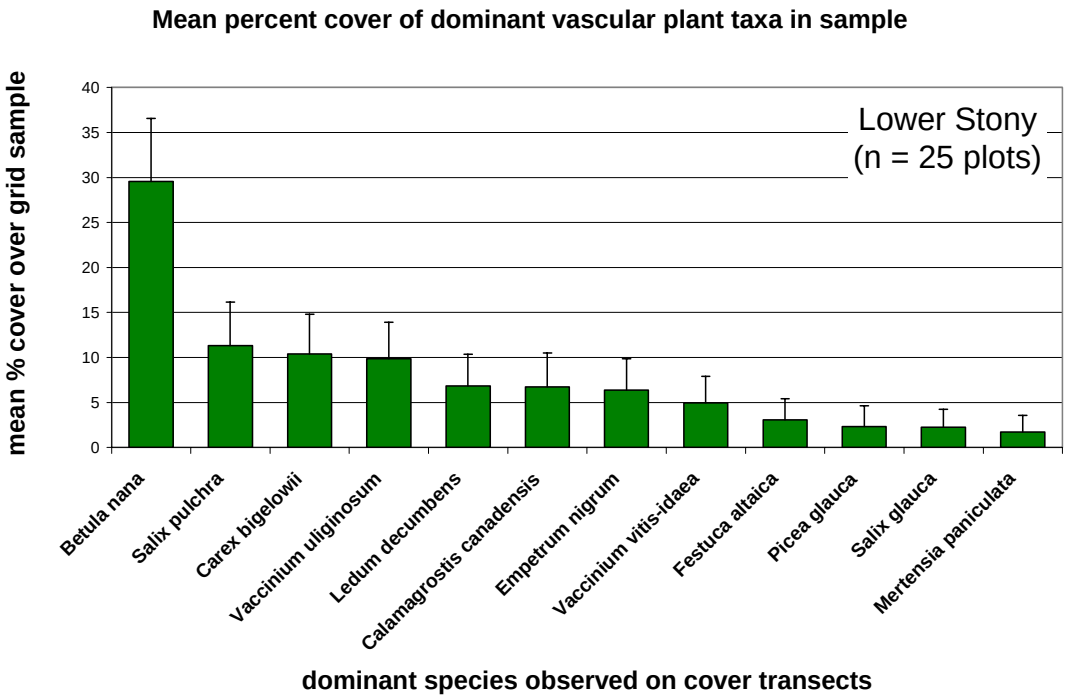

Figure 5.39A Estimated mean percent cover of the Lower Stony minigrid by twelve most abundant vascular plant species observed in sample.

B)

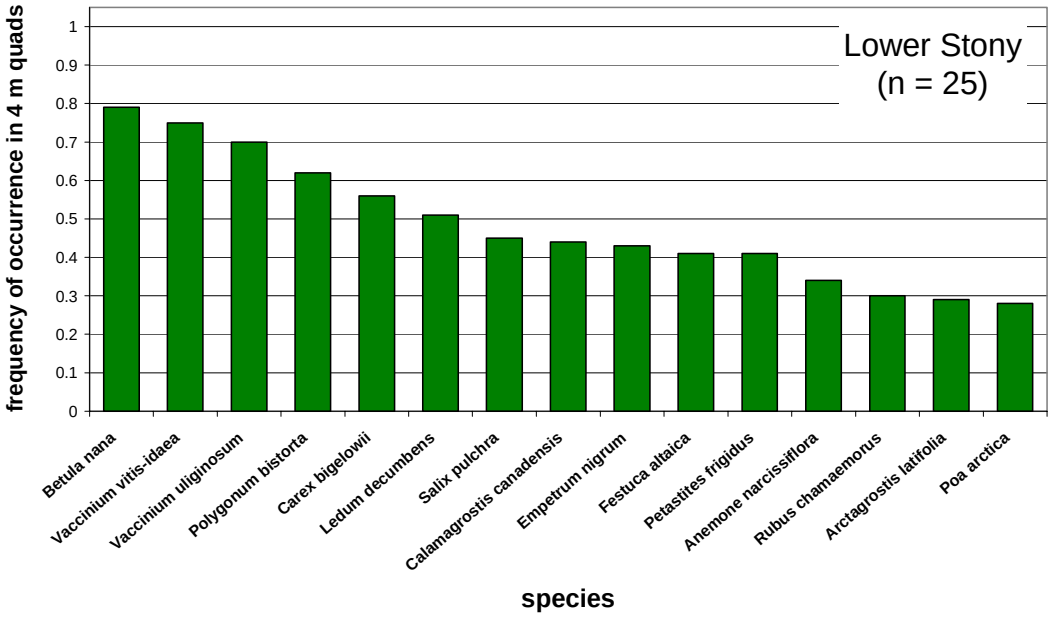

Figure 5.39B Frequency of 15 vascular plant species that occurred at highest frequencies within the Lower Stony Creek minigrid sample.

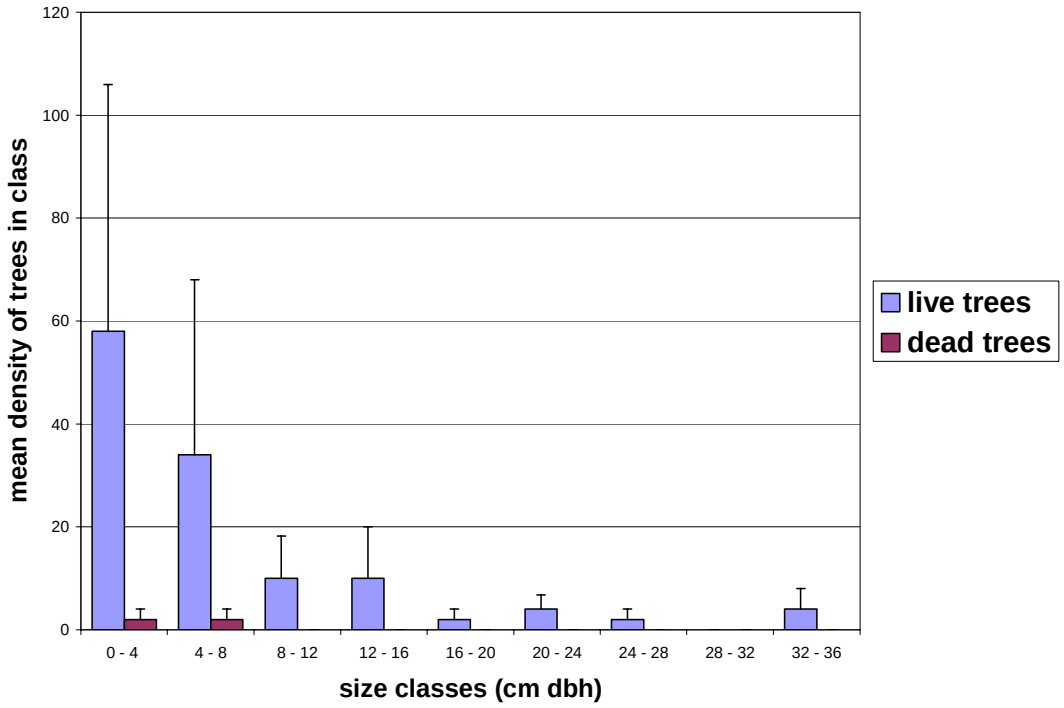

Figure 5.40. Size class histogram for population of live and dead white spruce trees measured in the Lower Stony Creek minigrid sample.

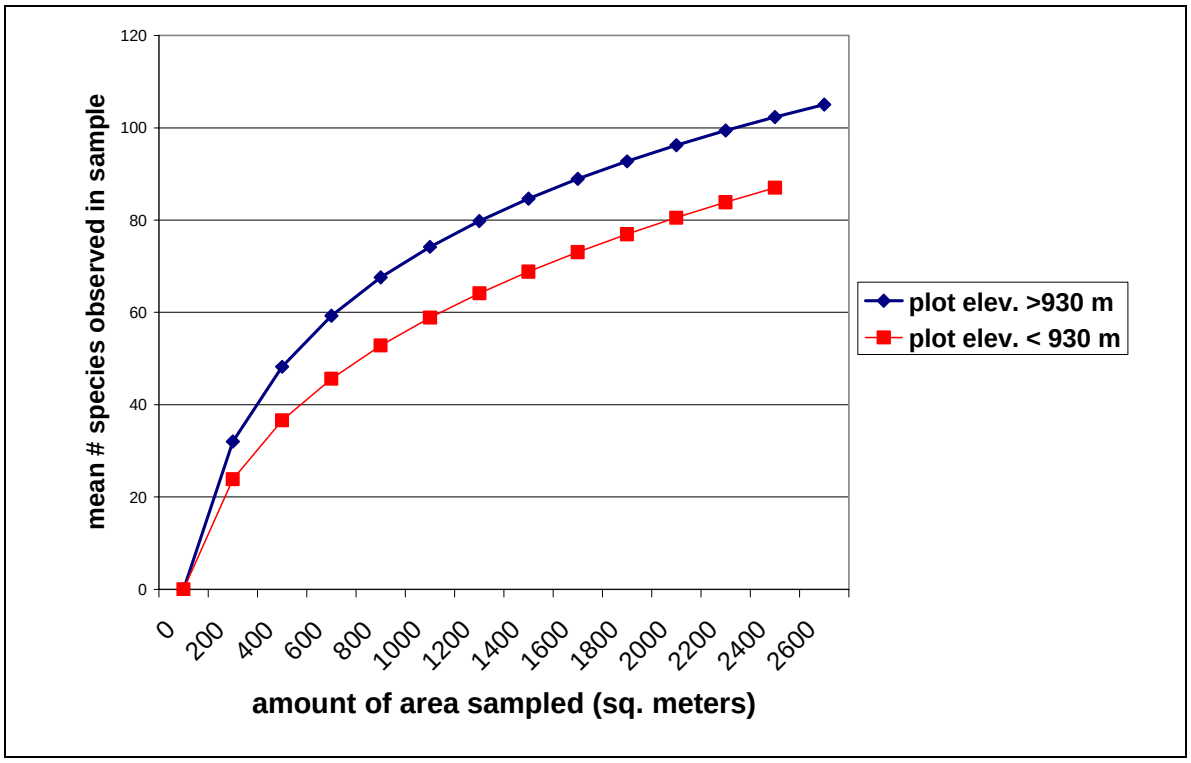

Figure 5.41 Cumulative species acquisition curves for groups of plots in two strata of elevation in the Lower Stony Creek minigrid sample (13 plots above median elevation, 12 plots below median elevation).

A)

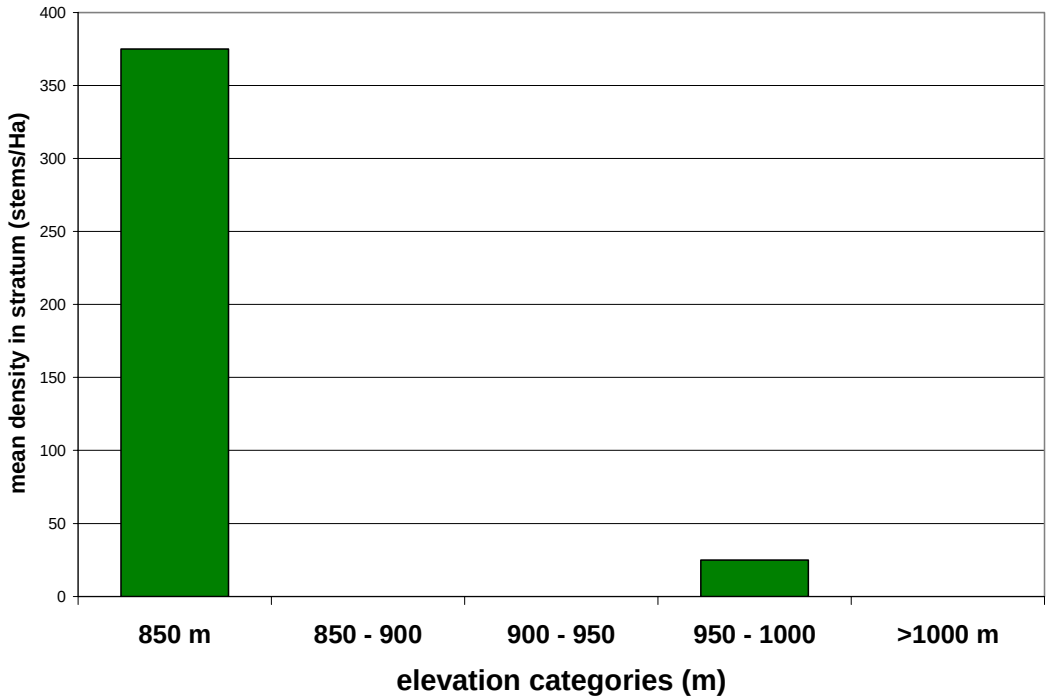

Figure 5.42A. Gradient analysis of tree density within the Lower Stony Creek minigrid, including both trees and saplings (all individuals >1.37 m in height combined).

B)

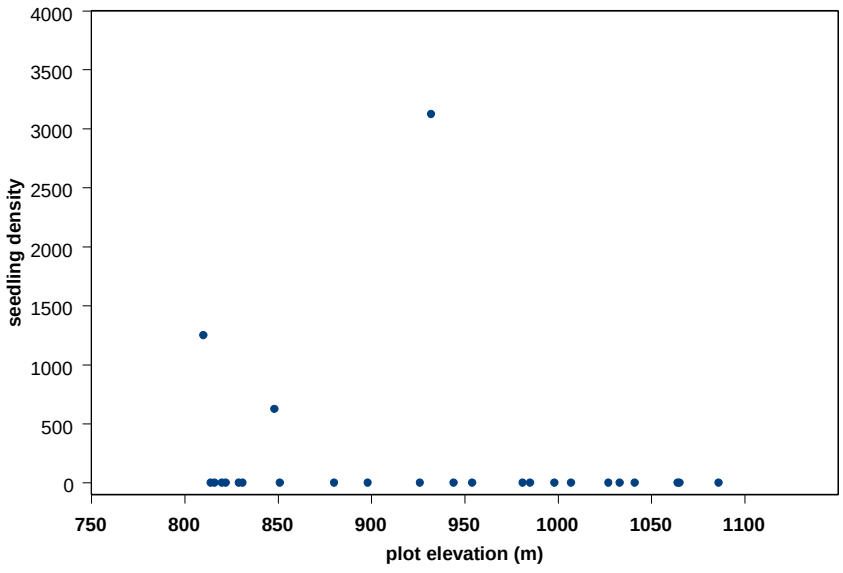

Figure 5.42B. Scatter plot showing relationship between seedling density and plot elevation for all 25 plots in the Lower Stony Creek minigrid.

Figure 5.43A. Panoramic image showing character of the alpine landscape in the upper elevations of the Primrose Ridge minigrid sample. Photo is looking north from point #11 down drainage feature on north side of the ridge.

Figure 5.43B. Photographs of tall scrub-forb vegetation in gully feature at lower elevation within Primrose Ridge minigrid. Photographs were both from plot # 24

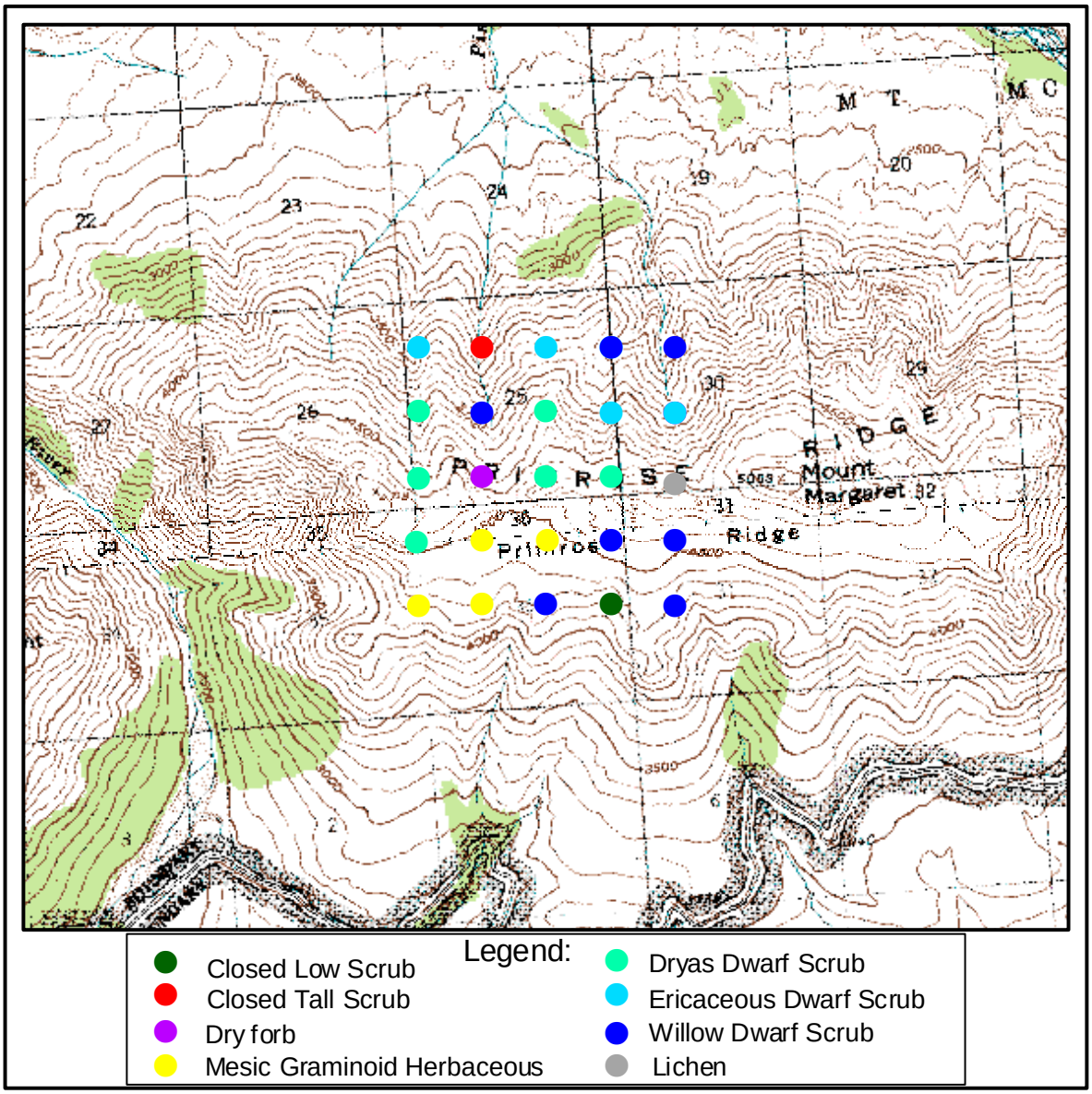

Figure 5.44. Map showing location of the 25 sample points measured in the Primrose Ridge minigrid sample, dots are color-coded to represent the Viereck level III vegetation types observed in the plots during field measurements.

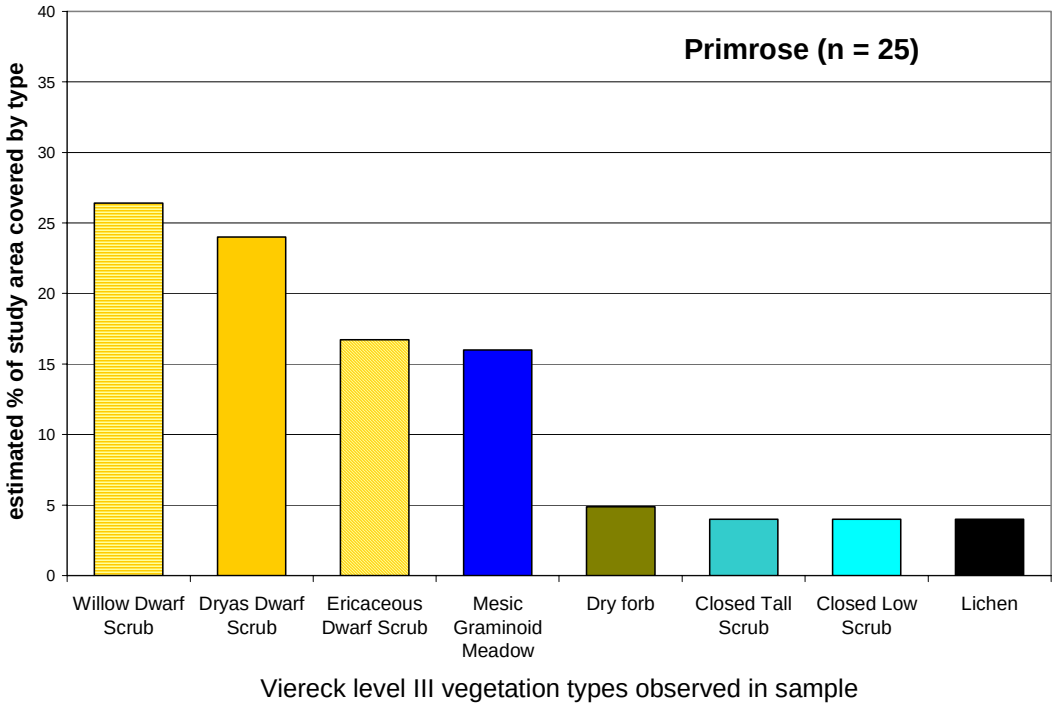

Figure 5.45A. Percentage of the Primrose Ridge minigrid occupied by eight Viereck level III vegetation types observed in sample.

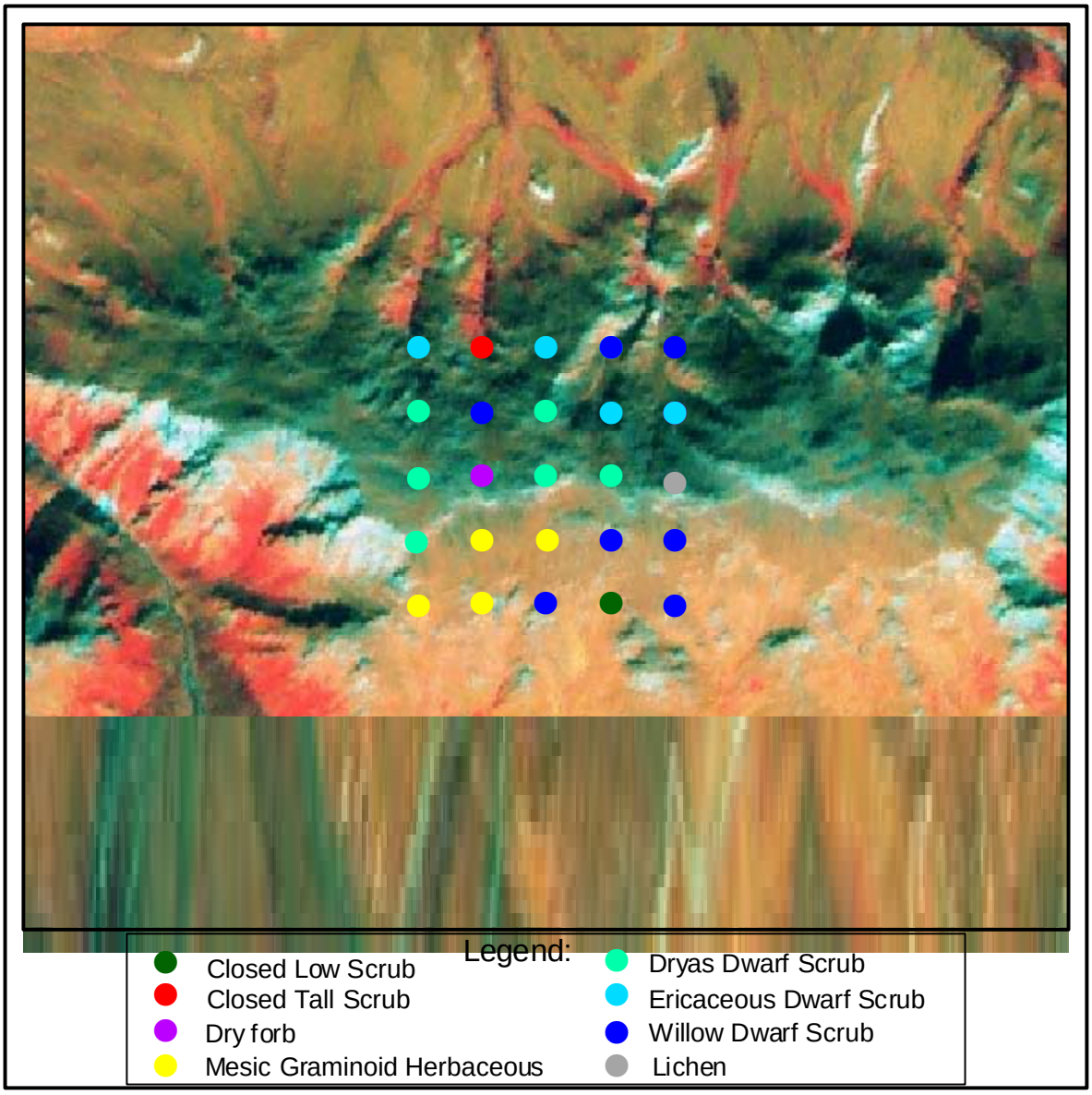

Figure 5.45B. Location of 25 sample points measured in the Primrose Ridge minigrid sample, projected over the SPOT satellite image (color IR spectrum) for the study area; dots are color-coded to the Viereck level III vegetation classifications made during field measurements.

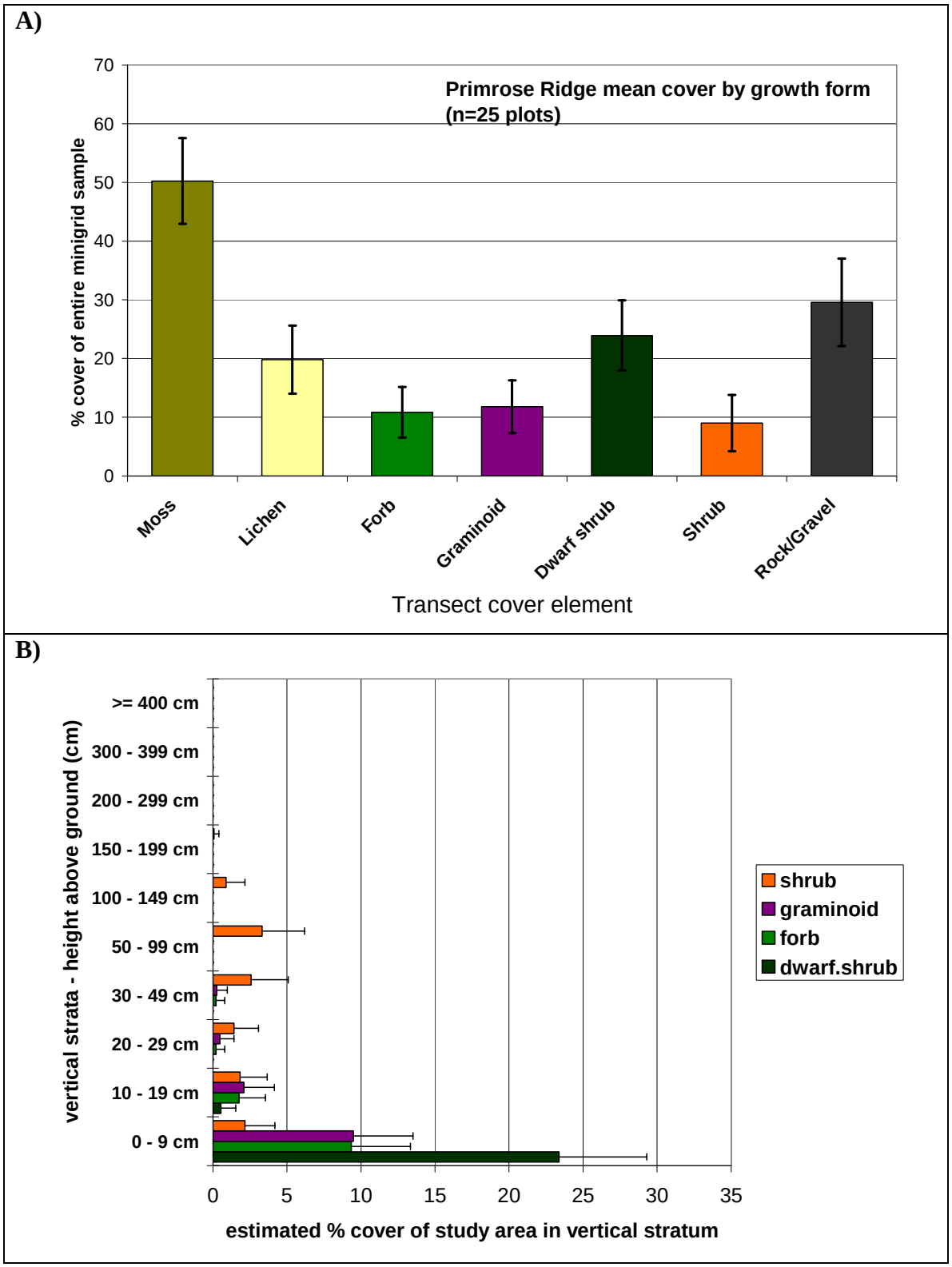

Figure 5.46. Percent cover of the entire Primrose Ridge minigrid sample by different aspects of the ground cover: A) percent cover of the area by different cover elements of the ground surface; B) vertical cover of four dominant growth form classes of vascular plants in minigrid.

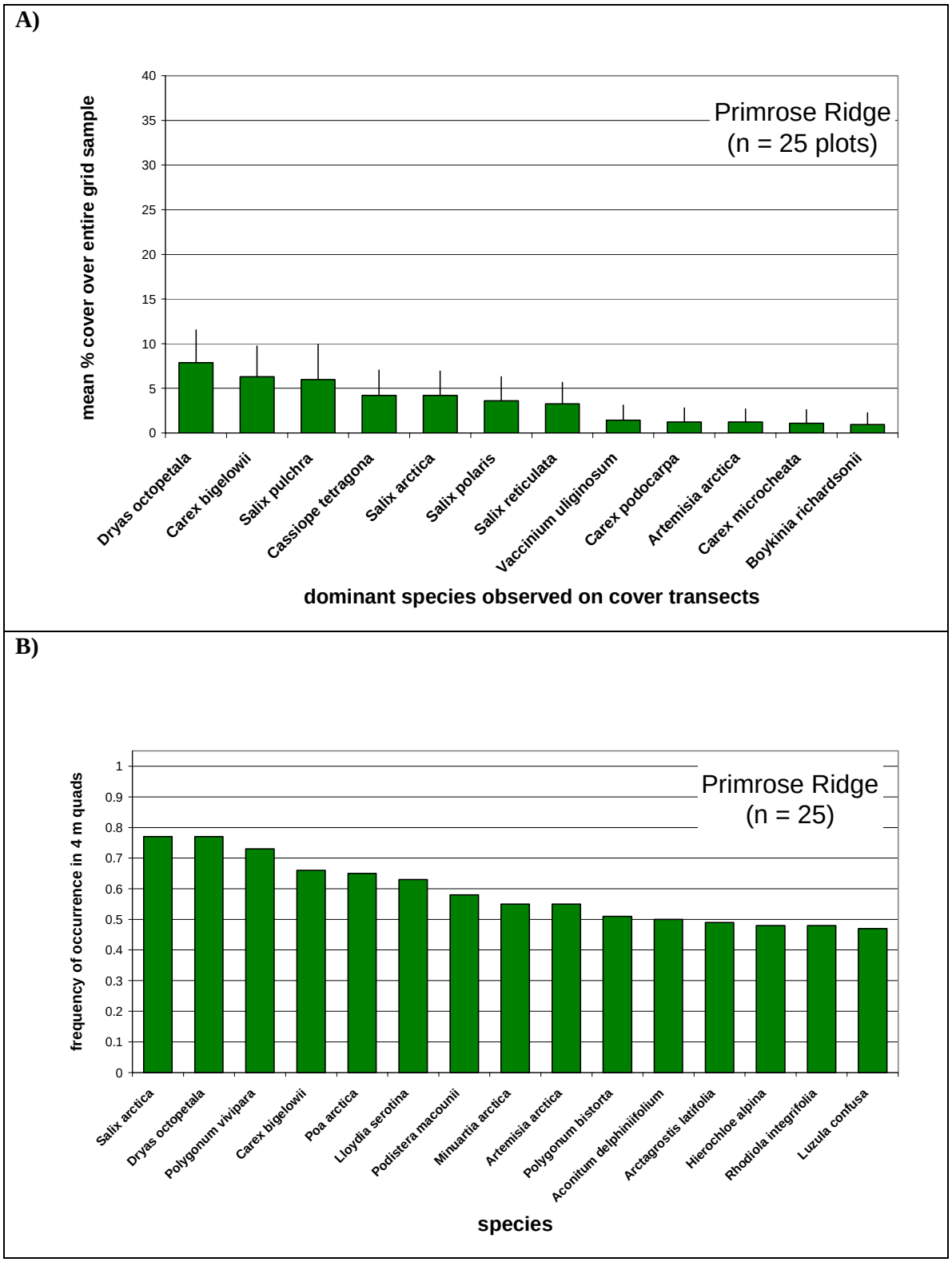

Figure 5.47. Most common vascular plant species observed in the Primrose Ridge minigrid sample: A) Twelve species that occurred at highest cover percentages in sample; B) frequency values for the 15 most common vascular plant species observed in the 4 m^2 quadrats.

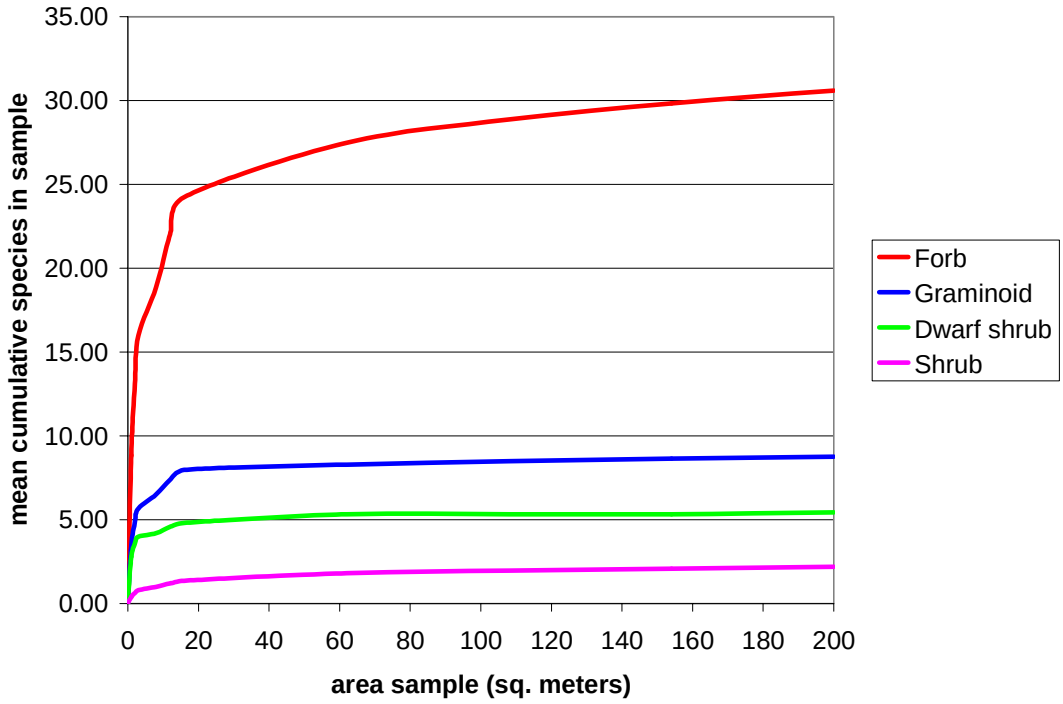

Figure 5.48. Mean species accumulation curves for four different vascular plant growth forms across all 25 plots in the Primrose Ridge minigrid sample.

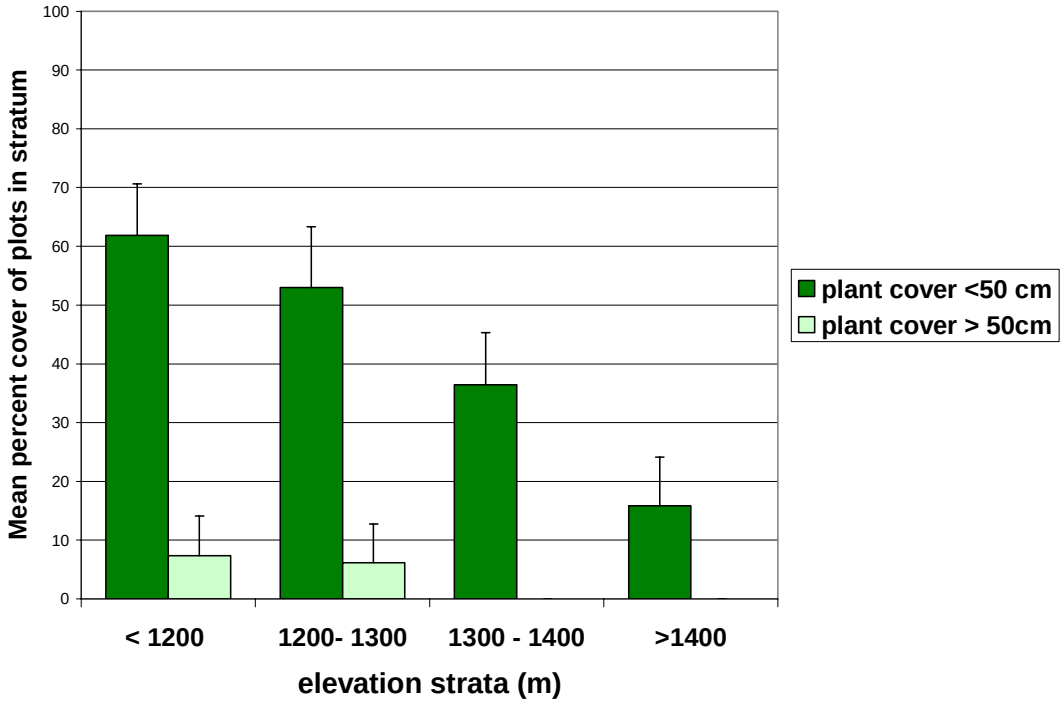

Figure 5.49. Gradient analysis of total vascular plant cover, in two vertical strata (>50cm and <50 cm above the ground), among four categories of elevation in the Primrose Ridge minigrid sample.

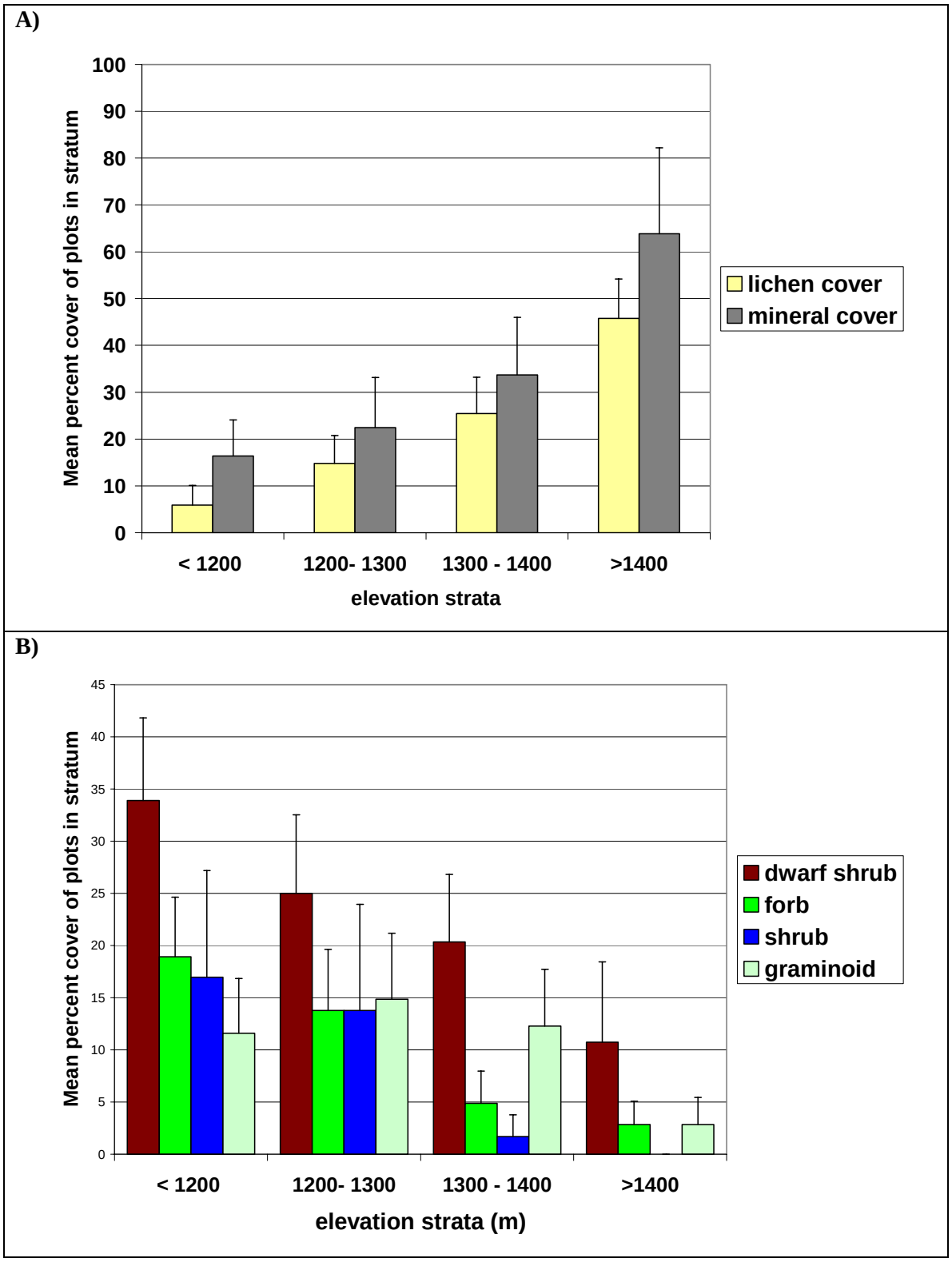

Figure 5.50. Gradient analyses of vegetative cover components among four categories of elevation in the Primrose Ridge minigrid sample: A) mineral cover and lichen cover; B) cover of four growth forms of vascular plants.

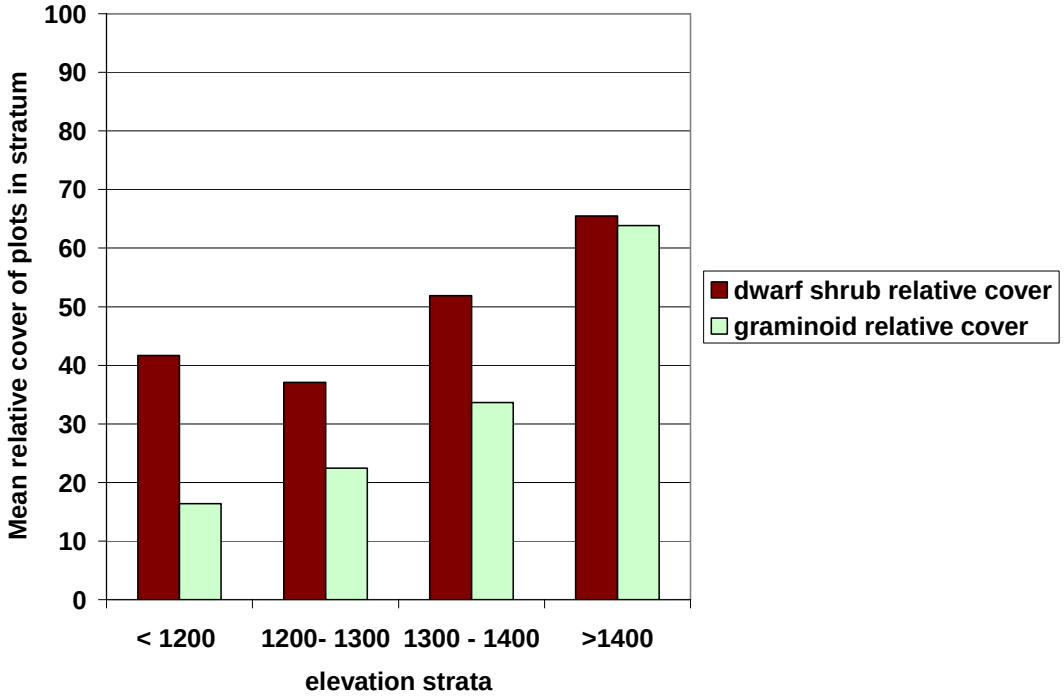

Figure 5.51. Gradient analyses of the relative cover of dwarf shrubs and graminoids within the vegetation among plots in four categories of elevation within the Primrose Ridge minigrid.

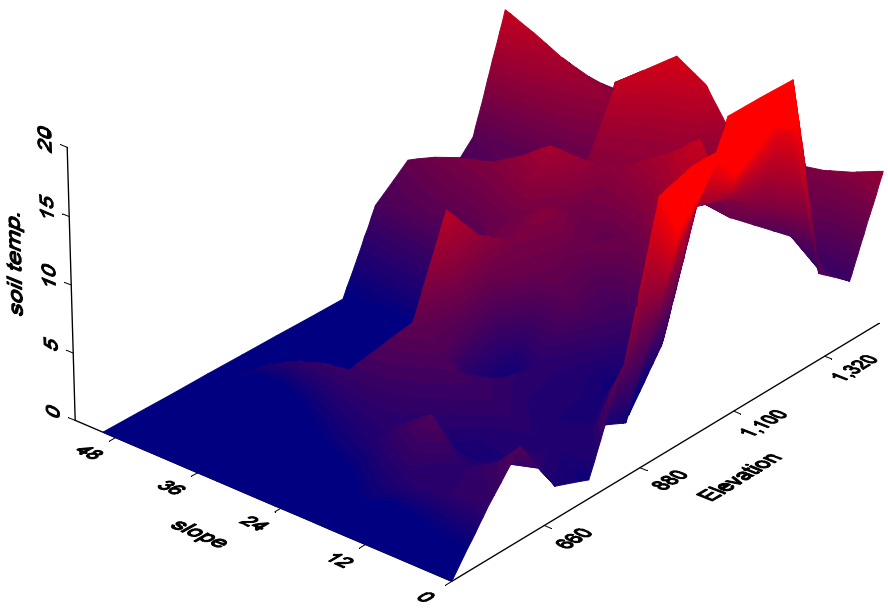

Figure 6.1. Response of soil temperature to slope angle and elevation within all plots measured for soil temperature in pilot study. Red hues denote warmer temperatures. Note apparent increase in temperature with elevation, a bit more varied response to slope angle.

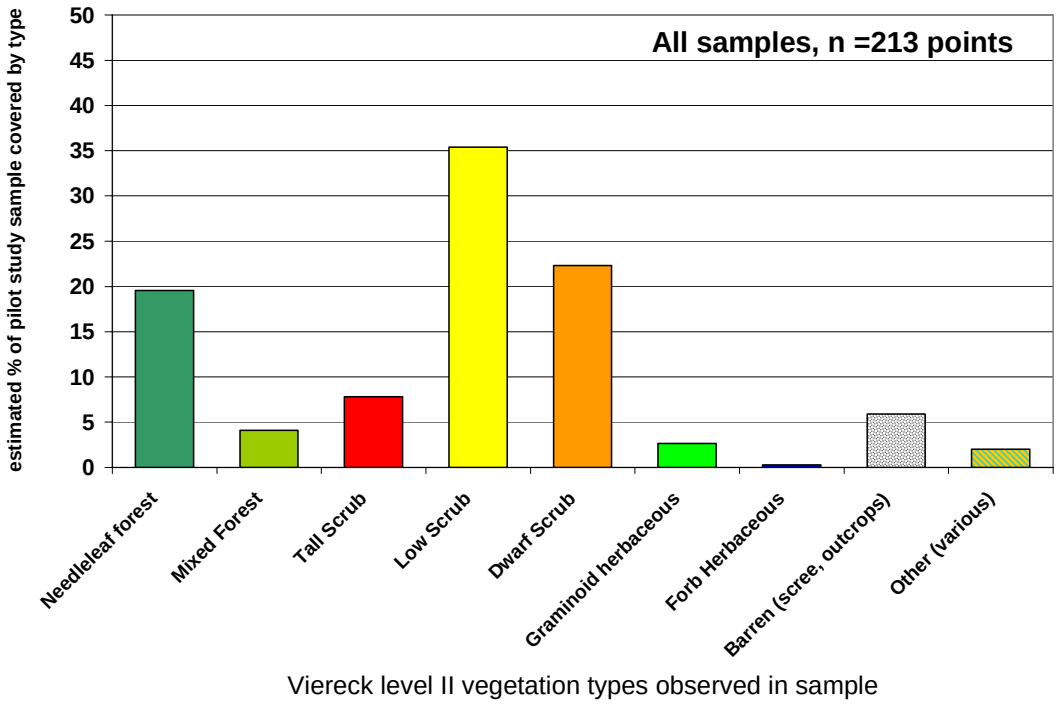

Figure 6.2. Histogram showing the percentage of the pilot study sample covered by nine Viereck level II vegetation classes.

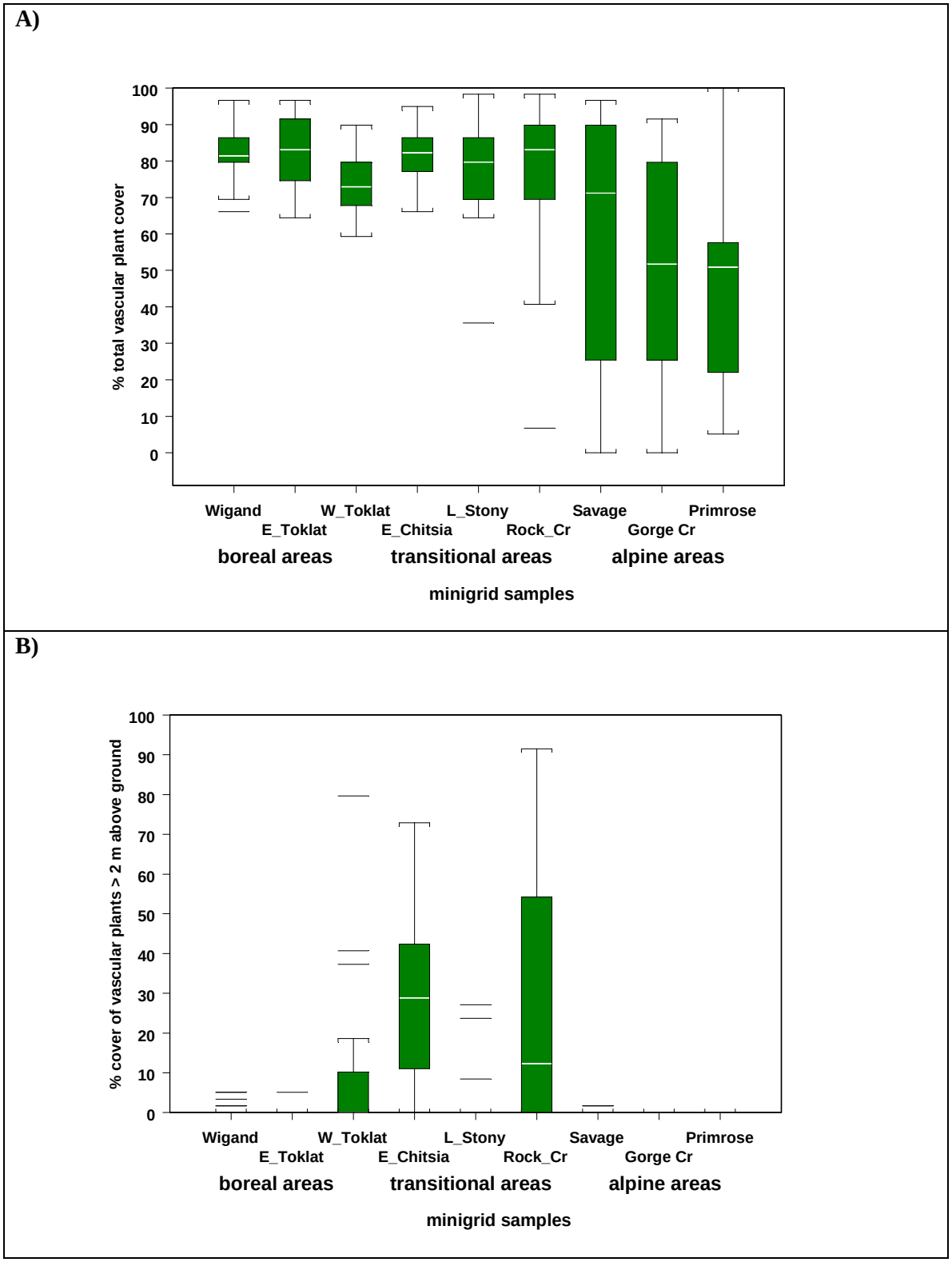

Figure 6.3. The ranges of variation in two aspects of vascular plant cover measured within and among nine minigrid samples in Denali National Park, Alaska: A) total vascular plant cover of plot; B) plant cover over two meters in height.

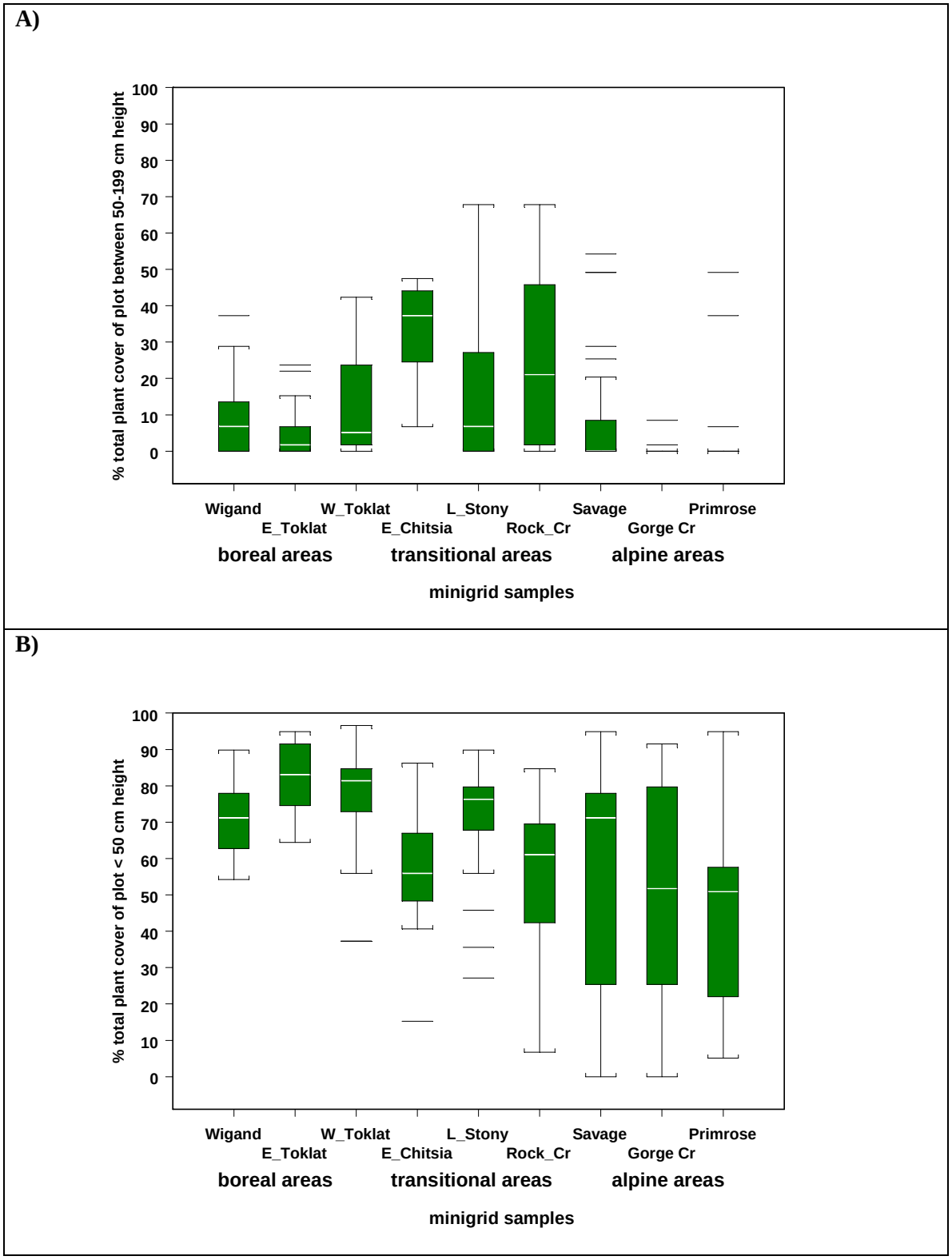

Figure 6.4. The ranges of variation in two aspects of vascular plant cover measured within and among nine minigrid samples in Denali National Park, Alaska: A) total vascular plant cover between 50 cm and 199 cm in height; B) total vascular plant cover less than 50 cm in height.

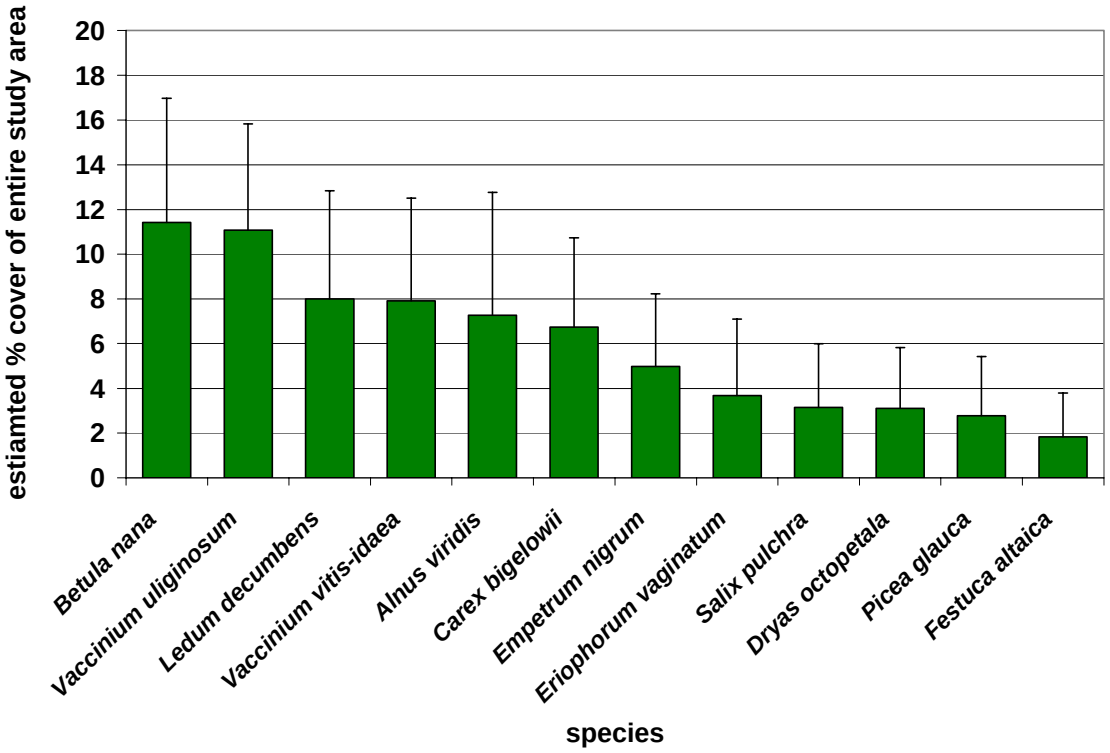

Figure 6.5. Estimated cover of 12 most abundant vascular plant species across entire pilot study sample population**.**

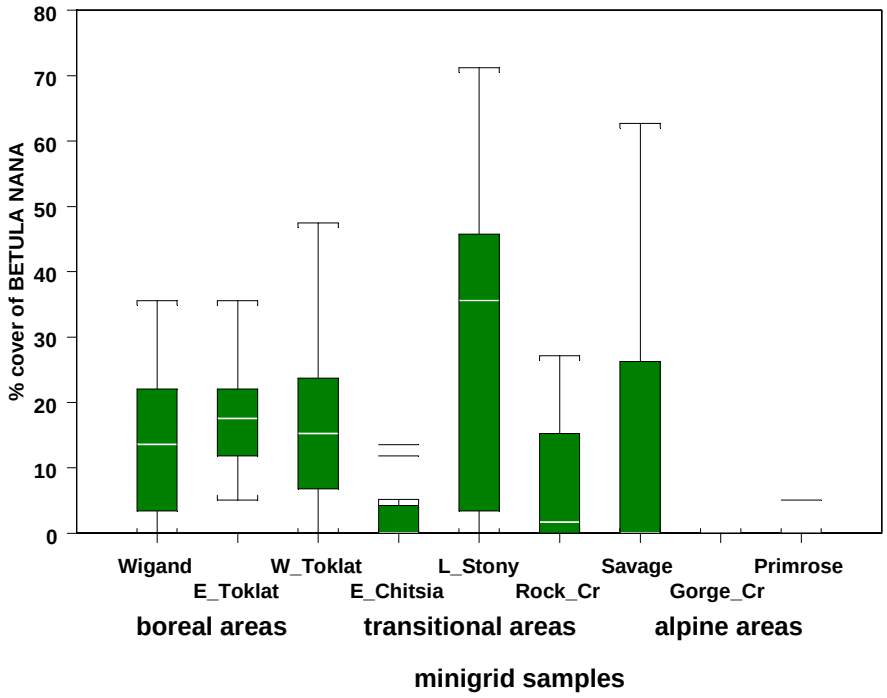

Figure 6.6. The ranges of variation in the cover of *Betula nana* within and among nine minigrid samples measured in Denali National Park and Preserve, Alaska.

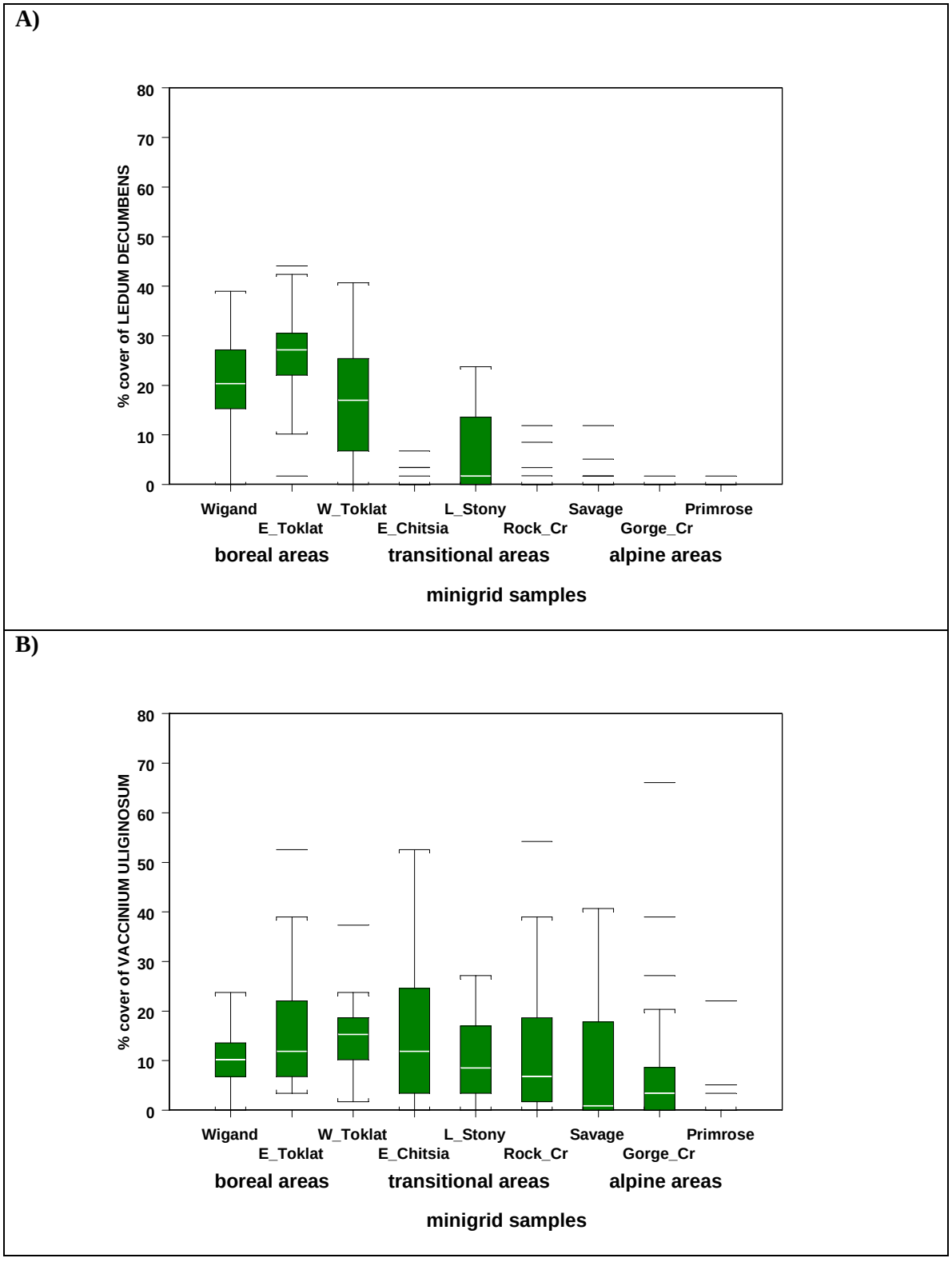

Figure 6.7. The ranges of variation in the cover of two dominant species within and among nine minigrid samples measured in Denali National Park and Preserve, Alaska: A) *Ledum decumbens*; B) *Vaccinium uliginosum*.

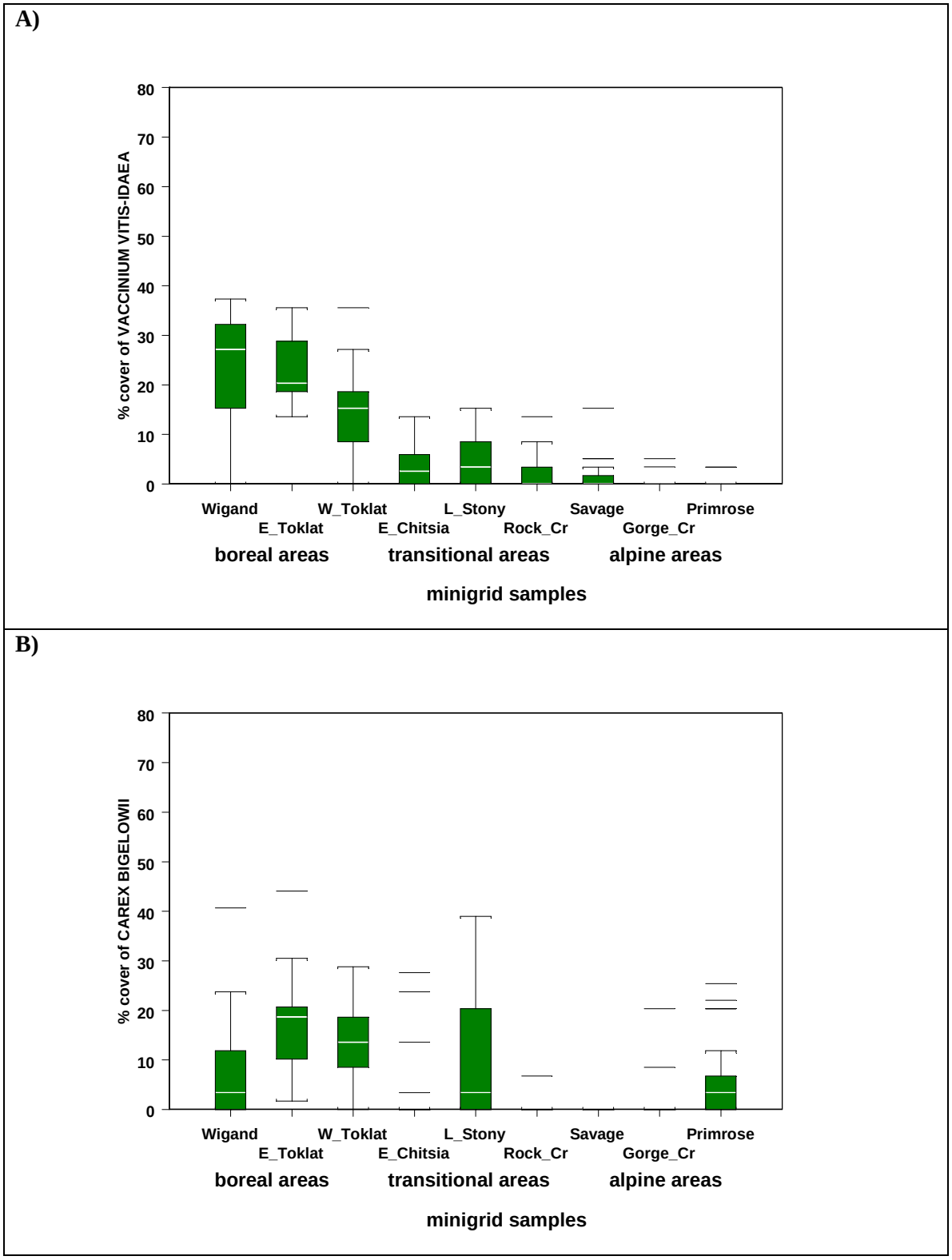

Figure 6.8 The ranges of variation in the cover of two dominant species within and among nine minigrid samples measured in Denali National Park and Preserve, Alaska: A) *Vaccinium vitis-idaea*; B) *Carex bigelowii*.

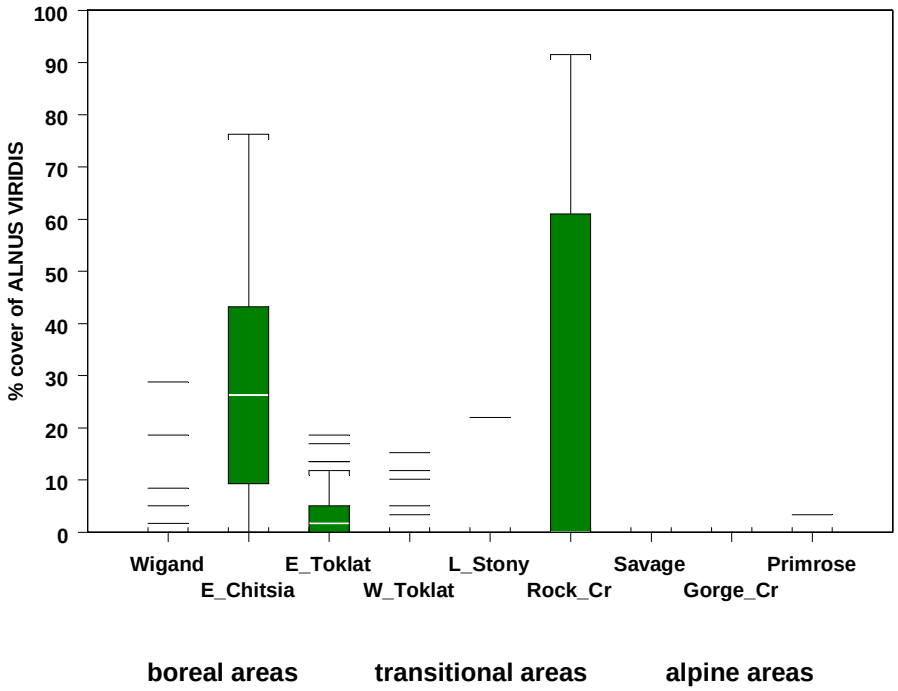

Figure 6.9. The ranges of variation in the cover of *Alnus viridis* within and among nine minigrid samples measured in Denali National Park and Preserve, Alaska.

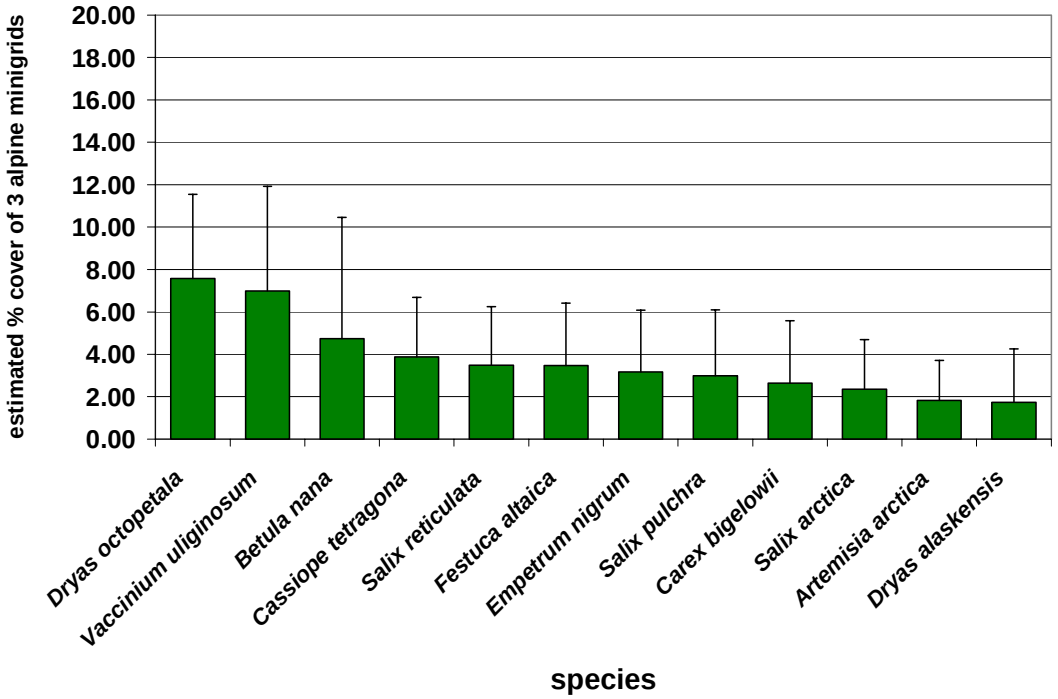

Figure 6.10. Estimated cover of 12 most abundant vascular plant species across three alpine minigrid samples measured in Denali National Park, Alaska**.**

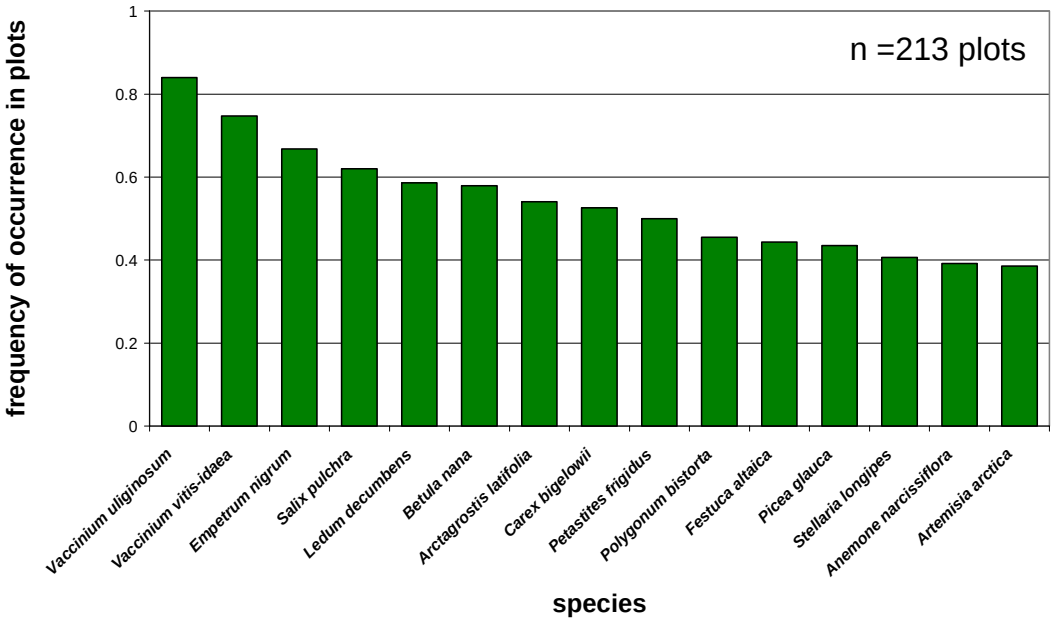

Figure 6.11. Frequency of occurrence of 15 most common species across nine minigrid samples measured in Denali National Park, Alaska.

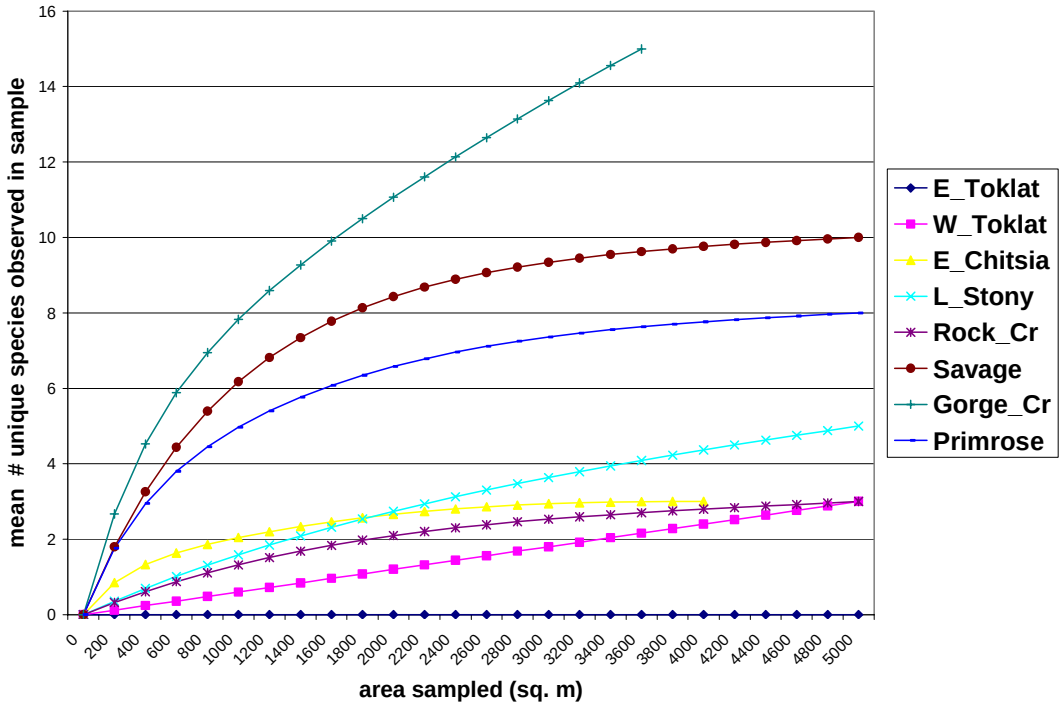

Figure 6.12. Species accumulation curves for Alaska-Yukon endemic species in nine minigrids measured in Denali National Park and Preserve, Alaska.

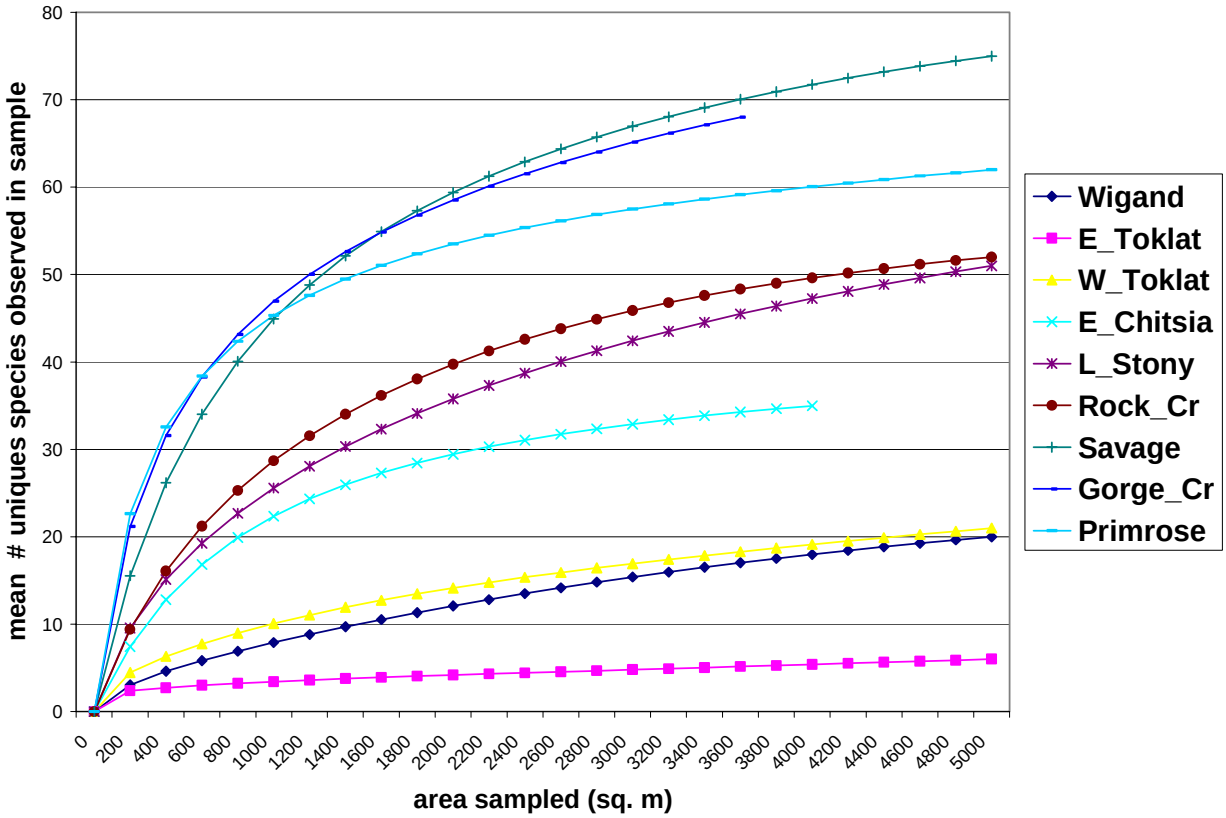

Figure 6.13. Species accumulation curves for species with amphiberingian geographic distribution among nine minigrids measured in Denali National Park, Alaska.

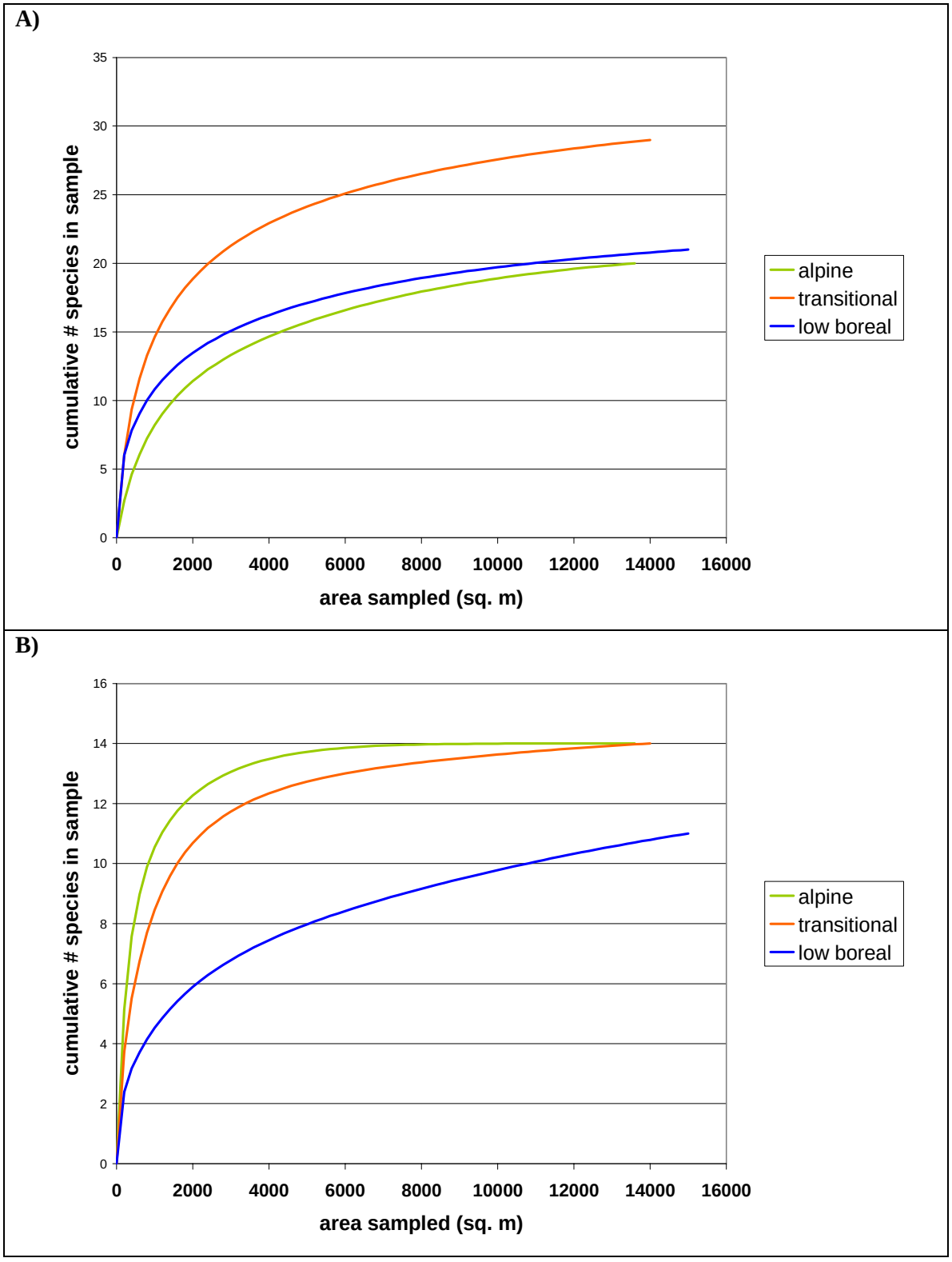

Figure 6.14. Species accumulation curves for two growth form classes of vascular plants among three groups of three minigrid samples (alpine, transitional, and boreal): A) **s**hrub; B) dwarf shrub.

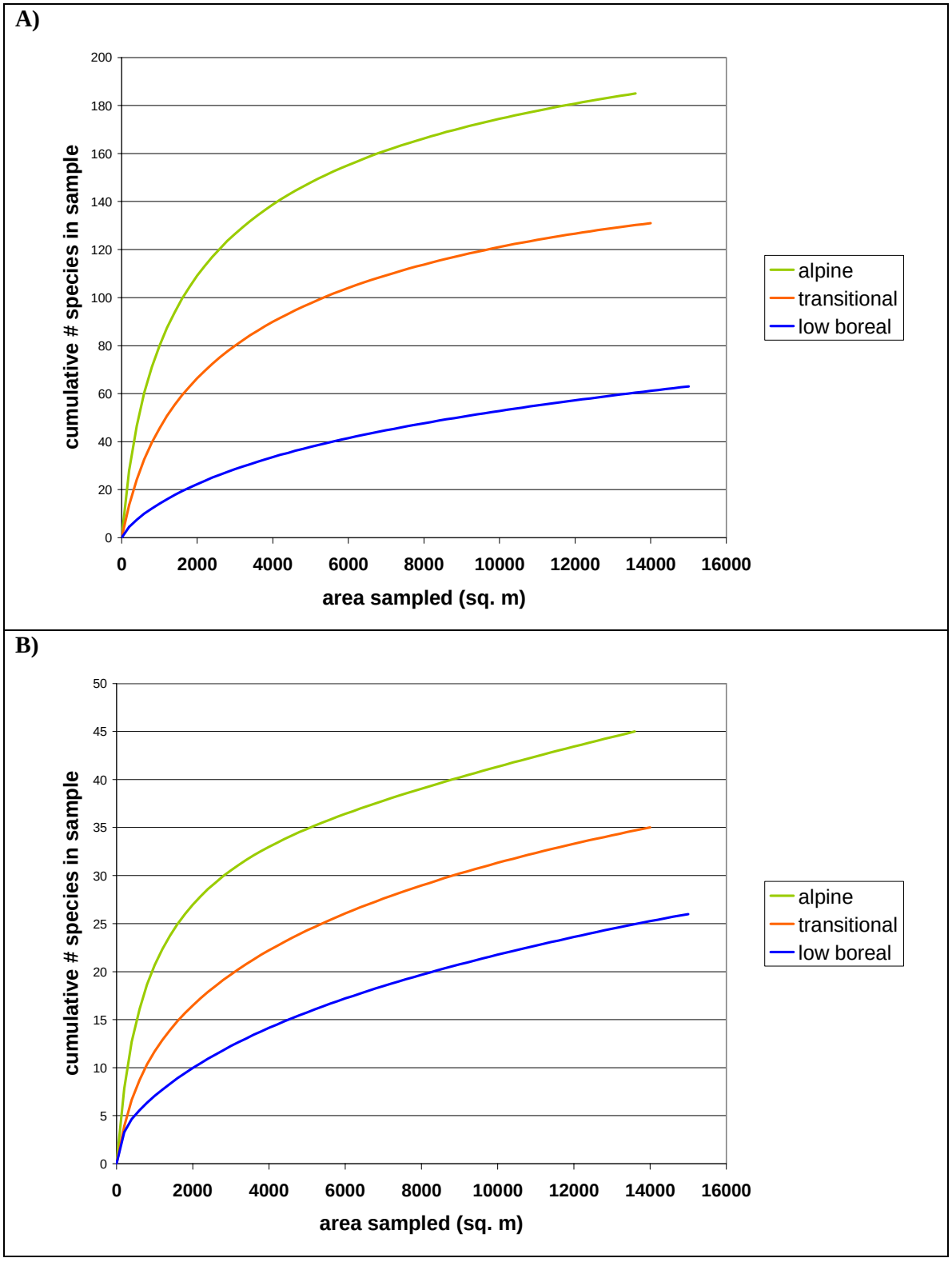

Figure 6.15. Species accumulation curves for two growth form classes of vascular plants among three groups of three minigrid samples (alpine, transitional, and boreal): A) forbs; B) graminoids.

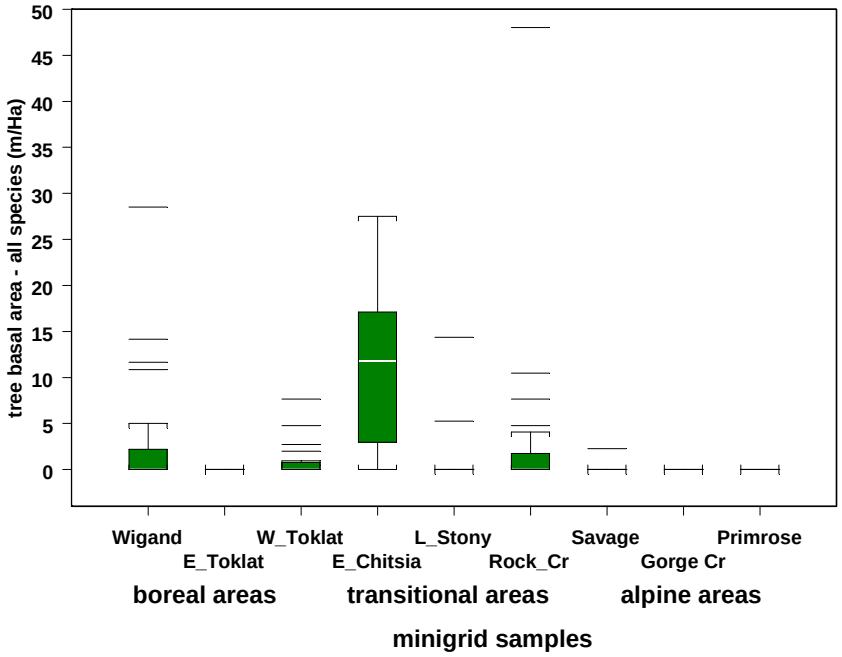

Figure 6.16. The ranges of variation in mean basal area of trees in plots within and among nine minigrid samples measured in Denali National Park, Alaska.

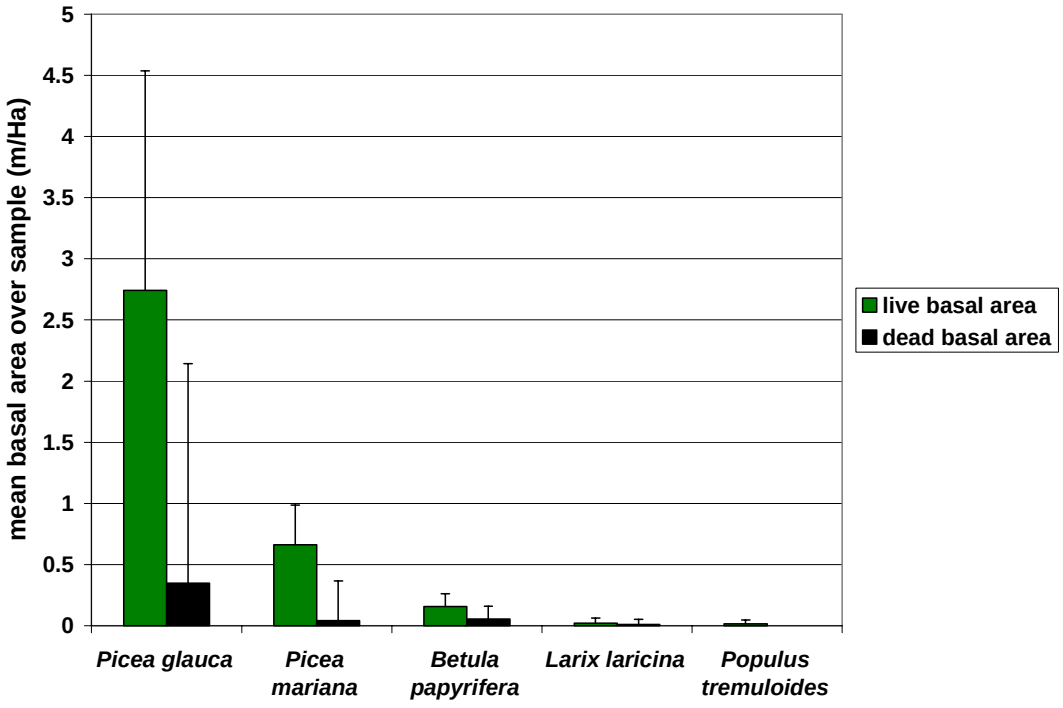

Figure 6.17. Estimated mean basal area, by species, of entire pilot study area by five tree species.

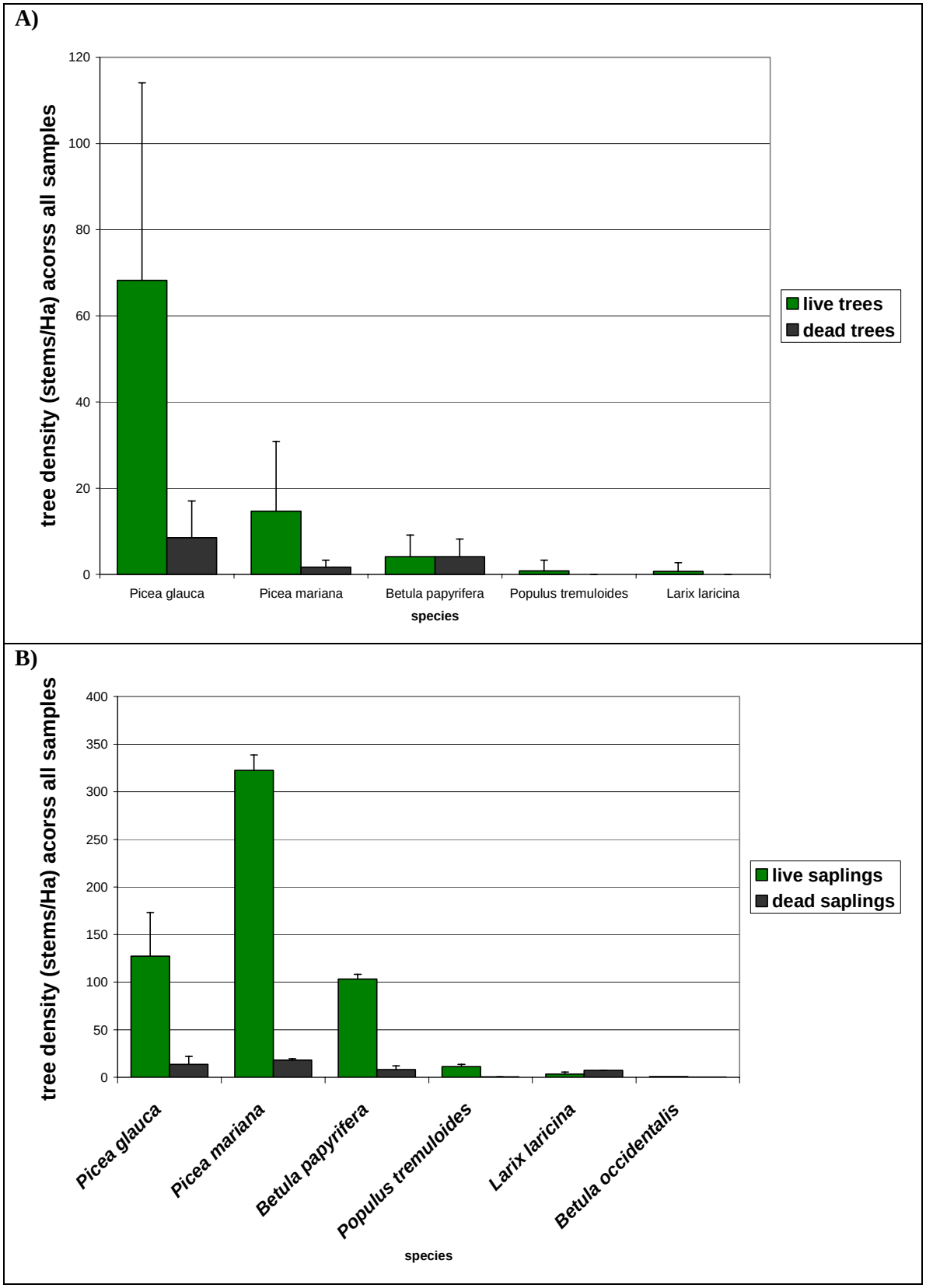

Figure 6.18. Estimated mean density, across entire pilot study sample area, of five tree species in two size classes: A) trees (>12 cm dbh); B) saplings (<12 cm dbh).

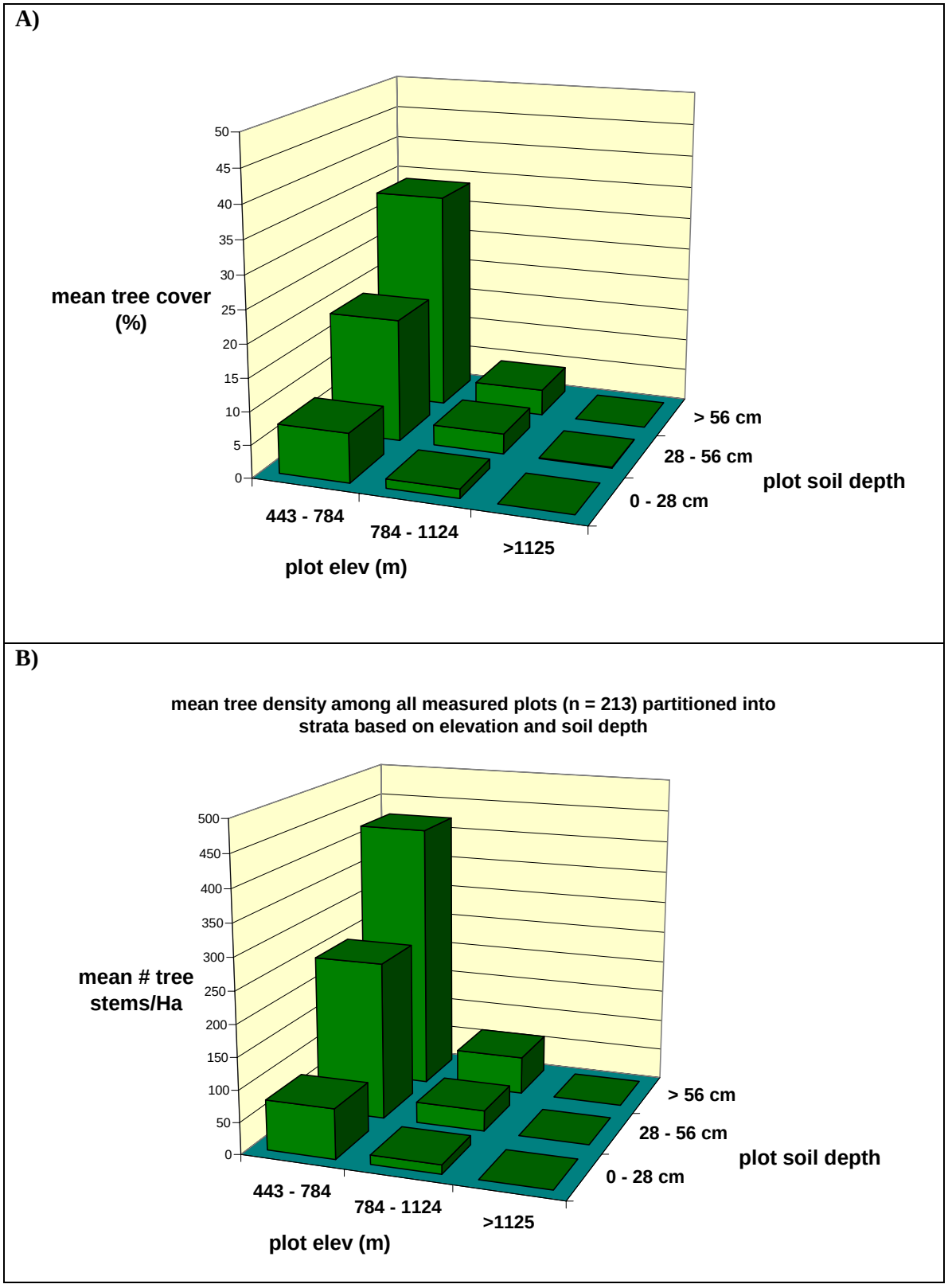

Figure 6.19. Two factor gradient analyses of two attributes of tree abundance across the pilot study data set separated into categories based on elevation and soil depth: A) percent cover of tree species; B) mean density of trees and saplings combined.

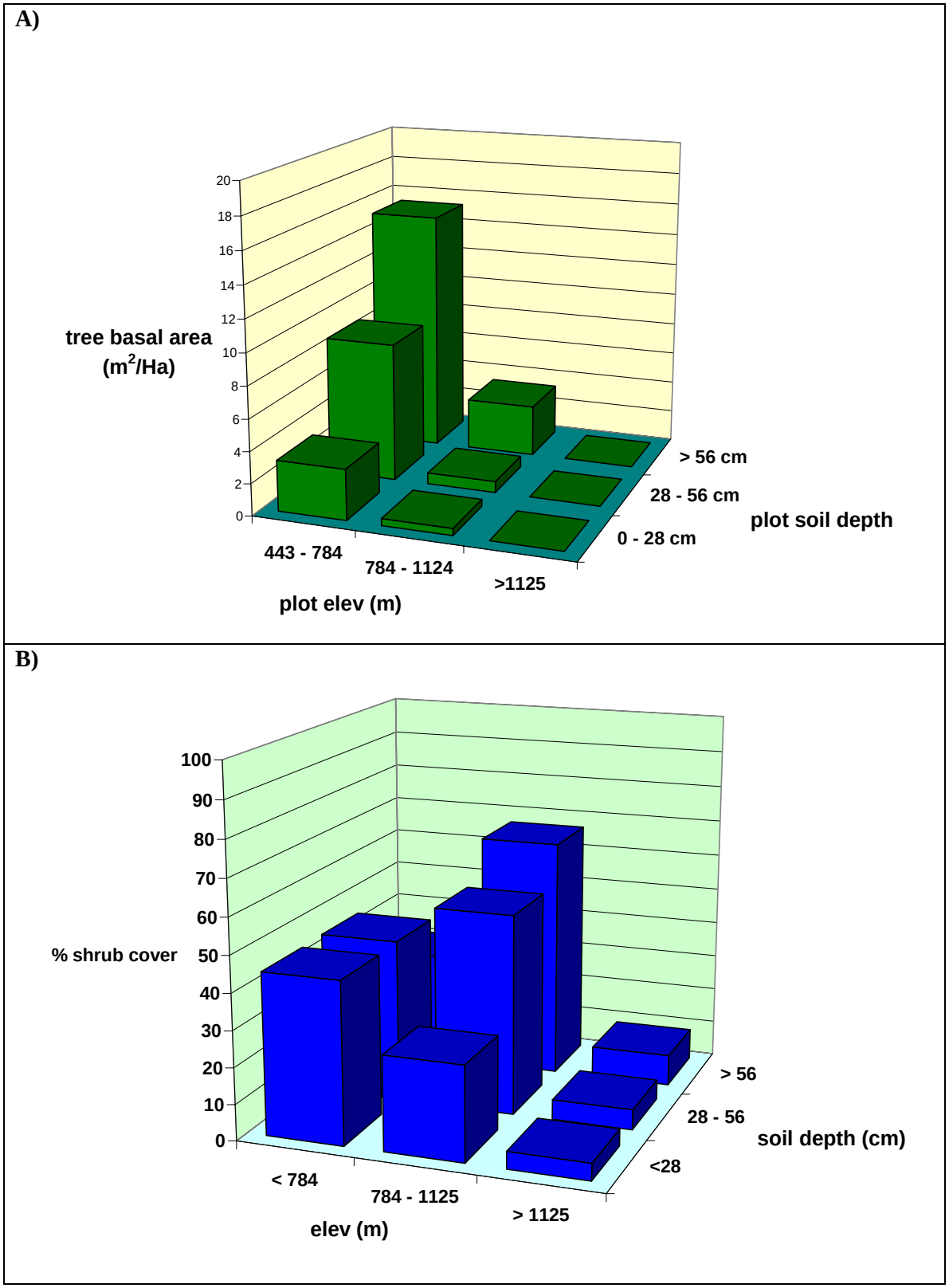

Figure 6.20. Two factor gradient analyses of two vegetation attributes across the pilot study data set separated into categories based on elevation and soil depth: A) basal area of tree species; B) percent cover of shrub taxa.

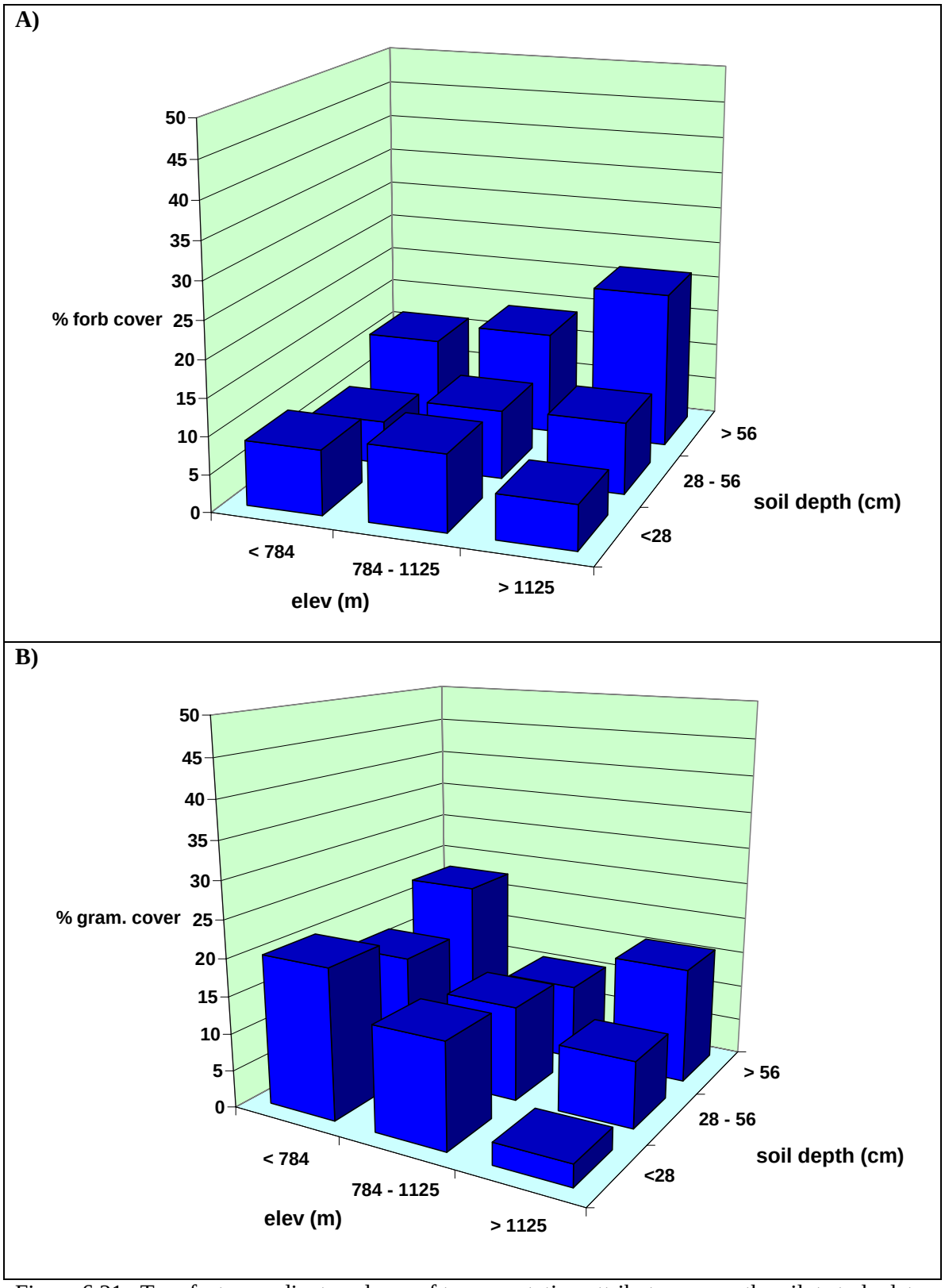

Figure 6.21. Two factor gradient analyses of two vegetation attributes across the pilot study data set separated into categories based on elevation and soil depth: A) basal area of tree species; B) percent cover of shrub taxa.

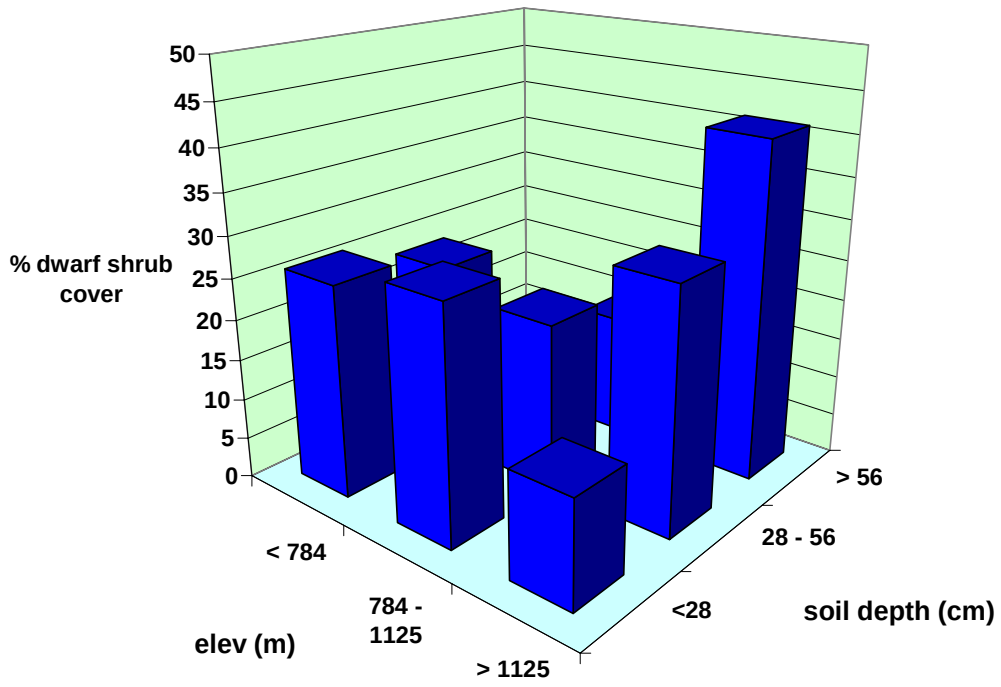

Figure 6.22. Two factor gradient analysis of cover by dwarf shrub taxa in categories described by elevation and soil depth.

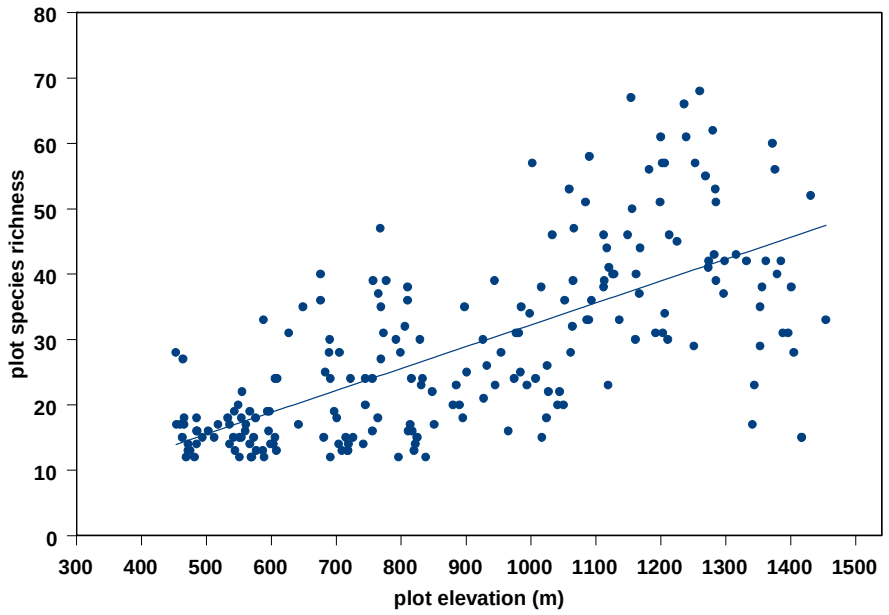

Figure 6.23. Relationship between plot elevation and number of vascular plant species observed in 200 m^2 vegetation plots among 213 plots measured in nine minigrids within Denali National Park, Alaska.

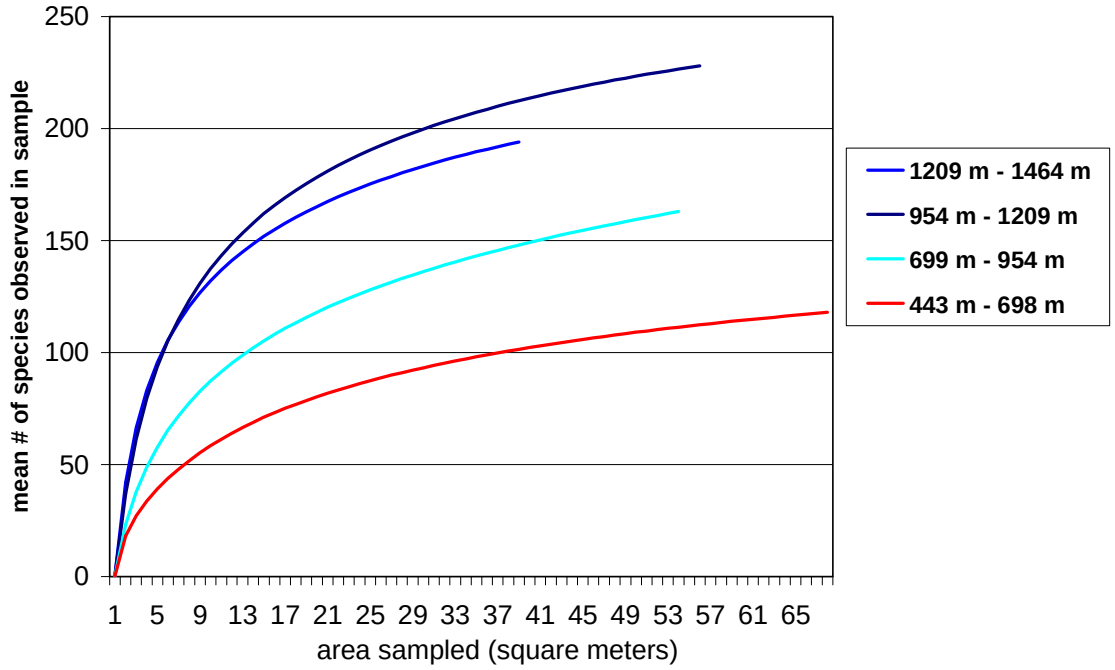

Figure 6.24. Vascular plant species accumulation curves for 213 pilot study plots separated into four categories of elevation.

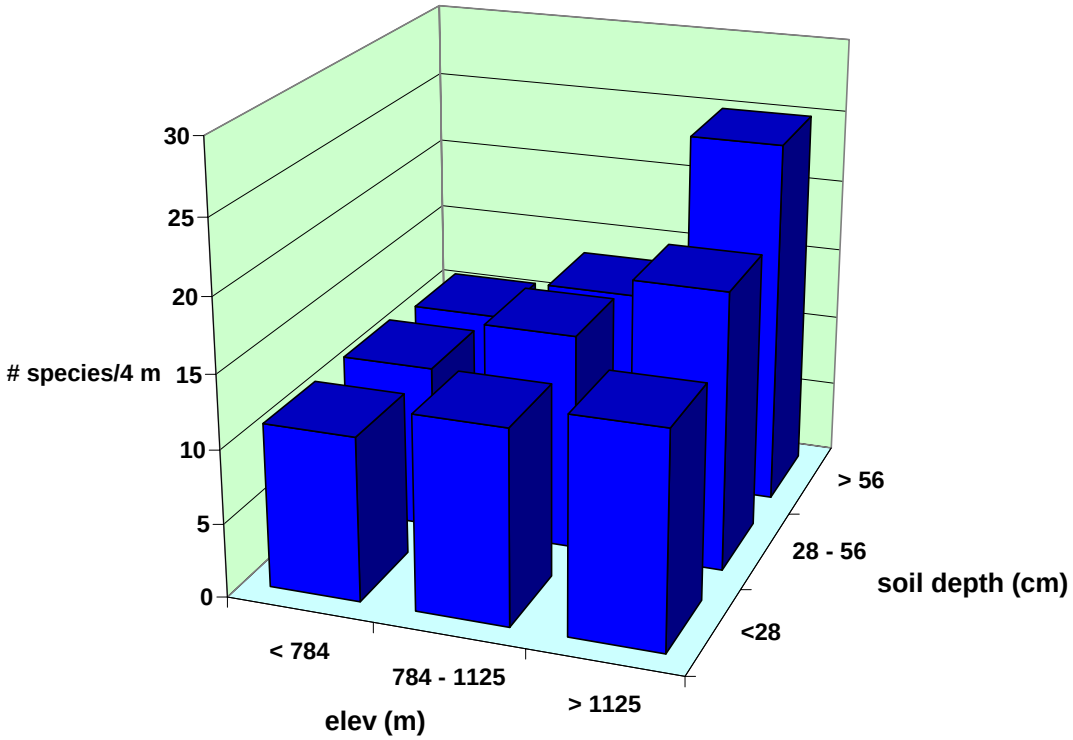

Figure 6.25. Two-factor gradient analysis of mean species richness of 4 m^2 quadrats of 213 pilot study plots separated into categories based on elevation and soil depth.