Summary of the 2013 Western Arctic Caribou Herd Project in McCarthy's Marsh, Seward Peninsula Alaska

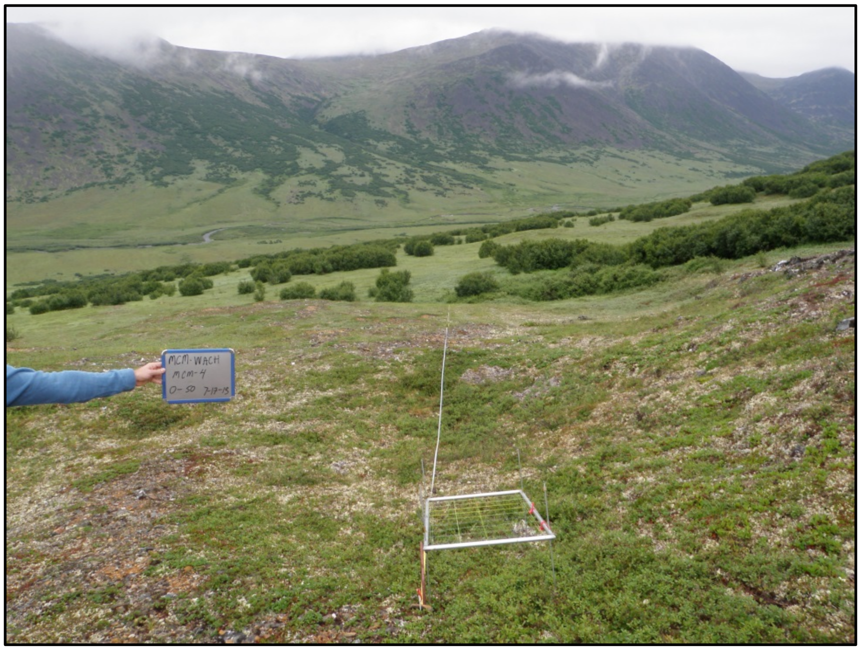

Photo: MCM4-Lava Creek transect photo by Justin R. Fulkerson

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Summary Prepared for:

Bureau of Land Management

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

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Introduction

The Western Arctic Caribou Herd (WACH) has increased dramatically in size over the last forty years, from approximately 75,000 animals in 1970 to 490,000 in 2003, and is now estimated at approximately 348,000 (Dau 2005, Joly *et al.* 2006). With the increase in population size the herd has increased the regional extent of its wintering grounds. The expansion in spatial extent of the wintering range and surge in population numbers has led to concern that the herd may be negatively impacting the vegetation (Joly *et al.* 2006). Additionally, this habitat experiences occasional tundra fires that have dramatic impacts on the vegetation. The vegetation communities that tend to be most impacted by fires are also those that caribou are particularly reliant on. The BLM and collaborators are therefore striving to understand the pace and trajectory of vegetation community assembly following disturbance by fire and by caribou grazing.

To assess the impacts of grazing by caribou (*Rangifer tardus granti*), 20 permanent range transects were established by the Bureau of Land Management (BLM) in 1981. These transects were located in the winter range of WACH, primarily in the Buckland River valley of the Seward Peninsula Alaska. Eighteen of these transects were located and reassessed between 1995 and 1996, and an additional seven transects were added to the study 1996, creating a total of 25 permanent transects (Joly *et al.* 2006). Transects closer to Buckland were revisited between August 12 and 23 of 2012 and the McCarthy's Marsh transects (Figure 1) were revisited from 15-17 July of 2013 by the Alaska Natural Heritage Program (Table 1). See Heitz and Carlson (2012) for a summary of 2012 findings. This report summarizes data collected from McCarthy's Marsh transects in 2013.

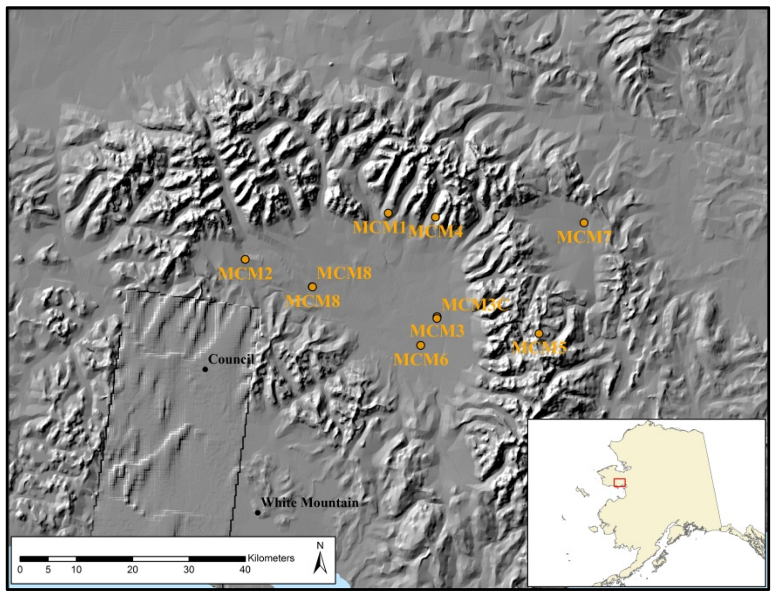

Figure 1. McCarthy's Marsh transect sites.

Methods

Ten transects were sampled using the point intercept method described by Floyd and Anderson (1987). A 1.0 m × 0.5 m sampling frame was strung every 10 cm along both axes to create 50 intercept points. The frame was placed every 4 m along a 50 m transect, for a total of 12 frames per transect (Figure 2). The first

Table 1. Field crew members and participation dates.

Crew member	Position	Affiliation	Field Dates
Justin Fulkerson	Botanist	AKNHP	15-17 Aug
Brian Heitz	Botanist	AKNHP	15-17 Aug
Randi Jandt	Senior Ecologist	AKNHP	15-17 Aug
Timm Nawrocki	Botanist	AKNHP	16-17 Aug

plant species or non-vegetative object observed under the string intercept point was recorded. If a lichen species was encountered as a secondary canopy layer, it was recorded as a second 'hit'.

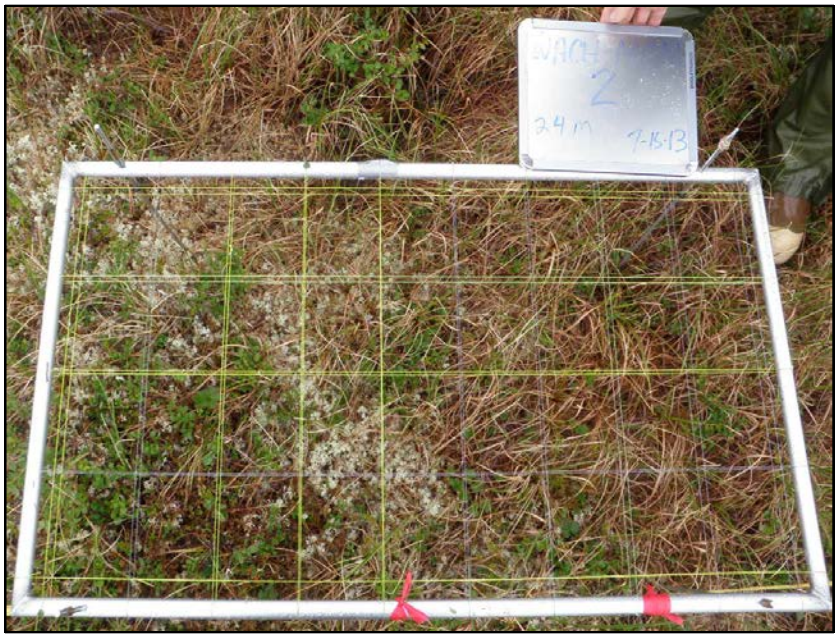

Figure 2. Overhead view of sampling frame at 24 m of MCM2.

For transect MCM 8-Control, there were two readings of the transect with the first performed on July 15 and the second on July 17. The end stake (50m) was found but the start (0m) could not be found as there were missing stakes and the fuel can plot marker was about 6 m away from GPS start point. The original transect, as described by Randi Jandt, was a 'continuous' transect line from 0m of 'MCM-8 Control' to '50m MCM-8 Burn' but with a gap between the transects. The start point was best estimated from GPS, photos, and transect azimuth on July 15 for the first reading and markers left in place. A second attempt to find the start stake (0m) was made on July 17 at the end of the field work, but the start stake could not be found. A second reading of the transect was performed on July 17 with a different 0m starting point than the first reading on July 15. This second start point was 1 m to the right (North) of the first reading. This second transect reading appeared to make a better 'continuous' transect line with the paired MCM8-Burned transect and appears more accurate based on old photos. Therefore we recommend using the July 17 data as the control transect rather than the July 15 data. A rebar and magnets were left in place at the transect start (0m).

Caribou diet in northern and western Alaska is largely composed of fruticose lichens (eg. *Cladina rangiferina, Cladina mitis/arbuscula, Cladina stellaris, Cetraria cucullata*) (Swanson and Barker 1992).We therefore made an effort to evaluate lichen abundance and utilization of the plot. Lichen height was measured once **r**andomly in one of four quadrats in the sampling frame to the nearest 0.5 cm. Utilization was recorded as classes ranging from 0 (no utilization) to 8 (extreme utilization), as described in the Cover Classes for Lichen Utilization booklet provided by the BLM that is adapted from Swanson and Barker (1992).

Soil temperature, soil moisture, active layer depth, and active layer restriction type were measured 1 m to the right of the transect at 5 m intervals for 10 measurements total. Soil temperature and soil moisture were measured between tussocks at a depth of 12 cm and 10 cm, respectively. Soil pH and the dominant soil texture were recorded at the 5 m and 45 m transect

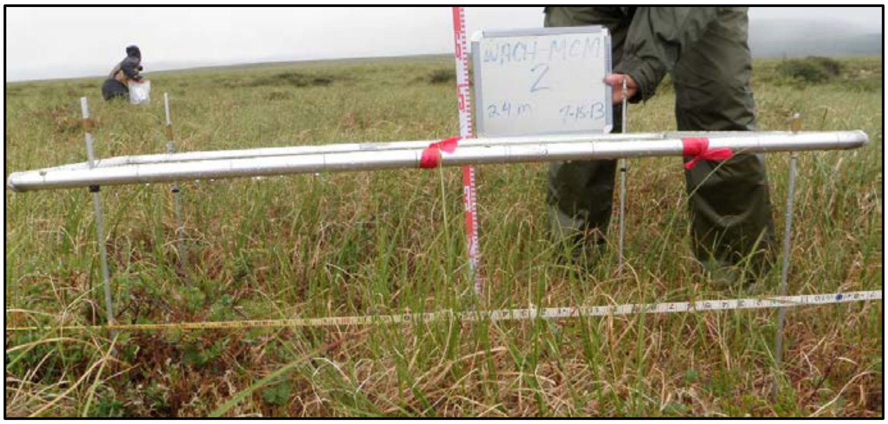

Figure 3. Side view of sampling frame at 24m of MCM2.

mark. Photos were taken at the transect start (0m to 50m view) and of each cardinal direction (0°, 90°, 180°, and 360°) at the 0m start. Overview (Figure 2) and side view (Figure 3) photos of the sampling frame at each sampling point were taken, along with a transect end (50m to 0m) view (Appendix A). Site descriptions of plot markers, transect azimuth and slope, area slope and aspect, macrotopography, and visible disturbances were recorded. Viereck classification of transect vegetation was determined from point frame data because the data captured on the Transect Description Form did not include a percentage of cover for the dominant species which is needed for vegetation classification. Original scanned data sheets, spreadsheet data, and template data sheets are in Appendix B.

Unknown and vouchered taxa were later identified deposited at the University of Alaska Anchorage Herbarium (UAAH). Thirty specimens were collected for McCarthy's Marsh transects and included with the Buckland 2012 specimens (Appendix C). Specimen label information can also be accessed online at the CPNWH website (http://www.pnwherbaria.org/). Data summarized originate from Excel spreadsheets and not FFI (FEAT/FIREMON Integrated, *see below*). Since previous years (pre-2013) data appear inconsistent in current Excel spreadsheet form, only MCM 2013 data was summarized for this report. Each species was categorized in the following vegetative classes: lichen, graminoid, shrub, forb, moss, or non-vegetated. Non-vegetated cover included barren, litter, rock, water, mud, and wood. Percent cover of each vegetated class was calculated for all transects and summarized. These summaries exclude the "second hit" lichens as the "second hit" was not recorded on every point therefore the incorporation of these data would introduce bias to the dataset.

FFI Data Entry

To provide a standardized and uniformed dataset for the WACH project, all available data was entered into a software tool for ecological monitoring, FFI (FEAT/FIREMON Integrated): Ecological Monitoring Utilities (version 1.04.02.23). This software provides a protocol of data entry and analysis. Since this project started in 1981, all transect vegetation data, plot description data, and lichen utilization information has been entered into FFI from scanned copies of the original data sheets. Due to time constraints, soil data collected in 2012 for the Buckland and MCM transects were not entered into FFI. Also Daubenmire ocular estimation of vegetation cover in 1995 was not entered, but the point intercept frame was entered. Data predating the 2013 visits were not extracted for statistical analysis in this summary report.

Data was entered according to FFI Data Instructions (Appendix D) and the instructions were edited by AKNHP staff with ‘track changes’ to note necessary clarification and/or important changes in the data entry procedures. Plant names have changed since the start of the WACH project in 1981; therefore current 2014 accepted taxonomic plant names were entered in FFI. Name changes were listed and a scanned copy of the data sheet documenting these taxonomic notes as are provided in Appendix D. The only major disturbance recorded was on Transect-22 in 2005 where a fire had occurred an unknown number of years prior. Burn severity and comments on ‘charred’ and ‘burned’ vegetation data were entered as appropriate in FFI (*see* Appendix D). Data sheets across all years had inconsistent Utilization Values that included “Historical Utilization” and/or separate “Current Utilization”. To make Utilization Evidence and Utilization Range consistent, only ‘Current Utilization’ was entered into the UV1 and UV2 fields for the Surface Fuels Protocol. Any Utilization that was marked as “Historical” or “HX” was noted in the comments section with its appropriate values (e.g., “3 HX” would be entered ‘0’ for Utilization Evidence and Utilization Range but ‘3-Historical’ in the comments column).

Results

Vegetation

Across all transects, shrubs (dwarf shrub and low shrub) had the highest mean canopy cover of 38.1% with a range of 26.5% to 49.3%, followed by graminoids with a mean cover of 32.0% and range of 5.7% to 54.2% (Figure 4; Appendix E). Lichen canopy cover ranged from 1.0% to 37.9%, with a mean of 18.2%. Non-vegetation cover ranged from 1.8% to 12% with a mean of

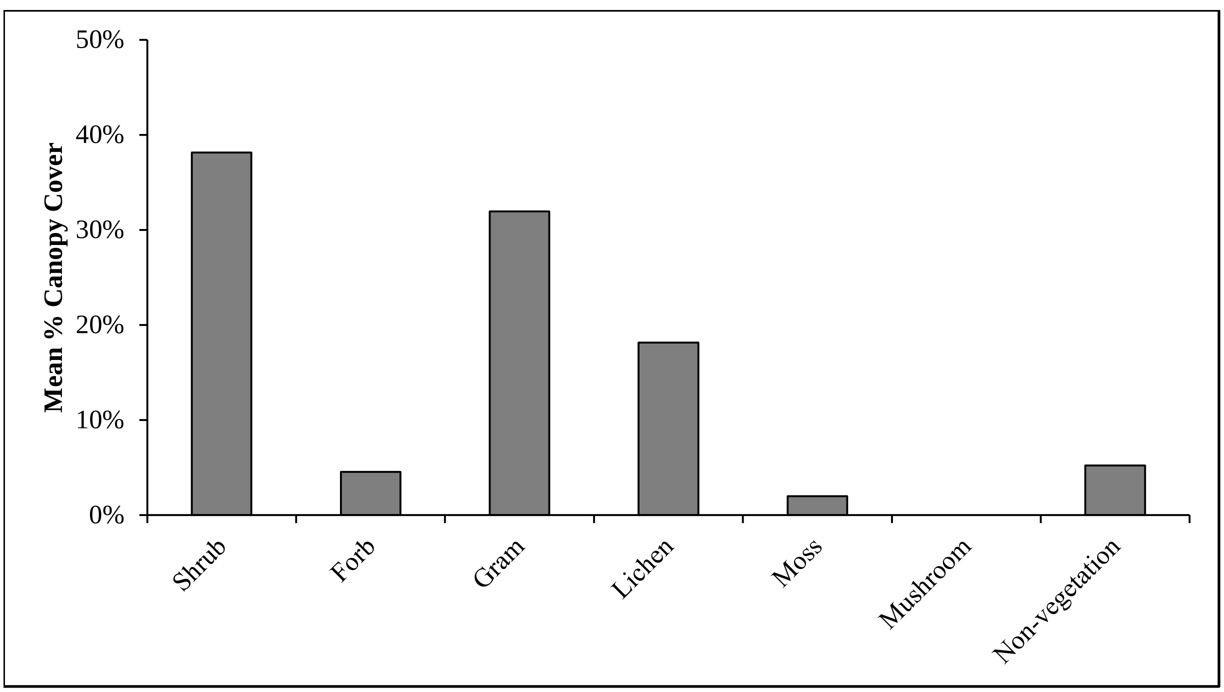

Figure 4. Mean percent canopy cover for all McCarthy’s Marsh transects in 2013.

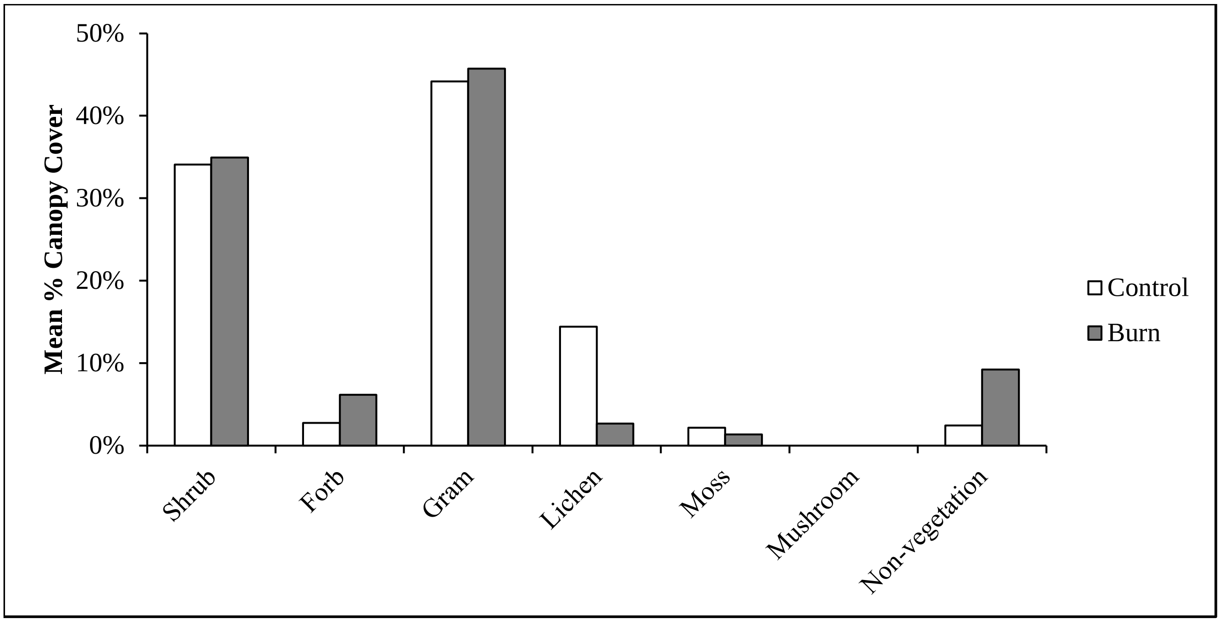

Figure 5. Mean percent canopy cover of unburned (control) and burned McCarthy's Marsh transects in 2013.

5.2%. Forb canopy cover ranged from 0.5% to 8.2% with a mean of 4.6%, Mean canopy cover for mosses (including liverworts) among transects was 2.0% and ranged from 0.5% to 3.5%. No fleshy mushrooms were recorded.

A comparison of burned transects (MCM-3B, MCM-8B) with the paired unburned transect (MCM-3C, MCM-8C), shows that the paired sites differ in forb, lichen, and non-vegetation canopy cover (Figure 5; Appendix E). Average forb canopy cover was higher in burned sites with 6.1% canopy cover compared to 2.75% in the unburned sites. Lichen canopy cover is markedly lower in burn sites with 2.65% mean canopy cover compared to 14.42% mean canopy cover in the unburned sites. Lastly, non-vegetation is markedly higher in burned sites with 9.23% mean canopy cover compared to 2.42% mean canopy cover in the unburned sites.

Seven species were encountered on McCarthy Marsh transects that were not recorded in 2005. The species previously unrecorded included: *Eriophorum chamissonis* (formerly *E. russeolum*), *Carex scirpoidea*, *Carex vaginata*, *Silene acaulis*, *Polemonium acutiflorum*, *Bistorta plumosa*, and *Astragalus umbellatus*.

Lichen Utilization

Across unburned transects, mean lichen height was 2.41 cm and ranged from 1.67 cm to 4.04 cm. In the two burned transects the mean lichen height was 1.87 cm with plot MCM-3B having a height of 2.21 cm and plot MCM-8B having a height of 1.54 cm. Mean Utilization across all transects was 0.37, ranging from 0 to 1.75 (Appendix E). Half of all transects recorded no utilization. These null utilization values correspond with trace to slight impacts, specifically there is little to "no appreciable disturbance to the lichen cover" or "slight grazing" (Swanson and

Barker 1992). At the burned paired sites, some caribou utilization was observed at both control transects but not at the burned transects.

Table 2. Soil textures at McCarthy's Marsh transects.

Dominant soil type	# of occurrences	Number of sites
Clay	4	2
Loam	3	2
Peat	7	4
Rubble	2	1
Block-angular	2	1

Soil

Soil texture was variable across transects, but peat was the most frequently encountered soil type followed by clay (Table 2; Appendix F). Permafrost was the most frequently encountered lower boundary layer except at sites MCM-1 and MCM-4 where rock formed the lower boundary (Appendix F). Additionally, MCM-5 had a mixed boundary layer of permafrost and rock. Average Active Boundary Soil Depth across all transects was 33.48 cm and ranged from 12.9 to 66.3 cm. Average soil temperature across all sites was 5.47°C and ranged from 3.51°C (MCM-7) to 9.86°C (MCM-4) (*summarized in* Appendix F). The average soil pH across transects was 4.9 and ranged from 4.15 (MCM-3B) to 6.05 (MCM-7) (*summarized in* Appendix F).

Discussion

Seven of the ten WACH McCarthy's Marsh transects were classified as Tussock Tundra and across all transects average cumulative shrub and graminoid cover occupied 70% of the top canopy. Burned transects had nearly equal shrub and graminoid canopy cover as unburned transects did, suggesting that fire disturbance has little effect on the shrub and graminoid cover 36 and 44 years after fire disturbance (MCM-3B and MCM-8B, respectively). However, shrub and graminoid canopy cover was likely greatly reduced in years shortly after fire. The nearly equal canopy cover of shrubs and graminoids in burned and unburned transects might be attributable to the quicker growth rate of shrubs and graminoids. Compared with vascular plants, growth rates of lichens are slow, and reestablishment of late-seral lichen (e.g. *Cladina stellaris* and *Cladina rangiferina*) communities following large scale disturbances occurs over decades. Other factors such as caribou utilization and climate change are also likely contributing to the differences in vegetation cover in burned and unburned areas. For example, latitudinal shrub expansion patterns have been observed in northern Alaska and circumpolar arctic regions (Sturm *et al*. 2001a, Tape *et al*. 2006). A cyclic dynamic feed has been found with the shrub expansion where shrubs increase the snow retention resulting in warmer soil temperatures, which increase nutrient turnover rates and promote further shrub growth (Sturm *et al.* 2001b, Tape *et al*. 2006). Greater shrub and graminoid canopy cover can induce greater lichen height but also reduce lichen abundance and diversity (Swanson 1996, Holt *et al.* 2008). The application of multivariate statistical methods, such as ordination, would be useful to identify both general and specific patterns of vegetation change over time, but are outside the scope of this summary.

In arctic ecosystems, lichens contribute nearly half of the botanical diversity and a large portion of the biomass (Neitlich and Hasselbach 2001), and ground-dwelling lichens constitute the majority of diet for western arctic caribou during winter. Lichen was markedly lower on transects that experienced a burn in comparison with the paired unburned sites. Lichen was greatest at the alpine sites, except for one lowland tussock tundra site (MCM-2). Estimates of caribou utilization indicate low use in recent years of this area with half of all plots having no detectible utilization. The lack of utilization in McCarthy's Marsh burned plots is consistent with other work and likely relates to reduced lichen abundance (*see* Gustine and Parker 2008).

If the shrub and graminoid develop a new upper canopy layer over time, as suggested by the increased growth rate in the burned plots, the lower canopy structure of lichen, forbs, and mosses may not be lost in future data collection since the current point frame methodology only captures the uppermost canopy layer. Indeed, field observations often found shrub or graminoid canopy cover to be the overstory layer but lichen and/or forbs abundant in the lower canopy layer. This was the reasoning for Jandt and Joly to measure a "second hit" if lichen was present in the lower canopy layer. Having lichen height measurements may artificially inflate lichen abundance as lichen height can increase with shrub canopy cover, yet still diminish in abundance and diversity (Swanson 1996, Holt *et al.* 2008). Depending on the assumptions of the data interpretation, future plot frame readings may want to consider line-point intercept or other methods to capture the entire vegetation profile rather than the uppermost top layer only.

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Appendix A. WACH Photos

On USB Mass Storage Device

Appendix B. Data Sheets and Summary

On USB Mass Storage Device

Appendix C. Herbarium Vouchers

On USB Mass Storage Device

Appendix D. Data Entry in FFI

On USB Mass Storage Device

Appendix E. Vegetation Summary

Table 3. Summary of 2013 average percent canopy cover of primary cover classes, average Utilization, and average lichen height in McCarthy Marsh transects.

	Forb	Gram	Lichen	Shrub	Moss	Non-Veg	Utilization	Lichen Height (cm)
MCM-1	4.3%	17.5%	24.5%	49.3%	0.5%	3.8%	0	3.58
MCM-2	2.7%	34.5%	31.5%	26.5%	2.2%	2.7%	0	3.64
MCM-3C	2.3%	54.2%	10.2%	30.0%	0.8%	2.5%	1.75	1.42
MCM-3B	6.7%	44.8%	1.0%	33.8%	1.7%	12.0%	0	2.21
MCM-4	0.5%	5.7%	37.9%	48.0%	0.5%	7.5%	0.75	2.25
MCM-5	8.2%	6.8%	32.8%	40.3%	3.5%	8.5%	0	1.67
MCM-6	7.5%	31.8%	13.2%	39.8%	3.0%	4.7%	0.083	4.04
MCM-7	4.7%	43.5%	7.5%	39.3%	3.2%	1.8%	1	1.85
MCM-8C	3.2%	34.2%	18.7%	38.2%	3.5%	2.3%	0.083	3.25
MCM-8B	5.6%	46.6%	4.3%	36.0%	1.0%	6.5%	0	1.54

Appendix F. Site Description Summary

Table 4. Summary of Transect Site Descriptions and Soil Layer for McCarthy's Marsh transects in 2013.

	Viereck Classification	Macrotopography	Elev. (m)	Transect Slope (%)	Avg. Soil Temp (°C)	Avg. Soil pH	Soil Texture	Boundary Layer	Avg. Active Layer Depth (cm)
MCM-1	2D2B Vaccinium Dwarf Shrub Tundra	Plateau	296	5	6.23°	5.6	Blocky, angular	80% Rock, 20% Permafrost	66.3
MCM-2	3A2D Tussock Tundra	Shoulder slope	179	0	4.96°	4.25	Peat	Permafrost	29
MCM-3C	3A2D Tussock Tundra	Nonpatterned	51	0	5.62°	5.6	Loamy	Permafrost	31.4
MCM-3B	3A2D Tussock Tundra	Nonpatterned	50	0	5.15°	4.15	Peat	Permafrost	37.9
MCM-4	2D2B Vaccinium Dwarf Shrub Tundra	Upper slope	350	26	9.86°	4.75	Rocky-Sandy-Loamy	Rock	12.9
MCM-5	2D1C Dryas-Lichen Dwarf Shrub Tundra	Plateau	645	0	5.37°	5.3	Rubbly	60% Rock, 40% Permafrost	30.3
MCM-6	3A2D Tussock Tundra	Flat	49	0	4.84°	4.2	Peat	Permafrost	33.4
MCM-7	3A2D Tussock Tundra	Nonpatterned	165	0	3.9°	6.05	Clayey	Permafrost	30.6
MCM-8C	3A2D Tussock Tundra	Flat	69	0	3.51°	4.6	Loamy	Permafrost	33
MCM-8B	3A2D Tussock Tundra	Flat	69	0	5.22°	4.25	Clayey	Permafrost	30

Appendix G. Summary of the 2012 Western Arctic Caribou Herd Habitat and Utilization Study

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Introduction

The Western Arctic Caribou Herd (WACH) has increased dramatically in size over the last forty years, from approximately 75,000 in 1970 to 490,000 in 2003, and is now estimated at approximately 348,000 animals (Dau 2005, Joly et al. 2006). With the increase in population size the herd has increased the regional extent of its wintering grounds. The increase in spatial extent of the wintering range and increase in population numbers has led to concern that the herd may be negatively impacting the vegetation (Joly et al. 2006). Additionally, this habitat experiences occasional tundra fires that has dramatic impacts on the vegetation that caribou are particularly reliant on and therefore efforts have been made to understand the pace and trajectory of community assembly following this disturbance.

Twenty permanent range transects were established by the BLM in the winter range of the WACH in 1981 to assess the impacts of grazing by caribou (*Rangifer tardus granti*). Eighteen of these transects were located and reassessed between 1995 and 1996, and an additional 7 transects were added to the study 1996 (Joly *et al.* 2006). Percent lichen composition declined between 1981 and 1996, while percent graminoid composition increased over the same period (see Joly and Jandt 2008). These 25 transects, were revisited between in August 12 and 23 of 2012 by in an effort to assess the current condition of vegetation and the trajectory of plant community change. The following report is a summary of the data collected in the summer of 2012.

Figure 1: WACH 2012 project area. Tansect locations are shown as red dots.

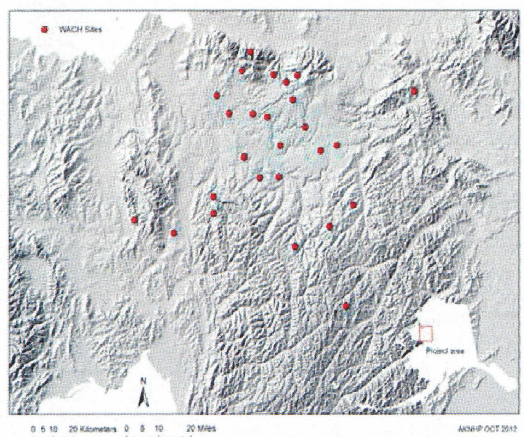

Table 1: 2012 field crew, positions, and affiliations.

Crew member	Position	Affiliation	Field Dates
Tina Boucher	Senior ecologist	AKNHP	11-19 Aug
Michael Duffy	Senior ecologist	Private contractor	19-27 Aug
Justin Fulkerson	Botanist	AKNHP	19-27 Aug
Brian Heitz	Botanist	AKNHP	11-27 Aug
Randi Jandt	Senior ecologist	AKNHP	11-27 Aug
Jennifer McMillan	Ecologist	BLM	20-21 Aug
Kelly Walton	Botanist	AKNHP	11-19 Aug

Methods

Twenty-nine transects were sampled botanist/plant ecologist crews each of two to four members (listed in Table 1), using the point intercept method described by Floyd and Anderson (1987). A 1.0 m x 0.5 m sampling frame was strung every 10 cm along both axes to create 50 intercept points. The frame was placed every 4 m along the identical 50 m transect, for a total of 12 frames per transect (See Jandt *et al.* for more details). The first species observed below each of the fifty string intercept point on the frame was

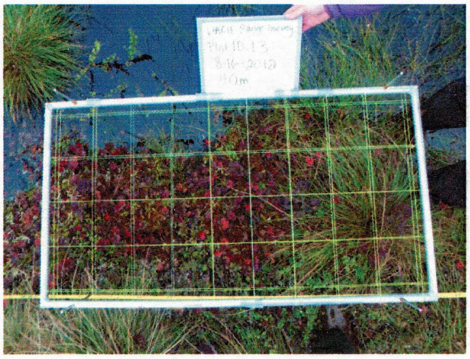

Figure 2: Transect in tussock tundra S of Fish Lake.

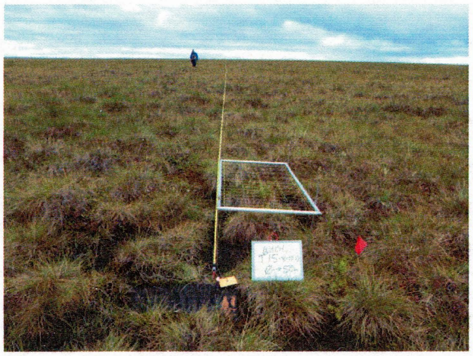

Figure 3: Point intercept sampling frame.

recorded. Non-vegetative observations (*e.g.*, rock, bare ground, water or wood) were also recorded. Each record was categorized as lichen, graminoid, shrub, forb, moss, or non-vegetated. We recorded for each 25 m radius plots with center at 25 m mark on transect line the dominant species for 5 different lifeform classes: tall shrub, low shrub, dwarf shrub, graminoid/herbaceous, and moss/lichen/water/bare. Specimens were collected and pressed to aid in identification of unknown taxa and are currently under curation at the Alaska Natural Heritage Program (AKNHP).

The heights of 4 lichens occurring within the quadrat frames were estimated for each transect. Utilization was recorded as classes ranging from 0 (no utilization) to 8 (extreme utilization), as described in the Cover Classes for Lichen Utilization booklet provided by the BLM.

Soil temperature, soil water content, active layer depth, and active layer restriction type were measured every 5 m along each transect. Soil pH and the dominant soil texture were recorded twice at each transect at distances of 5 m from each transect end.

Photos of each transect were taken from the 0 m and 50 m endpoints. Landscape photos facing four cardinal directions were taken from the O m transect end. At three points along each transect, images of the vegetation beneath the point intercept frames were both from overhead and also along the horizontal plane at the height of the vegetation.

Data Summary

Soils

It is axiomatic that soil properties influence plant communities and in 2012 we initiated additional measurements of the soils. Soil pH values ranged from 3.7 at dwarf shrub tussock tundra site T16 and lichen tussock tundra site (T21) to in to 6.1 at lichen tussock tundra site T22. Average soil water content ranged from 14% at the sedge/graminoid alpine tundra (T2) site and the boulderfield (T18) sites to 49% at lichen tussock tundra sites T9 and TUC2B. The 2012 soil water content data may underestimate the actual degree of soil moisture at some sites, as the water content sensor often failed to provide a reading in soils that were highly saturated. Average soil temperatures along transects ranged from 3° C at the Ulukluk Creek transects to 10° C at alpine fellfield (T18) and boulder field sites (T19).

Table 2: Dominant soil types and number of occurrences.

Dominant soil type	# of occurrences	Number of sites
Clay	3	2
Loam	10	7
Peat	38	21
Rubble	2	2
Sand	3	2

Average active layer depth (cm) measured using standard soil probe along each transect ranged from 6 to 60 cm. Permafrost was active layer boundary at the majority (T23) of the sites. Rock was recorded as an active layer boundary at seven transects. Both permafrost and rock was recorded as an active layer boundary at lichen tussock tundra site T22. Peat was the most common soil type, and occurred at 21 of the sites. Loamy soils were found at 7 sites (see Table 2).

Graminoids and shrubs had the highest coverage, and together make up nearly 75% of the canopy cover within transects. Shrub cover was greater than 20% at all transects and was primarily comprised of four species: *Vaccinium uliginosum, Ledum palustre, Betula nana*, and *Vaccinium vitis-idaea*. Graminoid species of the genera *Eriophorum* and *Carex* account for 38% of the total coverage of all transects. Graminoid cover was lowest (2%) in the boulderfield site (T19), where lichen cover was highest (47%).

The total lichen cover for all transects was 8%. Individual lichen species that had the greatest coverage were fruticose species *Flavocetraria cucullata, Cladina rangiferina*, and *Cladina mitis*, all of which are considered highly preferred by caribou (Pegau, 1968). Saxicolous crustose lichens covered nearly 50% of the sampled area at the boulderfield site (T19). The lowest lichen cover (0.3%) was at the sedge/grass tussock tundra site at the headwaters of the Tag River (T14). The average height of lichens at each transect ranged from 0.4 to 3.2 cm. Average lichen height was greater than 3 cm at only four out of the twenty-nine transects (transects 5,9,10, and UC2B). The greatest lichen height (10 cm) was measured in lichen tussock tundra at transect 10; this transect also had the greatest heights averaged by frame (4.5 to 5.25 cm).

Bryophyte coverage at each transect ranged from 1% (at transect 12) to 25% (at transect 6). Of the twelve taxa of bryophytes identified in the field, mosses of the genera *Sphagnum, Polytrichum*, and *Dicranum* were of greatest occurrence and cover. Fruiting fungi were scored as a cover class at only one transects (T20).

Utilization

Utilization rank values for individual frames of 1 m area ranged from 0 (no utilization) to 7 (severe utilization). Utilization averages for transects ranged from 0 to 5 (heavy utilization), with only 4 transects having average recent utilization equal to or greater than 4 (moderately heavy utilization). There were five transects with no recent utilization apparent.

Primary Vegetation Changes from 2005-2012

Between 2005 and 2012, non-vegetative cover averaged for all plots decreased by 6.4%, while graminoid cover increased by nearly the same amount. The percent cover for shrubs and forbs also showed increases (3.1% and 1.9%, respectively) for the same period. Lichen cover, however, decreased by 3.9%. The percent cover for mosses showed the lowest change (-1.1%) over the seven year period.

The greatest change in transect cover between 2005 and 2012 occurred in lichen tussock tundra at Traverse Peak, where non-vegetative cover decreased from 54% to 10%. At this site, canopy cover of graminoids and shrubs increased by 27% and 16% respectively, and lichen cover decreased by 6% (see Appendix Table).

Discussion

Overall, some consistent changes in cover classes were observed along these transects between the 2005 and 2012. All but two transects showed a decrease in bare ground, while most transect displayed modest increases in cover of shrubs and forbs. At the lichen tussock tundra site at traverse Peak (T22), most of the bare ground (which comprised over half of the transect in 2005), is now currently colonized by graminoids, shrubs, or forbs, whose combined cover increased in cover by 48% between 2005-2012. Most transects also displayed modest increases in cover of shrubs and forbs. Increase in shrub cover has been observed in other regions of arctic Alaska and is often attributed to climate change (see Tape et al. 2006). Changes in forb and graminoid cover was variable across transects, but the majority of transects displayed modest increases in these two cover classes.

Contrary to vascular plant cover, lichen cover decreased in all but three transects. In arctic ecosystems lichens contribute nearly half the botanical diversity and a large portion of the biomass (Neitlich and Hasselbach 2001), and ground-dwelling lichens constitute the majority of diet for western arctic caribou during winter. Compared with vascular plants, growth rates of lichens are slow, and reestablishment of late-succession lichen (e.g. *Cladina stellaris, Cladina rangiferina*) communities following large scale disturbances occurs over decades. Recent increases in the number of caribou of the western arctic, expansion of their winter ranges outside of a "historic core range", and subsequent declines in lichen cover in within the expanded ranges have contributed to speculation of the timing and changes in the population size and future winter ranges of the herd. While extensive research has demonstrated that grazing, including both consumption and trampling, reduces lichen cover and biomass in arctic and antarctic environments (e.g., Ahti 1959), the degree to which large-scale declines in lichen cover is attributable to disturbances, including grazing or fire, or to changes in the regional climate, is largely unknown.

The long term studies of the western arctic herd in the Seward Peninsula may help elucidate the patterns of vegetation change in relation to these factors. In particular the 2012 cover class data and utilization scores, along with future data from McCarthy's March, are essential in determining areas where lichen cover is still in decline, how these declines may relate to recent utilization, and the degree to which lichen cover has changed in areas with little or no apparent utilization.

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Appendix I. Summary of 2012 percent cover and change in percent cover since 2005 (parentheses) of primary cover classes and caribou utilization scores.

Transect	Forb	Gram	Lichen	Mosses	NONVEG	Shrub	Utilization
T1	6 (3)	22 (-5)	9 (-6)	8 (-6)	15 (3)	40 (10)	4.8
T2	10 (3)	47 (-1)	2 (-1)	10 (-6)	11 (-4)	21 (7)	0.0
T3	3 (1)	56 (14)	7 (-2)	2 (-2)	2 (-5)	30 (-7)	0.3
T4	4 (0)	40 (-4)	2 (-2)	6 (1)	5 (-2)	45 (6)	2.9
T5	12 (6)	34 (7)	11 (-2)	4 (-2)	10 (-4)	30 (-5)	0.9
T6	6 (-1)	29 (-5)	9 (-2)	25 (7)	2 (-2)	29 (3)	0.0
T7	8 (4)	44 (8)	7 (-5)	2 (0)	4 (-8)	37 (0)	0.6
T9	7 (0)	48 (4)	3 (-4)	9 (-1)	8 (-1)	26 (2)	0.3
T10	3 (1)	49 (6)	7 (-2)	2 (-2)	3 (-5)	37 (3)	0.5
T11	8 (4)	65 (7)	5 (-4)	1 (-1)	1 (-4)	20 (-1)	0.3
T12	0 (-1)	42 (-1)	2 (-2)	1 (-1)	6 (-4)	49 (9)	3.0
T13	10 (3)	54 (13)	7 (-11)	5 (-1)	3 (-5)	23 (1)	0.7
T14	7 (3)	55 (11)	0 (-3)	6 (-3)	3 (-7)	31 (0)	0.0
T15	3 (2)	48 (9)	5 (-4)	13 (-5)	5 (-9)	26 (6)	0.8
T16	5 (2)	38 (10)	3 (-7)	3 (-1)	3 (-7)	48 (3)	0.4
T18	6 (-3)	4 (0)	19 (8)	4 (-2)	7 (-11)	59 (6)	0.3
T19	0 (0)	2 (0)	47 (14)	2 (-1)	15 (-12)	34 (-1)	4.0
T20	6 (1)	16 (1)	9 (3)	2 (1)	13 (0)	54 (-5)	4.3
T21	3 (2)	47 (17)	9 (-7)	2 (-3)	1 (-13)	39 (4)	0.1
T22	9 (5)	48 (27)	4 (-6)	4 (2)	10 (-44)	27 (16)	0.0
T23	18 (13)	38 (7)	7 (-17)	5 (0)	3 (-6)	30 (3)	0.2
T24	4 (2)	5 (1)	29 (-8)	5 (2)	17 (3)	40 (0)	4.6
T25	6 (3)	7 (1)	9 (-8)	3 (-5)	4 (-7)	71 (15)	1.0
T26	4 (-5)	63 (23)	5 (-13)	2 (-2)	5 (-2)	23 (-1)	1.0
T27	3 (1)	58 (9)	2 (-7)	2 (0)	2 (-7)	34 (3)	0.5
UC1B	1	59	2	1	3	34	0.1
UC1U	2	43	6	2	5	44	0.8
UC2B	3	70	0	1	0	26	0.0
UC2U	2	60	3	1	5	30	0.2