



Vegetation Sampling in the Arctic Inventory and Monitoring Network, 2013 Progress Report

Natural Resource Data Series NPS/ARC/NRDS—2013/580



ON THE COVER

National Park Service biological technicians sample a vegetation plot near Devil Mountain Lake in Bering Land Bridge National Preserve, July 2013. The laser pointer apparatus used for point-intercept sampling is visible on the left. Jackets with netting hoods protect the samplers from numerous mosquitos. Photograph by: Kelly McMillen, NPS ARC/N.

Vegetation Sampling in the Arctic Inventory and Monitoring Network, 2013 Progress Report

Natural Resource Data Series NPS/ARCN/NRDS—2013/580

David K. Swanson

National Park Service
4175 Geist Road
Fairbanks, AK99709

November 2013

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from Arctic Inventory and Monitoring Network (<http://science.nature.nps.gov/im/units/arcn/>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/nrpn/>). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Swanson, D. K. 2013. Vegetation sampling in the Arctic Inventory and Monitoring Network, 2013 Progress Report. Natural Resource Data Series NPS/ARC/NRDS—2013/580. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	iv
Tables.....	iv
Abstract.....	v
Acknowledgments.....	vi
Introduction.....	1
Methods.....	2
Study Area	2
Sampling Methods.....	2
Results and Discussion	4
Distribution of Plots Across ARCN	8
Park Units	8
Elevation.....	8
Ecotypes	12
Literature Cited	15

Figures

	Page
Figure 1. The NPS Arctic Inventory and Monitoring Network (ARCN).....	1
Figure 2. Vegetation of ARCN, generalized from 44 ecotypes mapped by Jorgenson et al. (2009).	2
Figure 3. Layout of ARCN vegetation sampling plots.	3
Figure 4. The ARCN vegetation monitoring nodes.	4
Figure 5. Elevation distribution of plots in ARCN.	9
Figure 6. Elevation distribution of plots in individual NPS units of ARCN.....	10

Tables

	Page
Table 1. The ARCN vegetation monitoring nodes.....	5
Table 2. Physical characteristics of ARCN vegetation node sampling transects.	6
Table 3. Count of nodes, transects, and plots by NPS unit, completed as of August, 2013.....	8
Table 4. Distribution of plots amongst ARCN ecotypes ¹	13

Abstract

The National Park Service, Arctic Inventory and Monitoring Network (ARCN) is nearing completion of the initial round of sampling a system of permanent vegetation monitoring plots across 5 roadless National Park Service (NPS) units in northern Alaska. Plots are located at “nodes”, which consist of a base camp and approximately 20 plots accessible by foot or boat from the camp. Node locations are chosen for accessibility via fixed-wing aircraft and proximity to a variety of ecosystems. Plot locations are systematic along transects with a randomized start within strata based on major landforms. The main sampling element is plant cover and height by the point intercept method; data are recorded by species of vascular plants and by species or species-group of non-vascular plants. Additional data elements include tree diameters and a list of all vascular species on a fixed-area plot, and a soil and site description.

In 2013 we sampled 141 plots at 7 nodes. The total for the project is now 442 plots at 23 nodes sampled mainly in 2011-13. We anticipate sampling approximately 45 more plots at 2 nodes in 2014, at which point the first round of sampling will be considered complete. However, sampling of up to 5 additional nodes in the next several years is possible if data gaps are identified.

Coverage of the major ecological gradients by the plots was generally satisfactory. The distribution of plots by elevation shows some bias toward lower elevations. This is due to the fact that our landing sites (mainly lakes and river gravel bars) are concentrated at low elevations, and high-elevation areas are largely unvegetated and difficult to access. Ecotypes identified on an existing ARCN-wide map are generally well represented, with deficiencies noted in the coverage of alpine barren areas and tall shrub communities. For reasons of access efficiency and safety, these types are likely to remain under-sampled.

Acknowledgments

The data on in this report were collected by many NPS employees who have assisted in fieldwork over the past several years. They are (listed in alphabetical order): Alyssum Cohen, Kristen DeGroot, Brian Dykstra, Erin Flynn, Nicholas Jelinski, Kelly McMillen, Celia Miller, Fleur Nicklen, Peter Nietlich, Kumi Rattenbury, Abby Rosso, Sarah Schuette, and Tyler Teuscher.

Introduction

‘Vegetation and soils’ comprise one of the monitoring vital signs of the National Park Service Arctic Inventory and Monitoring Network (ARCN; Fig. 1) (Lawler et al. 2009). This monitoring vital sign has several component projects (Swanson and Neitlich 2011). The subject of the present report is the network-wide system of permanent monitoring plots that emphasize vegetation structure (plant cover by point-intercept and tree diameters) in an 8-m radius plot. This vegetation sampling project is commonly known as the “vegetation nodes” because plots are sampled in a cluster (node) around an aircraft access point. The vegetation nodes were established by ARCN to provide a network-wide sample of canopy cover of both vascular and nonvascular plants, and tree characteristics, by a highly repeatable method. The stated objectives for the vegetation node monitoring program are: 1) to detect change in major structural properties of vegetation within deliberately selected representative physiographic areas; and 2) to provide ground reference data for sampling and modeling based on remote sensing (Swanson and Neitlich 2011).

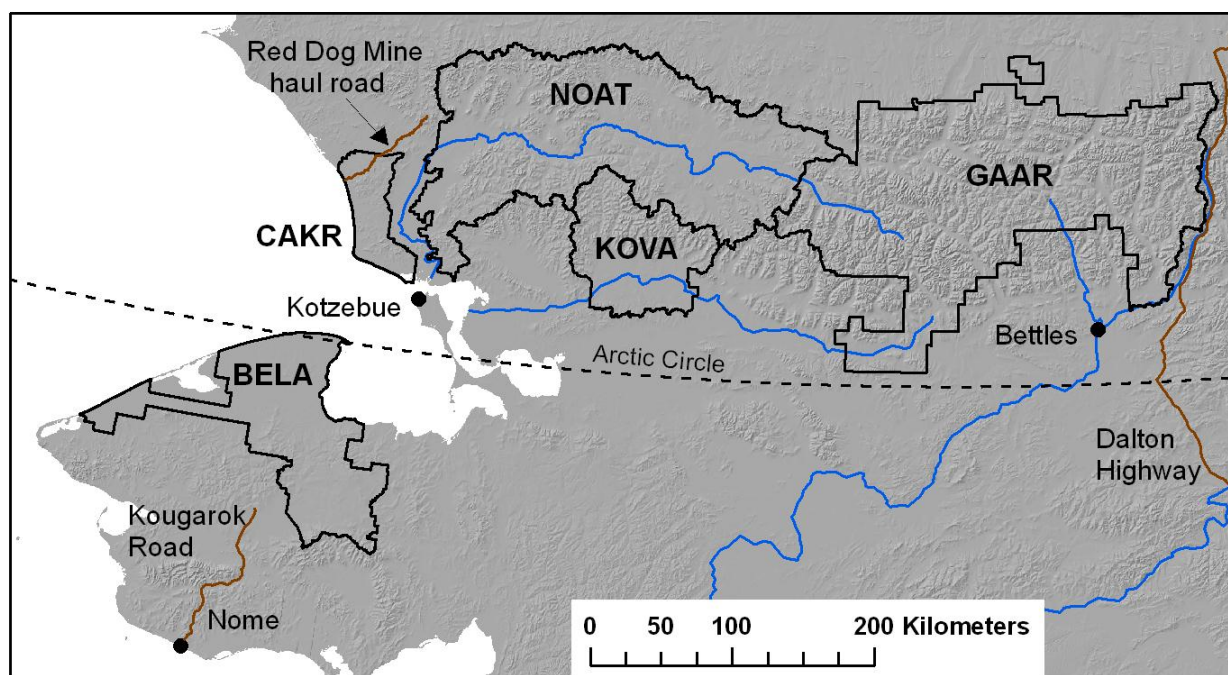


Figure 1. The NPS Arctic Inventory and Monitoring Network (ARCN). BELA – Bering Land Bridge National Preserve, CAKR – Cape Krusenstern National Monument, GAAR – Gates of the Arctic National Park and Preserve, KOVA – Kobuk Valley National Park, NOAT – Noatak National Preserve.

The vegetation node sampling scheme was tested in 2009-10 (Swanson 2010, Swanson 2011a), and its methods are detailed in a draft protocol (Swanson and Neitlich 2011). Sampling entered “production” phase in 2011 (Swanson 2011b) and continued in 2012 and 2013 (Swanson 2012 and this report). The initial sampling of the vegetation nodes is nearly complete, with only minor additions planned for 2014. Re-sampling is planned at a 10- to 15-year interval in the future. The purpose of the present report is to evaluate the progress to date, especially the plots’ coverage of major ecosystems in ARCN.

Methods

Study Area

ARCN is a mostly roadless area of over 8 million hectares, nearly one-fourth of the total land area nationwide managed by the National Park Service (Fig. 1). The vegetation of ARCN consists mainly of arctic tundra, with boreal spruce and birch forest in the south at low elevations in the interior parks (Fig. 2). Low shrub- and herb-dominated vegetation occurs in wetlands in the boreal forest and burned areas in the south, and on lowland tundra throughout the network. Sparse alpine vegetation and barrens dominate at high elevations. Tall shrub communities are most common on floodplains and near treeline. They occur in small patches at low to moderate elevations throughout the network, with their most extensive occurrences shown in Fig. 2.

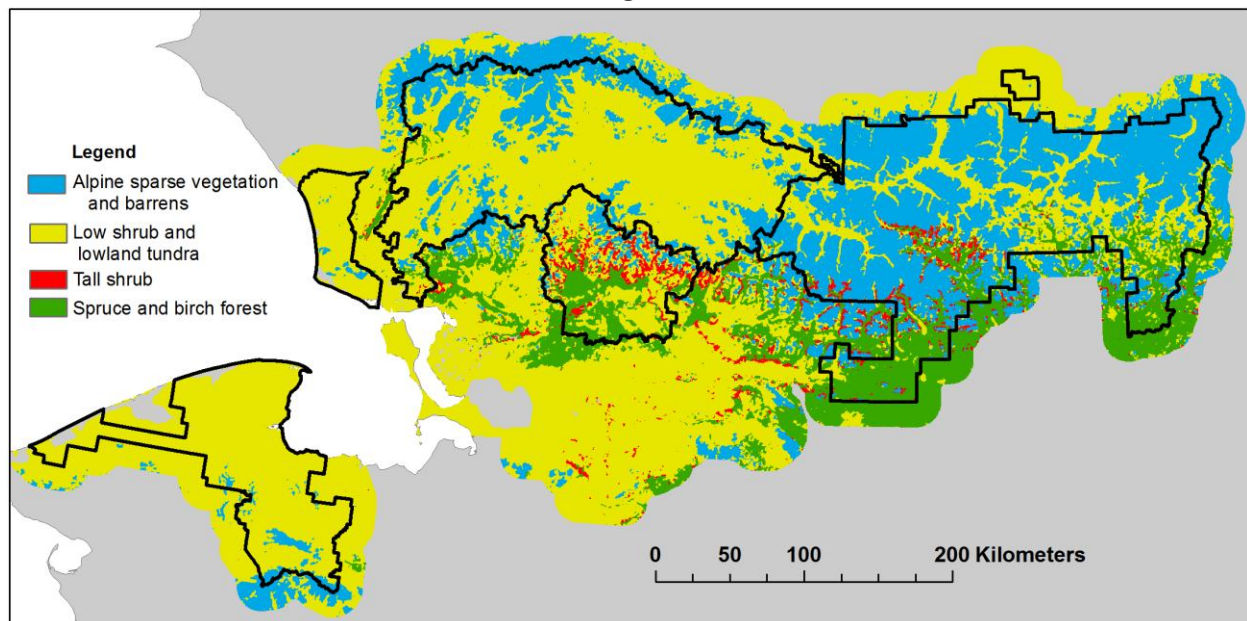


Figure 2. Vegetation of ARCN, generalized from 44 ecotypes mapped by Jorgenson et al. (2009).

Sampling Methods

Each vegetation node consists of a set of approximately 20 plots accessed from a central campsite. The node locations are chosen to be readily accessible and representative of major ARCN ecosystems. All nodes to date are accessible by fixed-wing aircraft landing on lakes or undeveloped gravel airstrips. The vicinity of each node is stratified into landform-based physiographic units, and proposed transect locations are placed within the strata. Transect starting points and azimuths are randomized, and plots are located systematically thereafter. A few plots locations were deliberately chosen to target features of special interest. Plots locations are recorded with a sub-meter resolution GPS and marked with a buried magnet for future re-sampling. At each plot, plant cover and height by species (or species group for many non-vascular plants) are measured by point intercept using a laser at 100 points spaced 25 cm apart (Fig. 3). Tree and sapling diameters, and seedling counts by species are made on an 8-m radius fixed-area plot (no trees were recorded in 2013). Comprehensive site and soil descriptions are made at each plot, and the intensity of herbivore effects on vegetation are assessed. For sampling method details see Swanson and Neitlich (2011).

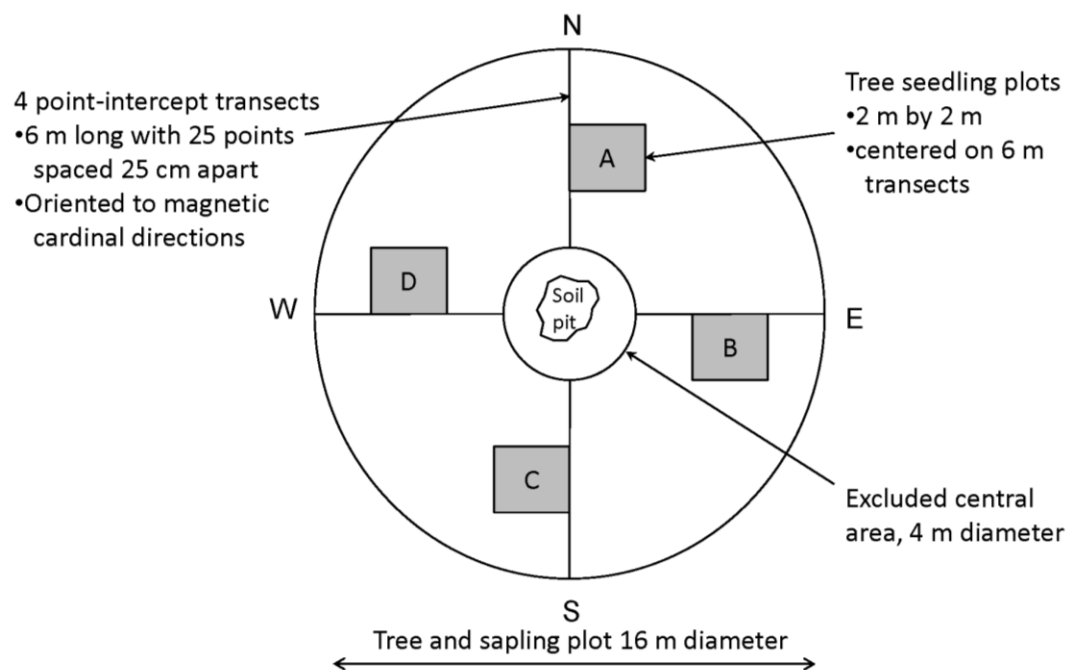


Figure 3. Layout of ARC vegetation sampling plots.

Results and Discussion

In 2013 we sampled 141 plots at 7 nodes. The total for the project is now 442 plots at 23 nodes (Fig. 4, Table 1). Four of the plots sampled in 2013 and 10 of the plots overall were in deliberately chosen locations, while the remainder were on systematic transects.

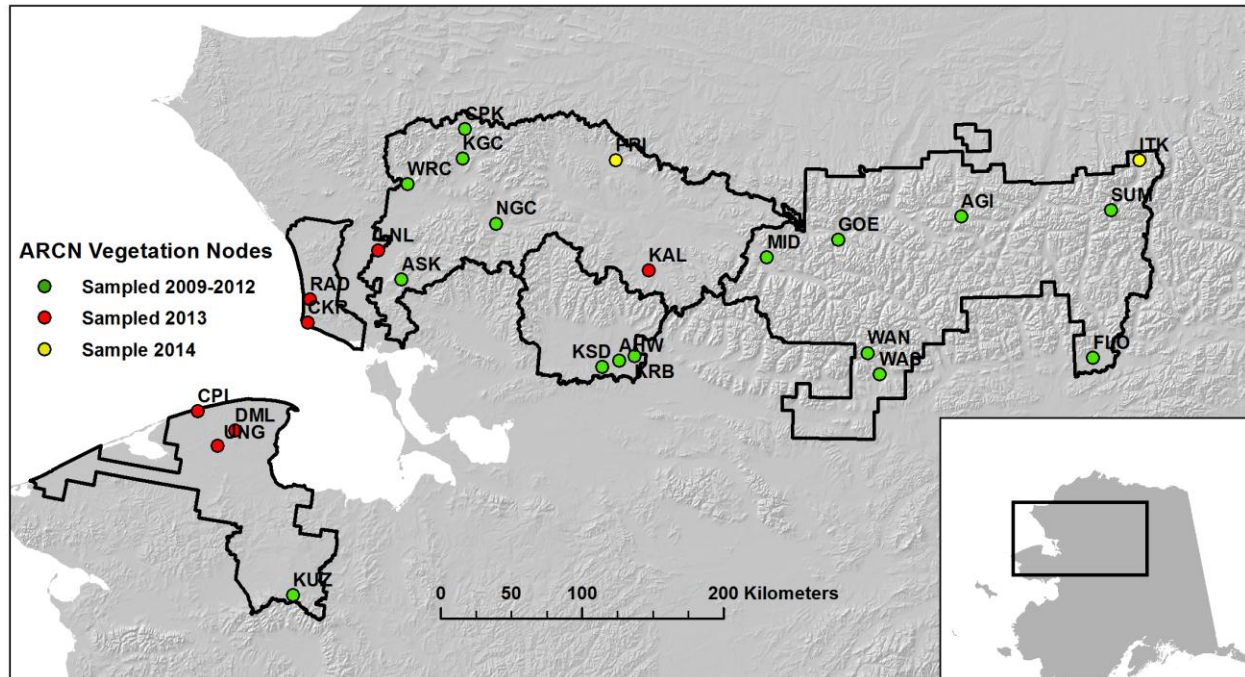


Figure 4. The ARCNA vegetation monitoring nodes. Node abbreviations are explained in Table 1.

Sampling has covered a wide variety of environments (Table 2). Most transects contained between 4 and 8 plots and had fairly consistent elevation, slope, soil parent material, depth to frozen material, and depth to water or saturated soil. Numerous plots had no frozen soil observed (“>” in Table 2), though permafrost is in fact present over most of ARCNA (Jorgenson et al. 2008). The “no frozen soil” observations were mostly in coarse-grained soils, which typically thaw to a depth of more than 50 cm each summer but are difficult to excavate beyond about 50 cm given our constraints for time and permitted surface disturbance.

The plan for 2014 is to sample two additional nodes (about 45 plots total), one in NOAT and one GAAR, both in mountainous areas (Fig. 4).

Table 1. The ARCN vegetation monitoring nodes.

NPS Unit	Node	Count of	Latitude	Longitude	
Abbreviation	Node Name	Plots¹	WGS84	WGS84	Sample Year
Bering Land Bridge National Preserve (BELA)					
<i>CPL</i>	Cowpack Lagoon	24 (3)	66.452	-165.173	2013
<i>DML</i>	Devil Mountain Lakes	18	66.367	-164.535	2013
<i>KUZ</i>	Kuzitrin Lake	18 (2)	65.390	-163.272	2009
<i>UNG</i>	Upper Nug	24	66.258	-164.771	2013
Cape Krusenstern National Monument (CAKR)					
<i>CKR</i>	Cape Krusenstern	11	67.111	-163.592	2013
<i>RAD</i>	Radio Hill	22 (1)	67.268	-163.667	2013
Gates of the Arctic National Park and Preserve (GAAR)					
<i>AGI</i>	Agiak Lake	21 (1)	68.068	-152.976	2010
<i>FLO</i>	Florence Creek Lake	16 (2)	67.141	-150.874	2009
<i>GOE</i>	Goedecke's Lake	22	67.920	-155.043	2012
<i>ITK</i>	Itkilik Lake	-	68.384	-149.925	2014 (proposed)
<i>MID</i>	Midas Lake	22	67.797	-156.23	2012
<i>SUM</i>	Summit Lake	24	68.074	-150.453	2012
<i>WAN</i>	Walker Lake North	15	67.199	-154.538	2012
<i>WAS</i>	Walker Lake South	13	67.064	-154.342	2012
Kobuk Valley National Park (KOVA)					
<i>AHW</i>	Ahnewetut Wetlands	13	67.089	-158.563	2012
<i>KRB</i>	Kobuk River Bar	11	67.126	-158.323	2012
<i>KSD</i>	Kobuk Sand Dunes	23	67.041	-158.834	2012
Noatak National Preserve (NOAT)					
<i>ASK</i>	Asik	21	67.472	-162.226	2011
<i>CPK</i>	Copter Peak	22	68.473	-161.469	2011
<i>PRI</i>	Primus Creek	-	68.364	-158.850	2014 (proposed)
<i>KAL</i>	Kaluich	17	67.672	-158.178	2013
<i>KGC</i>	Kagvik Creek	16	68.284	-161.453	2011
<i>LNL</i>	Lower Noatak Lowlands	21	67.637	-162.673	2013
<i>NGC</i>	Noatak Grand Canyon	24 (1)	67.894	-160.775	2011
<i>WRC</i>	Wrench Creek	20	68.080	-162.322	2011

¹Total count of plots at the node, with the count of deliberately chosen plots, if any, in parentheses.

Table 2. Physical characteristics of ARCN vegetation node sampling transects.

NPS unit ¹	Node ²	Transect Name	Count of Plots ³	Elevation Mean (SD), m	Slope Mean (SD), %	Soil Parent Material	Depth to Frozen ⁴ , Median, cm	Depth to Water ⁴ , Median, cm
Bering Land Bridge National Preserve (BELA)								
	CPL	Active beach	12	1 (1)	2 (2)	Marine, eolian	>	17
	CPL	Beach ridges	8	2 (1)	0 (1)	Marine, eolian	48	22
	CPL	Salt marsh	4	0 (1)	0 (0)	Marine	>	7
	DML	Drained lake	4	42 (2)	9 (10)	Lacustrine	30	16
	DML	Seepage slope	8	60 (5)	2 (1)	Organic/eolian	22	12
	DML	Tussock upland	6	57 (9)	3 (1)	Organic/eolian	20	20
	KUZ	Alpine	3	660 (33)	32 (7)	Residuum felsic	>	>
	KUZ	Lava	4	451 (7)	4 (2)	Residuum mafic	>	>
	KUZ	Slope	9	483 (19)	5 (4)	Colluvium/residuum felsic	>	>
	UNG	Lake plain	8	29 (1)	0 (0)	Organic/lacustrine	28	7
	UNG	Polygons	8	30 (2)	0 (0)	Organic/lacustrine	26	20
	UNG	Yedomas	8	49 (3)	5 (3)	Organic/eolian	28	23
Cape Krusenstern National Monument (CAKR)								
	CKR	Beach ridges	9	3 (1)	0 (0)	Marine	ND	ND
	CKR	Younger beach	2	4 (1)	0 (0)	Marine	ND	ND
	RAD	Limestone barrens	7	145 (26)	16 (5)	Colluvium, eolian/residuum calcareous	>	>
	RAD	Limestone footslope	7	57 (16)	9 (3)	Colluvium	45	18
	RAD	Lowland shrub	4	34 (3)	6 (3)	Organic/eolian	33	12
	RAD	Tussock lowland	4	42 (2)	4 (4)	Eolian	27	11
Gates of the Arctic National Park and Preserve (GAAR)								
	AGI	Alpine	4	1214 (71)	52 (14)	Colluvium	>	>
	AGI	Moraine	7	985 (16)	9 (10)	Till	>	>
	AGI	Talus	3	1049 (18)	61 (4)	Colluvium	>	>
	AGI	Willow	6	964 (15)	6 (3)	Till	42	18
	FLO	Floodplain	3	259 (6)	0 (0)	Alluvium	58	>
	FLO	Muskeg	6	255 (1)	0 (0)	Organic/alluvium	70	>
	FLO	Slope	5	322 (43)	17 (19)	Eolian	50	>
	GOE	Hills	8	1179 (78)	14 (12)	Colluvium/residuum fine sed-metamorphic	>	>
	GOE	Mountain slope	7	1136 (130)	26 (2)	Colluvium/residuum fine sed-metamorphic	>	>
	GOE	Valley bottom	7	894 (8)	3 (1)	Till	>	>
	MID	Hills	8	618 (23)	10 (7)	Colluvium, residuum coarse sed-metamorphic, till	>	>
	MID	Moraine	6	531 (7)	3 (1)	Till	>	>
	MID	Riparian	8	490 (5)	1 (1)	Alluvium	46	37
	SUM	Dryas plain	8	1091 (14)	5 (3)	Till	51	49

Table 2. (continued).

NPS unit ¹	Node ²	Transect Name	Count of Plots	Elevation Mean (SD), m	Slope Mean (SD), %	Soil Parent Material	Depth to Frozen ³ , Median, cm	Depth to Water ³ , Median, cm
	SUM	Mountain slope	8	1354 (156)	24 (10)	Colluvium	>	>
	SUM	Shrub slope	8	1129 (15)	4 (2)	Till	75	15
	WAN	Avalanche slope	4	846 (107)	36 (7)	Colluvium/ residuum coarse sed-metamorph	>	>
	WAN	Riparian spruce	4	208 (4)	4 (1)	Alluvium	34	>
	WAN	Spruce slope	7	396 (85)	17 (9)	Colluvium/ residuum coarse sed-metamorphic	>	>
	WAS	Moraine	6	224 (3)	10 (8)	Till	>	>
	WAS	Spruce slope	7	368 (94)	27 (17)	Colluvium/till	>	>
Kobuk Valley National Park (KOVA)								
	AHW	Polygons NE	5	30 (4)	1 (2)	Organic/alluvium	46	26
	AHW	Polygons SW	8	33 (2)	0 (1)	Organic/alluvium	54	20
	KRB	Big point bar	7	23 (4)	5 (7)	Alluvium	>	>
	KRB	Wet terrace	4	20 (3)	1 (2)	Organic/alluvium	34	29
	KSD	Dryas flats	6	76 (4)	3 (2)	Eolian	>	>
	KSD	Sandy woodland	7	73 (6)	4 (4)	Eolian	>	>
	KSD	Steppe	6	86 (2)	4 (5)	Eolian	>	>
	KSD	Wetland	4	58 (2)	3 (2)	Eolian, organic/lacustrine	40	38
Noatak National Preserve (NOAT)								
	ASK	Mountain slope	8	208 (84)	24 (10)	Colluvium/ residuum calcareous	>	>
	ASK	Terrace	6	97 (4)	1 (2)	Alluvium	>	>
	ASK	Tussock slope	7	172 (8)	8 (2)	Colluvium/ residuum mafic	>	>
	CPK	Carbonate barrens	6	630 (83)	58 (9)	Residuum calcareous	>	>
	CPK	Noncarbonate mountains	8	567 (70)	55 (24)	Colluvium/ residuum fine sed-metamorphic	>	>
	CPK	Shrub terrace	8	414 (16)	6 (4)	Alluvium	>	>
	KAL	East slope	5	476 (12)	8 (3)	Eolian/till	55	>
	KAL	West slope	6	472 (6)	2 (2)	Organic/eolian	32	27
	KAL	Wetland	6	455 (1)	1 (1)	Organic/eolian	38	22
	KGC	Floodplain	8	218 (4)	0 (1)	Alluvium	>	>
	KGC	Tundra lowlands	8	242 (7)	4 (4)	Organic/lacustrine	31	10
	LNL	Polygon plain	7	32 (1)	0 (1)	Organic/lacustrine	39	15
	LNL	Wet plain	7	33 (1)	0 (0)	Organic/lacustrine	38	5
	LNL	Young lake basin	7	31 (1)	0 (0)	Organic/lacustrine	50	0
	NGC	Mesic floodplain	6	144 (3)	3 (5)	Alluvium	75	>
	NGC	Tussock slopes	9	189 (12)	4 (4)	Organic/eolian	29	16
	NGC	Wet floodplain	8	146 (1)	0 (1)	Alluvium	30	3
	WRC	Alpine slope	4	292 (72)	36 (24)	Colluvium	>	>
	WRC	Floodplain	3	117 (1)	0 (0)	Alluvium	>	>
	WRC	Spruce slope	6	159 (16)	10 (4)	Colluvium	>	>
	WRC	Tussock plain	7	125 (3)	5 (7)	Organic/alluvium	42	17

Table 2. (continued).

¹ARCN NPS unit abbreviations are given in Fig 1.

²Node abbreviations are given in Table 2.

³Only systematically chosen plots are included

⁴">" indicates below the depth of observation, usually about 50 cm in the rocky soils where frozen material and water are typically not observed. "ND" indicates no data (soil pits were not dug). "Frozen" material was ice-cemented on the day of sampling (July to early August). "Water" refers to the lesser depth of: free water table in the soil pit (where present), or, in the case of fine-grained soils, saturated viscous soil.

Distribution of Plots Across ARCN

Park Units

As a measure of sampling intensity, we divided the total land area of ARCN (about 82,000 km²) by 442 plots to obtain an average of 185 km² of land area represented by each plot (Table 3). By this measure, sampling is most intensive in the smallest NPS unit (79 km²/plot in CAKR) and least intensive in the largest unit (255 km²/plot in GAAR). This situation will persist after the planned sampling of one additional node in each of GAAR and NOAT, which will bring the GAAR average down to about 220 km²/plot. The greater sampling intensity in CAKR and BELA is due largely to our inclusion of nodes there to cover coastal environments (which have very little areal extent), in addition to the inland environments present in all the NPS units.

Table 3. Count of nodes, transects, and plots by NPS unit, completed as of August, 2013.

NPS unit	Count of Nodes	Count of Transects	Count of Plots	Area of NPS unit, km ²	Area ¹ per plot, km ²
BELA	4	12	87	11275	130
CAKR	2	6	34	2672	79
GAAR	7	21	133	34301	258
KOVA	3	8	47	7092	151
NOAT	7	21	141	26570	188
All	23	68	442	81910	185

¹Area of NPS unit divided by the count of plots.

Elevation

Plots sampled to date are biased somewhat towards lower elevations (Figs. 5 and 6). This results from 1) the fact that fixed-wing access points (mostly river gravel bars and lakes) are in valley bottoms, 2) the safety and travel problems (cliffs, etc.) involved in sampling high-elevations, and 3) the fact that much high-elevation land has no soil or vegetation to sample. The bias toward lowlands is most severe in KOVA and NOAT. Our current plan is to place no more nodes in KOVA and accept the bias toward low elevations due to lack of landing sites in the highlands there. The nodes in NOAT and GAAR planned for sampling in 2014 are both in high-elevation areas, which should help to balance the elevation distribution for these units, though some low-elevation bias will persist.

Comparison of modern and historical aerial photographs shows that lower elevations are much more prone to change than high altitudes in ARCN, which are sparsely vegetated rock, talus, and scree (Swanson, 2013). This could change if climate change allows plants to colonize higher elevations, but large portions of high elevations should remain unvegetated indefinitely due to steep, unstable slopes and severe climate.

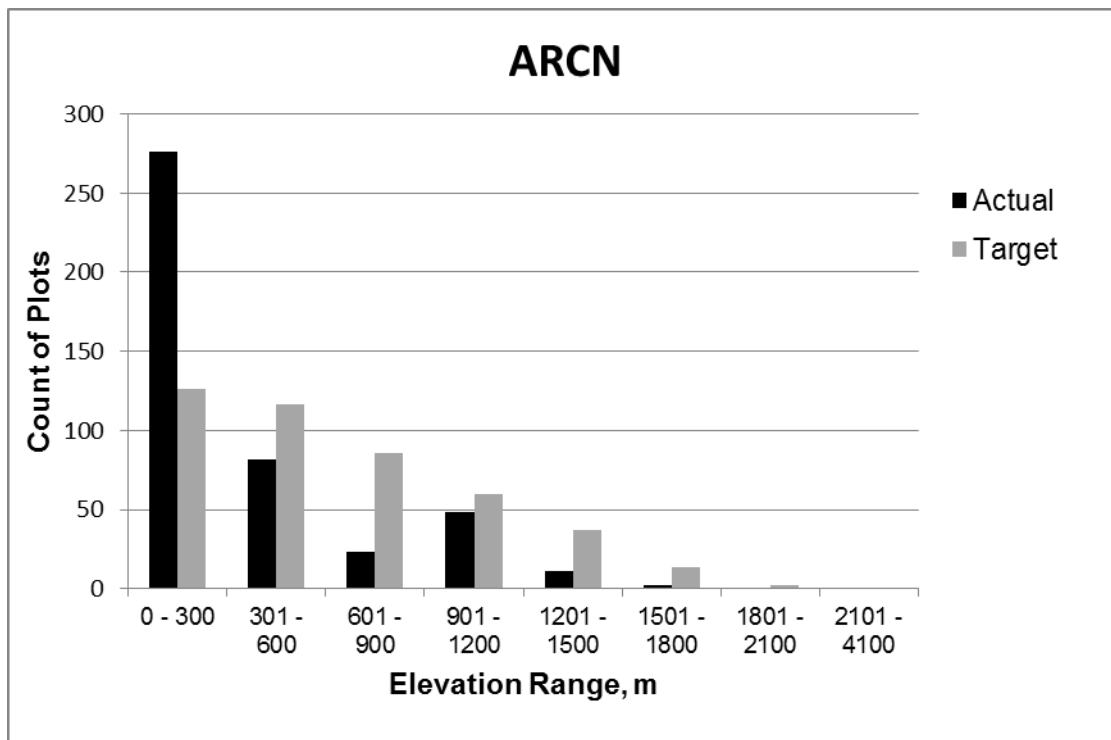


Figure 5. Elevation distribution of plots in ARCN. “Actual” bars give the count of plots in each elevation range. “Target” bars give the ideal distribution that would be produced by allocating the current sample of plots across elevations in proportion to the area in each elevation class.

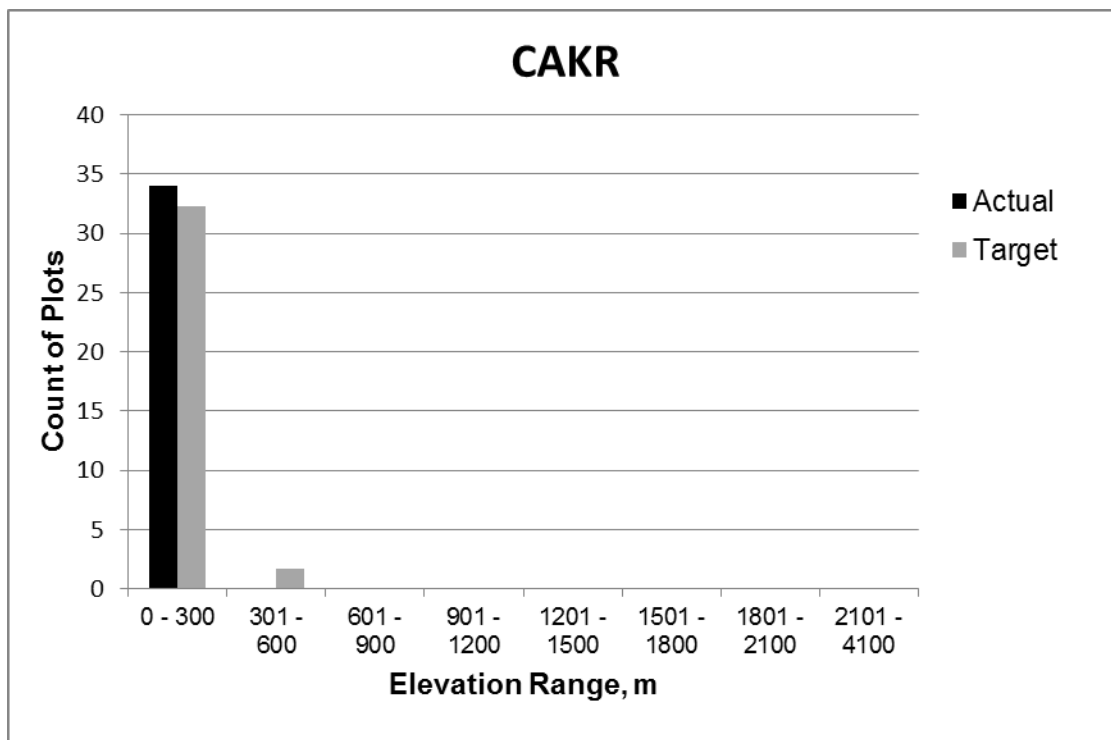
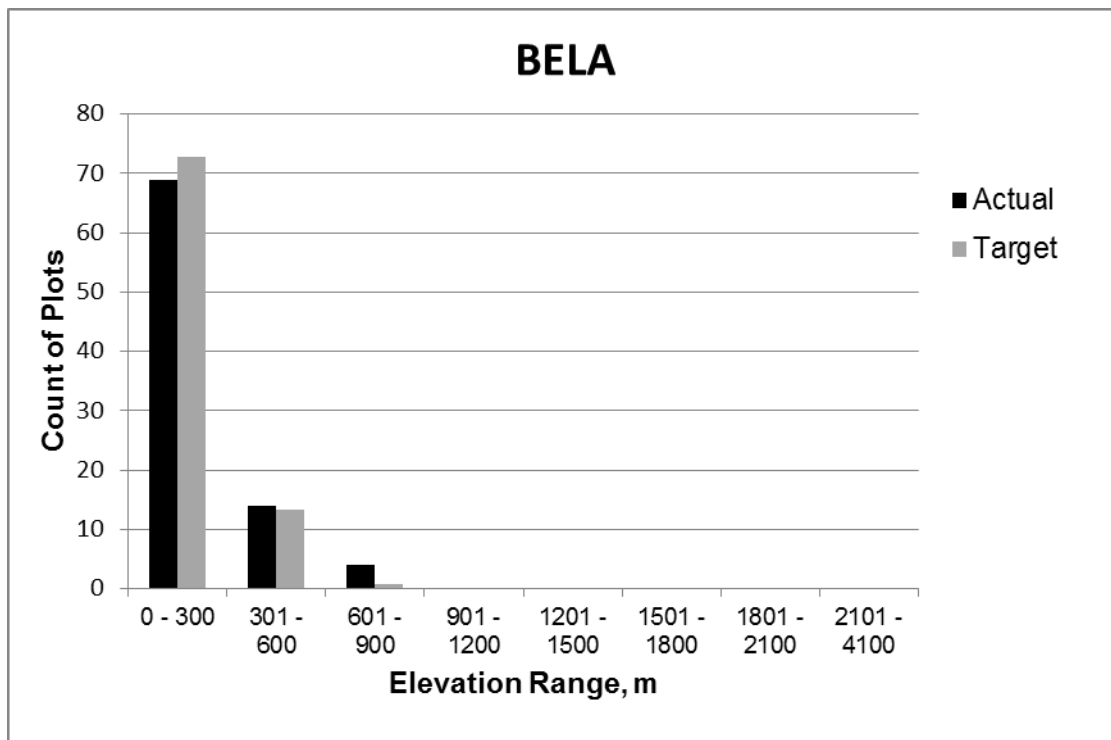


Figure 6. Elevation distribution of plots in individual NPS units of ARCN. “Actual” bars give the count of plots in each elevation range. “Target” bars give the ideal distribution that would be produced by allocating the current sample of plots across elevations in proportion to the area in each elevation class. The NPS unit abbreviations are explained in Fig. 1.

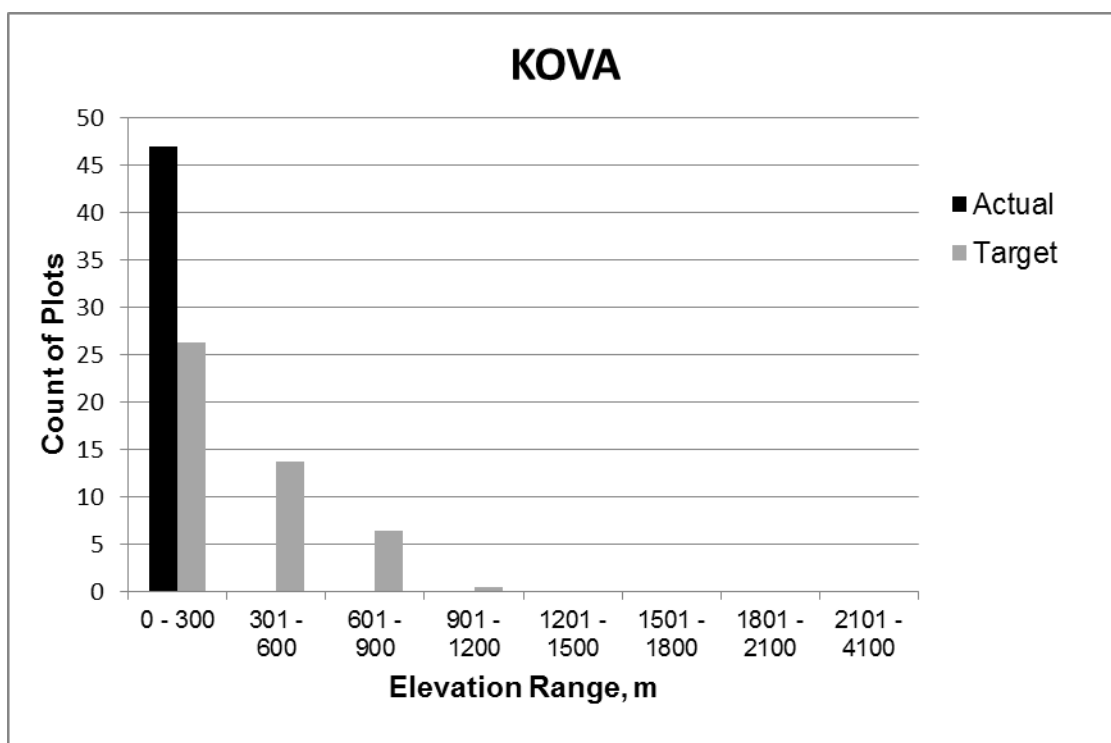
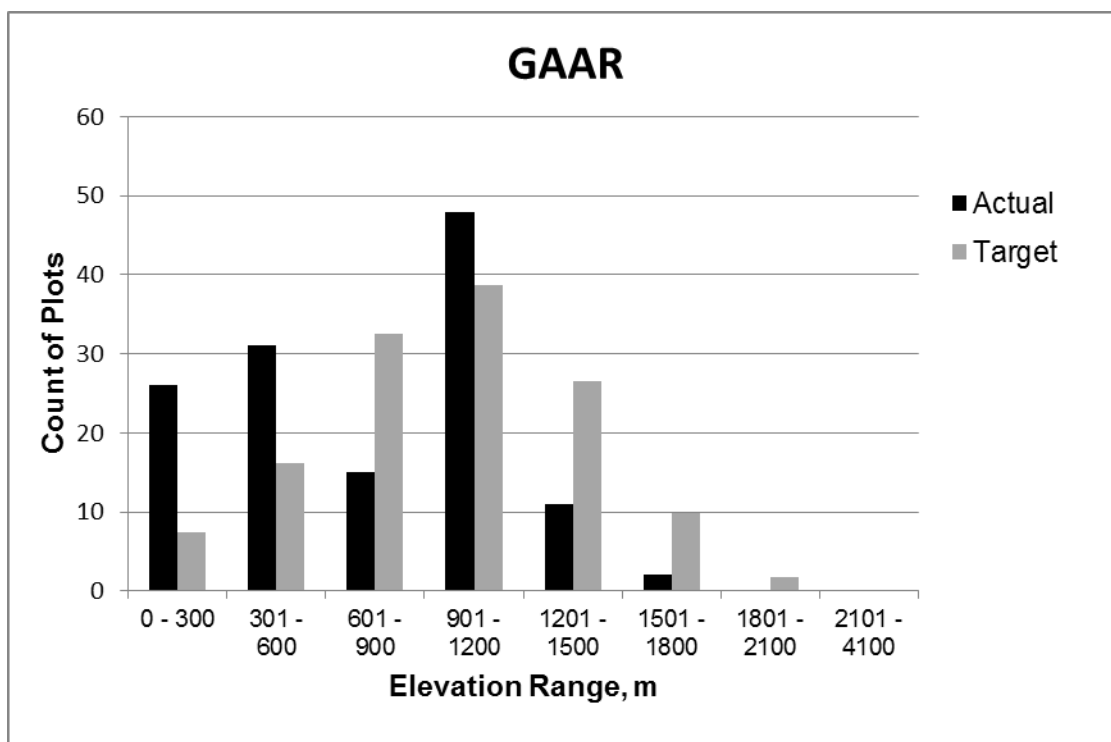


Figure 6 (continued)

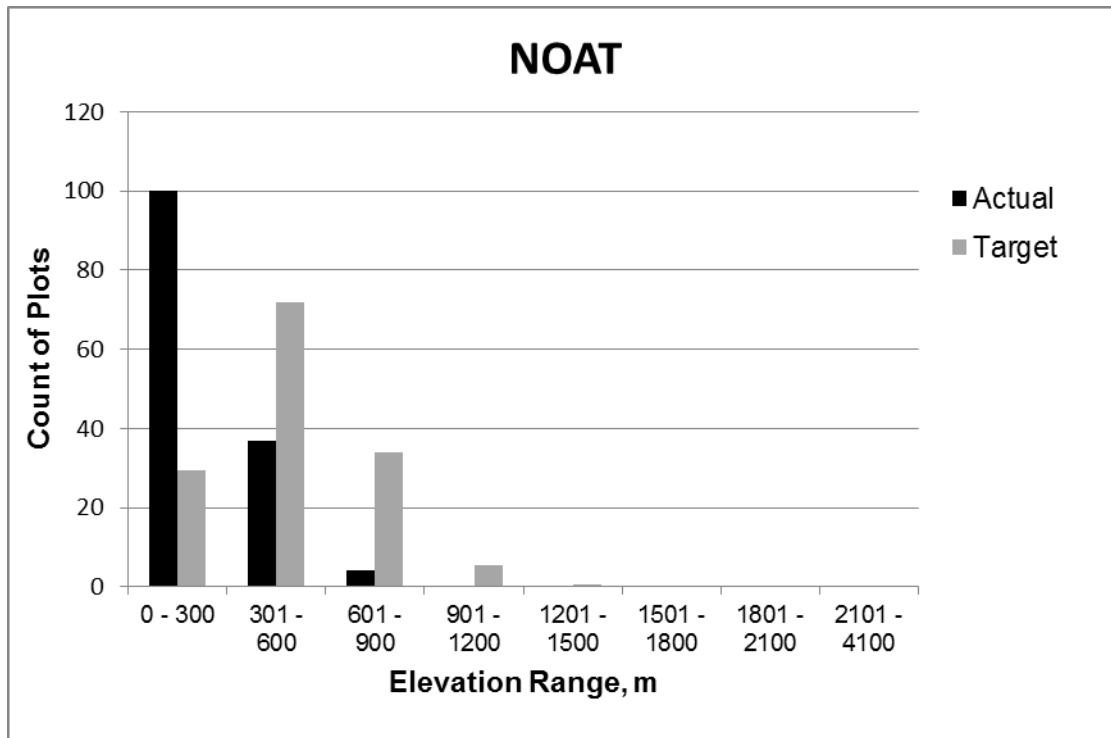


Figure 6 (continued)

Ecotypes

A picture of the dispersion of plots across ecosystems in ARCN is given by the classification of plots into the ecotypes (vegetation-soil landscape units) mapped by Jorgenson et al. (2009; Table 4). Because our sampling strata were landform areas, not these ecotypes, the count of plots by ecotype was not predetermined by the sampling scheme. When assessing sampling adequacy for ecotypes, we are most concerned with ecotypes that have both a low total count of plots (e.g., less than 10 total plots) and a large average area represented by each plot (e.g., the area in ARCN covered by the ecotype divided by count of plots in the ecotype is more than 300 km²). Ecotypes with weak samples by both measures are barren areas (Alpine Alkaline Barrens, Alpine Mafic Barrens, and Riverine Barrens), and several of the shrubs types (Riverine Birch-Willow Low Shrub, Upland Alder-Willow Tall Shrub, and Upland Willow Low Shrub). Barren areas currently have little soil or vegetation to sample that would justify the time required to travel and set up plots. Riverine Barrens were excluded from sampling because they are periodically under water during the field season and they are subject to erosion and deposition that would disrupt plot markers. The two alpine barren types have poor access due to high elevation and cliffs as described previously, and plot markers there are subject to downslope displacement. Nonetheless, we expect to obtain additional plots in alpine barren areas at the nodes planned for 2014. We have a good sample of the nearly barren alpine areas represented by the ecotype “Alpine Dryas Dwarf Shrub”.

Table 4. Distribution of plots amongst ARCN ecotypes¹

Ecotype	Count of Plots ²	Area ³ per Plot, km ²	Area ⁴ , % of ARCN
Alpine Acidic Barrens	15	482	9.23
Alpine Alkaline Barrens	4	749	3.83
Alpine Dryas Dwarf Shrub	29	405	15.00
Alpine Ericaceous Dwarf Shrub	28	58	2.08
Alpine Mafic Barrens	0		1.31
Alpine Wet Sedge Meadow	4	139	0.71
Coastal Barrens	2	43	0.11
Coastal Brackish Sedge-Grass Meadow	13	5	0.07
Coastal Crowberry Dwarf Shrub	6	8	0.06
Coastal Dunegrass Meadow	4	3	0.02
Lowland Alder Tall Shrub	2	274	0.70
Lowland Birch-Ericaceous-Willow Low Shrub	34	79	3.42
Lowland Black Spruce Forest	10	120	1.53
Lowland Ericaceous Shrub Bog	9	95	1.09
Lowland Sedge Fen	23	45	1.32
Lowland Sedge-Dryas Meadow	10	116	1.48
Lowland Willow Low Shrub	9	81	0.94
Riverine Alder or Willow Tall Shrub	7	68	0.61
Riverine Barrens	0		0.65
Riverine Birch-Willow Low Shrub	1	471	0.60
Riverine Dryas Dwarf Shrub	6	19	0.15
Riverine Poplar Forest	6	10	0.08
Riverine Wet Sedge Meadow	8	43	0.44
Riverine White Spruce-Poplar Forest	4	11	0.06
Riverine White Spruce-Willow Forest	9	42	0.48
Riverine Willow Low Shrub	5	27	0.17
Upland Alder-Willow Tall Shrub	7	572	5.11
Upland Birch Forest	2	145	0.37
Upland Birch-Ericaceous-Willow Low Shrub	41	225	11.78
Upland Dwarf Birch-Tussock Shrub	81	203	21.04
Upland Mafic Barrens	2	112	0.29
Upland Sandy Barrens	12	5	0.08
Upland Sedge-Dryas Meadow	15	330	6.33
Upland Spruce-Birch Forest	3	106	0.41
Upland White Spruce Forest	18	253	5.82
Upland White Spruce-Lichen Woodland	7	9	0.08
Upland Willow Low Shrub	5	398	2.54

¹Ecotypes are vegetation soil units mapped at 30-m pixel resolution in ARCN by Jorgenson et al. (2009). Ecotypes with both low overall plot count (less than 10) and high average area of land represented by each plot (more than 300 km² per plot) are written in **boldface** and discussed in the text.

²The total number of plots in each ecotype (ecotypes as identified using field data, not by GIS analysis of the ecotype raster);

³The area covered by the ecotype in ARCN (as mapped by Jorgenson et al. 2009) divided by the number of plots; this is a measure of sampling intensity: a large area indicates sparse sampling.

⁴The proportion of ARCN area covered by the ecotype, as mapped by Jorgenson et al. (2009).

Regarding the under-sampled shrub types, we hope to sample plots in Upland Willow Low Shrub in 2014, but future plots in the other two types are unlikely. The upland Alder-Willow Tall Shrub ecotype is of greatest concern because it is fairly widespread (about 5% of ARCN, Table 4). However, for several reasons we have chosen to allow this type to be under-sampled. Upland Alder-Willow Tall Shrub is most common in the mountains of KOVA, which as discussed previously will probably remain unsampled due to lack of landing sites. Crew productivity is very low in the Upland Alder-Willow Tall Shrub ecotype, owing to difficult travel, plot layout, and sampling. Finally, safety is an issue in dense brush due to poor grizzly bear visibility. The NPS Southwest Alaska Inventory and Monitoring Network chose to remove this ecotype completely from its vegetation sampling program for these same access and safety issues (Amy Miller, NPS-SWAN, personal communication). Fortunately, changes in tall shrub cover are fairly easy to detect in ARCN with remotely sensed imagery and are covered by the Terrestrial Landscape Patterns and Dynamic Vital Sign (Swanson 2013)

Literature Cited

- Holt, E. A. and P. N. Neitlich. 2010. Lichen inventory synthesis: Western Arctic National Parklands and Arctic Network, Alaska. Natural Resource Technical Report NPS/AKR/ARC/NRTR—2010/385. National Park Service, Fort Collins, Colorado.
- Jorgenson, T., K. Yoshikawa, M. Kanevskiy, Y. Shur, V. Romanovsky, S. Marchenko, G. Grosse, J. Brown, and B. Jones. 2008. Permafrost characteristics of Alaska. Proceedings of the Ninth International Conference on Permafrost. University of Alaska Fairbanks, Institute of Northern Engineering.
- Jorgenson, M. T., J. E. Roth, P. F. Miller, M. J. Macander, M. S. Duffy, A. F. Wells, G. V. Frost, and E. R. Pullman. 2009. An ecological land survey and landcover map of the Arctic Network. Natural Resource Technical Report NPS/ARC/NRTR—2009/270. National Park Service, Fort Collins, Colorado.
- Lawler, J. P., S. D. Miller, D. M. Sanzone, J. VerHoef, J., and S. B. Young. 2009. Arctic network vital signs monitoring plan. Natural Resource Report NPS/ARC/NRR-2009/088. U.S. Department of the Interior, National Park Service, Natural Resource program Center, Ft. Collins, Colorado.
- Swanson, D. 2010. Vegetation and Soils Monitoring Protocol Testing Arctic Inventory and Monitoring Network Progress Report, March 2010. National Park Service Unpublished Report, Fairbanks, Alaska. Available at <http://science.nature.nps.gov/im/units/arcn/documents/documents/ARC-N-VS24-VegVitalSignProgressReport-2010-03-10.pdf> (Accessed 5 October 2012).
- Swanson, D. 2011a. Vegetation and Soils Monitoring Protocol Testing Arctic Inventory and Monitoring Network Progress Report, December 2010. National Park Service Unpublished Report, Fairbanks, Alaska. Available at <http://science.nature.nps.gov/im/units/arcn/documents/documents/VegVitalSignProgRptDec2010.pdf> (Accessed 5 October 2012).
- Swanson, D. 2011b. Vegetation and Soils Vital Sign Monitoring Arctic Inventory and Monitoring Network Progress Report, December 2011. National Park Service Unpublished Report, Fairbanks, Alaska. Available at <http://science.nature.nps.gov/im/units/arcn/documents/documents/VegVitalSignProgRptDec2011.pdf> (Accessed 5 October 2012).
- Swanson, D. K. 2012. Vegetation sampling in the Arctic Inventory and Monitoring Network, 2009-2012. Natural Resource Data Series NPS/ARC/NRDS—2012/408. National Park Service, Fort Collins, Colorado.

Swanson, D. K. 2013. Three decades of landscape change in Alaska's Arctic National Parks: Analysis of aerial photographs. Natural Resource Technical Report NPS/ARCN/NRTR—2013/668. National Park Service, Fort Collins, Colorado.

Swanson, D. K. and P. Neitlich. 2011. Terrestrial vegetation monitoring protocol for the Arctic Alaska Network: Establishment, sampling, and analysis of permanent monitoring plots. Natural Resource Report NPS/XXXX/NRR—20XX/XXX. National Park Service, Fort Collins, Colorado. (In Review)